THE IMPACT OF CHINA HIGH SPEED RAIL ON REGIONAL ECONOMIC DEVELOPMENT

By
Bingqing Wang
Student Number (7142709)

Major Research Paper Presented to the
Department of Economics of the University of Ottawa
in Partial Fulfillment of the Requirements of the M.A. Degree

Supervisor: Professor Nguyen Van Quyen

ECO6999

Ottawa, Ontario, Canada
August 2018

Abstract

China has a vast territory with uneven resource distribution and unbalanced economic development. Agglomeration of urban centers have been taking place at a rapid rhythm over the last few decades. The capacity of railway transport is not sufficient to support national economic development, and the challenge is especially evident during festive seasons. There is an increasing demand for more carrying capacity to meet the growth in transport needs, and China's high-speed railway (HSR) system is designed to address transport demands. This paper analyzes the significance and impact of China's HSR on regional economic development. It is shown that the HSR system has positive average treatment effects on regional economy during the construction period; however, the average treatment effects become negative during the operation period. It is suggested that the negative treatment effects were caused by the movement of workers and funds from less developed HSR cities to more developed HSR cities in search of higher returns. For this reason, the paper suggests that in order to fully enjoy the economic benefits brought by HSR, local governments should carry out policy reforms, such as increasing government spending on education and government spending on technology development to enhance local competitiveness.

Table of Contents

1. Introduction

When it comes to economic development, transport plays a major role. Transport infrastructures work as a facilitator of economic growth and economic integration. This is the reason why there has been a focus on investments in transport infrastructures (Fujita et al., 1999). Key to this idea has been the function of high-speed rail (HSR), which is a major shift in transport policy and which has been at the forefront of the development of China HSR. As initially believed, HSR was considered as a way of increasing the accessibility between major towns (Vickerman, 2012). In Europe, numerous studies have analyzed the manner in which regional economic development can be affected by changing accessibility. Evidence from countries like France suggests that HSR could also be important in promoting intra-regional integration (Garmendia et al, 2012). The significant positive impact of HSR on regional economic development in Europe prompted China to invest $50 billion on its HSR system in 2009, with a total expected construction cost of $300 billion. The investments include four vertical and four horizontal networks – four running North-South and four running East-West – with a total length of 12,000 km. This HSR network is considered as a major pillar of national economic development and a facilitator of regional growth. It has been expected that the HSR network would not only provide increasing transport services among regions, but also enhance regional development. This paper analyzes the impact that the HSR in China has on regional economic development. In particular, the paper focuses on the analysis of the impact on the cities across the Beijing-Wuhan HSR line, the longest rail line in this system, and provides an answer to the research question of <<Does the Beijing-Wuhan HSR line have a positive impact on the GDP of the cities that it crosses?>>

The rest of the paper is organized as follows. Section 2 reviews the relevant literature on the relationship between infrastructures and economic growth. Section 3 explains the methodology. Section 4 presents the data sources used in the estimation. Section 5 reports the results. A discussion of the results is given in Section 6. The policy implications of the analysis are discussed in Section 7. Some concluding remarks are given in Section 8.

2. Literature Review

The research on the impact of rail road on economic growth can be traced back to Nerlove (1966), who examined the importance of railroad to American economic growth and found that railroad lead to an increase in national income of through the provision of transportation services. Since then, a large literature on the subject has appeared.

Most current studies emphasize the economic effects of railroad networks. It has been suggested that proximity to railroad networks has a positive impact on GDP per capita of a nation through wider industry sectors (Banerjee et al., 2012). There are also major benefits of railways when it comes to decentralization of urban population. The same has been witnessed for industrialized countries. For instance, it was argued that the proposed HSR network in the European Union could boost territorial polarization between advanced towns and remote regions (Gutierrez et al, 1999). In London, the new HSR networks have been geared towards wooing business service jobs to some of the central areas of the city in a bid to create multiplier impacts to regenerate the surrounding depressed urban areas. The construction of the HSR systems in both France and Spain has been perceived as a policy lever aimed at enhancing market integration. It has also been seen as a tool that can promote economic growth (Garmendia et al, 2012). Hall (2009) argued that HSR networks serve as a facilitator in the development of remote regions surrounding mega cities. By analyzing the accessibility impacts of the HSR network in England, Hall (2009) asserted that cities which are directly linked to that network would reap more benefits as opposed to the rest that lack connections. Knowledge of the transit-induced accessibility remains important for different reasons. First and foremost, improved market access helps in transforming industries that are expanding into other regions, and this results in spatial diffusion of growth in urban and remote regions, especially for developing nations (Vickerman, 2012). At a certain level, accessibility dynamics attributed to transport enhancements in local national borders might be important in reducing regional disparities. It may also affect core-periphery urban structural relationships. On the other hand, there could be significant variations in the transit-induced accessibility effects when the total population that can be accessed using the transportation network from a certain town is considered. Given that the current measurement of accessibility is normally determined by the population of rail stations, contour measures or weighted average time of travel only improves collection of accessibility information locally (Gutierrez et al, 1999). The benefits of accessibility reaped by areas from other regions in the network could also serve a major role in assessing the market potentials.

The above studies on the impact of HSR on economic growth in developed countries show that transport infrastructures positively affect economic growth and development of a nation both directly and indirectly. However, the impact of HSR on the economy may differ in developing countries compared to developed nations due to their different economic status and other aspects. The case of Pakistan shows that besides boosting accessibility, development of infrastructures is accompanied by trade and investment opportunities to regions that were not connected in the past (Mohmand et al, 2017). In addition, it offers access to products, services, and job opportunities via the multiplier effect (Mohmand et al, 2017). The benefits are also evidenced in India, where HSR has helped to speed economic growth. This has been achieved by unlocking untapped potential in the nation (Kumar & Prakash, 2017). In the same vein, it must be emphasized that delayed delivery of goods has had a negative impact on local sectors, thereby reducing the anticipated output (Kumar & Prakash, 2017). These studies show that development of HSR in developing nations also helps to spur economic development.

As for the studies focused on China, by using the distance-related proximity index to determine the evolution of rail networks in a number of prefecture cities in the period between 1906 and 2000 in China, Wang et al. (2009) concluded that the expansion of the railway networks has made major contributions to China’s economic development. In a case study, the World Bank (2014) contended that the advantages attributed to HSR causing a major shift in regional connections in China would not only benefit the country at the national level, but also at the regional levels. HSR has brought about an increase in economic growth in the cities across the rail lines through the productivity effects, employment effects, and tourism effect. This result is confirmed by Ke et al. (2017), who found that cities along the HSR line experience high per capita GDP growth than non-HSR cities, although the treatment effects of HSR is heterogeneous among HSR cities. However, Liu Yong, a director at the Research Office of the Regional Economic Research Department and Development Strategy of the State Council Development Research Center, argued that one of the most important rail lines, the Beijing-Kowloon line, had only been used as a communication line, and did not contribute to regional economic integration (Xu, 2010). The results in the literature on the impact of HSR on China's economic growth are thus mixed and inconsistent.

3. The model and estimation

The econometric model used in this paper to measure the impact of HSR on economic growth of a city is due to Xe et al. (2017) and Hsiao et al. (2012).

