Study on the interaction between Port Freight Transport and Railway in the Upper reaches of the Yangtze River

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Abstract. In recent years, the Yangtze River Economic Belt has gradually built an integrated transportation system. Under this context, the dynamic cooperative development of waterway and railway is measured by the natural experiment of newly built freight railway in port cities along the upper reaches of the Yangtze River. A difference-in-difference model is adopted to estimate the impact of this railway on water transport in the surrounding area. It is found that instead of substitute the water transport, the railway actually promotes the growth of waterway freight volume, therefore, the complementation effect is more obvious. The results expand the empirical understanding of the interactive relationship between waterway and railway transportation in the upper reaches of the Yangtze River and provide important policy implications.

1. Introduction

The Yangtze River, as the 3rd largest water system in the world, also constitutes the largest inland river network freight channel in China (Jiang et al., 2018). The economic belt in the upper reaches of the Yangtze River established in the sense of modern transportation includes urban agglomerations and industrial belts along the river (Cheng et al.2016). Specifically, the upper reaches of the Yangtze River and the Chongqing Shipping Center radiate the surrounding Chengdu-Chongqing urban agglomeration, which has greatly promoted the development of the surrounding areas (Notteboom, 2012; Han & Wang, 2001). In this paper, the exogenous event of newly built freight railway in recent years is used to study the dynamic relationship between the waterway and the railway in the upper reaches of the Yangtze River, potential results are of great significance to coordinate the regional development in the upper reaches of the Yangtze River and speed up the economic development of Sichuan and Chongqing.

Existing literatures points out that inland waterway transport is better than railway transport in terms of freight volume and capacity, but the transport speed is slower. The advantage of water transport is that it is usually suitable for larger goods and long-distance transportation, such as coal, ore and other goods, which is environmentally friendly and cost-effective (Diziain et al., 2014; Sihn et al., 2015). Railway freight transport also has unique comparative advantages in land occupation, transport safety and transport capacity, but the construction cost and operation cost are higher (Wang et al.,2019). The coordination degree of China's railway and waterway transport is fluctuating, yet indicating that the development between these two modes has become dynamic and more coordinated in recent years (Zou et al.,2007). As far as we know, most studies focus on the competition and substitution effects between waterway and railway transport from a qualitative point of view, but there
are few quantitative studies on them (Yang et al., 2018; Li et al., 2018; Hooi Lean et al., 2014; Zhao et al., 2019).

This manuscript attempts to explore the interactive relationship between waterway freight volume and railway construction in the upper reaches of the Yangtze River from the perspective of qualitative and quantitative analysis. Therefore, the key questions of this paper are: what is the impact of the new freight railway in the upper reaches of the Yangtze River on the waterway freight volume of the related port cities? Is the impact more substitutive or complementary? Solving these problems is conducive to the establishment of a coordinated and complementary freight system along the Yangtze River. Promoting the joint development of railways and waterways as well. From the perspectives of ports, railway construction and long-term regional development, this paper estimates the impact of railway construction on waterway transportation in the upper reaches of the Yangtze River. The application of difference-in-difference model (DID model) (Dehejia & Wahba, 2002) in this context, also provides a new perspective for the study of the interaction between railway and waterway system. The empirical results provide practical guidance for water transport and railway departments to effectively promote the construction of integrated transport system along the Yangtze River and promote the coordinated development of railways and waterways in the upper reaches of the Yangtze River.

The structure of the remaining text is as follows: The second part introduces the research background and literature review, the third part introduces the methodology and design, the fourth part analyzes the empirical results, and the fifth part is the conclusion and enlightenment.

2. Research background and literature review

The Yangtze River integrates golden waterways and land coastlines, and has many advantages in the comprehensive utilization of waterway resources, shoreline resources and land resources. The cargo throughput of the above ports has shown a steady upward trend in the past decade. Meanwhile, the freight railway network in the upper reaches of the Yangtze River is growing year by year. With the high-speed operation of economy and society, the requirements of the integrated transportation system are also increasing.

