Proceedings of Business and Economic Studies, 2024, Volume 7, Issue 2
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Study on the Influence of Lanzhou–Urumqi High-Speed Railway on Regional Accessibility and Economic Development

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Abstract: The Lanzhou–Urumqi high-speed railway is an important part of the railway network connecting Gansu, Qinghai, and Xinjiang, and it is of far-reaching significance in facilitating China's western development. An accessibility model and a double difference model were built to analyze the impact of the Lanzhou–Urumqi high-speed railway on regional accessibility and economic development of the areas along the line before (2012–2014) and after (2017–2019) its opening. The results show that the regional accessibility remains unchanged before and after the operation of this railway line. However, there is a spatial difference in improvement, that of central cities being better. The opening of the high-speed railway is conducive to driving the overall economic development of the region and promoting the comprehensive and coordinated development of regional economies.

Keywords: Lanzhou–Urumqi high-speed railway; Regional economy; Double difference model; Accessibility model; Empirical analysis

Online publication: April 29, 2024

1. Foreword

In December 2014, the first national railway Class I double-track electrified fast railway in Northwest China, the Lanzhou–Urumqi high-speed railway was officially put into operation. The Lanzhou–Urumqi high-speed railway has a total length of 1,776 km and a designed maximum speed of 250 km/h. The Lanzhou–Urumqi high-speed railway runs from Lanzhou in Gansu Province in the east to Urumqi in Xinjiang Province in the west, passing through Xining and Hexi Corridor in Qinghai Province. It is 795 km long in Gansu Province, passing through Lanzhou, Zhangye, Jiayuguan, and other cities; It is 268 km long in Qinghai Province, passing through Xining and other cities; It is 713 km long in Xinjiang Province, passing through Urumqi, Hami, Turpan and other cities. The Lanzhou–Urumqi high-speed railway is an important part of the railway network of Gansu, Qinghai, and Xinjiang, which has far-reaching significance in helping the implementation of the development strategy of western China and the sound and rapid economic development of ethnic minority areas [1].

At present, many studies have focused on the impact of the opening of high-speed railways on the change of urban accessibility and regional economic development. In terms of theoretical research, some scholars have concluded that high-speed railway contributes to the enhancement of regional accessibility and regional economic growth, providing theoretical support for the study of how high-speed railway affects regional economic development [2]. In terms of empirical research, the research methods commonly used in accessibility research include the economic potential model, weighted average travel time, network analysis, gravity model, cost-weighted grid method, etc., and the research diversification trend is obvious. When studying the accessibility of the Shiwu high-speed railway, Li *et al*. used two evaluation methods, weighted average travel time and generalized weighted travel time, to build a model, and concluded that the opening of the high-speed railway significantly improved the accessibility level of cities along the line [3]. In the field of studying the impact of high-speed railway operation on regional economic development, some research results verify the impact of high-speed railway on regional economy by using the Difference-in-Differences (DID) model and gray prediction method [4]. In other studies, by analyzing the development status of high-speed railways domestically and internationally and its impact on the regional economy, the regional economic effect of high-speed railways and the impact mechanism of high-speed railways on the economic development of cities along the line are empirically analyzed [5].

The opening of a high-speed railway will directly affect the regional accessibility and regional economic development level along the line. If the impact of high-speed railways on both is positively correlated, it indirectly proves that the degree of accessibility has an indirect impact on the level of economic development. If the degree of accessibility is high, it will compress the spatiotemporal distance between the city and the region, and optimize the spatial structure of the city and the region, which is of great significance to strengthening the regional economic connection. Therefore, to analyze the impact of the Lanzhou–Urumqi high-speed Railway on regional accessibility and regional economic development, the accessibility model and DID model are constructed respectively.

