The effect of infrastructure construction and reducing transportation time cost on local GDP and urban-suburbs differences: Evidence from Shanghai–Hangzhou high speed railway, China [*]

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Abstract

How much impact does reducing transportation costs have on local GDP in densely populated areas? In this article, I use the Shanghai Hangzhou high speed railway in densely populated areas of China to explore the causal effect of high-speed rail speed increase on local GDP using the difference method (DID), and further investigate how this effect plays a role between urban and suburbs areas. The research results show that the new high-speed rail elevated line, which began operation in 2010, greatly improves the speed of the existing high-speed rail, further reducing the time cost and uncertainty of commuting between cities. The improvement of infrastructure and the reduction of time costs (increased transportation speed) have had a positive impact on local GDP. I will further explore whether reducing the time cost of commuting between cities will increase the willingness to commute between cities.

1 Introduction

The high-speed railway connecting Shanghai and Hangzhou started construction in 2009 and began operation in 2010, increasing the original operating speed of the high-speed railway from 200 to 250 kilometers per hour to 350 kilometers per hour. (Xinhua News Agency, 2010) This will further reduce the cost of commuting time in this densely populated and economically developed region. In this paper, I explore the impact of this rate of growth (time cost reduction) on local GDP and commuting willingness.

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This sample is based on course project of ECON 497: Applied and Computational Economics
All code, data, and output can be found at https://github.com/Shuhang2022/Writingsample

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In 2020, the Chinese government website forwarded a report from a state-owned newspaper calling for the promotion of high-speed rail freight. Therefore, it becomes infeasible to study time costs and uncertainty by studying inventory levels around 2010 (People's Daily, 2020). Due to the difficulty in obtaining data, I am using the macro indicator GDP. In the final exploration section, I will discuss better indicators to measure the impact of reducing time costs and changes in commuting willingness.

This paper may related to some published literature. "Can Time Space Compression Promote Urban Economic Growth? Evidence from China's High speed Rail Projects" (Yao et al., 2020) used panel data from 285 Chinese cities from 2007 to 2017 to study the impact of high-speed rail (HSR) on urban economic growth, combining endogenous growth models and differnece in difference analysis. Expanded the horse-mass theory to explain how China uses high-speed rail to avoid the middle-income trap, and also examined the effective boundaries of high-speed rail. "Does the high-speed rail network improve economic growth?" (Ma & Liu, 2021) uses social network analysis (SNA) and panel threshold models to discuss whether China's high-speed rail (HSR) construction promotes urban economic growth, and provides strong evidence that the high-speed rail network has a nonlinear impact on the urban economy. "Does high speed rail connection really promote local economy? Evidence from China's Yangtze River Delta." (Gao et al., 2019) used county-level panel data in the Yangtze River Delta region of China to examine the impact of high-speed rail connection on the local economy and a linear strategy is used to construct potential high-speed rail connection variables as instrumental variables for actual high-speed rail connections. Both the difference in difference method and instrumental variable method indicate that high-speed rail connections hinder the local economy. However, many literature has different focuses and has drawn different conclusions.

This paper expands the literature on the impact of high-speed rail on local GDP growth, focusing on using high-speed rail as an example to investigate whether the increase in traffic speed between cities and the decrease in uncertainty have an impact on local GDP, and further studies the differences in the impact of high-speed rail on urban and suburbs areas. Taking Huzhou City and Jiaxing City as examples, both cities are located in the northern part of Zhejiang Province, about 150 kilometers away from China's economic center Shanghai and about 100 kilometers away from Zhejiang's economic center Hangzhou. At the same time, these two cities were once a special administrative region of Zhejiang Province before 1983, and later split into two cities (Huzhou Government, n.d.), thus having similarities in various aspects. Due to government planning reasons, Jiaxing opened a new elevated railway in 2010, mainly operating the high-speed railway connecting Shanghai and Hangzhou. As a result, the high-speed railway was increased from 200 to 250 kilometers per hour to 350 kilometers per hour, while Huzhou was unable to open a direct high-speed railway connecting Shanghai. Therefore, it is necessary to detour from Hangzhou to Jiaxing and then to Shanghai, which increases the commuting time by about 2 hours compared to the high-speed train Jiaxing (30 minutes to Shanghai). This article selects GDP data from 2007 to 2018 and uses the difference method to study the impact of high-speed rail direct transportation on local GDP. At the same time, Anji in the suburbs of Huzhou and Tongxiang in the suburbs of Jiaxing also have similarities, both located in the north of Hangzhou. In 2009, when the construction of the Jiaxing high-speed railway