The topography of the upper reaches of the Yangtze River is very different, so inland waterway transport will not be completely replaced by railways. The results show that the railway built along the upper reaches of the Yangtze River expands the economic hinterland of water transportation (Zhang et al., 2020), promotes the construction of water transport infrastructure, and increases the port freight throughput.

The provision of transport services is an economic activity that flows from supply to the acceptance for the purpose of meeting the needs of the society. Inland river transport is a mode of transportation of people and goods in the region, and the relationship between inland river transport and other transport modes and regional economic growth has always been a hot topic for scholars (Chen & Jiang, 2013).

Diana study found that before the popularity of railways in Japan in the 19th century, inland river shipping dominated freight transport in urban areas, but with the development of railways and roads, inland river shipping declined (Diziain et al., 2014). In the United States, with the great development of railways and highways, inland waterway transportation also experienced a period of decline and stagnation. In the 1930s, the freight turnover of inland waterway transport dropped to only 1.4% of the domestic freight turnover. However, after the Second World War, due to the gradual channelization of waterways and the improvement of infrastructure conditions, the proportion of inland waterway freight transport increased and remained at about 12% (Banerjee et al., 2012).

Scholars have pointed out that in the face of increased business competition and rising fuel prices, the energy efficiency provided by transport services is very important (Zhoua et al., 2017) The EU White Paper on Transport Policy sets out ten main requirements for the establishment of competitive and resource-efficient transport systems, (Tzannatos et al., 2016). Given the importance of social, environmental and economic sustainability goals in the development of newly industrialized countries
it was noted that land use of road infrastructure could be reduced by increasing waterway use, while achieving environmentally friendly inland water transport systems by reducing the use of road transport that produces higher greenhouse gas emissions.

From the perspective of research methods, the difference-in-difference model (DID model) is a research tool to scientifically evaluate the policy effect. (Shao et al., 2017) use DID model to investigate the impact of high-speed rail on urban service industry agglomeration. The study found that high-speed rail plays a positive role in promoting the agglomeration of urban service industry along the route.

3. Methodology design

3.1. Data Source
To apply the difference-in-difference mode, the treatment group and control group has been identified according to whether the railway has been built and pass through the objective city within the research range from 2010 to 2017. Data sources include the National Bureau of Statistics, China Transportation Statistical Yearbook, China Urban Statistical Yearbook and etc. Stata14.0 is used for statistical analysis. As most of the macroeconomic data are unstable in reality, direct regression may lead to pseudo-regression problems. Therefore, this paper uses LLC panel unit root test to examine the stationarity of panel data (Cao& Guo, 2019). The results reject the original hypothesis of the existence of unit root under the LLC test (table 1), which proves the stability of the data and ensures the feasibility of the model.

Table 1 Unit root test results

| Variable                              | Test method | Test value | P value |
|---------------------------------------|-------------|------------|---------|
| Port cargo throughput                 | LLC         | -2.0946    | 0.0181**|
| Port Mining construction materials    | LLC         | -4.2426    | 0.0000***|
| Port Chemical fertilizers and pesticides | LLC       | -380.4     | 0.0000***|
| Port Grain                            | LLC         | -53.972    | 0.0000***|
| Railway freight volume                | LLC         | -2.3638    | 0.0090***|

Note: *, **, *** indicate that the regression coefficient is significant at the level of 10%, 5%, 1%, respectively.

3.2. Variable definition

3.2.1. Dependent variable.
In this paper, the port cargo throughput is used to measure the waterway freight volume of port cities along the upper reach of Yangtze river, specifically according to the different types of goods sent by the port, it is divided into port coal and products, crude oil, metal ores, iron and steel, mineral construction materials, cement, wood, chemical fertilizers and pesticides and port grain throughput, etc., according to the availability of data during the sample period. Finally, the port mineral construction material throughput, port chemical fertilizer and pesticide throughput and port grain throughput are selected as the refinement index of waterway freight volume in port cities.