Let N and T denote, respectively, the number of cities and the number of time periods covered by the model. Here both N and T are given positive integers. This paper uses the growth of real GDP per capita of as a proxy for economic growth. Consider a city, say $i, i = 1, \dots, N.$ Let y_{it}^0 denote the real GDP per capita of city i in period t if it is not a city node in the HSR system and y_{it}^1 denote the real GDP per capita of city i in period t if it is connected to the HSR system. Now for city $i,$ either it is connected to the HSR system or it is not. This means at any one time only one of the two variables y_{it}^0 and $y_{it}^1.$ Thus, for a more general notation, if we let y_{it} denote the real GDP per capita of city i in period $t,$ then we have

(1) $$y_{it} = d_{it} y_{it}^1 + (1 - d_{it}) y_{it}^0,$$

where

(2) $$d_{it} = \begin{cases} 1 \ \ if \ \ the \ \ unit \ \ is \ \ under \ \ treatment \ \ at \ \ time \ \ t, \\ 0 \ \ otherwise. \end{cases}$$

Let T_1 be a positive integer, with $T_1 < T$, and suppose that none of the N cities being considered is a city node of the HSR system for the periods $t = 1, \dots, T_1$. We have

(3) $$y_{it} = y_{it}^0, \qquad (i = 1, \dots, N, t = 1, \dots, T_1).$$

Suppose that in period T_1 exactly one city, say city 1, is connected to the HSR system. Under this scenario, we have

(4) $$y_{1t} = y_{1t}^1, \qquad (t = T_1 + 1, \dots, T),$$

and

(5) $$y_{it} = y_{it}^0, \qquad (i = 2, \dots, N, t = T_1 + 1, \dots, T).$$

Now for each $t = T_1 + 1, \dots, T$, the value $y_{1t} = y_{1t}^1$ is observed. If city 1 had not been connected to the HSR system, then the observed real GDP per capita of city 1 in period $t, t = T_1 + 1, \dots, T$, would have been y_{1t}^0 instead of y_{1t}^1, and the impact of the HSR system on the real GDP per capita of city 1 would be measured by the real GDP per capita differential

(6) $$\Delta_{1t} = y_{1t}^1 - y_{1t}^0, \qquad (t = T_1 + 1, \dots, T).$$

However, because y_{1t}^0 is not observable, the real GDP per capita differential cannot be directly computed. To obtain an estimate for Δ_{1t}, we need somehow compute the counterfactual outcome y_{1t}^{0}. To construct the counterfactuals, one supposes that there are some common factors that drive all the cross-sectional units although the impact of these common factors may vary from one cross-sectional unit to another. The common factors can be macroeconomic policies, trade developments, technological progress, shocks – economic as well as political – and so forth. More precisely, it is assumed that y_{it}^{0}, the outcome of the ith unit at time t without policy intervention, is generated by a factor model of the form

$$(7) \qquad y_{it}^{0} = \sum_{k=1}^{K} b_{ik} f_{kt} + \alpha_i + \epsilon_{it}, \qquad (i = 1, \dots, N, t = 1, \dots, T),$$

where $b_{ik}, i = 1, \dots, N, k = 1, \dots, K,$ are parameters. Also, for each $t = 1, \dots, T,$ $f_{kt}, k = 1, \dots, K,$ are the common factors at time $t,$ with the common factors possibly varying through time; α_i denotes the fixed individual specific effects; and ϵ_{it} denotes the ith unit random idiosyncratic component with $E(\epsilon_{it}) = 0$.

Stacking the N variables $y_{it}^{0}, i = 1, \dots, N,$ into a vector yields

$$(8) \qquad \begin{pmatrix} y_{1t}^{0} \\ y_{2t}^{0} \\ \cdots \\ y_{Nt}^{0} \end{pmatrix} = \begin{pmatrix} b_{11} & \cdots & b_{1K} \\ \cdots & \cdots & \cdots \\ b_{N1} & \cdots & b_{NK} \end{pmatrix} \begin{pmatrix} f_{1t} \\ \cdots \\ f_{Kt} \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \cdots \\ \alpha_N \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \cdots \\ \epsilon_{Nt} \end{pmatrix}, \qquad (t = 1, \dots, T).$$

Following Hsiao et al. (2012) the following assumptions are made:

Assumption 1: $\|(b_{i1}, \dots, b_{iK})\| = c < \infty$ for $i = 1, \dots, N.$

Assumption 2: $(\epsilon_{1t}, \dots, \epsilon_{Nt})$ is $I(0)$ with $E[(\epsilon_{1t}, \dots, \epsilon_{Nt})] = 0$ and

$$E\left(\begin{pmatrix} \epsilon_{1t} \\ \cdots \\ \epsilon_{Nt} \end{pmatrix} (\epsilon_{1t}, \dots, \epsilon_{Nt})\right) = V,$$

where V is a constant diagonal matrix. Every residual term ϵ_{it} are independent and identically distributed. They all have the same distribution with zero mean and the same variance.

Assumption 3: $E\left(\begin{pmatrix}\epsilon_{1t}\\ \cdots\\ \epsilon_{Nt}\end{pmatrix}(f_{1t},\dots,f_{Kt})\right)=0.$

Which means that the common time varying factor f_{it} is orthogonal to the error terms.

Assumption 4: $Rank(B)=K, where\ \ B=\begin{pmatrix}b_{11} & \cdots & b_{1K}\\ \cdots & \cdots & \cdots\\ b_{N1} & \cdots & b_{NK}\end{pmatrix}.$

This assumption indicates that the number of cities, N, is greater than the number of unobservable common time-varying factors, f_t. Hsiao et al. (2012) remarked that this assumption is reasonable since many literatures e.g. Sargent and Sims (1977); Giannone et al. (2005); Stock and Watson (2005) have shown that a certain number of common factors are enough to explain most of the variance of macroeconomic data.

Assumption 5: $E(\epsilon_{jt}|d_{it})=0\ \ for\ \ i\neq j.$

This assumption implies that the j[th] unit's idiosyncratic components are not correlated with d_{it} for $i\neq j$. Assumption 5 is important since Hsiao et al. (2012) shows that only when assumption 5 holds can we estimate $(\beta_1,\beta_2,\dots,\beta_N)$ in equation (14) below which is then used to get the predictor for counterfactual y_{1t}^0, and in turn, the average treatment effects.

Let $(a_1,a_2,\dots,a_N)$ be a vector lying in the null space of B. Without any loss of generality, we suppose $a_1=1$. Multiplying (8) with $(a_1,a_2,\dots,a_N)$, we obtain

$$(9)\qquad (a_1,a_2,\dots,a_N)\begin{pmatrix}y_{1t}^0\\ y_{2t}^0\\ \cdots\\ y_{Nt}^0\end{pmatrix}=(a_1,a_2,\dots,a_N)\begin{pmatrix}b_{11} & \cdots & b_{1K}\\ \cdots & \cdots & \cdots\\ b_{N1} & \cdots & b_{NK}\end{pmatrix}\begin{pmatrix}f_{1t}\\ \cdots\\ f_{Kt}\end{pmatrix}$$

$$+(a_1,a_2,\dots,a_N)\begin{pmatrix}\alpha_1\\ \cdots\\ \alpha_N\end{pmatrix}+(a_1,a_2,\dots,a_N)\begin{pmatrix}\epsilon_{1t}\\ \cdots\\ \epsilon_{Nt}\end{pmatrix},$$

$$=(a_1,a_2,\dots,a_N)\begin{pmatrix}\alpha_1\\ \cdots\\ \alpha_N\end{pmatrix}+(a_1,a_2,\dots,a_N)\begin{pmatrix}\epsilon_{1t}\\ \cdots\\ \epsilon_{Nt}\end{pmatrix},\qquad (t=1,\dots,T).$$

Note that the second equality in (9) has been obtained by using the assumption that

$(a_1, a_2, \dots, a_N)$ is a vector lying in the null space of B. Next, using the fact $a_1 = 1$, we can rewrite (9) as

$$(10) \qquad y_{1t}^0 = -(a_2, \dots, a_N)\begin{pmatrix} y_{2t}^0 \\ \dots \\ y_{Nt}^0 \end{pmatrix} + (a_1, a_2, \dots, a_N)\begin{pmatrix} \alpha_1 \\ \dots \\ \alpha_N \end{pmatrix} + (a_1, a_2, \dots, a_N)\begin{pmatrix} \epsilon_{1t} \\ \dots \\ \epsilon_{Nt} \end{pmatrix}$$

$$= -(a_2, \dots, a_N)\begin{pmatrix} y_{2t}^0 \\ \dots \\ y_{Nt}^0 \end{pmatrix} + \beta_1 + \epsilon_{1t} + (a_2, \dots, a_N)\begin{pmatrix} \epsilon_{2t} \\ \dots \\ \epsilon_{Nt} \end{pmatrix}, \qquad (t = 1, \dots, T),$$

where we have let

$$\beta_1 = (a_1, a_2, \dots, a_N)\begin{pmatrix} \alpha_1 \\ \dots \\ \alpha_N \end{pmatrix}.$$

