Counties Left Behind:

The Distributional Impact of High-Speed Rail Upgrade in China

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Yu QIN[1]

yq38@cornell.edu

Dyson School of Applied Economics and Management,

Cornell University

Ithaca, NY, 14850

Abstract:

In this paper, I study the impact of China's high-speed rail upgrade in 2004 and 2007 on the counties locating on the affected railway lines. As the high-speed rail upgrade reduces the number of trains stopped by counties and increases the effective distance from counties to cities, a natural question raised is whether the faster commuting between cities through high-speed rail is at the cost of GDP loss in small counties. By adopting a standard difference-in-difference model as well as accounting for non-random placement of high-speed rail, it shows that there is a 4-6 percent reduction in GDP and GDP per capita after the high-speed rail upgrade in 2007 in the counties locating on the affected railway lines, which translates into 253-378 million *yuan* in real term. Moreover, the GDP reduction in the high-speed rail bypass counties can be largely explained by the concurrent drop in fixed asset investment. However, there is no evidence suggesting that the welfare of rural residents is affected by the high-speed rail upgrade, measured by per capita rural income.

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1. Introduction

High-speed rail is a type of passenger rail transport that travels significantly faster than normal trains. The first high-speed rail device was implemented in Germany in 1903. However, the passion towards high-speed rail still keeps going even after more than 100 years of its debut. Until now, more than 10 countries in the world have high-speed rail, including Spain, Japan, Germany, France, China, the United States and so on (UIC, 2010).[2] In addition to the operating ones, there are quite a number of countries planning to upgrade their railway lines into high-speed rail, such as India, Russia, Brazil, Canada and so on (UIC, 2010).

Railway is one of the most important infrastructure in China. With the third largest railroad network and the largest high-speed rail network, China has around 86,000 kilometers operating railway lines, among which 8,358 kilometers are high-speed railway lines with hourly speed greater than 200 kilometers. With the intensive construction of new high speed railway lines and the speed acceleration of existing railway lines, the average speed and maximum speed of China railways have been lifted up dramatically in recent years.

Extensive literature has tried to set up a causal relationship between access to railroad and various aspects of economic development in both developing and developed countries. (Donaldson 2010; Donaldson and Hornbeck 2011; Banerjee et al. 2010; Atack et al. 2010) Donaldson (2010) finds that railroad in colonial India reduced trade costs and interregional price

[2] A complete list also includes Belgium, Italy, The Netherlands, United Kingdom, Korea, Taiwan (China) and Turkey.

gaps, and increased interregional trade, international trade and real income. Using a newly constructed geographic information system (GIS) database on railroads in 1870-1890 in the United States, Donaldson and Hornbeck (2011) finds that removing all railroads access in 1890 would reduce GNP by 6.3%, which roughly doubles the estimation by Fogel (1964) who believes the railroad network in the United States is less effective than canal networks. The estimation by Atack et al. (2010) suggests that railroads in the Midwestern United States in the mid of nineteen century has little impact on population densities, while it significantly facilitates the urbanization of the Midwestern regions. In the context of China, Banerjee et al. (2010) evaluates the impact of railroad construction on GDP growth at the county level. They find that increasing the distance to railroad of a county by 1% will reduce the total GDP growth by 0.019%.

As suggested by the above literature, being near to the railway line brings prosperity to the region. However, different from other infrastructure, such as road and highway, railway line itself cannot foster economic growth. It is the trains running on the lines that matters which schedules are designed by the government. Thus, the impact of railroad should be heterogeneous across different regions with different train frequency. As an extreme case, railroad will be almost useless if there is no train stopped by that area. Therefore, any policy arrangement or public project affecting the distribution of train frequency is likely to impact the return to railway lines in different regions.

From this aspect, this paper also relates to the literature on the distributional impact of public infrastructure. Among previous works, Duflo and Pande (2007) documents the distributional impact of dam constructions in India, where districts located downstream from a dam benefits while districts with dam located are negatively affected in terms of rural poverty. Baum-Snow (2007) studies the distributional impact of interstate highway on population in the United States. He finds that one new highway passing through a central city reduces its population by about 18 percent, which leads to suburbanization.

In this paper, I am going to examine the distributional consequences of China's high-speed rail upgrade in the year 2004 and 2007, which is part of a railway speed acceleration project starting from 1997. During the ten years, the average train speed in China has been lifted up from around 50km/hr to 70.2km/hr during six rounds of speed acceleration (in 1997, 1998, 2000, 2001, 2004 and 2007, respectively.) Especially in the last round, China Railway High-speed (CRH) trains with a maximum speed around 200-250km had been introduced to the public, with the name "Harmony" (*he xie hao*,) connecting big cities with significant less travelling time spent. For example, the travelling time from Beijing to Shanghai by train was reduced from 17.5 hours to 10 hours from 1996 to 2007, while the travelling time from Beijing to Guangzhou was reduced from 32 hours to 20.5 hours during the same period.

However, as speed is attained partially at the cost of stops, so counties with existing railway services may find new lines bypassing them (Economist, 2011). Indeed, around 3,000 passenger train stops out of around 6,100 train stops in China have been abandoned in the most recent ten years due to the speed acceleration project, especially after year 2004. That is to say, even the high-speed trains help facilitate economic activities across cities due to significantly less travelling time (or less effective distance,) it may actually do harm to the small counties along the accelerated railway lines, as their access to railway services is deprived by the high speed transportation between big cities.

Therefore, I am planning to study the impact of high-speed rail upgrade by comparing the economic outcomes of the counties locating on the affected railway lines with the counties locating on non-affected railway lines. As the selection into high-speed rail upgrade mainly depends on which cities the lines are connected to, the counties affected by the speed acceleration can be regarded as less endogenous to county economic condition and growth potentials. Therefore, my parsimonious specification will be a difference-in-difference setting, in order to compare the high-speed rail affected counties and non-affected counties, before and after. To strengthen my estimation, I will also instrument the placement of affected counties by whether a county is located in the five main railway lines in China (four lines connecting Beijing to the north (Haerbin,) south (Guangzhou and Hong Kong) and east (Shanghai,) while one connects the east (Lianyungang) to the west (Urumqi).) My assumptions for the IV estimation is that counties located on the main railway lines are associated with higher likelihood of being selected into high-speed rail upgrade, while its placement on main railway lines affect economic development only through its impact on speed acceleration.

The outcome variables used in this paper are collected from the China Economic and Social Development Statistical Database, which is compiled from all the publicly available statistical yearbooks and other published statistical reports. It includes general economic variables, such as county level GDP per capita and GDP by different sectors, as well as investment variables, such as fixed asset investment and real estate investment. The estimation using OLS and Two-Stage Least Square (2SLS) consistently shows that being located in the speed acceleration railway lines on average decreases a county's total GDP by around 4-6 percent, which is around 253-378 million *yuan*, given the average county level GDP as 6.32 billion *yuan* in 2006. In addition, the reduction of GDP is likely to be investment driven, as evidenced by the 9-11 percent reduction of fixed asset investment in the affected counties.

This paper adds to the literature in two ways. First, as far as I know, this is the first paper studying the impact of high-speed rail projects, especially documenting its distributional impact to the small cities/counties. As more countries are planning to implement high-speed rail upgrade, such externalities should be considered to avoid exacerbation of regional inequality. Second, this paper adds to the literature on the impact evaluation of railroad infrastructure by documenting the capital flows (fixed asset investment) before and after a railroad specific shock which is not examined in previous literature.

The paper is organized as follows. Section 2 describes the policy background of high-speed rail upgrade in China. Section 3 describes the data used in this paper and the identification strategy. Section 4 shows the findings and Section 5 concludes.