3.2.2. Control variable.
This paper also selects the urbanization rate (UR), employment situation (Employed), energy consumption per unit industrial value added (ECRGDP), road freight volume (ROAD), railway freight volume (RAIL) and so on, please see Table 2 for literature details.

Table 2 Variable definition

| Variable symbol | Variable name and measurement | Literature source |
|-----------------|-------------------------------|------------------|
GDP
The gross domestic product of the region, the final result of the production activities of all resident units in the region within a certain period of time, is equal to the sum of the added value of all industries. (Shao et al., 2017)

PGDP
The per capita GDP, the GDP is calculated compared with the resident population (or registered population) in this area. (Cao, 2010)

IGDP
The regional gross domestic product index (last year = 100), the current price GDP is converted into the value calculated at the previous year = 100 price, so that the value of the two different periods is comparable and truly reflects the change of material volume (the growth rate of GDP). (Yun Xiang et al., 2016; Zhang, 2017)

UR
Urbanization rate, the proportion of urban population in the total population (including agriculture and non-agriculture), and the measurement index of urbanization. (Shao et al., 2017)

Employed
Employment, reflecting the employment situation in the region from a macro point of view (Shao et al., 2017)

ECGDP
Energy consumption per unit of gross domestic product, a comprehensive index to measure the energy consumption level of a region, usually calculated on the basis of energy consumed by 10,000 yuan of GDP (Zhou et al., 2017)

ECRGDP
Energy consumption per unit of industrial value added refers to the energy consumed for each unit of industrial value added produced in this area within a certain period of time. The ratio of industrial energy consumption to industrial value added (Zhou et al., 2017)

ROAD
The product of the tonnage of goods (Dai et al, 2014)

PORT
Port cargo throughput (Cao, 2010; Zou et al., 2007)

RAIL
Railway freight volume (Dai et al, 2014)

MINE
Port Mining construction materials (Wei, 2003)

CHEMICAL
Port Chemical fertilizers and pesticides (Wei, 2003)

GRAIN
Port Grain (Wei, 2003)

t
Time virtual variable, the year of the port city along the river after the completion of the freight railway is 1, otherwise it is 0 (Dehejia & Wahba, 2002)

treated
City virtual variable, when there is a newly built freight railway in the port city along the river, the value of the city is 1 for the experimental group; otherwise it is 0 for the control group. (Dehejia & Wahba, 2002)

t×treated
The interactive item of railway factor, time factor and urban factor indicates whether the freight railway is newly opened in the city during the sample period, and when there is a new freight railway operation in the port city along the river during the sample period, the city takes the value of 1 as the experimental group, otherwise the value of the control group is 0. (Dehejia & Wahba, 2002)

3.3. Model design
In this paper, the difference-in-difference model is used to evaluate the influence of the newly built freight railway in the upper reaches of the Yangtze River on the waterway freight volume of port cities. In the process of empirical analysis, in order to control the influence of other factors, the fixed effect model is adopted.

$$\text{water}_{it} = \alpha + \beta_1 \text{treated}_{it} + \beta_2 t_{it} + \beta_3 t_{it} \times \text{treated}_{it} + \alpha_4 \text{Control}_{it} + \epsilon_{it}$$ (1)

Among them, the explained variable water_{it} is the waterway freight volume of port cities along the cities, which is measured by port freight throughput (port_{it}), port mineral construction materials throughput (mine_{it}), port chemical fertilizer and pesticide throughput (chemical_{it}) and port grain throughput (grain_{it}). The model is shown in (2)-(5):
\[ \text{port}_{it} = \alpha + \beta_1 \text{treated}_{it} + \beta_2 t_{it} + \beta_3 t_{it} \times \text{treated}_{it} + a_4 \text{Control}_{it} + \epsilon_{it} \]  
(2)