Equation (10) suggests that one can use $(y_{2t}, \dots, y_{Nt})$ instead of $(f_{1t}, \dots, f_{Kt})$ to predict y_{1t}^0. Then, for any vector $(a_1, a_2, \dots, a_N)$ in the null space of B, we have[1]

$$(11) \qquad y_{1t}^0 = \beta_1 + (\beta_2, \dots, \beta_N)\begin{pmatrix} y_{2t}^0 \\ \dots \\ y_{Nt}^0 \end{pmatrix} + u_{1t}, \qquad (t = 1, \dots, T),$$

where

$$(12) \qquad (\beta_2, \dots, \beta_2) =$$
$$-(a_2, \dots, a_N)\big(I_{N-1} - cov\big((\epsilon_{2t}, \dots, \epsilon_{Nt}), (y_{2t}^0, \dots, y_{Nt}^0)\big)var[(y_{2t}^0, \dots, y_{Nt}^0)]^{-1}\big),$$

and

$$(13) \qquad u_{1t} = -(a_2, \dots, a_N)\begin{pmatrix} \epsilon_{2t} \\ \dots \\ \epsilon_{Nt} \end{pmatrix}$$

[1] See Hsiao et al. (2012), equation (10).

$$-(a_2,\dots,a_N)\left(cov\left((\epsilon_{2t},\dots,\epsilon_{Nt}),(y_{2t}^0,\dots,y_{Nt}^0)\right)var[(y_{2t}^0,\dots,y_{Nt}^0)]^{-1}\right)\begin{pmatrix} y_{2t}^0 \\ \vdots \\ y_{Nt}^0 \end{pmatrix}.$$

In (12) and (13), $var[(y_{2t}^0,\dots,y_{Nt}^0)]$ and $cov\left((\epsilon_{2t},\dots,\epsilon_{Nt}),(y_{2t}^0,\dots,y_{Nt}^0)\right)$ denote the long-run variance and long-run covariance.

Note that (11) has the form of a simple linear regression model, and a least squares estimate of $(\beta_1,\beta_2,\dots,\beta_N)$ can be obtained by solving the minimization problem

(14) $$min_{(\beta_1,\beta_2,\dots,\beta_N)}\frac{1}{T_1}\sum_{t=1}^{T_1}\left(y_{1t}^0-\beta_1-(\beta_2,\dots,\beta_N)\begin{pmatrix} y_{2t}^0 \\ \vdots \\ y_{Nt}^0 \end{pmatrix}\right)^2.$$

Let $\left(\hat{\beta}_1,\hat{\beta}_2,\dots,\hat{\beta}_N\right)$ be the solution of the minimization problem (14). The predicted counterfactual outcome for city 1 in period t can then be defined as

(15) $$\hat{y}_{1t}^0=\hat{\beta}_1+\left(\hat{\beta}_2,\dots,\hat{\beta}_N\right)\begin{pmatrix} y_{2t}^0 \\ \vdots \\ y_{Nt}^0 \end{pmatrix}, \qquad (t=T_1+1,\dots,T).$$

A prediction for the impact of the HSR on the real GDP per capita of city 1 is then given by

(16) $$\widehat{\Delta}_{it}=y_{1t}^1-\hat{y}_{1t}^0=y_{1t}^1-\hat{\beta}_1-\left(\hat{\beta}_2,\dots,\hat{\beta}_N\right)\begin{pmatrix} y_{2t}^0 \\ \vdots \\ y_{Nt}^0 \end{pmatrix}, \qquad (t=T_1+1,\dots,T).$$

The steps used to find the combination of control group as the best predictor equation are as follows:

1. Using data for the period before the change occurred, regress y_{1t} on a constant and the values of $y_{jt}, j\neq 1$, (for different combinations of cities. In this paper, 8 cities are selected as control cities, so for each combination of m regressors (*m* ranges from 1 to 8), an equation with the highest R^2 value is selected as best equation candidate for predicting

the value of y_{1t} in the absence of the change. The above procedure gives 8 possible equations. To choose the best prediction equation, the information criterion AICC is used. The model with the lowest value of the AICC is chosen as the best prediction model.

2. The next step is to use the best prediction equation to generate $\hat{y}_{1t}^{0}$, the predicted values of y_{1t} for city 1 for the time period after the change has occurred. The difference between the actual and predicted values of real GDP per capita for city1 for the time period after the change has occurred is the estimated effect in period *t* of the change: $\hat{\Delta}_{1t} = y_{1t}^{1} - \hat{y}_{1t}^{0}, t = T_1, \dots, T$.

If $\hat{\Delta}_{1t}$ is found to be stationary, it is argued that the average treatment effect (ATE) over the whole policy evaluation period $T_1 + 1 \leq t \leq T$ can be consistently obtained by using the following equation:

(17) $$\frac{1}{(T-T_1)} \sum_{t=T_1+1}^{T} \hat{\Delta}_{1t}.$$

4. Data

The HSR railway line analyzed in this paper connects Beijing West Railway Station to Wuhan East Rail. Ten HSR cities along the Beijing-Wuhan line are selected as treatment cities while 8 non-HSR cities are considered as control cities. The purpose of this paper is to find out whether HSR has led to any differences in terms of development and economic improvement between the HSR cities and non-HSR cities, and the extent of the differences, if there is any. Followed by Xiao et al. (2017), all cities in the treatment and control groups are prefectural-level cities.[2]

4.1. Treatment group choice

The treatment group includes 10 major cities along the Beijing-Wuhan HSR rail line. These cities are Baoding, Handan, Luohe, Xianning, Xiaogan, Xingtai, Zhengzhou, Xuchang, Xinyang, Zhumadian. Beijing and Wuhan are excluded from the selection of treatment group, the reason for this is that both Beijing and Wuhan are not prefectural-level cities. Beijing is a municipality that is directly under the central government and is treated administratively as a province, while Wuhan is the capital of Hubei province and is a sub-provincial city.

4.2. Control group choice

Different from the "traditional" control group (which we need to do balance check and ensure that control group and treatment group have similar characteristics before the treatment), the control group in this paper should serve as good predictors of specific outcomes before the onset of the implementation of the HSR project. The important criteria were that the control group needs to be exogenous to the HSR treatment.

[2]See Xiao et al. (2017) for detailed explanation of how to choose prefectural-level cities for analysis.

Following Xiao et el. (2017), the criteria of control group selection are as follows. First, I exclude all the cities that are in the HSR lines. This includes both cities that HSR were completed or still under construction. Second, neighboring, cities of the 10 treatment cities were excluded. This is because HSR construction may lead to reallocation of resources between cities, and the neighboring cities' economic growth may be affected by it (Kline and Moretti, 2014). So, cities that bordered HSR cities are not included in the control group. The 8 prefectural cities satisfying the above two criteria of exogeneity are then selected. These include Yichang, Shiyan, Shangqiu, Sanmenxia, Puyang, Huaihua, Chengde, and Anyang. The per capita real GDP of each city is calculated using the nominal GDP divided by the population, and then divided by the provincial CPI index. All the data are obtained from China data online.

5. Results

I constructed the predictive equations using pre-treatment period data and chose the best prediction equation and combination for the 10 HSR cities by the AICC Criterion. Table 1 below shows that all the HSR cities along the Beijing-Wuhan HSR lines studied present good in-sample fit with R-square above 0.99. These results suggest that the predictive models, which are chosen according to the AICC criterion, perform well and the per capita real GDP of HSR cities and their predicted counterfactuals are reasonably comparable in the post-treatment period.

Table 1

In-sample fit result

Prefectural-level city	R-square	F-statistics
Baoding City in Hebei Province	1.0000	99999.00
Handan City in Heibei Province	0.9996	314.92
Luohe City in Henan Province	1.0000	99999.00
Xianning City in Hubei Province	0.9980	144.31
Xiaogan City in Hubei Province	0.9987	97.42
Xingtai City in Hebei Province	0.9964	34.88
Xuchang City in Henan Province	0.9995	267.67
Zhengzhou City in Henan Province	1.0000	99999.00

Figures 1-10 show the real GDP per capita of each HSR city over time from 1997 to 2016. The graph contains two paths – the actual and the predicted paths – with the actual one representing the actual real GDP per capita observed while the predicted line indicates the predicted counterfactual outcome using the prediction model. The result shows the trends and dynamics of the Beijing-Wuhan HSR cities, as a result of treatment effects. For most of the cities (except for Handan and Xiaogan), there is a positive impact of HSR within 2 years after the construction (2007 and 2008), although the treatment effects all become negative after that. The trends of the annual real GDP per capita indicate that once the construction of the HSR has started the real GDP per capita of the HSR cities grew significantly. However, this effect gradually faded away after construction and became even negative during the operation period.