began, Tongxiang established a direct station to Hangzhou, while Anji did not have high-speed railway facilities and needed to detour through Changxing (another suburban area in the north of Huzhou) to reach Hangzhou, resulting in additional time costs. I compared the GDP of two suburban areas and compared it with that of urban areas, using high-speed rail as the research object to explore the impact of transportation time cost construction on economic growth in rural areas and the differences in its impact on urban and rural areas.

Figure 1[1] below are maps for Geographical background.[2]

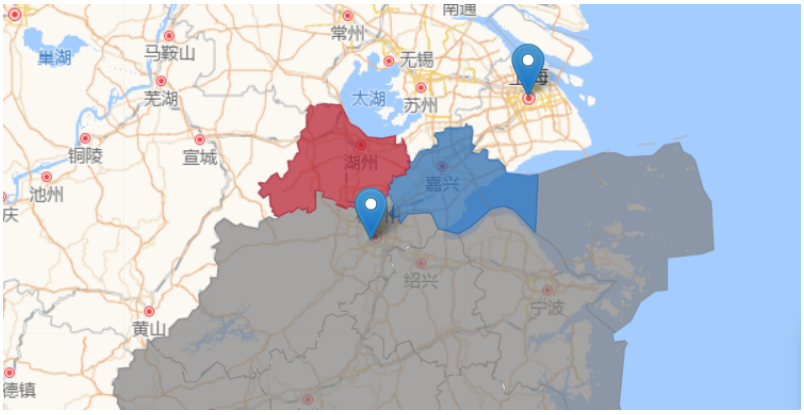

Figure 1: Geographical background

2 Example from Zhejiang: Set up and analysis

The research object is whether reducing the cost of commuting time between cities (increasing high-speed rail speed) will have an impact on local GDP, and the differences in this impact between cities and suburbs. At the local level, Huzhou City serves as the control group and Jiaxing City serves as the treatment group, depending on whether the city has a high-speed railway with a speed of 350 kilometers per hour that directly connects to Shanghai. At the suburban level, we used Anji in the suburbs of Huzhou City as the control group and Tongxiang in the suburbs of Jiaxing City as the treatment group, depending on whether the city has a high-speed railway with a speed of 350 kilometers per hour that directly connects to Shanghai. And further compared the annual GDP of suburban and urban areas. Yit is the annual GDP of city i observed during time periods t and i, with a focus on the entire city and suburbs. Y0it is the annual GDP of urban (suburban) i during the period without high-speed rail construction. Y1 is the annual GDP of cities (suburbs) with high-speed rail. Dit represents the processing method for high-speed railways. Due to the impact of high-speed rail construction on GDP, I observed the impact of construction and operation on GDP in 2009, which is the year when construction began. I selected the annual GDP data from 2007 to 2013 from the annual economic data yearbook and city comparison published by the Jiaxing Municipal Bureau of Statistics to study the long-term impact on GDP.

[1]Map plots are generated by Leaflet and leafletCN packages in Rstudio developed by Lang, Dawei. 2017

[2]The shaded areas are Jiaxing City for blue and Huzhou City for red. The pin above is Shanghai for studying the city overall and the pin below is Hangzhou for studying suburbans.