\[ \text{mine}_{it} = \alpha + \beta_1 \text{treated}_{it} + \beta_2 t_{it} + \beta_3 t_{it} \times \text{treated}_{it} + a_4 \text{Control}_{it} + \epsilon_{it} \]  
(3)

\[ \text{chemical}_{it} = \alpha + \beta_1 \text{treated}_{it} + \beta_2 t_{it} + \beta_3 t_{it} \times \text{treated}_{it} + a_4 \text{Control}_{it} + \epsilon_{it} \]  
(4)

\[ \text{grain}_{it} = \alpha + \beta_1 \text{treated}_{it} + \beta_2 t_{it} + \beta_3 t_{it} \times \text{treated}_{it} + a_4 \text{Control}_{it} + \epsilon_{it} \]  
(5)

The explanatory variable treated, equals 1 represents the experimental group, and 0 equals to the control group. When the port cities along the river have newly built freight railways during the sample period, the cities take the value of 1 as the experimental group, otherwise the value of the control group is 0, and the year of the port cities along the river after the completion of the railway is 1, otherwise it is 0. Subscript i and t refer to i region and t year, respectively. \( \epsilon_{it} \) is a random interference term, \( t_{it} \times \text{treated}_{it} \) is interactive item, which is a comprehensive influence variable of the new railway and time in the port cities along the Yangtze River. The coefficient we are interested in \( \beta_3 \), measured is the difference of port throughput between the experimental group and the control group before and after the new constructing of the freight railway along the Yangtze River. We expect \( \beta_3 \) to be positive in model (2), which means that the new constructing of the freight railway along the Yangtze River in the upper reaches of the Yangtze River will promote the port freight transport; on the contrary, it means that the new railway will restrain the freight throughput of the local port. \( \text{Control}_{it} \) is a group of observable control variables that affect waterway transportation, including regional GDP index, urbanization rate, employment situation, energy consumption per unit of industrial value added, road freight volume, and railway freight volume. In the model (3)-(5), other control variables refer to the definition in Table 4-1. We expect \( \beta_3 \) to be positive in model (3)-(5) as well.

4. Empirical results and analysis

4.1. Statistical results

Table 3 shows the statistical results of the main variables. As can be seen from Table 5-1, the average values of t and treated are 0.411 and 0.714 respectively, indicating that about 70 percent of port cities have newly built freight railway between 2010 and 2017, and 41.1 percent of the samples are the year after the completion of the railway.

Table 3. Descriptive statistical analysis

| Variable | Average | Max | Min | Median | Standard deviation | p25 | p75 |
|----------|---------|-----|-----|--------|-------------------|-----|-----|
| lnGDP    | 7.3986  | 9.8782 | 6.2864 | 7.1549 | 0.9033 | 6.9282 | 7.3490 |
| lnPGDP   | 10.2534 | 11.0618 | 9.4889 | 10.2472 | 0.3432 | 10.0273 | 10.4757 |
| lnIGDP   | 4.7126  | 4.7630 | 4.6357 | 4.7082 | 0.0302 | 4.6854 | 4.7443 |
| lnUR     | 3.7612  | 4.1604 | 3.3697 | 3.7481 | 0.1745 | 3.6585 | 3.8495 |
| lnEmpl~d | 5.8164  | 7.4486 | 5.2118 | 5.6823 | 0.6846 | 5.3876 | 5.7862 |
| lnECRGDP | 0.5735  | 1.4586 | -0.8370 | 0.6651 | 0.5145 | 0.3256 | 0.9279 |
| lnROAD   | 12.4224 | 14.1421 | 6.4140 | 13.2685 | 2.4203 | 12.5502 | 13.8451 |
| lnPORT   | 6.9367  | 9.8895 | 5.4596 | 6.3081 | 1.3219 | 5.9583 | 7.7166 |
| lnRAIL   | 6.2093  | 7.7565 | 4.2627 | 6.1758 | 1.0263 | 5.5121 | 7.2871 |
| lnMINE   | 8.5399  | 10.2455 | 7.2759 | 8.3923 | 0.8943 | 7.6971 | 9.1578 |
| lnCHEM~L | 3.8054  | 8.0298 | 0.0000 | 3.2581 | 2.6361 | 1.0986 | 6.1494 |
| lnGRAIN  | 3.8442  | 7.6962 | 0.0000 | 4.4773 | 2.0647 | 2.5649 | 4.8978 |
| t        | 0.4107  | 1.0000 | 0.0000 | 0.0000 | 0.4964 | 0.0000 | 1.0000 |
| treated  | 0.7143  | 1.0000 | 0.0000 | 1.0000 | 0.4558 | 0.0000 | 1.0000 |

