

# The Effect of the Opening of Chengdu-Chongqing High-speed Rail on the Urbanization of Cities Along the Rail Line

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**Abstract.** With its benefits of high speed, high safety, and environmental friendliness, high-speed rail has emerged as a significant trend in the development of the modern transportation sector. It also plays a major role in boosting the economics and urbanization of China's metropolitan clusters. Taking the Chengdu-Chongqing region and its cities along the route as an example, this study examines the urbanization process of the Chengdu-Chongqing urban agglomeration both before and after the construction of high-speed rail by using data pertaining to the launch of the high-speed rail network in the region from 2012 to 2018. Using the difference in difference technique, this study examines and evaluates the real effects of the high-speed railway's opening on the urbanization process of Chengdu-Chongqing and the cities along its path. (DID). Based on empirical data, the Chengdu-Chongqing urban agglomeration's resident population's rate of urbanization has significantly increased since the high-speed railway opened, and can facilitate and support the Chengdu-Chongqing region's urbanization trend.

**Keywords:** High-speed railway, DID, urbanization.

## 1. Introduction

The stage of improvement in transportation, as an important part of the infrastructure of modern societies, constrains the breadth and depth of socio-economic activities. A well-developed transport network is a necessary condition for the realization of social production and the advancement of urbanization. Luqi Wang et al. argue that transport networks can establish intercity or intracity connections, which are conducive to urban economic development and improved quality of life [1]. Because of its great speed and high level of safety, high-speed rail has emerged as one of the major trends in the growth of the transportation business in the modern era. At present, China is making great efforts to improve regional cohesion by planning the opening and improvement of high-speed railways, so as to promote the process of regional urbanization. Guineng Chen and João de Abreu e Silva point out that high-speed railways play an important role in improving regional accessibility, stimulating economic growth, changing employment and investment patterns, and promoting changes in land use patterns [2]. According to Shaobo Wang et al., the layout of the high-speed railway network needs to be improved so that it can be very important to the integration process. They contend that high-speed railways have the capacity to reconfigure space, which can lead to the reconfiguration and redistribution of industry and population [3].

Throughout current literature, Academics investigate the impact of high-speed rail on the urbanization process. According to research by Anthony Perl and colleagues, the building of rapid transit increases city accessibility, has the effect of "spatial and temporal integration," and can alter the city's industrial trajectory by quickening the flow of production factors into the area, which supports the city's and its surrounding neighborhood's industrial agglomeration [4]. Overall, the construction of high-speed rail lines influences cities' industrial structures and geographical arrangements, supporting the method of polycentric urban growth. He Xuan assessed the cities along the Wuhan-Guangzhou High-Speed Railway in terms of accessibility by adopting the Data Envelopment Analysis (DEA) method, and research discovered that the opening and building of high-

speed trains greatly advances interregional economic growth, intercity connection, and the urbanization process in addition to making cities along the route more accessible [5]. However, with the improvement of urban accessibility, some smaller cities along the region have been significantly affected, with increased population selectivity and mobility, and lower production and operation costs for local enterprises, thus generating a certain degree of "siphon effect". Feng Wang and other scholars investigate the impact of the Yangtze River Delta urban agglomeration on urbanization by constructing a double-difference model, and discover that, in terms of population mobility, high-speed railroads have a detrimental effect on long-term population migration, while in terms of industrial structure, high-speed railways increase the proportion of the value-added of the tertiary industry, which encourages modernizing the industrial structure and raising the standard of urbanization [6]. A key factor in achieving the planned growth of cities inside urban agglomerations is the ongoing expansion of the network of high-speed rail, and urban integration will be further strengthened. Scholars such as Sakdirat Kaewunruen analyzed the correlation between high-speed railways and population dynamics in Shanghai and Minhang District by means of analysis of variance (ANOVA), discovered that building and enhancing high-speed rail may boost employment in cities and tangentially drive-up home values [7]. High-speed rail's beneficial effects on urbanization does not occur directly and automatically, but essentially through collaboration with urban development and inter-regional accessibility.