2. The High-Speed Rail Upgrade Project

2.1 Railway network in China

China is the third earliest country in Asia having railroad, after Japan and India. The first railroad in China was constructed in the year 1876 by the British, which was a local railway near Shanghai. During the 73 years after the first railroad in China and before the founding of People's Republic of China, around 23,000 kilometers railroad had been paved in China, while half of them was destroyed during the World War II.

Since 1949, railroad construction resumed and had been emphasized in almost all the "Five-Year Plans" of China. By the late 1990s, the operating railroad length had been increased to around 66,000 kilometers, with six main railway lines in different directions: 1) Beijing-Shanghai (*jinghu xian*); 2) Beijing-Haerbin (*jingha xian*); 3) Beijing-Guangzhou (*jingguang xian*); 4) Beijing-Hong Kong (*jingjiu xian*); 5) Lianyunguang-Urumqi (*longhai-lanxin xian*); 6) Beijing-Baotou (*jingbao xian*).

In the end of year 2002, the new Minister of Railways, Zhijun Liu had proposed his "Great Leap Forward" ideology which encouraged further expansion of railroad network and technology upgrade, including high-speed rail construction (Liu, 2003). The *Mid-long Term Railway Network Plan* (*zhong chang qi tie lu wang gui hua*) enacted by the State Council in the year of 2005 set the goal of expanding railroad length to 100,000 kilometers by the end of 2020, which had been further revised as 120,000 kilometers in the year of 2008, with a budget of investment around 4,000 billion *yuan* (State Council, 2004, 2008). By the end of year 2007, all the provinces in China had been connected with the railroad network, as shown in Figure 1. However, it is clearly shown that the railroad coverage in the west (relatively poor area) is significantly lower than the east.

2.2 Railway speed acceleration and high-speed rail upgrade

Mainly in response to the profit loss under the competition of road and air transportation, China Railways Ministry started several rounds of speed acceleration on existing railway lines spanning from 1997 to 2007. The project had two stages. In the early stage, train speed had been lifted up gradually in the first four waves, namely 1997, 1998, 2000 and 2001. In the year of 1997, the first round of speed acceleration initiated in three main railway lines connecting from Beijing to Shanghai, Guangzhou and Haerbin. The average speed of passenger train had been lifted up from around 48.1 kilometers per hour to 54.9 kilometers per hour. Subsequently in 1998, 2000 and 2001, another three waves of speed acceleration have been implemented in the main railway lines and nationwide, lifting up the average speed of passenger train to 61.6 kilometer per hour by the end of 2001.

In the later stage, speed acceleration mainly targeted on upgrading the existing railway tracks into high-speed rail, with sustained speed greater than 200 kilometers per hour or higher. In 2004, around 1,960 kilometers of railway tracks had been upgraded to high-speed rail, with 19 pairs of city-to-city nonstop passenger trains operating on it. In 2007, the upgraded high-speed rail had been increased to around 6,000 kilometers with 257 pairs of CRH trains operating on a daily basis, which significantly shortened the effective distance between big cities. For example, the travelling time from Beijing to Fuzhou, the provincial capital of Fujian in the south of China, was reduced from around 33 hours to 19.5 hours with the introduction of CRH trains in 2007. The travelling time by train was cut by more than half from Shanghai to Nanchang and Changsha, which are the two provincial capitals in the southeast of China. According to the vice Minister of China Railways Ministry, the travelling time between cities by CRH trains was on average reduced by 20-30 percent (Sina, 2007).

The dramatic increase of high-speed rail in the year 2007 reflects the “Great Leap Forward” culture proposed by the ex-Minister of China Railways Ministry, Zhijun Liu, who was on the stage since 2003 and got removed for investigation of corruption early 2011. During his tenure, China has invested huge amount of money on expanding railway lines, upgrading and constructing high-speed railway lines. As most of the high-speed railway lines were updated from existing railway tracks, slow trains on the upgraded lines were squeezed out for the accommodation of CRH trains. As a consequence, the number of operating slow trains had been significantly decreased with the increase of high-speed rail mileage. For example, before high-speed rail upgrade, 352 pairs of daily slow passenger trains operate nationwide in 2002. However, the number drops to 224 in 2007 according to the passenger train schedule in the two years, respectively.

Even though high-speed railways benefit the transportation from city to city, it may do harm to the economy of the small counties along the upgraded high-speed railway lines through two possible mechanisms. First, as the high speed of train is attained partially at the cost of stops, the CRH trains targeting at effective travelling time between cities generally stop much less in small stations. Therefore, the small counties are expected to have less trains stopped by, or more non-stop passage trains, which decreases the return to railroad in those affected counties. Second, as the effective distance between cities significantly decreases with high-speed rail, the relative distance from small counties to cities actually increases. Thus, capital and labor is likely to flow out from the affected counties and into the well connected cities for better return. Therefore, the small counties are expected to have less investment and more migrants to the nearby cities.

2.3 Program placement

As upgrading existing railway lines for speed acceleration is costly, not all the railway lines were selected for upgrade. In the early period of speed acceleration (1997-2001,) the project mainly targeted on the three main railway lines connecting Beijing to Haerbin (north,) Shanghai (east) and Guangzhou (south) in the first two rounds. The project was later implemented in another two main railway lines, one connecting Beijing to Hong Kong and the other connecting Lianyungang (east) to Urumqi (west), as well as another line connecting Hangzhou (east) to Zhuzhou (southeast) in 2000. The project was expanded to several other regional railway lines nationwide later in 2001.

In order to transiting into high-speed rail, the three main railway lines connecting Beijing to Haerbin, Shanghai and Guangzhou had been partially upgraded to high-speed rail in 2004, with around 20 pairs of nonstop high speed trains operating on it. Later in 2007, the upgrading had been completed in the three main lines, and the other two main lines (Lianyungang to Urumqi and Beijing to Hong Kong,) as well as three other regional lines (Hangzhou to Zhuzhou, Guangzhou to Shenzhen and Qingdao to Jinan.)

Overall, the priority of high-speed rail upgrade went to the main railway lines first, as they connect big cities, such as Beijing, Shanghai and Guangzhou, which have huge demand for railway transportation. Besides the main lines, several regional railway lines were selected for upgrade as they pass through regions of high economic growth, such as the Pearl River Delta Region (Guangzhou to Shenzhen) and the affluent regions in Zhejiang Province (Hangzhou to Zhuzhou).

3. Data and identification

3.1 Railroad data

Railroad data used in this paper contains two parts. In the first part, each county will be matched to its railway status in 2002 and 1996 for estimation purpose. As my sample for estimating the impact of high-speed upgrade is during 2002 to 2009, the railway status in 2002 is relevant. In addition to my main estimation, I will examine the impact of speed acceleration in early stage using the observations during 1996-2003, where railway status in 1996 is needed. Each county has two questions specific to its railway status for 1996 and 2002: 1) Whether this county has railroad passing through or not; 2) If the answer is "yes" to the previous question, which railway line passes through this county. The data is compiled by hand using *People's Republic of China Railroad Atlas* published in 2008. The new railway lines constructed during 1996-2008 are recorded in the National Railroad Yearbook published during 1998-2008 annually. Therefore, the railway status of each county can be identified in 1996 and 2002.

In the second part, frequency of daily passenger train stops in each county during 1996-2007 is collected for descriptive purpose. The information is manually input from the published passenger train schedules in each year. Each train stop is matched to its county using *China Train Station Encyclopedia* published in 2003. The train stops not listed in the book is matched from online resources. Around 100 out of 6,000 train stops cannot be matched to its county as they are very small stations. However, as those small stations generally have very few trains to stop by, it does not affect my descriptive statistics too much.