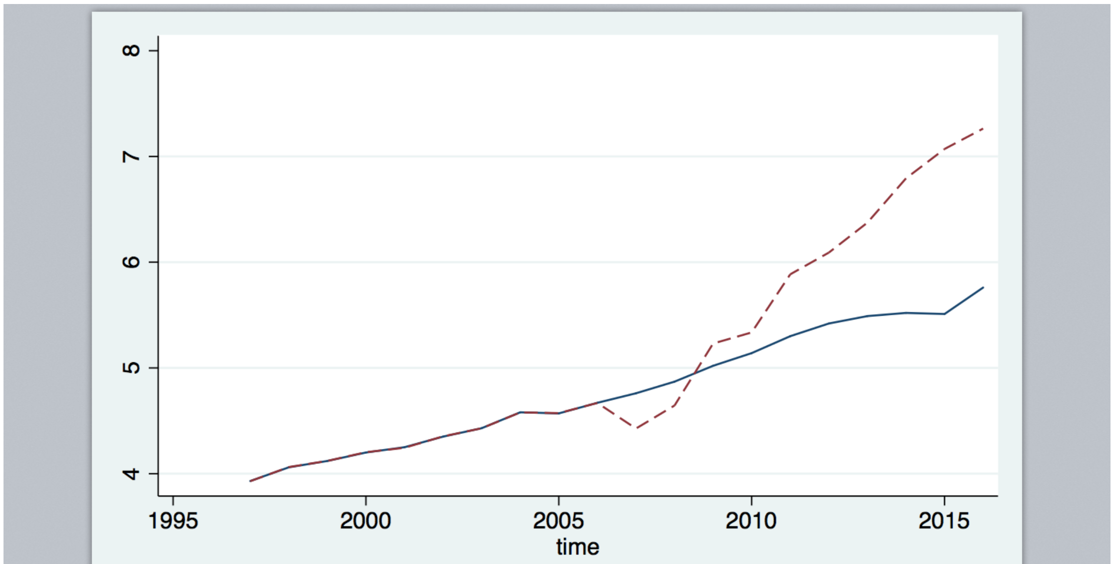

Figure 1. per capita GDP of Baoding from 1997 to 2016

actual predicted

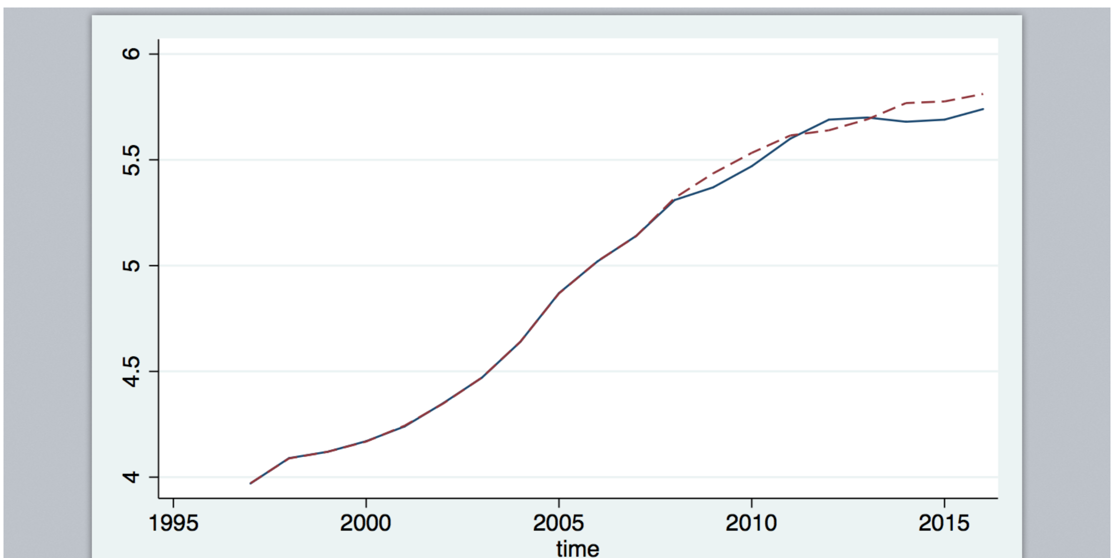

Figure 2. per capita GDP of Handan from 1997 to 2016

actual predicted

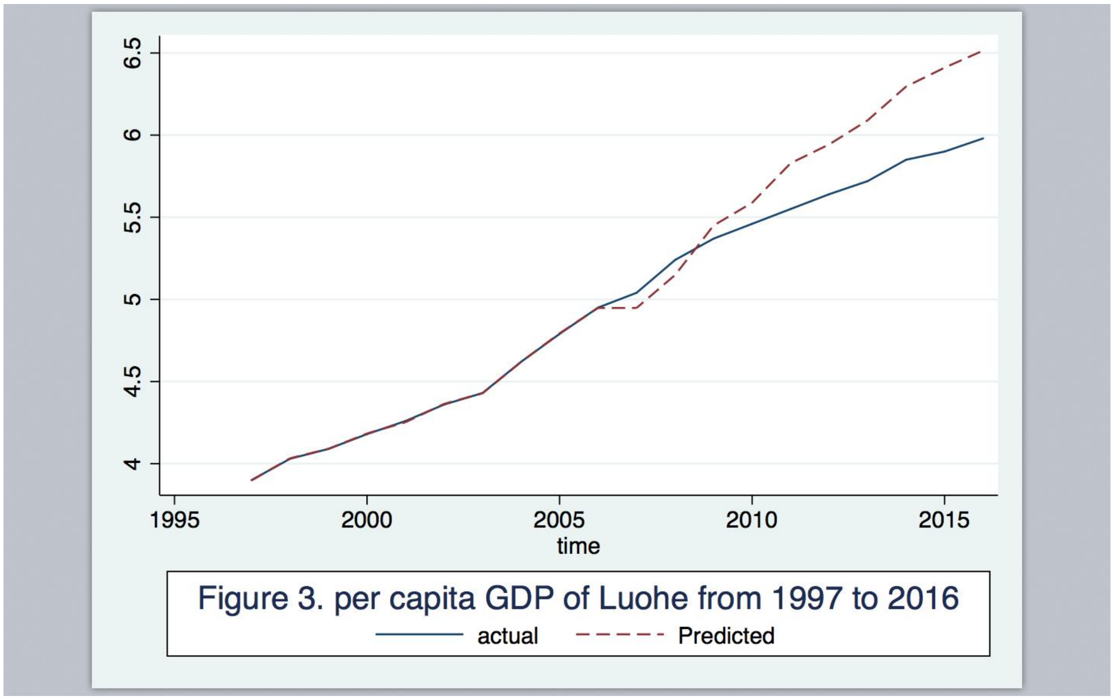

Figure 3. per capita GDP of Luohe from 1997 to 2016

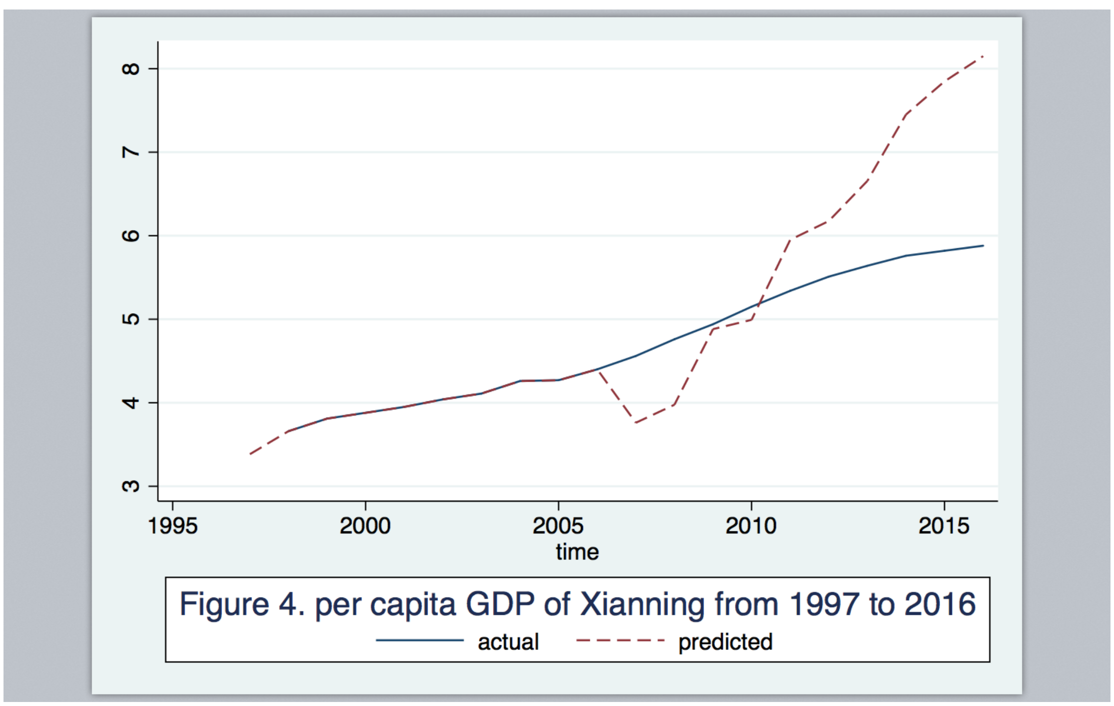

Figure 4. per capita GDP of Xianning from 1997 to 2016

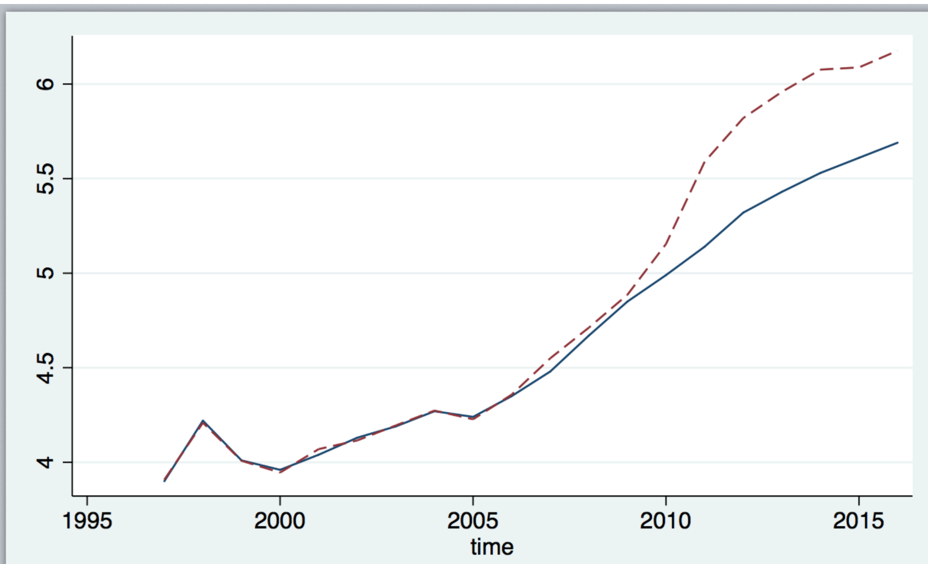

Figure 5. per capita GDP of Xiaogan from 1997 to 2016

actual predicted

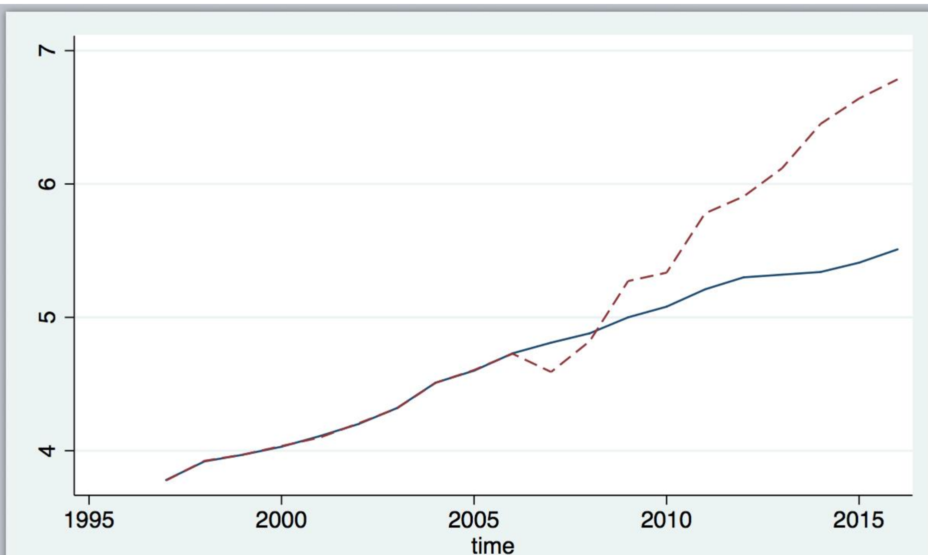

Figure 6. per capita GDP of Xintai from 1997 to 2016

actual predicted

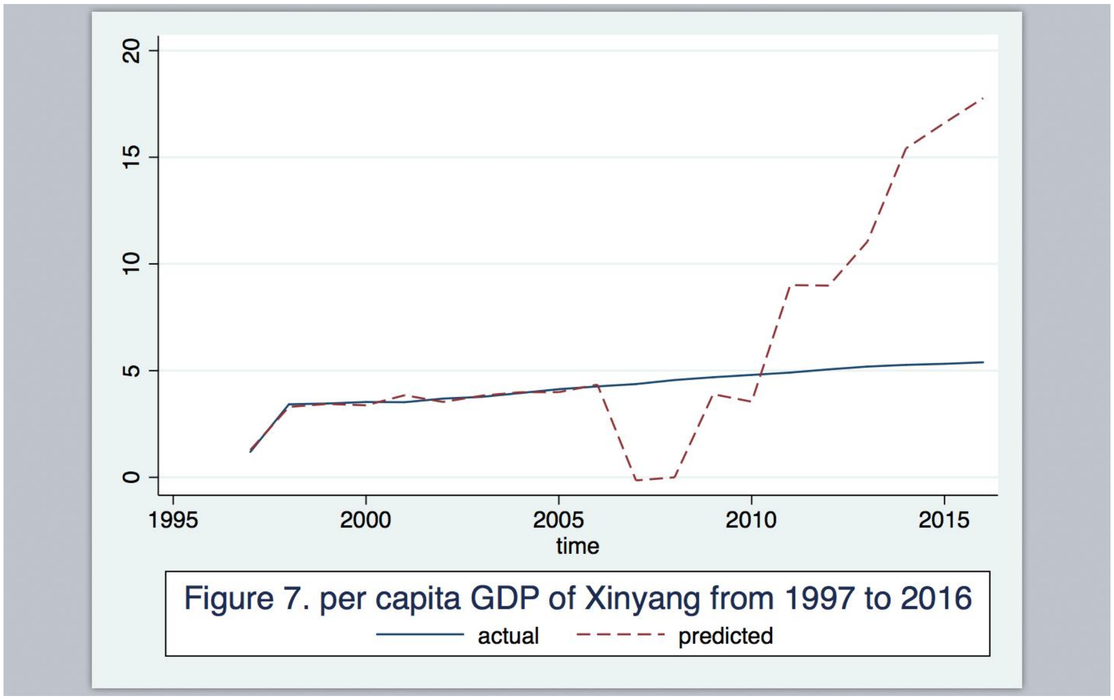

Figure 7. per capita GDP of Xinyang from 1997 to 2016