2. Accessibility model and differential model of Lanzhou–Urumqi high-speed railway construct

Using economic modeling and econometric methods, this paper studies the influence of the Lanzhou–Urumqi high-speed railway on regional economic development and accessibility. Firstly, an accessibility model is constructed to calculate accessibility indexes and accessibility differences among cities. Secondly, a difference-difference model is constructed to study the relationship between variables. Finally, the paper makes an empirical analysis of the accessibility and economic development of the Lanzhou–Urumqi high-speed railway and draws a conclusion based on the calculation results.

2.1. Accessibility model

2.1.1. Weighted average travel time

The weighted average travel time is a feasibility index for evaluating accessibility. This method measures intra-regional and inter-regional urban accessibility from the perspective of time cost, which is related to urban scale and quality of transportation facilities.

The specific formula is as follows [6].

$$A_i = \sum_{j=1}^{n} T_{ij} M_j / \sum_{j=1}^{n} M_j \quad (1)$$

$$M_j = \sqrt{GDP_j \times P_j} \quad (2)$$

where A_i is the traffic accessibility of the city, the smaller the A_i value, the higher the accessibility, and vice versa; T_{ij} is the shortest travel distance from City i to City j; M_j is the economic strength of the destination city j, that is, its comprehensive economic attraction and the radiation force affecting the surrounding area; GDP_j is the GDP of city j; P_j is the population of j city; i and j are the first cities and destinations; n is the number of cities passed through.

2.1.2. Accessibility coefficient

The accessibility coefficient is more intuitive to the analysis evolution of the accessibility of each city, making the comparison of the results obvious. When the accessibility coefficient is greater than 1, it indicates that the accessibility of the city is higher than the regional average level; otherwise, it is lower than the average level.

$$A'_i = A_i / \sum_{i=1}^{n} A_i / n \tag{3}$$

In the formula: A'_i is the urban accessibility coefficient; n is the number of cities.

2.2. DID Model

2.2.1. Principle of difference-in-differences method

The basic principle of using the DID method to study high-speed railways is as follows: Taking the year of the opening of the high-speed railway as the limit, the research sample is divided into two periods before and after the opening. The first part is the "control group" before the opening. The objects in this group are the neighboring cities close to the cities along the opening of the high-speed railway, and the influence of the opening of the high-speed railway is little or almost no. The other group is the "experimental group," the object of this group is the city along the high-speed railway opening, which is greatly affected by the opening of the high-speed railway. The DID model is based on the comparative analysis of the two groups of objects to find out the impact of the high-speed railway before and after its opening [7].

2.2.2. DID model construction

DID model was used to select the Lanzhou, Xining, Zhangye, Jiayuguan, and Urumqi passed by the Lanzhou–Urumqi high-speed railway as the experimental group, and Baiyin, Jinchang, Wuwei, Changji, and Haidong as the control group. This paper analyzes the impact of high-speed railway opening on regional economic development from two aspects of GDP and GDP growth rate and finally puts forward corresponding policy suggestions to promote the coordinated development of the regional economy. The premise of the DID model establishment is that the experimental group and the control group had a high degree of similarity in economic level and geographical orientation before the opening of the high-speed railway. To this end, the experimental group and the control group were tested, and the parallel trend of GDP growth rate and total value was obtained. The parallel trend test of the GDP growth rate is shown in **Figure 1**. The parallel trend test of GDP is shown in **Figure 2**.