Figure 2 shows the number of operating passenger railway stations from 1996 to 2007. Around

3,000 passenger train stations have been shut down during the ten years of speed acceleration, especially during the high-speed rail upgrade (starting 2004). More surprisingly, Figure 3 shows that the number of counties with effective passenger train stops is decreasing as well even with expansion of new railway lines. That means, the number of counties being opted out for passenger trains in the existing lines has exceeded the number of counties with new access to railroad. However, the accessibility of railroad in cities has not been reduced during the speed acceleration, if not slightly increased.

Figure 4 shows the average daily train stops in cities and counties during 1996-2007, namely how many trains stopped in a certain county/city in a day during that period. It is clear that cities have much more trains to stop by than counties. The average daily train stops is around 70-90 times for cities during 1996-2007, compared to merely 20-30 times for counties. Furthermore, after year 2004, the average daily train stops displays a decreasing trend for counties, while an increasing trend for cities, which is in accordance with the fact that the train station in small counties were skipped after the introduction of high-speed rail.

Figure 5 and 6 provide the distribution of average daily train stops in counties in 1996 and 2007, respectively. Two stylized facts can be revealed from the two maps. First, the accessibility to trains is distributed unequally across counties. The county with the least accessibility to railroad only had one daily train stopped by in 1996, while the county with the most accessibility had 345 daily trains stopped by. In 2007, the county with most accessibility to railroad had 165 trains stopped by, which was reduced by half. Second, the accessibility to trains had been decreased during the speed acceleration. The median of train access is 18 trains in 1996 and 14 trains in 2007. It can be told by the color of the two maps that the average accessibility to trains had been decreased from 1996 to 2007, with the speed acceleration during the ten years.

3.2 County statistics data

The county statistics dataset is collected from the China Economic and Social Development Statistical Database provided by China National Knowledge Infrastructure (CNKI), which is compiled from all the publicly available statistical yearbooks and other published statistical reports.[3] I include all the counties and county level cities in China except 1) counties belonged to four municipalities, namely Beijing, Shanghai, Tianjin and Chongqing, as they are directly governed by the municipalities and too near to the start of main railway lines. 2) counties in Tibet, as none of them have access to railroad until 2007, which is not necessary to be included in the sample based on my identification strategy. Therefore, a total of 1,878 counties are included in my sample, with information on county GDP, GDP per capita, rural income, fixed asset investment and so on over 1996-2009.

3.3 Identification strategy

The main goal of this paper is to identify the impact of high-speed rail upgrade on the economic growth of counties locating on the affected railway lines. As introduced in Section 2, two rounds of high-speed rail upgrade had been implemented in 2004 and 2007 on existing railway lines. My hypothesis is that as high-speed rail upgrade reduced the number of trains

[3] The database is available at http://tongji.cnki.net/kns55/Dig/dig.aspx### with institutional access.

stopped in counties and increased the relative effective distance between counties and cities, it negatively impacted the economic growth in the counties locating on the affected railway lines.

A natural way of thinking is to compare the counties located on the affected railway lines to counties located on other railway lines, before and after each round of high-speed rail upgrade. A problem posed by difference-in-difference analysis is the non-random placement of policy (Duflo and Pande, 2007). That is, in our context, the placement of high-speed rail upgrade is not randomly selected. However, as the selection of affected railway lines mainly depend on the cities it connects, rather than the counties it bypasses, it can be treated as a natural experiment to the counties locating on railway lines. This argument is similar to Michael (2008) and Datta (2011), where both of them argue that if highway is built to connect cities A and B, it must pass through areas that lies between the two, which affects the outcomes in such areas. But for some regional lines selected into the program which only passes through a few counties and cities, the decision of selecting into the high-speed rail upgrade may also depend on the counties it crosses. Such counties may in fact bias my estimation.

Therefore, I am going to employ an instrument to identify the program selection. Specifically, I am going to use whether a county is located on the main railway lines to identify whether it is affected by the speed acceleration or not. As mentioned in Section 2.1, there are six main railway lines in China. I exclude the railway line from Beijing to Baotou (*jingbao xian*) in the identification strategy here as it mainly serves for freight trains instead of passenger trains. [4,5]

[4] One may doubt the definition of main railway lines in China. However, the definition here follows the published train schedule, where each main railway line is a section of the schedule.

The five main railway lines are shown in Figure 7.

Two assumptions for valid instrumental variables are: 1) being located on the main railway lines is correlated with being affected by the high-speed rail upgrade; 2) being located on the main railway lines affects economic growth only through its impact on railway acceleration. Assumption 1 holds as can be seen from the list of selected railway lines for high-speed rail. The first stage F statistic will be reported in the next section. Assumption 2 is somewhat strong in the sense that the main railway lines generally locate in relatively developed regions. However, it will not blur our estimation for two reasons. First, as shown in Figure 8, even though the counties located in the main railway lines on average have higher GDP than counties located in other railway lines, the GDP growing trend of the two groups are similar. Therefore, it is hard to say there is any systematic difference between the two groups in terms of economic growth. Second, even if counties located in the main railway lines are selected as they have better economic potential, it will only downward bias my estimate as I argue the counties located on the accelerated railway lines are negatively affected in the later period of the project.

My estimation equation of a standard difference-in-difference can be written as:

$$\mathrm{Outcome}_{i,t} = \beta_0 + \beta_1 \mathrm{HSR}_{i,t} * \mathrm{After}_{i,t} + \gamma \mathrm{Year}_{i,t} * \mathrm{Province}_{i,t} + \delta \mathrm{County}_{i,t} + \varepsilon_{i,t} \qquad (1)$$

Where $\mathrm{Outcome}_{i,t}$ is the economic outcome of county i in time t. In this paper, we mainly care about three categories of outcome variables: 1) yearly county level GDP and GDP per capita,

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Therefore it is convincing that the main railway lines defined here is objective.

[5] The railway line from Beijing to Baotou mainly serves as transporting coals from Shanxi Province, the largest coal production base in China, to other provinces.

which represents the overall performance of a county; 2) yearly county level investment measure, mainly fixed asset investment is also included in the outcome variables of interest, as investment is an important driving force of GDP growth in China, and a possible mechanism through which speed acceleration impacts the local economy as discussed in Section 2.2 (Qin et al. 2006; Yu, 1998); 3) yearly county level rural income per capita, which is a welfare measure of rural residents in the counties. $\mathrm{HSR}_{i,t} * \mathrm{After}_{i,t}$ is the difference-in-difference term, where the dummy variable $\mathrm{After}_{i,t}$ denotes whether county i in time t has been affected by high-speed rail upgrade or not. $\mathrm{Year}_{i,t} * \mathrm{Province}_{i,t}$ controls for year by province time trend. $\mathrm{County}_{i,t}$ controls for county fixed effect. $\varepsilon_{i,t}$ is the error term.

The reduced form instrumental variable estimation can be written as:

$$\mathrm{Outcome}_{i,t} = \beta_0 + \beta_1 \mathrm{Mainline}_i + \beta_2 \mathrm{Mainline}_i * \mathrm{Year\_d}_{i,t} + \gamma \mathrm{Year}_{i,t} * \mathrm{Province}_{i,t} + \delta \mathrm{County}_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where $\mathrm{Mainline}_i$ denotes whether county i locates in any of the five main railway lines or not; $\mathrm{Mainline}_i * \mathrm{Year\_d}_{i,t}$ denotes $\mathrm{Mainline}_i$ interacting with a series of year dummies. Other variable definition is the same as in Equation (1).