Table 4 shows the Pearson and Spearman correlation coefficients of all variables. Through the analysis of Table 4, it is found that after the new built freight railway, the port cargo throughput, port mineral construction material throughput, port chemical fertilizer and pesticide throughput and port grain throughput all showed positive growth. After a comprehensive comparison of the four indicators, the waterway freight volume showed a positive growth.
The Pearson correlation coefficients among the four freight volume indicators which indirectly reflect the waterway demand are all significantly positive correlation at the level of 1%, indicating that the port cargo throughput is consistent with mineral construction material throughput, chemical fertilizer and pesticide throughput and grain throughput. At the same time, the growth rate of GDP has a significant positive effect on waterway freight volume. The control variables have a significant effect on the urbanization rate, employment situation, unit industrial value added and water freight volume.

Table 4 Variable correlation coefficient table

|          | lnPORT | lnMINE | lnCHEM | lnGRAIN | i | transal | lnGDP | lnGDP^2 | lnUR | lnemp-d | lnECR-P | lnROAD | lnRAIL |
|----------|--------|--------|--------|---------|---|---------|-------|---------|------|---------|---------|--------|--------|
| 1        | 0.8794*** | 0.8799 *** | 0.5628*** | 0.2573 | 0.2844 | 0.4762*** | 0.3033*** | 0.2044 | 0.4715*** | 0.5114*** | -0.5744*** | -0.4735*** | 0.1182 |
| 0.8794*** | 1      | 0.6719*** | 0.5924*** | 0.4552*** | 0.4722*** | 0.3619*** | 0.2593*** | 0.1776 | 0.4085*** | 0.2805*** | -0.5514*** | -0.4256*** | -0.0627 |
| 0.7115*** | 0.6719*** | 1      | 0.5024*** | 0.3485 | 0.1837 | 0.5217*** | 0.2281 | 0.2588 | 0.4976*** | 0.6835*** | -0.5095*** | -0.3151*** | 0.5567*** |
| 0.6561*** | 0.5262*** | 0.8768*** | 1      | 0.2755*** | 0.6118*** | 0.2385 | 0.0929 | 0.1939 | 0.08 | 0.435*** | -0.4659*** | -0.6076*** | -0.1099 |
| 0.2585*** | 0.4754*** | 0.1914 | 0.2226 | 1      | 0.5627 *** | 0.4233*** | 0.4301*** | -0.4317*** | 0.4145*** | 0.0618 | -0.457*** | 0.1201 | -0.1123 |
| 0.2446   | 0.4004  | 0.1145  | 0.6172*** | 0.1673*** | 1   | 0.0416 | -0.2886*** | 0.0869 | -0.1712 | 0.2739*** | -0.1107 | -0.1149 | -0.4117*** |
| 0.8111*** | 0.6075*** | 0.0691 | 0.5483*** | 0.3115** | 0.1987 | 1      | 0.0697*** | 0.4015*** | 0.8856*** | 0.6577*** | -0.82*** | 0.0961 | 0.4941*** |
| 0.5902*** | 0.3828*** | 0.2682*** | 0.0573 | 0.4615*** | -0.2397 | 0.999*** | 1      | -0.4308*** | 0.8268*** | 0.1492 | -0.6055*** | -0.1048 | 0.5582*** |
| 0.1512   | 0.129   | 0.2021 | 0.2397 | 0.0653 | -0.0948 | 0.4044*** | 1      | -0.1039*** | -0.0543 | 0.3157*** | -0.4174*** | 0.1152 |
| 0.7148*** | 0.5446*** | 0.5575*** | 0.2094 | 0.4185*** | -0.0771 | 0.8312*** | 0.8536*** | -0.2813*** | 1 | 0.3675*** | -0.7555*** | 0.0083 | 0.6018*** |
| 0.8272*** | 0.5924*** | 0.6658*** | 0.6575*** | 0.1555 | 0.3026*** | 0.9496*** | 0.4467*** | 0.0985 | 0.7086*** | 1      | -0.4581*** | -0.2271 | 0.3791*** |
| -0.7106*** | -0.0232*** | -0.5222*** | -0.3525*** | -0.498*** | -0.1378 | -0.8844*** | -0.6899*** | -0.2036*** | -0.0851 | -0.7585*** | 1      | 0.3316*** | -0.229*** |
| -0.7952*** | -0.0146*** | -0.5197*** | -0.6091*** | -0.1221 | -0.2698*** | -0.9895*** | -0.4798*** | -0.4245*** | -0.6323*** | -0.697*** | 0.7208*** | 1      | -0.1384 |
| 0.2697*** | 0.0359 | 0.1065*** | -0.1108 | -0.0260 | -0.4541*** | 0.5813*** | 0.5425*** | 0.072 | 0.4422*** | 0.5197*** | -0.3126*** | -0.4941*** | 1       |