2.1 Model

The average annual GDP of the four groups is represented as follows:
GDP before 2009 for Huzhou E{Yi0| Ci0=0, Di0=0}
GDP before 2009 for Jiaxing E{Yi0| Ci0=1, Di0=0}
GDP after 2009 for Huzhou E{Yi1| Ci1=0, Di1=0}
GDP after 2009 for Jiaxing E{Yi1| Ci1=1, Di1=1}

year \ treatment	$D_{Jiaxing,t}$	$D_{Huzhou,t}$
2007	0	0
2008	0	0
2009	1	0
2010	1	0
2011	1	0
2012	1	0
2013	1	0

Table 1: Treatment assigned

And difference in difference(DID) equation:

$$\begin{aligned} DID_{it} = [E\{Y_{i1}|C_{i1}=1, D_{i1}=1\} - E\{Y_{i0}|C_{i0}=1, D_{i0}=0\}] \\ -[E\{Y_{i1}|C_{i1}=0, D_{i1}=0\} - E\{Y_{i0}|C_{i0}=0, D_{i0}=0\}] \end{aligned} \tag{1}$$

which is the net difference of the effect of high-speed railways on local GDP before and after its construction.

The treatment group(Jiaxing) obtained the net change before and after treatment E{Yi1| Ci1=1, Di1=1} - E{Yi0| Ci0=1, Di0=0} subtracting the net change before and after the control group (Huzhou) E{Yi1| Ci1=0, Di1=0} - E{Yi0| Ci0=0, Di0=0} to eliminate effects other than treatment, such as time and other constructions.

2.2 The DID in regression form

$$Y_{it} = \alpha + \beta_1 C_{it}\{1 = \text{Jiaxing}\} + \beta_2 Post_{it}\{1 = \text{high-speed rail (after 2009)}\} + \beta_3 C_{it} D_{it}\{\ 1 = \text{Jiaxing AND } 1 = \text{high-speed rail (after 2009)}\} + \xi_{it} \tag{2}$$

Based on the above regression form and DID function in 2.1, by plugging in dummy variables, the net effect of the high-speed railways can be computed as follow:[3]

$$Y_{it} = [(\alpha + \beta_1 + \beta_2 + \beta_3) - (\alpha + \beta_1 + 0)] - [\alpha - \alpha] \tag{3}$$

2.3 Output

This section includes statistical results, and figures[4].

2.3.1 Time series DID analysis

Figure 2[5], Figure 3[5], and Figure 4[5] show the Comparison curve of Annual GDP split by City (overall) and DID curve of Annual GDP split by City with treatment effect.

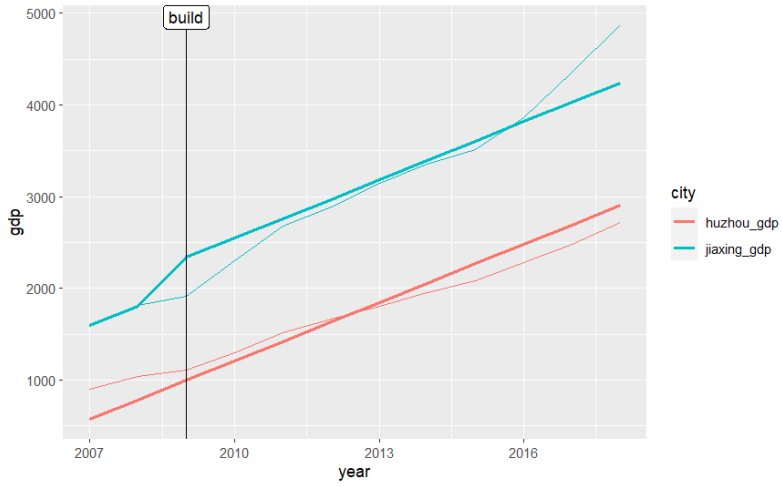

Figure 2: Fitted comparison of Annual GDP split by City (overall)(whole time period)

[3]note that the α and β here in each part of the equation may not be the same

[4]All output are generated by RStudio

[5]The data is sourced from public statistical yearbook and city comparison, the Bureau of Statistics of Jiaxing City. plotted using Rstudio.