4 Findings

4.1 Descriptive statistics

Table 1 shows the descriptive statistics for county level railway status and economic outcome indicators. As mentioned in Section 3.3, only counties with railroad are included. Thus, in total we have 957 counties in my sample, with 171 of them locating on five main railway lines and 786 counties locating on other railway lines. On average, around 28 trains stopped in counties locating on main railway lines on a daily basis, compared to around 22 trains stopped in counties locating on other railway lines. However, in 2007, both number dropped, from 28 to 21 and from 22 to 18, respectively. It is evidenced that the decrease in train stops is more severe for counties locating on main railway lines than others.

In terms of economic outcomes, counties locating on main railway lines on average have higher GDP, GDP per capita, fixed asset investment as well as rural income. The GDP doubled from 2003 to 2007 for both groups of counties. And the fixed asset investment almost tripled for both groups. However, the growth rate of rural income is less than GDP growth also in both groups of counties.

4.2 OLS estimation

Table 2 and 3 show the OLS regressions for the impact of high-speed rail upgrade in 2004 and 2007. Estimation results are reported for two sub-samples: 2005-2009 and 2002-2009. The observations before 2002 are not included as four earlier rounds of speed acceleration occurred in 1997, 1998, 2000 and 2001. I will report a separate estimate for the four waves of speed acceleration after the main result.

Table 2 shows the impact of high-speed rail upgrade on county level GDP and GDP per capita. Column 1-4 suggests a significant GDP and GDP per capita reduction after the high-speed rail upgrade in 2007 in the counties locating on the affected railway lines, which is around 4-5 percent in magnitude. However, the impact of the earlier upgrade in 2004 is not significant with a negative magnitude in Column 2 and 4. The insignificant coefficient can be explained by two facts. First, the mileage of high-speed rail upgrade in 2004 is 1,960 kilometers, which is only one third of the completed upgrade in 2007 (around 6,000 kilometers.) Second, only 19 pairs of nonstop city transit trains were operating on the upgraded lines in 2004, compared to 257 CRH trains operating on the high-speed rails in 2007. Both facts illustrate that the intensity of the railway lines upgrade in 2004 less than the intensity in 2007.

The reduction of GDP is likely to be driven by a reduction of investment, as suggested in Table 3. The decrease of fixed asset investment in the high-speed rail affected counties in 2007 is around 9-11 percent, which is doubled compared to the reduction of GDP. However, the impact of high-speed rail on the welfare of rural residents is trivial in the affected counties.

4.3 IV estimation

Table 4 and 5 reports the reduced form estimation following Equation (2). For both tables, it can be seen from the significance of the coefficients that the instruments, namely being located on the main railway lines over years, are good explanatory variables of GDP and GDP per capita variations at the county level. Moreover, being located on the main railway lines is more disadvantaged for county economic growth during the high-speed rail upgrade. For example, the coefficients on Mainline*Year07 are negative in all of the four regressions in Table 4, with three of them significant. The coefficients for Mainline*Year08 and Mainline*Year09 are all negative and generally larger than the coefficient for Mainline*Year07, which describes the trend of increasing discrepancy of GDP growth between counties locating on main railway lines and other lines.

Table 6 and 7 reports the Two-Stage Least Square (2SLS) estimation for the impact of high-speed rail on county economic growth. The First stage F statistic is 12.16 for the endogenous variable "HSR07*After" and 71.91 for "HSR04*After," which shows the strong correlation between instruments and endogenous program placement. The magnitude and significance for the 2SLS estimation is similar to the OLS estimation, except for the coefficient of HSR04*After on the impact of GDP growth (Column 2, Row 1 of Table 6). The coefficient is negative without significance in the OLS regression in Table 2. However, the coefficient is negative and significant at the 0.05 level in the 2SLS estimation, which is in consistence with the significantly negative coefficient on Mainline*Year04 in the reduced form estimation (Column 2, Row 3 of Table 4.)

To summarize, the findings in Table 2-7 suggests that high-speed rail upgrade hurts the economic growth of the counties locating on the affected railway lines. More specifically, the GDP and GDP per capita of such counties are decreased by 4-6 percent, which is around 253-378 million *yuan*, given the average county level GDP as 6.32 billion *yuan* in 2006. Furthermore, the reduction of fixed asset investment is doubled in terms of GDP reduction, which is around 9-10 percent in terms of magnitude. This reduction can be translated as a reduction of 254-283 million *yuan*, given the average county level fixed asset investment as 2.83 billion *yuan* in 2006. Therefore, it can be concluded that the GDP reduction is mainly investment driven and can be almost fully explained by the drop in fixed asset investment. However, there is no evidence that the welfare of rural residents, in terms of rural income, is affected by high-speed rail upgrade.

4.4 Impact of previous speed acceleration on county economic development

As mentioned in Section 2.2, four rounds of mild speed acceleration had been implemented in the main railway lines and other lines prior to high-speed rail upgrade starting from 2004. In this section, I will provide an estimate of the impact of previous speed acceleration projects on county economic development using exactly the same specification and instruments in Equation (1) and (2). The main purpose of the estimation is to investigate the possible differential impact of mild speed acceleration in previous years compared to the intensive high-speed rail upgrade under "Great Leap Forward."

The estimation using OLS and 2SLS is both shown in Table 8. Variables "Speed97," "Speed98," "Speed00" and "Speed01" denote for the four rounds of speed acceleration in 1997, 1998, 2000 and 2001, respectively. Different from the main estimation for high-speed rail upgrade, the impact of the four rounds of speed acceleration is almost non-significant for most of the coefficients. Specifically, for the 32 coefficients in eight estimations, none of them are significant at the 0.05 level. Seven coefficients are significant at the 0.1 level, with four being positive and three being negative. In addition to that, none of the coefficients using 2SLS is significantly negative at the 0.1 level. Therefore, the estimation suggests that counties being located on the accelerated railway lines before 2003 were not disadvantaged in terms of economic development. Actually, the impact of such mild railway speed acceleration is trivial for the counties being locating on the affected railway lines.[6]

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[6] The result should be interpreted with caution as there happened to be a change of statistical reporting method in 1997 and 1998 in China which is overlapped with the first and second round of speed acceleration. Due to the inconsistency in reporting method, the missing values of

5 Conclusion

In this paper, I study the impact of high-speed rail upgrade starting in the year 2004 on the counties locating on the affected railway lines. As the high-speed rail upgrade reduces the number of trains stopped by counties and increases the effective distance from counties to cities, a natural question raised is whether the faster commuting between cities through high-speed rail is at the cost of GDP loss in small counties. By comparing GDP and GDP per capita of counties located on the affected railway lines to counties located on other railway lines, it is shown that there is a significant GDP and GDP per capita reduction after the high-speed rail upgrade in 2007 in the counties locating on the affected railway lines, which is around 4-5 percent in magnitude. After accounting for nonrandom high-speed rail placement, the 2SLS estimation shows consistent estimation in terms of significance and magnitude. Moreover, the GDP reduction in the high-speed rail bypass counties, which is around 253-378 million *yuan*, given the average county level GDP as 6.32 billion *yuan* in 2006, can be largely explained by the concurrent drop in fixed asset investment. However, there is no evidence suggesting that the welfare of rural residents is affected by the high-speed rail upgrade, measured by per capita rural income.