Note: the upper triangle is the result of Spearman correlation analysis, and the lower triangle is the result of Pearson correlation analysis. *, **, *** indicate that the regression coefficient is significant at the level of 10%, 5%, 1%, respectively.

4.2. Analysis on the factors affecting the Waterway freight volume before and after the completion of Freight Railway in Port cities along the Yangtze River

Table 5 compared the intra-group mean difference and inter-group mean difference of waterway freight volume before and after the completion of the freight railway in port cities along the Yangtze River. The results show that the port cargo throughput of the experimental group is lower than that of the control group before the completion of the freight railway in port cities. After the completion of the freight railway, during the study period, the port throughput of the cities with newly built freight railway is 25.6% higher than those without, and compared with their own performances before the freight railway is completed, the difference is up to 102.6%. This result reveals that the port throughput could be increased if cities exist new opening railways. In the port cities along the river, during the sample period after the completion of the freight railway, the port mineral construction material throughput of the cities with new built railway increased by 90.6% compared with those without, and increased by 98.5% compared with their own performances before the completion of the railway. The port grain throughput increased by 90.1%, and the port chemical fertilizer and pesticide throughput also increased by 266.9%. The above analysis results show that there is a significant difference between the construction of freight railways and the growth of water freight volume in the port cities along the Yangtze River.
Table 5 Intra-group mean difference and inter-group mean difference of waterway freight volume built by freight railways in port cities along the Yangtze River