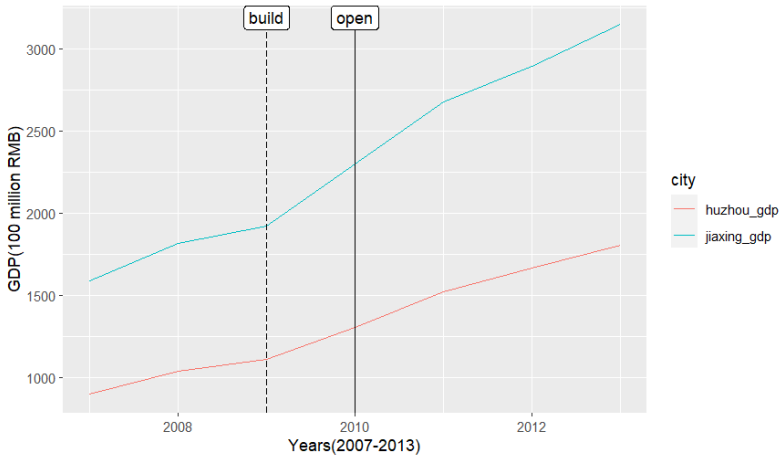

Figure 3: Comparison of Annual GDP split by City (overall) (2007-2013)

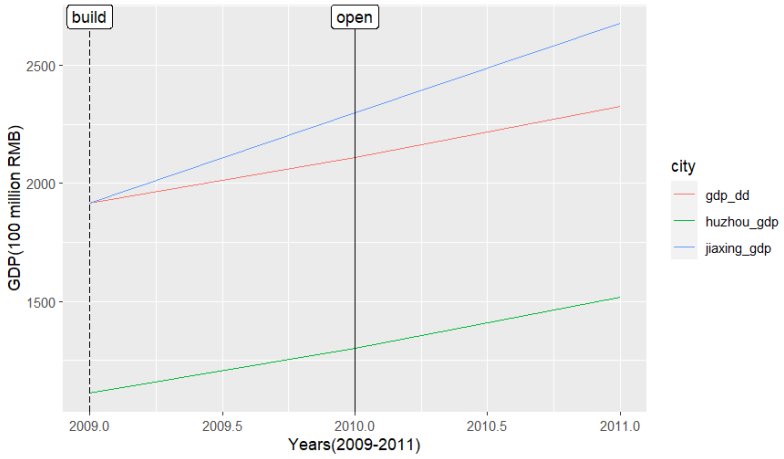

Figure 4: Counterfactual of Annual GDP split by City with treatment effect

By selecting GDP data from Jiaxing City and Huzhou City from 2007 to 2013 and using our DID regression model, we obtained the following estimated effects.

DID regression	regression output	difference of treatment	net difference(effect)
$\alpha + \beta_1 + \beta_2 + \beta_3$	3289.268	1589.028	1589.028
$\alpha + \beta_1 + 0$	1700.24		
α	965.415	0	
α	965.415		

Table 2: Effect to city (overall)

Thus, the estimated effect of local GDP from the construction of high-speed railways has been obtained with a p-value of 0.05663[6] and it's not significant at the α = .05 level, but is significant at the 10% level. There is still bias in this model, so further exploration of bias is necessary.

We can consider the methods described above with the following approach: Huzhou City and Jiaxing City are two groups, one group receiving treatment, that is, building a high-speed railway, and the other group receiving a placebo.

2.3.2 Differences in impact on urban areas and suburbs

Figure 5[5] shows the changes in urban regional GDP of Jiaxing City and Huzhou City before and after the construction of high-speed rail.

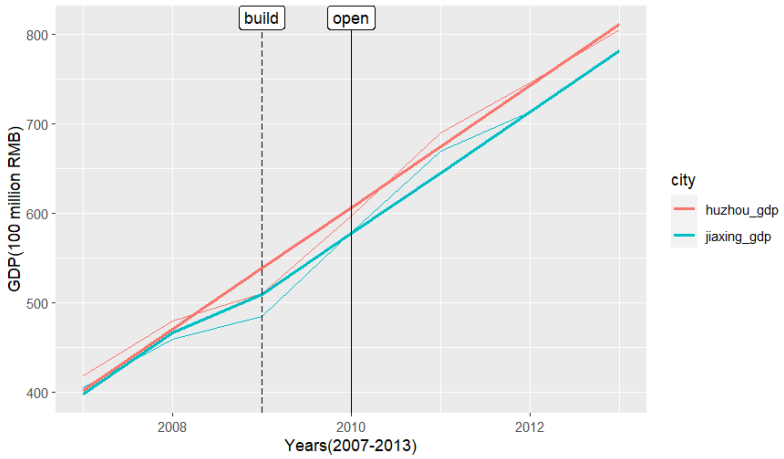

Figure 5: Fitted comparison of urban areas GDP before and after

We can find that the construction of high-speed rail has almost no effect on the GDP of the urban area, even a slight decline in urban GDP.