In addition to the main estimation, a comparison between the impact of high-speed rail

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economic outcome variables prior to 1998 take up to around two thirds of the total observations collected from the China Economic and Social Development Statistical Database. Therefore, the estimation for the impact of speed acceleration in the third and fourth waves is more convincing than the first two waves in 1997 and 1998.

upgrade and previous rounds of speed acceleration is made, which suggests the negative impact of speed acceleration appears only after the starting of high-speed rail upgrade. This comparison also reflects the consequence of "Great Leap Forward" culture in the Railway System, starting around 2003, under the tenure of ex Minister of Railways Zhijun Liu. However, with the corruption investigation under Liu in early 2011, as well as the high-speed rail accidents shortly after that, China is rethinking its high-speed rail strategy.

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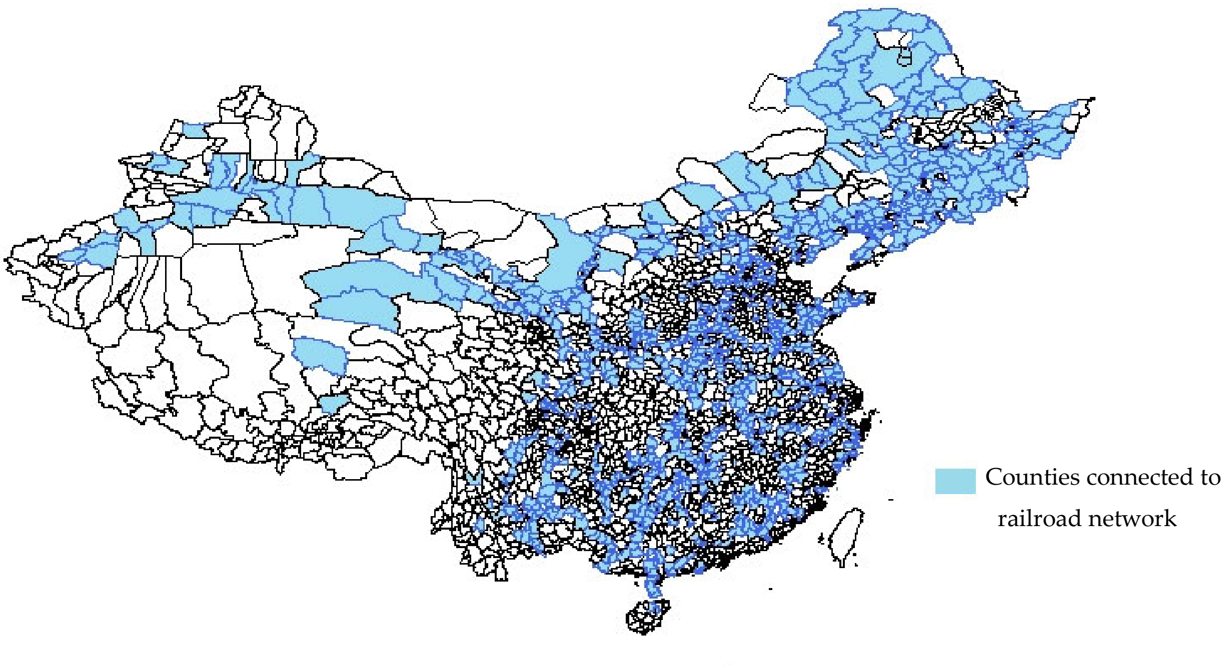
Figure 1. Counties Connected to Railroad Network by Year 2007



GIS source: China Data Center (University of Michigan) and *People's Republic of China Railroad Atlas*

Figure 2. The Decreasing Trend of Passenger Train Stations (1996-2007)

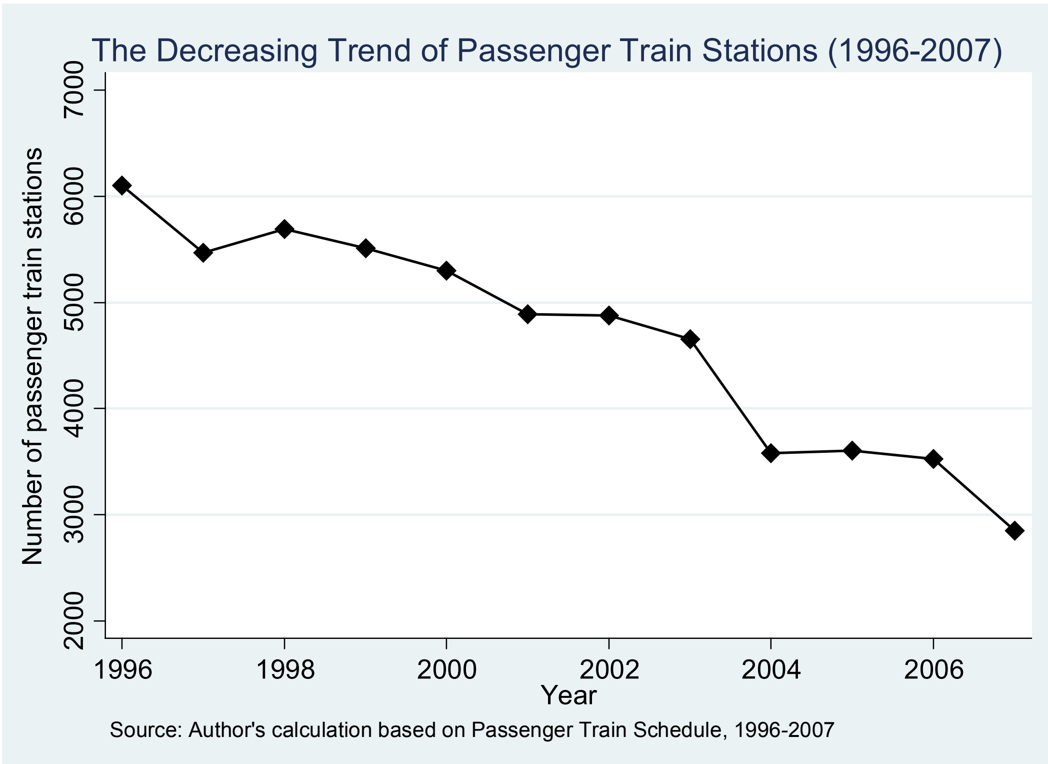


Figure 3. Railway Accessibility and Railway Length (1996-2007)

Figure 4. Average Daily Train Stops by City and County (1996-2007)