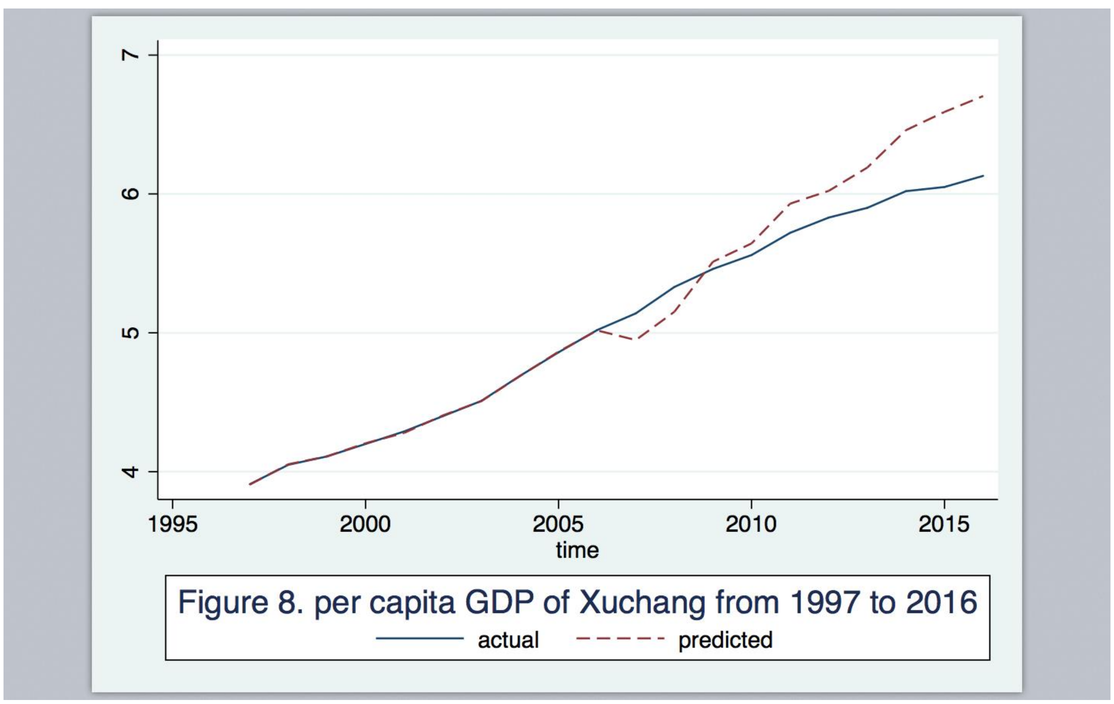

Figure 8. per capita GDP of Xuchang from 1997 to 2016

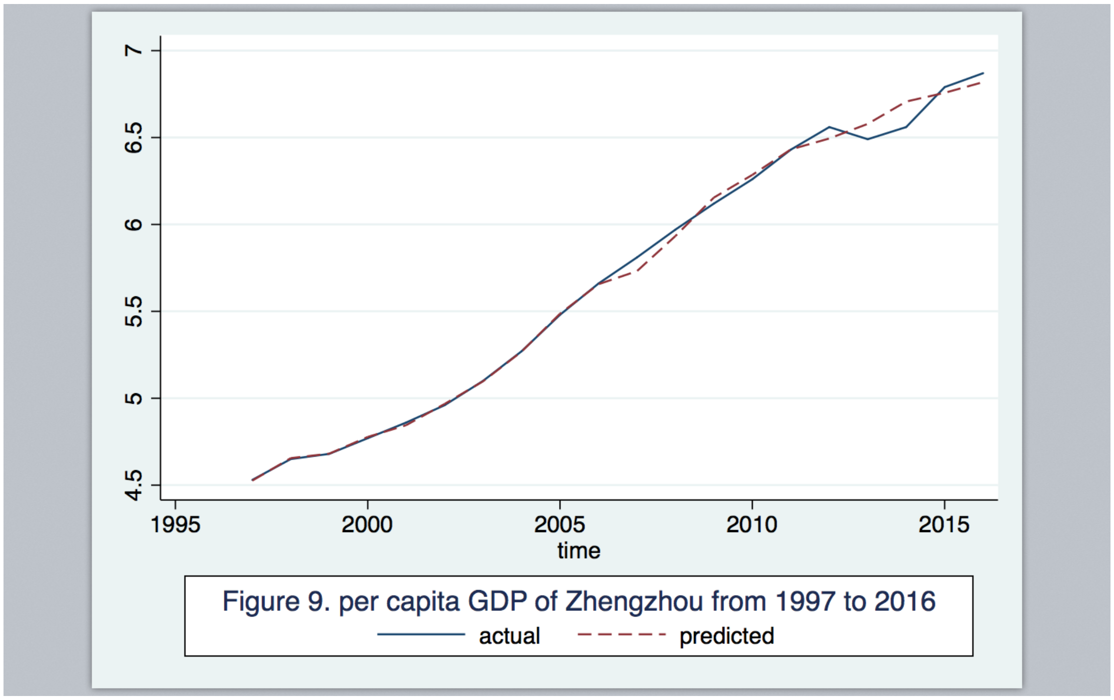

Figure 9. per capita GDP of Zhengzhou from 1997 to 2016

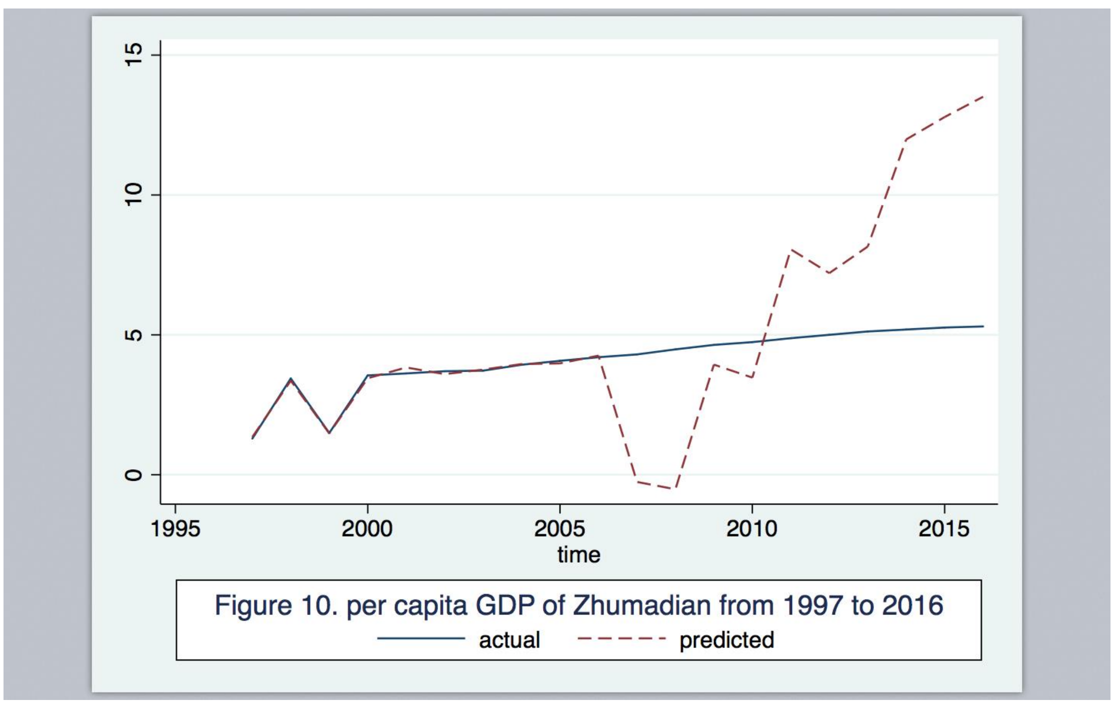

Figure 10. per capita GDP of Zhumadian from 1997 to 2016

In addition, the ATEs of the treatment cities differed significantly in both sign and magnitude. Two cities – Xinyang and Zhumadian in Henan Province – show positive ATEs, but the results are not statistically significant at 5% level, and are thus excluded from the analysis below. The evaluation of the ATEs are thus based on the results of the remaining 8 cities of which the treatment effects are statistically significant at the 95% confidence interval. Table 2 below reports the results of ATEs for the 8 cities during the construction periods (i.e. from 2007 to 2008). As can be seen from the table, around 75% of the HSR cities (6 out of 8) studied had positive ATEs during the construction period. These cities included Baoding, Luohe, Xianning, Xingtai, Zhengzhou, Xuchang, Xinyang and Zhumadian. In summary, we can, therefore, conclude that the Beijing-Wuhan HSR project has significantly raised the real per capita GDP for most of our treatment cities during the construction period. Most of the ATEs were larger than 10%, indicating that for cities that significantly gained from HSR projects, local gross income was at least 10% higher than what would have been in the absence of the HSR projects within our policy evaluation period.