The connection between urbanization and high-speed rail has been analyzed in depth, but few academics have concentrated on how high-speed rail affects an area's or a premium urban agglomeration's urbanization process, such as the Chengdu-Chongqing region and its cities along the route in China. Jiao Li et al. discovered that building high-speed rail can improve spatial aggregation within the Chengdu-Chongqing urban agglomeration through the use of fractal theory, and the network of high-speed trains should be continuously improved to promote the development of the western urban agglomeration [8]. Qi Wang et al. found that the coupling coordination between high-speed railway accessibility and urbanization in Chengdu-Chongqing region shows obvious spatial variability utilizing the coupling coordination model, and the core cities tend to lead the development of high-quality urbanization [9]. However, few existing studies have used econometric models to empirically analyze the Chengdu-Chongqing region. Which indicators best reflect the impact of the high-speed rail line on urbanization in the neighboring municipalities and the Chengdu-Chongqing area? Is the impact of high-speed railway opening significant? An empirical study of these issues is of contributing significance to improve the research related to urbanization in the Chengdu-Chongqing area.

Based on the DID model, this study selects the information regarding the launch of high-speed rail in the vicinity of Chengdu-Chongqing between 2012 and 2018, and tries to investigate implications of high-speed rail opening on the urbanization of the Chengdu-Chongqing region and the cities along its routes. In this study, the rate at which the resident population is urbanizing is used as the explanatory variable, regression analysis is conducted to reveal the significance of the indicator data, and the reliability of the results is verified by the robustness test.

## **2. Concept Definition**

### **2.1. Urbanization**

Urbanization, as defined by scholars at home and abroad from different perspectives, is different but common. Combining dynamic and static perspectives to understand urbanization, it describes the process of a country or region's rural-to-urban population shift, which raises the proportion of the population of the region's cities to its total population [10].

### **2.2. Urbanization Rate of Resident Population**

The urbanization rate of the resident population refers to the ratio of the total number of urban residents to the total resident population of an area. In this case, urbanization is the movement of

people from the countryside to the towns and cities, which leads to the concentration of people in the towns and cities, thus causing the total number of people in the towns and cities to rise, and thus increasing the region's degree of urbanization [11].

### 3. Research Design

#### 3.1. Model Construction

According to the Chengdu-Chongqing Urban Agglomeration Development Plan, the principal prefecture-level cities in Sichuan Province along the Chengdu-Chongqing route include: Chengdu, Zigong, Luzhou, Deyang, Mianyang (except for Beichuan County and Pingwu County), Dazhou (except for Wanyuan City), Suining, Neijiang, Leshan, Nanchong, Meishan, Yibin, Guang'an, Ya'an, Ziyang, and other 15 cities.

The primary focus of this study is the high-speed railway opening time between Chengdu and Chongqing, as well as the expansion of high-speed commuter trains in the route's cities that were chosen to be included in the experimental sample. The city sample selected in this paper consists of nine prefecture-level cities and one county-level city, namely: Chengdu, Chongqing, Longchang, Neijiang, Suining, Deyang, Mianyang, Dazhou, Ziyang, Meishan and Guang'an.

##### 3.1.1 Experimental group

This paper's experimental group was chosen based on the cities that inaugurated high-speed rail between 2012 and 2015. Besides, cities should have high-speed railway stations along the Chengdu-Chongqing high-speed railway after its completion at the end of 2015. Cities that satisfy the above two conditions at the same time are Chengdu, Chongqing, Neijiang, Longchang and Suining.

##### 3.1.2 Comparison group

The control group selection criteria include cities that have opened high-speed rail between 2012 and 2015. Besides, cities should have not set up their high-speed railway stations and have not opened high-speed railways again in the cities along the Chengdu-Chongqing high-speed railway during 2015-2018. Cities that meet the above two conditions at the same time are Deyang, Mianyang, Dazhou, Meishan and Guangan.

##### 3.1.3 Specific modelling and interpretation

The sample cities were divided into experimental and control groups,  $Treatment_{i,t}=1$  for the experimental group and  $Treatment_{i,t}=0$  for the control group;  $Post_{i,t}=1$  means that high-speed rail is available in city  $i$  in that year and thereafter, while  $Post_{i,t}=0$  means that city  $i$  does not have access to high-speed rail in year  $t$ ; Focus on the coefficients of  $Treatment_{i,t}*Post_{i,t}$ . The specific models and explanations are given below:

$$Urbanization_{i,t}=\beta_0+\beta_1 Treatment_{i,t}*Post_{i,t}+\beta_2 X_{i,t}+\lambda_i+\lambda_t+\varepsilon_{i,t} \quad (1)$$

$Urbanization_{i,t}$  denotes the rate of urbanization of city  $i$ 's resident population during time  $t$ , as measured by the aforementioned indicator system;  $\beta_0$  is the intercept term;  $Treatment*Post_{i,t}$  is a dummy variable to reflect whether the city where it is located has opened the high-speed rail, which means in the event that the high-speed rail is operational, the value will be 1; otherwise, it will be 0;  $\beta_1$  denotes the coefficient of the impact of whether the high-speed rail is opened on the urbanization rate of the population;  $X_{i,t}$  denotes the control variable;  $\beta_2$  is the coefficient of the control variable;  $\lambda_i$  and  $\lambda_t$  denote the city's and time's fixed effects, respectively;  $\varepsilon_{i,t}$  denotes the phrase for random disruption.