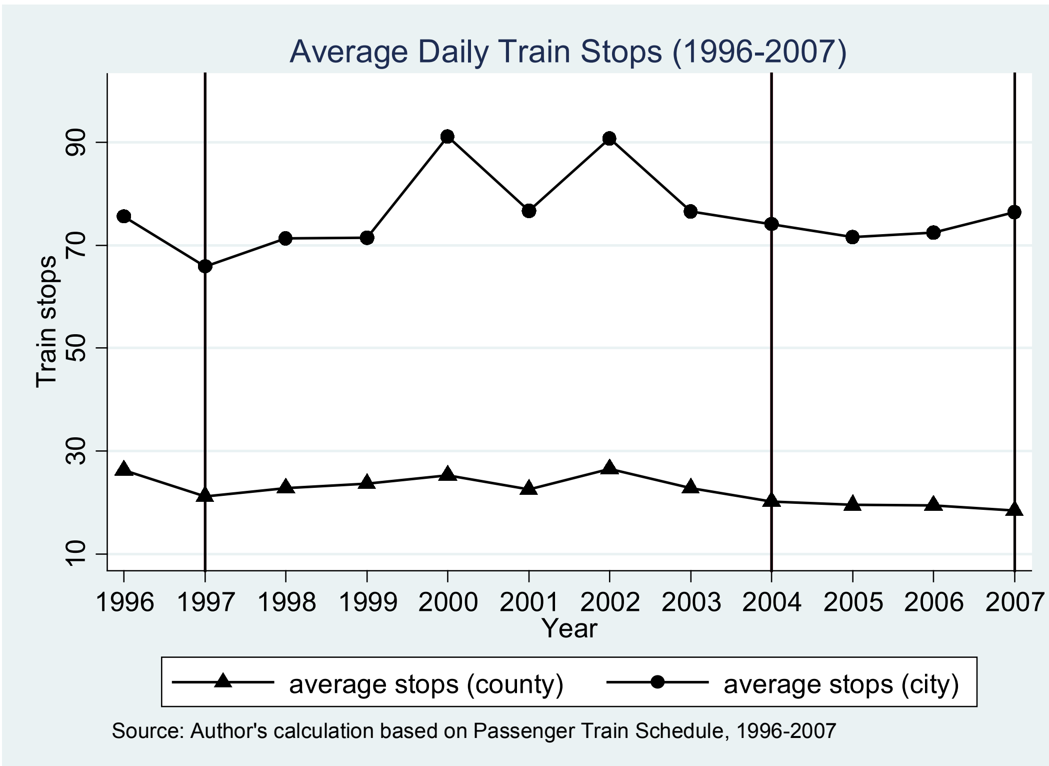
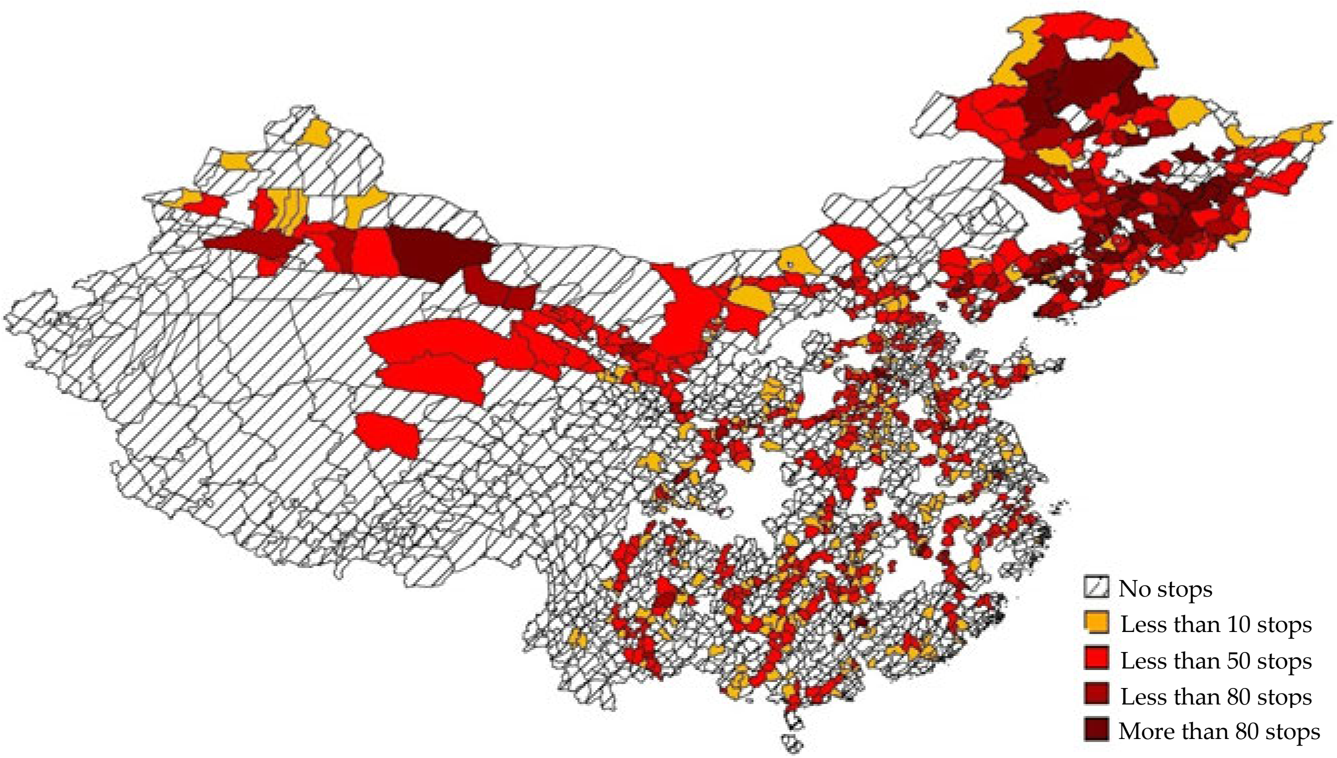
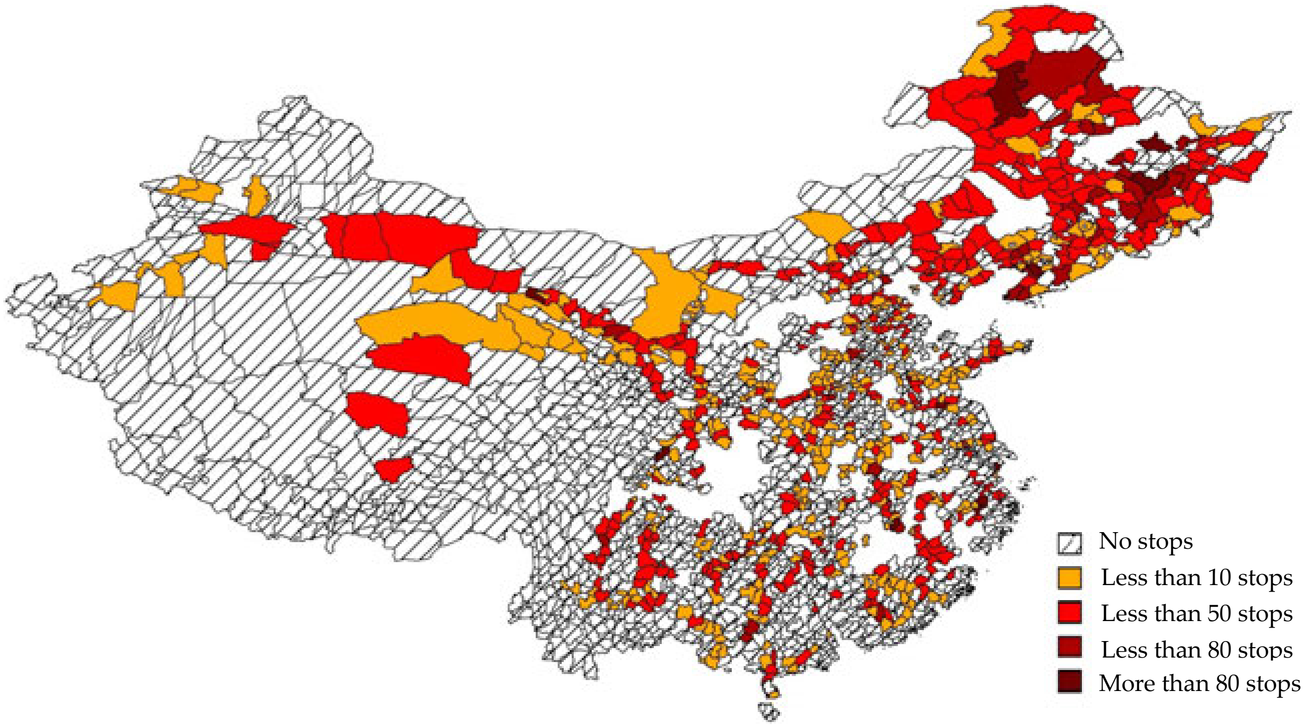