The p-value is 0.923637 which shows that there is no statistically significant effect of high-speed rail to urban GDP at the α = .05 level. There may be many potential reasons for this, including the difficulty in changing the construction of the urban area. As a result, the main high-speed railway stations in Jiaxing city have been built in the urban area close to suburbs, and multiple sub-stations have been built in the suburbs.

From this, the conclusion can be drawn that the construction of high-speed rail does not have a significant effect on urban areas. Furthermore, we use the difference in difference (DID) method to study the effect of building high-speed rail on the suburbs. Choose Anji in the

[6]Empirical results were tested using robust standard errors (all same below).

suburbs of Huzhou City and Tongxiang in the suburbs of Jiaxing City as a comparison. The specific background can be seen in the Introduction section.

Figure 6[5] and Figure 7[5] show the comparison curves of GDP for Anji and Tongxiang, and Figure 8[5] shows the difference in difference(DID) curve after the construction of high-speed rail.

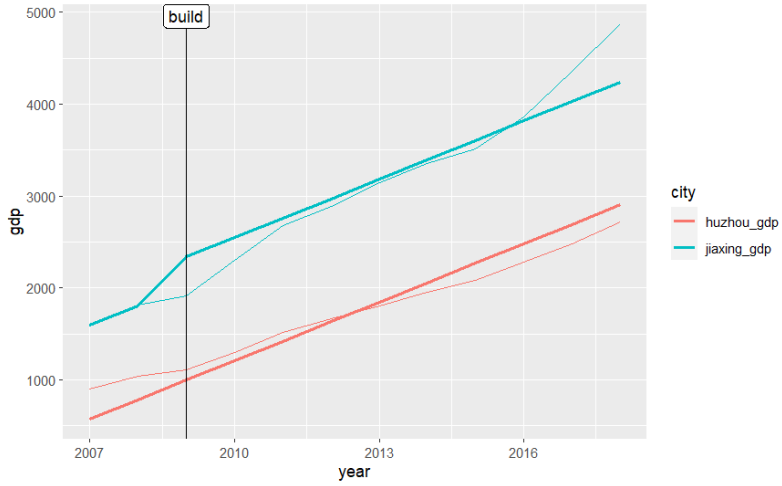

Figure 6: Fitted comparison of Annual GDP split by City (suburban area) (whole time period)

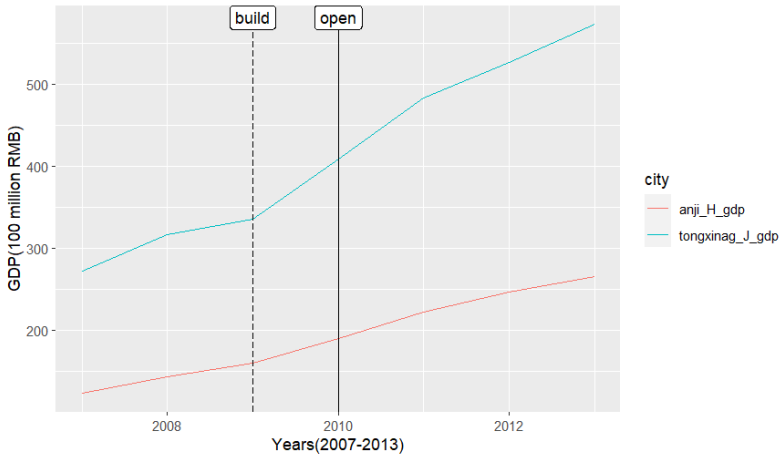

Figure 7: Comparison of Annual GDP split by City (suburban area) (2007-2013)