|                      | Logarithm of port cargo throughput | Logarithm of port chemical fertilizer and pesticide throughput | Logarithmic value of Port Mine Construction material Throughput | Logarithm of port grain throughput |
|----------------------|------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------|-----------------------------------|
|                      | No new freight railway construction in the port cities along the Yangtze River during the sample period | Exist new freight railway construction in the port cities along the Yangtze River during the sample period | Diff (T-C) | No new freight railway construction in the port cities along the Yangtze River during the sample period | Exist new freight railway construction in the port cities along the Yangtze River during the sample period | Diff (T-C) | No new freight railway construction in the port cities along the Yangtze River during the sample period | Exist new freight railway construction in the port cities along the Yangtze River during the sample period | Diff (T-C) |
|                      |                                    |                                                              |                                                               |                                    |                                                              |                                                               |                                    |                                                              |                                                               |
| The year before the completion of the freight railway in the port cities along the river | -77.389 | -78.16 | -0.771*** | The year before the completion of the freight railway in the port cities along the river | -288.040 | -290.806 | -2.766*** | The year before the completion of the freight railway in the port cities along the river | -57.987 | -58.066 | -0.079 |
| The year after the completion of the freight railway in the port cities along the river | -78.103 | -77.847 | 0.256 | The year after the completion of the freight railway in the port cities along the river | -290.004 | -290.102 | -0.097 | The year after the completion of the freight railway in the port cities along the river | -58.463 | -57.557 | 0.906*** |
| Diff (T-C) | -0.714 | 0.313 | 1.026*** | Diff (T-C) | -1.964 | 0.704 | 2.669*** | Diff (T-C) | -0.476 | 0.509 | 0.985*** |

Note: *, **, *** indicate that the regression coefficient is significant at the level of 10%, 5%, 1%, respectively.

4.3. Analysis of the influence of the newly built Railway along the Yangtze River on the Waterway freight volume

Taking seven port cities along the Yangtze River in Sichuan and Chongqing in the upper reaches of the Yangtze River as samples, four indicators reflecting waterway demand are set: Port cargo throughput (InPORT), port mineral construction material throughput (InMINE), port chemical fertilizer and pesticide throughput (InCHEMICAL), port grain throughput (InGRAIN) as dependent variables, and other variables are added to the model to analyze the impact of railway on waterway freight volume. From model 1 to model 8, the DID regression results of port cities along the upper reaches of the Yangtze River are given, in which model 1, model 3, model 5 and model 7 are pure virtual variable regression models without adding any variables. Model 2, model 4, model 6 and model 8 are models with urbanization rate, employment situation, unit industrial added value, GDP growth rate, road freight turnover volume and railway freight volume. On the whole, the fitting effect of the model is good, and the specific results are shown in Table 6.
Table 6 Estimation results of basic models

| Variable | lnPORT | lnMINE | lnCHEMICAL | lnGRAIN |
|----------|--------|--------|------------|---------|
|          | Model1 | Model2 | Model3     | Model4  |
| t×treated| 1.8203*** | 1.0264*** | 0.3564* | 0.9853*** |
|          | (3.68) | (3.3) | (4.69) | (4.98) |
| Railway factor t | -1.0291*** | -0.714* | -0.4807** | -0.4706** |
|          | (-4.62) | (-2.66) | (-4.17) | (-2.59) |
| Time factor treated | 0.1652 | 0.7707*** | 0.3564* | -0.070 |
|          | (0.45) | (-2.85) | (1.72) | (-0.39) |
| City factor lnGDP | 0.1652 | -0.7707*** | 0.3564* | -0.070 |
| Regional GDP index | 10.949*** | 10.5766*** | 4.3923*** | 12.9296*** |
| lnUR | 8.7161*** | 6.1956*** | 13.7172*** | -6.6463*** |
| Urbanization rate | (4.85) | (4.79) | (2.93) | (-2.3) |
| lnEmployed | 1.257*** | -0.095 | 6.1808*** | 1.8681*** |
| lnEmployed | (3.28) | (-0.32) | (5.59) | (2.35) |
| lnECRDGP | 1.8003*** | 0.908*** | 2.3576* | -1.9636*** |
| ln per unit of industrial value added | (3.83) | (2.51) | (1.92) | (-3.15) |
| lnROAD | -0.1672** | -0.2009** | 0.9531*** | -0.1114 |
| highway cargo turnover | (-1.7) | (-2.54) | (3.3) | (-4.62) |
| lnRAIL | -0.9442*** | -0.6776*** | -1.8682*** | -0.5152 |
| lnGRAIN | 6.5586*** | -77.3888*** | 7.9829*** | -5.9787*** |
| _cons | 1.257*** | (4.85) | (69.25) | (2.93) |
| Constant | 30.06 | (-4.3) | (-5.25) | (-5.37) |
| F value | 23.15 | 216.48 | 38.86 | 82.31 |
| Prob>F | 0.00000000 | 0.00000000 | 0.00000000 | 0.00000000 |
| R-squared | 0.1441 | 0.8696 | 0.3678 | 0.8046 |

Note: the t value is in parentheses; *, **, *** indicate that the regression coefficient is significant at the level of 10%, 5%, 1%, respectively.