Table 2

Results of the selected eight HSR cities for detailed illustration

Baoding City in Hebei Province			
Year	Actual	Predicted	Treatment
2007	4.76	4.426693	0.333307
2008	4.87	4.644109	0.225891
Average	4.815	4.535401	0.279599
2009	5.02	5.230574	-0.210574
2010	5.14	5.335379	-0.195379
2011	5.3	5.885164	-0.585164
2012	5.42	6.090714	-0.670714
2013	5.49	6.373838	-0.883838
2014	5.52	6.792644	-1.272644
2015	5.51	7.0704	-1.5604
2016	5.76	7.263412	-1.503412

Handan City in Heibei Province			
Year	Actual	Predicted	Treatment
2007	5.14	5.139115	0.000885
2008	5.31	5.319685	-0.009685
Average	5.225	5.2294	-0.0044
2009	5.37	5.435992	-0.065992
2010	5.47	5.533001	-0.063001
2011	5.6	5.615075	-0.015075
2012	5.69	5.639545	0.050455
2013	5.7	5.691497	0.008503
2014	5.68	5.768336	-0.088336
2015	5.69	5.77604	-0.08604
2016	5.74	5.811352	-0.071352
Luohe City in Henan Province			
Year	Actual	Predicted	Treatment
2007	5.04	4.947949	0.092051
2008	5.24	5.148368	0.091632
Average	5.14	5.0481585	0.0918415
2009	5.37	5.449797	-0.079797
2010	5.46	5.588284	-0.128284
2011	5.55	5.828844	-0.278844
2012	5.64	5.943235	-0.303235
2013	5.72	6.089816	-0.369816
2014	5.85	6.295738	-0.445738
2015	5.9	6.410715	-0.510715
2016	5.98	6.514419	-0.534419
Xianning City in Hubei Province			
Year	Actual	Predicted	Treatment
2007	4.56	3.760205	0.799745

2008	4.76	3.97603	0.78397
Average	4.66	3.8681175	0.7918575
2009	4.94	4.881543	0.058457
2010	5.15	4.992921	0.157079
2011	5.34	5.950631	-0.610631
2012	5.51	6.175358	-0.665358
2013	5.64	6.655769	-1.015769
2014	5.76	7.450163	-1.690163
2015	5.82	7.847772	-2.027772
2016	5.88	8.149793	-2.269793
Xiaogan City in Hubei Province			
Year	Actual	Predicted	Treatment
2007	4.48	4.549843	-0.069843
2008	4.67	4.711982	-0.041982
Average	4.575	4.6309125	-0.0559125
2009	4.85	4.885938	-0.035938
2010	4.99	5.154527	-0.164527
2011	5.14	5.5892	-0.4492
2012	5.32	5.820213	-0.500213
2013	5.43	5.958536	-0.528536
2014	5.53	6.076425	-0.546425
2015	5.61	6.088066	-0.478066
2016	5.69	6.176433	-0.486433
Xingtai City in Hebei Province			
Year	Actual	Predicted	Treatment
2007	4.81	4.590565	0.219435
2008	4.88	4.820305	0.059695
Average	4.845	4.705435	0.139565
2009	5	5.272136	-0.272136

2010	5.08	5.335092	-0.255092
2011	5.21	5.780148	-0.570148
2012	5.3	5.905888	-0.605888
2013	5.32	6.118294	-0.798294
2014	5.34	6.450802	-1.110802
2015	5.41	6.640928	-1.230928
2016	5.51	6.784746	-1.274746
Xuchang City in Henan Province			
Year	Actual	Predicted	Treatment
2007	5.14	4.947982	0.192018
2008	5.33	5.151456	0.178544
Average	5.235	5.049719	0.185281
2009	5.46	5.511961	-0.051961
2010	5.56	5.643668	-0.083668
2011	5.72	5.930079	-0.210079
2012	5.83	6.02221	-0.19221
2013	5.9	6.190218	-0.290218
2014	6.02	6.458973	-0.438973
2015	6.05	6.590679	-0.540679
2016	6.13	6.704681	-0.574681
Zhengzhou City in Henan Province			
Year	Actual	Predicted	Treatment
2007	5.81	5.731145	0.078855
2008	5.97	5.933108	0.036892
Average	5.89	5.8321265	0.0578735
2009	6.12	6.15457	-0.03457
2010	6.26	6.285033	-0.025033
2011	6.43	6.431642	-0.001642
2012	6.56	6.49438	0.06562

2013	6.49	6.578401	-0.088401
2014	6.56	6.706895	-0.146895
2015	6.79	6.757292	0.032708
2016	6.87	6.818666	0.051334

6. Discussion of the results

HSR construction has been associated with different views. There have been varying impacts and benefits of HSR – both socially and economically. Some of the studies show that HSR has positive impact on regional economic growth, and argue that HSR has resulted in changes in regional organizational structure (e.g. Duranton, 2012). These studies states that HSR has enabled the spread of industries in cities that are found along the railway. The expansion of the spatial organization is based on the fact that the HSR connects several regions in a very short time, and makes business more convenient in that it facilitates the supply chain of raw materials and final products; it also improves tertiary industries in smaller towns.

Although the above studies demonstrate that the onset of an HSR system ended up facilitating trade between cities and movement of goods among cities as well as reduced trading time drastically, other studies find different results and indicate that there was no direct connection between HSR and regional economic growth. For example, Cheng (2015), by using quasi-experimental design, concludes that all the cities with an upgrade of the HSR ended up with lower GDP per capita. Thus, the exact impact on local economic activities and regional economies has not been clearly demonstrated.

The results of this paper show some evidence that HSR has a positive impact on the regional economy that it crosses; however, this positive impact only lasts for a short period (2 years during the construction period for most cities analyzed), and the influence of HSR then fades away gradually. In addition, we can also see that the impact of HSR differs in different HSR cities. I shall now some potential explanation for these results.

6.1. Possible reasons for positive impact of HSR on economic growth

6.1.1. Direct increase in government spending through HSR construction

HSR infrastructure projects require heavy investments during the construction period, and increase in government expenditures on HSR construction contribute directly to the GDP of the HSR cities. In addition, the construction of HSR employs local workers, and this will increase local employment opportunities. These factors could explain why positive treatment effects on regional economic growth were observed for most HSR cities within 2 years of the construction period.

6.1.2. Tourism city

For some tourist cities, HSR has accelerated the development of local tourism, stimulated a sharp rise in consumption, and local income has also increased significantly. For example, in contrast with other HSR cities, Figure 9 shows that the overall ATEs of HSR for Zhengzhou is positive. Zhengzhou is famous for its places of interests, such as Songshan Mountain and Shaolin Temple. Development of HSR is likely to attract more tourists in that it becomes more convenient for them to travel. The shortening of the travel time increases the attractiveness of the tourist city, and, in turn, promote the development of the local catering industry, hotel accommodation, retail, entertainment, museums, and cultural facilities. These all help to promote economic growth in these tourist cities. Therefore, HSR has expanded the scope of tourism and may have a greater ATE in tourism city than other cities.

6.1.3. Transportation hub city and central city

Although this paper does not demonstrate positive impacts during the operation period, other papers show positive impacts of HSR for some HSR cities. This does not mean that the results of this paper contradict those of other studies since this might be due to the different characteristics of selected treatment cities.

HSR has enhanced transportation in most transportation hub cities. The HSR lines have also created a number of new regional transportation hub cities. The construction of HSR has reinforced the own geographical advantages of its city nodes, and this presents a major opportunity for an HSR city to develop its economy. In this regard, Banister and Berechman (2001) find that the TVG in France has led to economic agglomeration at central cities, making the central city more attractive compared to the surrounding cities.