#### 3.2. Variable Selection

##### 3.2.1 Explanatory variable

Since the research of this topic mainly focuses on the effect of building high-speed rail on the process of urbanization, and a common and important indicator reflecting the urbanization rate is the

urbanization rate of the resident population, this paper selects the urbanization rate of the resident population as the explanatory variable.

### 3.2.2 Principal explanatory factor

The influence of high-speed rail openings or closures on the urbanization process of the cities along the Chengdu–Chongqing corridor is the main topic of this article, so the interaction term  $Treatment_i * Post_{i,t}$  of the two dummy variables of high-speed rail opening or not and whether or not it will be opened in 2015 are selected as the primary variables used in this paper's explanation.

### 3.2.3 Control variable

In order to ensure the analytical effect of the regression model, this paper adds other variables that will affect the urbanization process in the model to control the influence of other factors. According to the relevant research, this paper adds four control variables in the model, namely, GDP per capita, education level, the proportion between tertiary and secondary industries, and fixed investment, and the meanings of the variables and their references are explained as follows:

(1) GDP per capita: the ratio of the total GDP of a region to its average annual population. the process of urbanization can be driven by the development of the economy, and urbanization and economic growth are positively correlated, thus, a region's level of urbanization will rise in response to an increase in per capita GDP in the area, so per capita GDP is chosen as one of the control variables in this study [10, 12].

(2) Level of education (LOE): the proportion of a city's overall population to the number of students enrolled in higher education institutions. According to related research, the degree of higher education partly reflects the quality of the population, and, education makes the quality of the population and labour productivity increase, thus positively contributing to the process of urbanization [13].

(3) Ratio of secondary industry's total value to tertiary industry's total value (Ratio): during the industrial structure optimization process, especially the encouragement of secondary and tertiary industry development can make the rural population continuously transform to the urban population, which will increase the number of urban population and thus easy to form the agglomeration economy to promote economic growth, and at the same time, it also helps with optimizing and modifying the structure of consumption, which can make the modernization and restructuring of the economic structure, and then accelerate the process of urbanization [13].

(4) Investment in Fixed Assets (IF): the ratio of the total investment in fixed assets to the total GDP of a city. Investment in fixed assets is the main factor affecting economic growth, and is also one of the "troika" driving China's economic development, which contributes significantly to economic expansion, and economic growth is conducive to industrial agglomeration and the accumulation of human capital, which makes the city scale continue to expand, the number of cities continue to increase, and thus accelerate the development of urbanization [13]. The development of urbanization [13, 14].

## 3.3. Data Source

In this paper, the research data comes from nine prefecture-level cities and one county-level city (2012-2018). The data of urbanization rate used are from the annual yearbook of each city. The urbanization rate of population, GDP per capita, education level and the ratio of secondary to tertiary industries and the ratio of investment in fixed assets to GDP were obtained from the statistical bureau of each city and the China Urban Yearbook. Data on railway opening times and stations are from the China High Speed Rail Network and the five literatures listed at the end. And some of the missing data were obtained using calculations. The sample size is 430 in total.

## 4. Empirical Analysis

### 4.1. Parallel Trend Test

The premise of using DID model for empirical analysis is that the selected variables should pass the parallel trend test. Before this paper adopts the classical DID model to analyze the impact of the opening of high-speed railway on the urbanization process of Chengdu-Chongqing and its cities along the route, the experimental group and the control group undergo a parallel trend test to make sure that, prior to the high-speed railway's inauguration, the two sets of cities' urbanization processes are following the same development trend.

This study examines the development trajectory of the urbanization rate using 2015—the year the Chengdu-Chongqing high-speed train opened—as the base period (i.e.: the local population's rate of urbanization) of the sample cities in the three years prior to 2015 to make comparisons and judge whether it is consistent; as well as, whether there is a significant contrast between the urbanization rates of the experimental group and the control group in the three years following the opening of the high-speed railway as a means of highlighting the effect of the high-speed rail line's opening on the sample cities' urbanization process.