From the third row of table 6, the influence of railway factors on the growth of water freight volume is observed: the railway factor is the product item of time factor and urban factor. In the pure virtual variable regression model without adding any control variables, in addition to the port mining construction materials, the impact of the new freight railway on the promotion of water freight volume is significantly positive at the level of 1%. By adding other variables to the DID model, the influence coefficient of railway factor t×treated is still significantly positive, the significance level of port grain throughput has a downward trend, and the other three indicators are still significantly positive at 1% level, indicating that the new built railway in ports city has significantly promoted the increase of water freight volume of Sichuan and Chongqing in the upper reaches of the Yangtze River, and the railway has become a very important factor affecting the growth of water freight volume.

From the fourth row of table 6, the influence of time factor on economic growth is estimated: in the pure virtual variable regression model without adding any control variables, it was significantly negative at 1% level. When other variables are added to the DID model, the influence coefficient of time factor is still negative, but its significance level has a downward trend, but it remains significantly negative at 5% level, indicating that the growth rate of water freight volume in Sichuan and Chongqing has a gradual downward trend over time.

From the fifth row of table 6, the influence of urban factors on economic growth is analyzed: in the pure virtual variable regression model without adding any control variables, only the port grain throughput is significantly positive at 1% level and the mining material throughput is positive at 10% level. With the addition of other variables in the DID model, the influence coefficient of urban factors changed, and the original significant port grain throughput and mining material throughput were not significant at this time, but the port cargo throughput and chemical fertilizer and pesticide throughput were significantly negative at 1% level, indicating that the growth rate of water freight volume in the policy implementation group (port cities with new built railways) decreased after excluding railway factors.

From rows 6 to 11 of Table 6, the impacts of other variables on the growth of water freight volume are obtained: the real growth rate of regional GDP has a significant positive impact on port cargo...
throughput, port mineral construction material throughput, port chemical fertilizer and pesticide throughput, and port grain throughput. The results show that the growth rate of GDP is in line with the level of regional economic development. When the regional economic development increases to a certain extent, it will accelerate the exchange of talents and the flow of goods in the region. The urbanization rate has a positive effect on waterway volume. The results show that with the improvement of urbanization rate and employment rate, the region should release the driving force of economic growth by combining the advantages of natural resources and the basis of industrial development. Highway cargo turnover has a negative impact on port cargo throughput and port mineral construction material throughput. Railway freight volume has a significant negative impact on port freight volume, but the impact on port grain throughput is not significant. The results show that inland water transport is not the only mode of freight transport in the upper reaches of the Yangtze River, when the total volume of goods is certain, the more the turnover of road goods and railway goods, the less the volume of waterway freight transportation. These three modes of transport maintain a relative balance in the total amount of goods transported.

5. Conclusions
The construction of the railway along the Yangtze River is of great significance to the development of the western part of the country and the promotion of the inland economy. In this paper, the port cities along the upper reaches of the Yangtze River from 2010 to 2017 are taken as samples, and a DID model is used to study the influence of the new built freight railway in the upper reaches of the Yangtze River on the waterway freight volume. The results show that the new built railways not only play an alternative role but also promote the water freight volume of the port cities, but generally speaking, the promoting and complementing effect is more obvious. Railway and waterway focus on different types freight products, railway is suitable for the goods with strong time sensitive, and waterway is suitable for the bulk commodities, such as coal, mineral building materials, etc., which explains that the net interaction effects of the two modes of transport are more complementary.

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