Figure 5. Daily Average Train Stops in the Counties, 1996



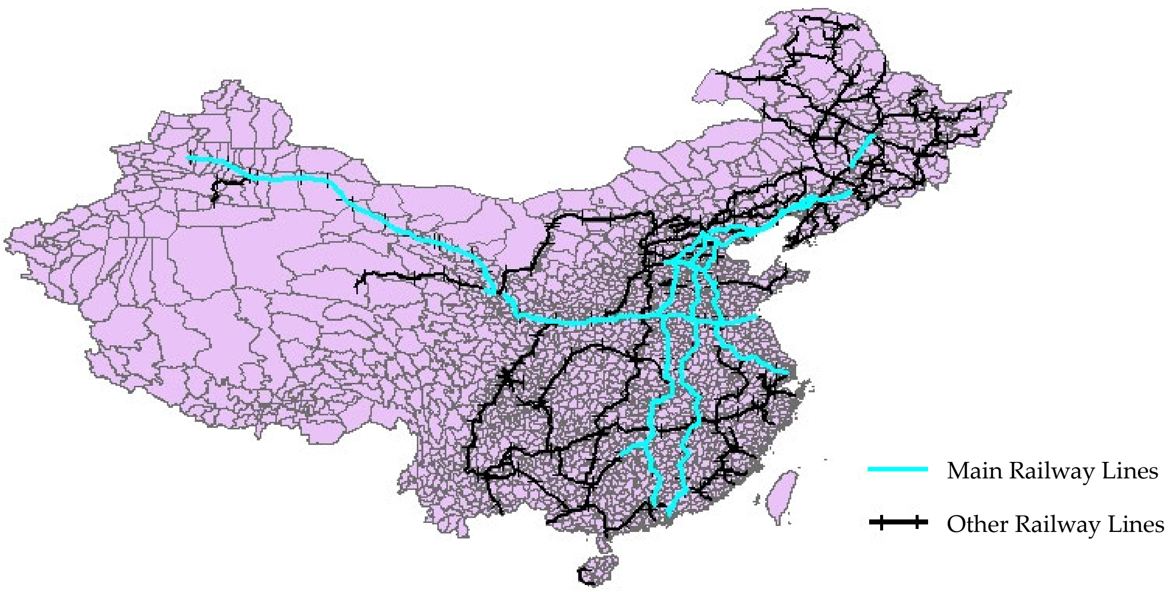
GIS source: China Data Center (University of Michigan)

Figure 6. Daily Average Train Stops in the Counties, 2007



GIS source: China Data Center (University of Michigan)

Figure 7. China Railway Network (Year 2000)



GIS source: China Data Center (University of Michigan)

Figure 8. County GDP Growth Trend by Railway Lines

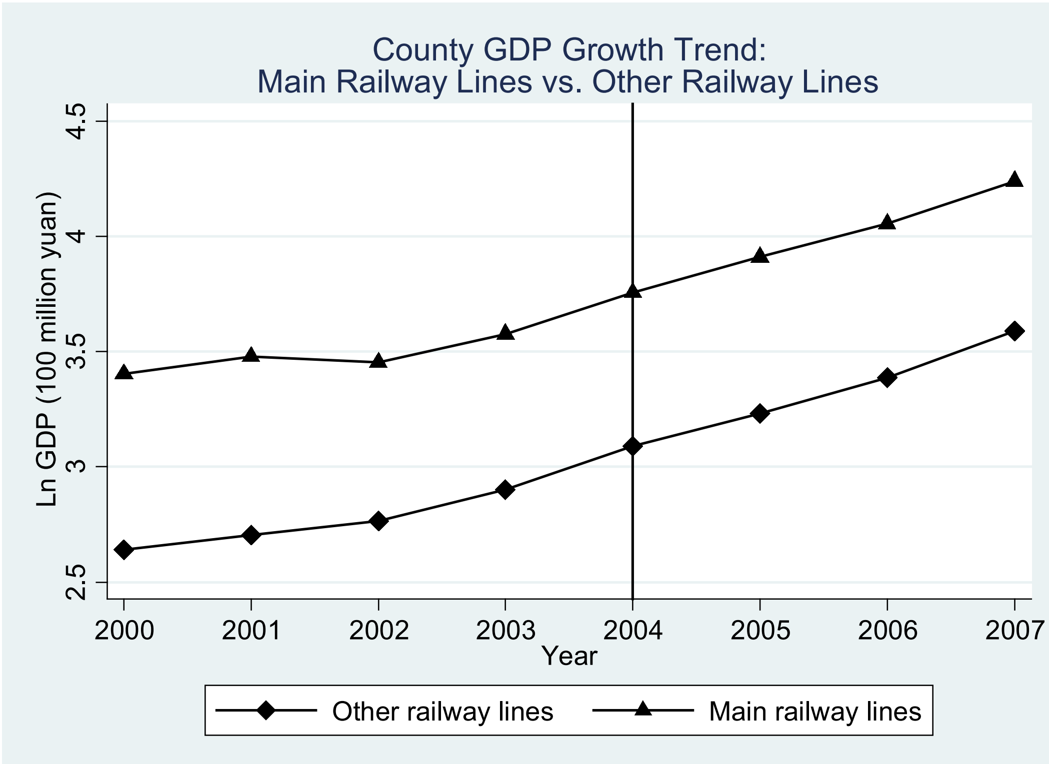


Table 1. Descriptive Statistics

	2003		2007		Source
A. Railway Status	Main RL	Other RL	Main RL	Other RL	
Number of Counties	171	786	171	786	People’s Republic of China Railroad Atlas
Average Daily Train Passenge (with Stops)	27.67	21.74	20.79	17.62	China Passenger Train schedule (annually)
	(26.22)	(22.91)	(20.04)	(17.87)	
B. Economic Outcomes					
GDP (100 million *yuan*)	47.19	36.72	94.77	73.61	China Economic and Social Development Statistical Database
	(44.29)	(37.59)	(107.65)	(74.94)	
GDP Per Capita (1000 *yuan*)	9.58	7.24	16.06	15.01	China Economic and Social Development Statistical Database
	(14.87)	(4.96)	(15.42)	(12.19)	
Fixed Asset Investment (100 million *yuan*)	15.03	12.56	41.87	36.87	China Economic and Social Development Statistical Database
	(17.16)	(15.82)	(40.59)	(37.30)	
Rural Income Per Capita (*yuan*)	2824.79	2767.12	4607.55	4405.33	China Economic and Social Development Statistical Database
	(823.56)	(1110.01)	(1321.38)	(1645.09)	

Notes. 1. Main RL stands for "Main Railway Lines"; Other RL stands for "Other Railway Lines."

Table 2. The Impact of High-Speed Rail on County GDP and GDP Per Capita (OLS)

	Dependent Variables			
	Ln GDP		Ln GDP Per Capita	
	2005-2009	2002-2009	2005-2009	2002-2009
HSR04*After		-0.04		-0.09
		(0.03)		(0.08)
HSR07*After	-0.04***	-0.05***	-0.05***	-0.05***
	(0.01)	(0.02)	(0.01)	(0.02)
County Fixed Effect	Yes	Yes	Yes	Yes
Province*Year Fixed Effect	Yes	Yes	Yes	Yes
R-Squared	0.99	0.98	0.92	0.92
Observations	4204	6722	4139	5768

Notes . 1. Standard errors are clustered at the county level. 2. * significant at the 0.1 level; ** significant at the 0.05 level; *** significant at the 0.01 level.