On the whole, the economic development level of the experimental group is higher than that of the control group in this parallel trend test. Due to the small number of sample cities in this experiment and the opening of Chengdu-Chongqing high-speed railway has a slightly different impact on the sample cities along the line, and there are other factors in addition to the start of high-speed train lines, which possess a particular effect on the parallel trend test, but the development trend is basically the same.

### 4.2. Empirical Result

#### 4.2.1 Descriptive statistics

Table 1 shows the results of the descriptive statistics of this experiment. In terms of the explanatory variables, the urbanization rate of the main population of the city (Urbanization) its minimum value is 31.60 and the maximum value is 76.60, which shows that there is a large gap between its extremes, which indicates that there are large differences in the urbanization rate of the resident population between the sample cities.

**Table 1.** Descriptive statistics

| Variable     | (1)<br>N | (2)<br>mean | (3)<br>sd | (4)<br>min | (5)<br>max |
|--------------|----------|-------------|-----------|------------|------------|
| id           | 70       | 5.500       | 2.893     | 1          | 10         |
| year         | 70       | 2,015       | 2.014     | 2,012      | 2,018      |
| Urbanization | 70       | 48.92       | 10.72     | 31.60      | 76.60      |
| TP           | 70       | 0.714       | 0.455     | 0          | 1          |
| GDP          | 70       | 38,686      | 14,000    | 19,281     | 80,503     |
| LOE          | 70       | 0.0128      | 0.0134    | 0.000285   | 0.0454     |
| Ratio        | 70       | 1.286       | 0.548     | 0.470      | 2.624      |
| IF           | 70       | 1.093       | 0.857     | 0.413      | 4.232      |

In terms of the main explanatory variables, the mean value of the interaction term  $Treatment_i * Post_{i,t}$  (TP) for the two dummy variables of whether the high-speed railway opens or not and whether it opens in 2015 is 0.714, and the standard deviation is 0.455, whose standard deviation is smaller, indicating that its degree of discretization is lower and has a higher degree of representativeness.

In terms of the control variables, the degree of level of education (LOE), the proportion of the secondary industry's total value to the tertiary industry's total value (Ratio), and the investment in fixed assets (IF) have smaller standard deviations, indicating that the degree of dispersion of these three variables is low and highly representative; the minimum value of GDP per capita is 19,281, and

the maximum is 80,503, which shows that there is a large gap between its extremes, indicating that the GDP per capita varies greatly between sample cities, and it is clear that the GDP per capita of the sample cities is impacted by the installation of high-speed rail.

#### 4.2.2 Relevance analysis

The findings of variables' correlation are displayed in Table 2. The correlation coefficients between GDP per capita, level of education (LOE) and the urbanization rate of resident population (Urbanization) are 0.885 and 0.782 respectively, which indicates that both of them show a significant positive correlation with the explanatory variables, that is to say, the growth of GDP per capita and the level of education will result in the growth of the population's rate of urbanization and vice versa. That is to say, an increase in GDP per capita and education level leads to an increase in the urbanization rate of the resident population and vice versa. The correlation coefficients between the ratio of the total value of the secondary industry to the total value of the tertiary industry (Ratio), The resident population's rate of urbanization and the investment in fixed assets (IF) are -0.195 and -0.347, respectively, which indicate that both of them have negative correlations with the explanatory variables, and it also implies that changes in fixed asset investments and the ratio of the secondary industry's total value to the tertiary industry's total value do not always result in a rise in the pace of urbanization of the local populace. urbanization rate to increase and could perhaps have the opposite impact on it.