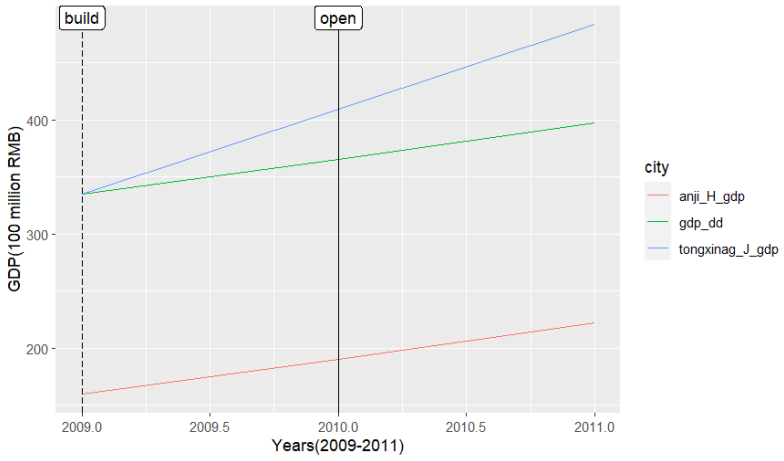

Figure 8: Counterfactual of Annual GDP split by City (suburban area) with treatment effect

From the above comparisons, it can be found that the construction of high-speed railways also has an impact on suburb Tongxiang. We also used the models shown in 2.1 and 2.2 to bring in data[7] from these two regions and calculate the effect.

DID regression	regression output	difference of treatment	net difference(effect)
$\alpha + \beta_1 + \beta_2 + \beta_3$	601.008	306.828	306.828
$\alpha + \beta_1 + 0$	294.18		
α	132.485	0	
α	132.485		

Table 3: Effect to suburban area

Thus, the estimated effect of suburban areas for construction of high-speed railways has been obtained and eliminated potential bias.

From above, it can be concluded that the construction of high-speed railways has an effect on the suburbs with a p-value of 0.01309 which shows it is statistically significant at the α = .05 level.

Comparing the curves of suburban and urban areas together, we can see more clearly the impact of high-speed rail on GDP. As shown in Figure 9[5].

[7]The GDP data comes from the Jiaxing Bureau of Statistics, which has been divided into multiple districts of urban and suburban areas in detail, so there are no problems such as geographical overlap between urban and suburban areas.

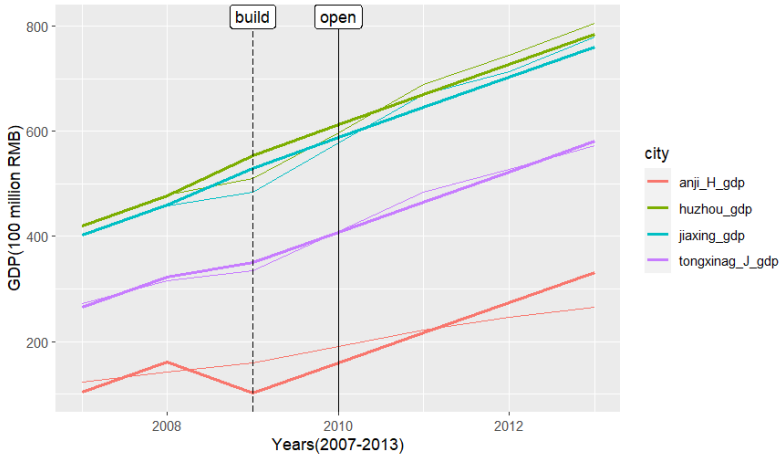

Figure 9: Fitted comparison of Annual GDP (urban vs suburban) (2007-2013)

3 Vulnerability and Bias

It is not absolutely sure whether the results obtained are right counterfactual or wrong counterfactual. Even though there are many similarities between the two regions explained in the introduction section, there are still differences, such as Jiaxing City, which is adjacent to the sea and has a port of Jiaxing[8], while Huzhou is located inland with part of mountainous areas in its suburbs. In terms of population, labor, investment, personal income, government revenue, industry index, agriculture index, and other perspectives, there are more differences, and variables even more difficult to estimate using models, such as the abilities of the mayor and his team[9].

3.1 Further exploration of bias

We chose Changxing, another suburban area of Huzhou, to compare with Tongxiang. The two both started building the new 350km/h high-speed railways in 2009, so there should not be a significant difference in GDP between the two before and after the construction of high-speed railways.