6.2. Possible reasons for negative impact of HSR for the longer period

As discussed in Sub-sub-section 6.1.3, the central cities along an HSR line, such as Beijing and Wuhan, may "suck blood" out the other HSR cities along the same rail line. The acceleration of urbanization is uneven, and the central cities display strong siphoning effect in the presence of an HSR system. For the primary city in the economic circle, HSR can promote the overall growth of its economic scale and consolidate its core position in the urban agglomeration. However, HSR also provides new challenges for small- and medium-sized cities along the line. Although one might think that HSR can improve the accessibility of relatively backward areas, enhance their economic potential and location factors – and thus improve their status among the cities – we should note that the economic gap between less developed cities and central cities is large. Indeed, from the analysis of GDP, it has been found that cities like Wuhan have a higher GDP than the selected treatment cities due to the economic benefits of the HSR.

Table 3

Average real GDP per capita for year 1997-2016

City	Average real GDP per capita from 1997-2016

Baoding City	14416.50087
Handan City	17673.44711
Luohe City	18300.90649
Wuhan City	54641.18905
Xianning City	15127.93793
Xiaogan City	12901.67585
Xingtai City	12994.8958
Xinyang City	9714.743588
Xuchang City	20719.55231
Zhengzhou City	40125.91661
Zhumadian City	9068.862886

Since the onset of HSR helps to facilitate trade and increase human interaction, it is more likely that the development of HSR might further shift the talents and funds in relatively less developed areas of the province to the central cities with lower business costs along the HSR line in search of better employment and investment opportunities. On the other hand, the headquarters of more enterprises will move to the key hub cities of HSR networks. The treatment cities selected in this paper are those that are relatively less developed compared to the central cities. Thus, it could be due to the siphoning effect of central cities that the improvement of transportation via HSR results in a fall in economic growth for the selected treatment cities in this paper. The findings of negative treatment effect caused by HSR in the longer run are consistent with those of some studies on HSR lines in Japan. For example, Sasaki et al. (1997) found that the first HSR line, namely the Shinkansen HSR line in Japan, has induced employment growth in larger cities, such as Osaka and Tokyo, but lower employment in smaller and less developed cities like Nagoya. Furthermore, the outflow of workers in the less developed HSR cities would also lower local consumption, which further reduces local economic growth.

7. Policy implications

Although some previous studies suggest that very few treatment cities directly linked to an HSR network made advances in their own economic development, I would argue that this does not mean that the development of HSR cannot have any positive impact on HSR cities, including the less developed HSR cities. In order to avoid the siphoning effect and to allow smaller HSR cities to fully enjoy the potential economic benefits that would be brought about by the construction and operation of an HSR network, local governments should pay more attention to the complementary policies. As argued by Yu et al. (2011), the development of transportation infrastructures alone is not sufficient for less developed areas in China to boost its economic growth. Local governments should also highlight cultural and educational developments; increase in government spending on science and technology in order to increase the competitiveness of the city; and retain talented people and attract more investments into local area.

8. Conclusion

This paper sought to find out whether and how HSR has influenced the economic development of the cities it has connected. By using the methodology introduced by Hsiao et al. (2012) and Ke et al. (2017), this study finds a mixed impact of HSR on economic growth, namely a positive treatment effect of HSR for 75% of the HSR cities examined during the construction period, but negative treatment effect for the remaining cities during the operation period. In addition, the results also show that the effect of HSR varies according to the location of the cities in the HSR network. Possible explanations for the results of this study would be that increase in government spending and increase in employment to construct the HSR line have direct positive impact on local economic growth. However, after the construction period, the improved infrastructure has led to the siphoning effect that both talented people and funds move from the relatively less developed HSR cities to more developed central cities along the same HSR line, with the ensuing consequences of reducing investments and consumption in the local areas, and this, in turn, result in negative ATEs. Moreover, since the gain in the local economy is higher for those cities that are more industrialized due to their higher abilities to employ and produce, this paper suggests that local government should pay more attention to complementary policies to improve the competitiveness of the city to fully explore the potential economic benefits by HSR.

References

Banerjee, A., E. Duflo, and N. Qian (2012): "On the Road: Access to Transportation Infrastructure and Economic Growth in China," *Natl. Bureau Econ. Res.* 2012

Banister, D. and Y. Berechman (2001): Transport investment and the promotion of economic growth, *Journal of Transport Geography*, 9(3), 209–218.

Cheng, Y. S. (2015): "High-speed rail networks, economic integration and regional specialization in China and Europe" Travel Behaviour and Society, 1-14.

Duranton, G. (2012): "Urban growth and transportation," *The Review of Economic Studies*, 1407-1440.

Fujita, M., P. Krugman, and A. Venables (1999): *The Spatial Economy*, MIT Press

Garmendia, M., V. Romero, and J. de Ureña (2012): "High-Speed Rail opportunities around metropolitan regions: the cases of Madrid and London," *Journal of Infrastructure Systems*, *18*, 305-313

Giannone D, Reichlin L, Sala L. (2005): Monetary policy in real time. In *NBER Macroeconomics Annual 2004*, Gertler M, and Rogoff K (eds). MIT Press: Cambridge, MA; 161–200.

Gutierrez, J., R. González, and G. Gómez (1996): "The European high-speed train network: Predicted effects on accessibility patterns," *J. Transp. Geogr. 4*, 227–238

Hall, P. (2009): "Magic carpets and seamless webs: Opportunities and constraints for high-speed trains in Europe," *Built Environ*, *35*, 59–69.

Hsiao, C. (2014): Analysis of panel data. Cambridge: Cambridge University Press.

Ke, X., H. Chen, Y. Hong, and C. Hsiao (2017): "Do China's High-Speed-Rail Projects Promote Local Economy? "New evidence from a panel data approach, http://econ.tulane.edu/seminars/Hsiao_Rail.pdf

Kline, P., and E. Moretti (2014): "Local economic development, agglomeration economies, and the big push: 100 years of evidence from the Tennessee Valley authority," *Quarterly Journal of Economics*, 129(1), 275–331.

Kumar, M and O. Prakash, (2017): "Study On Application of High Speed Rails On Existing Rail Routes in India," *International Journal of Engineering Sciences & Research Technology.*

Mohmand, T., W. Aihu, and S. Abubakr (2017): "The impact of transportation infrastructure on economic growth: empirical evidence from Pakistan," *Transportation Letters*, 9:2, 63-69.

Nerlove, M. (1966): "Railroads and American Economic Growth," *The Journal of Economic History, 26* (1), 107-115.

Sargent TJ, Sims CA. (1977): Business cycle modeling without pretending to have too much a-priori economic theory. In *New Methods in Business Cycle Research*, Sims C *et al.* (eds). Federal Reserve Bank of Minneapolis: Minneapolis, MN.

Sasaki, K., T. Ohashi, and A. Ando (1997): "High-speed rail transit impact on regional systems: Does the Shinkansen contribute to dispersion?" *Annals of Regional Science*, 31(1): 77–98.

Stock JH, Watson MW. (2005): *Implications of dynamic factor models for VAR analysis*. NBER Working Paper No. 11467, July 2005: 1–65.

Vickerman, R. (2012): "*High-Speed Rail –The European Experience,"* in J. M. de Ureña, ed. Territorial Implications of High Speed Rail: A Spanish Perspective, Ashgate, Farnham, 17-31.

Wang, J., F. Jin, and H. Mo (2009): "Spatiotemporal evolution of China's railway network in the 20th century: An accessibility approach, "*Transp. Res. Part A Policy Pract. 43*, 765–778.

World Bank (2014): *Regional Economic Impact Analysis of High Speed Rail in China*, http://www.worldbank.org/content/dam/Worldbank/document/EAP/China/high_speed-rail-%20in-china-en.pdf

Xu, H, and B. Li (2010): Fifteen years of the Beijing-Kowloon Railway: Unpredictable Success in City Development along the Line. *21st Century Business Herald (Guangzhou),* http://discovery.163.com/10/1220/09/6OBBLTC9000125LI_all.html

Yu, N., M. Jong, S. Storm, and J. Mi (2012): "Transport Infrastructure, Spatial Clusters and Regional Economic Growth in China," *Transport Reviews*, 32:1, 3-28.