Table 3. The Impact of High-Speed Rail on County Investment and Rural Income (OLS)

	Dependent Variables			
	Ln Fixed Asset Investment		Ln Rural Income Per Capita	
	2005-2009	2002-2009	2005-2009	2002-2009
HSR04*After		-0.06		-0.01
		(0.05)		(0.01)
HSR07*After	-0.09**	-0.11***	0.00	-0.01
	(0.04)	(0.04)	(0.01)	(0.01)
County Fixed Effect	Yes	Yes	Yes	Yes
Province*Year Fixed Effect	Yes	Yes	Yes	Yes
R-Squared	0.88	0.90	0.97	0.96
Observations	3526	5644	3721	5366

Notes . 1. Standard errors are clustered at the county level. 2. * significant at the 0.1 level; ** significant at the 0.05 level; *** significant at the 0.01 level.

Table 4. The Impact of High-Speed Rail on County GDP and GDP Per Capita (Reduced Form)

	Dependent Variables			
	Ln GDP		Ln GDP Per Capita	
	2005-2009	2002-2009	2005-2009	2002-2009
Mainline	0.55***	-0.26***	0.22***	-0.47***
	(0.02)	(0.04)	(0.02)	(0.04)
Mainline*Year03		-0.01		0.05
		(0.01)		(0.07)
Mainline*Year04		-0.04**		0.00
		(0.02)		(0.03)
Mainline*Year05		-0.04		0.01
		(0.02)		(0.04)
Mainline*Year06	-0.02**	-0.06**	-0.01	0.00
	(0.01)	(0.03)	(0.01)	(0.05)
Mainline*Year07	-0.04**	-0.08**	-0.04***	-0.03
	(0.02)	(0.03)	(0.02)	(0.05)
Mainline*Year08	-0.05***	-0.09***	-0.07***	-0.05
	(0.02)	(0.03)	(0.02)	(0.05)
Mainline*Year09	-0.07***	-0.11***	-0.09***	-0.08
	(0.02)	(0.03)	(0.03)	(0.05)
County Fixed Effect	Yes	Yes	Yes	Yes
Province*Year Fixed Effect	Yes	Yes	Yes	Yes
R-Squared	0.99	0.98	0.92	0.92
Observations	4204	6722	4139	5768

Notes . 1. Standard errors are clustered at the county level. 2. * significant at the 0.1 level; ** significant at the 0.05 level; *** significant at the 0.01 level.

Table 5. The Impact of High-Speed Rail on County Investment and Rural Income (Reduced Form)

	Dependent Variables			
	Ln Fixed Asset Investment		Ln Rural Income Per Capita	
	2005-2009	2002-2009	2005-2009	2002-2009
Mainline	-0.38***	-1.20***	-0.18***	-0.17***
	(0.06)	(0.07)	(0.01)	(0.02)
Mainline*Year03		0.06		0.01
		(0.04)		(0.01)
Mainline*Year04		0.01		0.00
		(0.06)		(0.01)
Mainline*Year05		0.02		-0.02
		(0.06)		(0.01)
Mainline*Year06	-0.04	-0.06	-0.01	-0.02*
	(0.05)	(0.06)	(0.01)	(0.01)
Mainline*Year07	-0.06	-0.09	-0.01	-0.03*
	(0.05)	(0.06)	(0.01)	(0.02)
Mainline*Year08	-0.11*	-0.13*	-0.01	-0.03
	(0.06)	(0.07)	(0.01)	(0.02)
Mainline*Year09	-0.15**	-0.17**	0.00	-0.02
	(0.06)	(0.07)	(0.01)	(0.02)
County Fixed Effect	Yes	Yes	Yes	Yes
Province*Year Fixed Effect	Yes	Yes	Yes	Yes
R-Squared	0.88	0.90	0.97	0.96
Observations	3526	5644	3721	5366

Notes . 1. Standard errors are clustered at the county level. 2. * significant at the 0.1 level; ** significant at the 0.05 level; *** significant at the 0.01 level.

Table 6. The Impact of High-Speed Rail on County GDP and GDP Per Capita (2SLS)

	Dependent Variables			
	Ln GDP		Ln GDP Per Capita	
	2005-2009	2002-2009	2005-2009	2002-2009
HSR04*After		-0.09**		-0.08
		(0.03)		(0.10)
HSR07*After	-0.04***	-0.05***	-0.06***	-0.06***
	(0.01)	(0.02)	(0.01)	(0.01)
County Fixed Effect	Yes	Yes	Yes	Yes
Province*Year Fixed Effect	Yes	Yes	Yes	Yes
R-Squared	0.99	0.98	0.92	0.92
Observations	4204	6722	4139	5768

Notes . 1. Standard errors are clustered at the county level. 2. * significant at the 0.1 level; ** significant at the 0.05 level; *** significant at the 0.01 level. 3. First stage F statistic is 12.16 in 2005-2009 sample; 12.16 and 71.91 for the two endogenous variables in 2002-2009 sample, respectively.

Table 7. The Impact of High-Speed Rail on County Investment and Rural Income (2SLS)

	Dependent Variables			
	Ln Fixed Asset Investment		Ln Rural Income Per Capita	
	2005-2009	2002-2009	2005-2009	2002-2009
HSR04*After		-0.11		-0.02
		(0.07)		(0.01)
HSR07*After	-0.09**	-0.10***	0.00	-0.01
	(0.04)	(0.04)	(0.01)	(0.01)
County Fixed Effect	Yes	Yes	Yes	Yes
Province*Year Fixed Effect	Yes	Yes	Yes	Yes
R-Squared	0.88	0.90	0.97	0.96
Observations	3526	5644	3721	5366

Notes . 1. Standard errors are clustered at the county level. 2. * significant at the 0.1 level; ** significant at the 0.05 level; *** significant at the 0.01 level. 3. First stage F statistic is 12.16 in 2005-2009 sample; 12.16 and 71.91 for the two endogenous variables in 2002-2009 sample, respectively.

Table 8. The Impact of Speed Acceleration on County Economic Development, 1996-2003

	Ln GDP		Ln GDP Per Capita		Ln Fixed Asset Investment		Ln Rural Income Per Capita	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Speed97	0.02	-0.06	0.09	0.20*	0.21	0.10	-0.12*	-0.11
	(0.03)	(0.06)	(0.06)	(0.11)	(0.15)	(0.22)	(0.07)	(0.09)
Speed98	0.09*	0.07	0.18*	0.19*	-0.31*	-0.33	0.02	0.04
	(0.05)	(0.08)	(0.10)	(0.10)	(0.18)	(0.26)	(0.05)	(0.05)
Speed00	-0.02	0.02	-0.07	-0.08	0.04	-0.02	-0.02*	0.00
	(0.03)	(0.04)	(0.05)	(0.06)	(0.11)	(0.24)	(0.01)	(0.03)
Speed01	-0.01	0.01	-0.06	-0.06	-0.07	-0.08	0.00	0.01
	(0.02)	(0.01)	(0.07)	(0.06)	(0.09)	(0.07)	(0.01)	(0.01)
County Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province*Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.99	0.99	0.94	0.94	0.83	0.83	0.90	0.90
Observations	4079	4079	3008	3008	3070	3070	2571	2571

Notes . 1. Standard errors are clustered at the county level. 2. * significant at the 0.1 level; ** significant at the 0.05 level; *** significant at the 0.01 level. 3. First stage F statistics are 29.5, 48.71, 108.86 and 8775.15 for the four endogenous variables, respectively.