**Table 2.** Pairwise correlation

| Variable         | (1)                | (2)                | (3)                | (4)                | (5)   |
|------------------|--------------------|--------------------|--------------------|--------------------|-------|
| (1) Urbanization | 1.000              |                    |                    |                    |       |
| (2) GDP          | 0.885*<br>(0.000)  | 1.000              |                    |                    |       |
| (3) LOE          | 0.782*<br>(0.000)  | 0.738*<br>(0.000)  | 1.000              |                    |       |
| (4) Ratio        | -0.347*<br>(0.003) | -0.276*<br>(0.021) | -0.359*<br>(0.002) | 1.000              |       |
| (5) IF           | -0.195<br>(0.106)  | -0.272*<br>(0.023) | -0.340*<br>(0.004) | -0.237*<br>(0.048) | 1.000 |

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

#### 4.2.3 Regression analysis

Table 3 displays the regression analysis findings for this study. The F-statistic of this experiment whose coefficients for all variables are 0 passes the F-test; the value of  $R^2$  is 0.8784, which is between 0-1 and all close to 1, which indicates that all control variables GDP, LOE, Ratio, IF are able to explain the reason for 87.84% of the variation in the explanatory variable TP. The p-value of GDP per capita is  $0.000 < 0.01$ , indicating that it is significant at the 1% level; the p-value of LOE is  $0.012 < 5\%$ , indicating that it is significant at the 5% level; the p-values of the proportion between the total value of the secondary and tertiary industries (Ratio) and the p-value of the investment in fixed assets (IF) are greater than 0.1 for both of them, indicating that they are not significant at the 10% level. 10% level are not significant.

To sum up, the degree of education and GDP per capita have the most effects on the rate of urbanization of the resident population, while all the variables chosen for this article can have some effect on it, that is to say, the changes of both of them can have a direct impact on the rate at which the resident population is urbanizing. The ratio of the total value of the secondary industry to the total value of the tertiary industry and investment in fixed assets do not have a significant impact, i.e., they do not have much effect.

**Table 3.** Benchmark regression

| U     | Coefficient | Std. err. | t     | P> t  | [95% conf. interval] |          |
|-------|-------------|-----------|-------|-------|----------------------|----------|
| TP    | 5.5537      | 1.0911    | 5.09  | 0.000 | 3.3741               | 7.7334   |
| GDP   | 0.0006      | 0.0001    | 11.18 | 0.000 | 0.0005               | 0.0007   |
| LOE   | 151.2134    | 58.6292   | 2.58  | 0.012 | 34.0881              | 268.3388 |
| Ratio | -1.3843     | 1.0124    | -1.37 | 0.176 | -3.4069              | 0.6382   |
| IF    | 0.14473     | 0.6597    | 0.22  | 0.827 | -1.1732              | 1.4627   |
| _cons | 22.9398     | 2.6366    | 8.70  | 0.000 | 17.6725              | 28.2070  |

## 5. Conclusion

The economic growth of Chengdu-Chongqing and the cities along its path is positively impacted by the opening of the high-speed train, thus promoting its urbanization process. Using panel data from nine prefecture-level cities, one county-level city, and 430 sample sizes between 2012 and 2018, this study develops a DID framework to examine how Chengdu-Chongqing's urbanization process has been impacted by the launch of the high-speed train and the cities along its path and the conclusions obtained are as follows: Firstly, the construction of a high-speed rail line facilitates the economic growth of Chengdu-Chongqing and the surrounding districts, which can accelerate the rate of urbanization of the cities; Secondly, higher education in Chengdu, Chongqing, and its surrounding cities will benefit from the opening of the high-speed railway, which can raise the level of labor force participation and the urban population's quality of education, thus accelerating the process of urbanization.

The following countermeasures are suggested in this research based on the aforementioned conclusions. First, the construction of high-speed railway should be increased so that it can cover a wider area. Due to the special geographic conditions of Chengdu-Chongqing region, which is dominated by hills and basins, it is not only necessary to build high-speed railways with other regions and strengthen external links, thus broadening the links between Chengdu-Chongqing region and other regions to promote the development of Chengdu-Chongqing region's economy and other aspects, but it is also necessary to set up high-speed railways between prefectural-level cities and county-level cities and even townships within the Chengdu-Chongqing region, which is beneficial for the traffic in the inner city, and thus can promote This will facilitate intra-urban traffic, which will increase the mobility of labor between populated regions and outlying ones within the Chongqing-Chongqing region, raise the level of labor, reduce the distance between rural and urban locations, and raise the economic level of townships, thus accelerating the process of urbanization. Second, it attracts more highly educated talents and improves the quality of education, thus promoting the level of education. Based on the paper's study, it is clear that building high-speed rail may improve educational attainment and that there is a strong positive relationship between the pace of urbanization in the area and the level of education. Therefore, attracting more highly educated talents in Chengdu-Chongqing area and improving their education level can help to improve the education level, which in turn has a significant promotion effect on the urbanization rate.

## Authors Contribution

Each author made an equal contribution and their names were listed alphabetically.

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