[8]For more information about the port of Jiaxing: https://www.ufsoo.com/port/jiaxing/

[9]The mayor here refers to the mayor and government team who manage the entire city, including the urban and suburban areas.

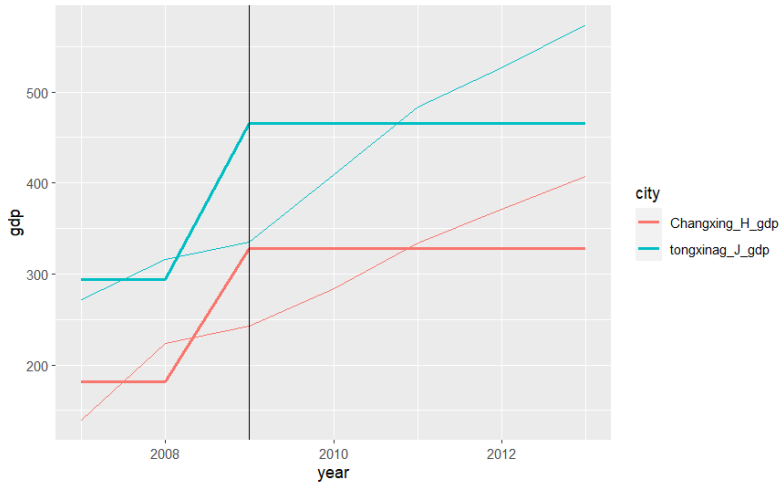

Figure 10: Time dummy comparison of Annual GDP split by City (bias) (2007-2013)

The Fighre 10[5] using a time dummy is not obvious, and it is difficult for us to conclude whether there are significant changes before and after. Therefore, we create a time trend Fighre 11[5], and there is no significant change if the two curves are parallel.

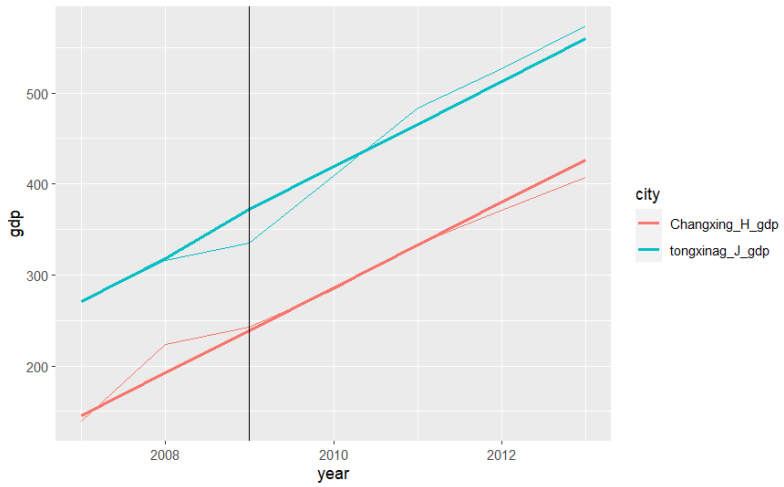

Figure 11: Time trend comparison of Annual GDP split by City (bias) (2007-2013)

The regression output shows a p-value of 0.6662979 which means it is not statistically significant at the α = .05 level. So, there is no significant effect before and after the high speed train was built. We can see that there has been no significant change in the GDP of the two suburbs with high-speed rail.

4 Conclusion

By studying the effect of high-speed rail on local GDP, and using the difference in difference (DID) method, it can be concluded that high-speed rail has a positive impact on local GDP, which can be demonstrated at both the city overall and suburban levels. Similarly, it was found that the construction of high-speed railways did not have a significant effect on the GDP of urban areas, but had on the suburbs. From this, we can explore the differences in the effect of building high-speed railways on urban and suburban areas. In fact, in the case of Jiaxing City, decision-makers built high-speed trains along the boundaries of multiple suburban areas and built the main high-speed railway station facing the urban population almost in the middle of two major urban areas but also close to suburbans, in order to promote a balance of economic development between urban and suburban(rural) areas and also the balance of economic development between different areas of the suburbs.

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