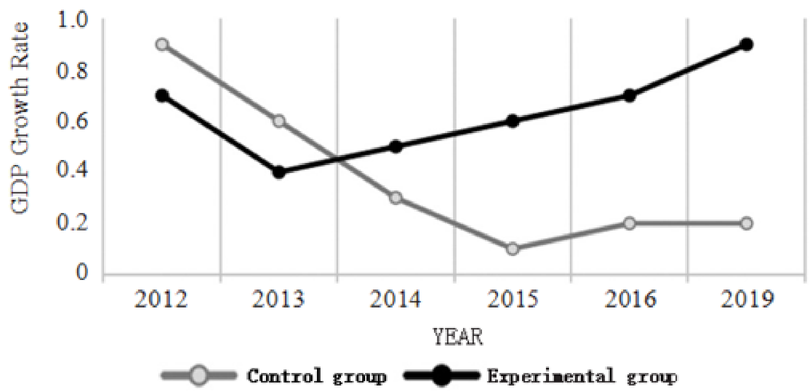

Figure 1. Parallel trend test on GDP growth rate

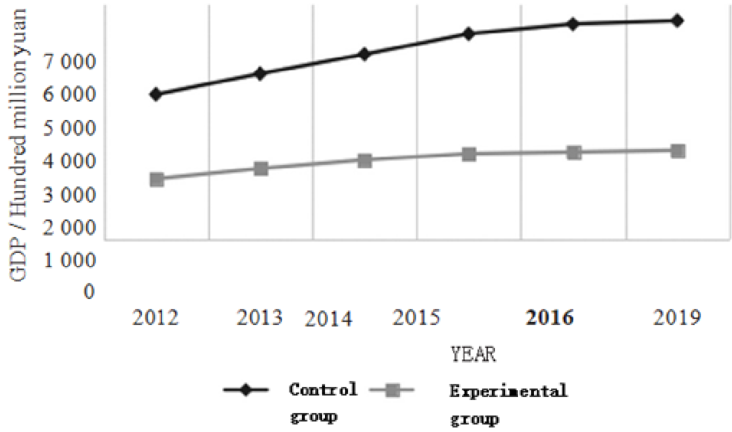

Figure 2. Parallel trend test on GDP

According to **Figures 1** and **2**, the economic and social development trends of the experimental group and the control group in 2012–2014 and 2017–2019 were similar, which met the prerequisite for applying the difference-difference method. Therefore, the study of the Lanzhou–Urumqi high-speed railway is suitable for the DID model.

The DID model was constructed as follows:

$$y_{it} = \alpha + \beta_u treat_{it} + \beta_t treat_{it} + \beta treat_{it} \times time_{it} + \varepsilon_{it} \quad (4)$$

Where: *yit* is the explained variable; *i* is the city; *t* is the time, specifically the year in this model; *α* is a constant term; *β* is the difference-difference estimator; β_u and β_t are estimated values of the virtual variables compared with city and time, respectively. *εit* is the disturbance term; When $treat_{it} = 0$, it means that city *i* in year *t* is the control group or the virtual variable of the experimental group. When $treat_{it} = 1$, it means city *i* in year *t* is the control group. The $time_{it}$ is the virtual variable before or after the opening of the high-speed railway in the year *t*. When $time_{it} = 0$, it means that the city in the year *t* is before the opening of the high-speed railway; when *time* = 1, it means that the city in the year *t* is after the opening of the high-speed railway.

The y_{it} before and after the opening of the high-speed railway in the experimental group were respectively recorded as

$$y_{it} = \begin{cases} a + \beta_u + \varepsilon_{it}, treat_{it} = 1, time_{it} = 0 \ (Before) \\ \alpha + \beta + \beta + \beta + \varepsilon, treat = 1, time = 1 \ (After) \end{cases}$$

In the control group, the y_{it} before and after the opening of the high-speed railway was recorded as

$$y_{it} = \begin{cases} a + \varepsilon_{it}, treat_{it} = 0, time_{it} = 0 \ (Before) \\ \alpha + \beta_t + \varepsilon_{it}, treat = 0, time = 1 \ (After) \end{cases}$$

To sum up, the value of income or loss after and before the opening of the high-speed railway can be expressed as the difference between the income or loss of the experimental group before and after the opening of the high-speed railway and the control group before and after the opening of high-speed railway, the expression is:

$$\Delta y_{it} = [(\alpha + \beta_u + \beta_t + \beta + \varepsilon_{it}) - (\alpha + \beta_u + \varepsilon_{it}) - (\alpha + \beta_t + \varepsilon_{it}) - (\alpha + \varepsilon_{it})] \ (5)$$

The simplification is $\Delta y_{it} = \beta$, that is, the differential estimator *β* is equal to the net policy impact.

Since it is insufficient to only include $treat_{it}$ and $time_{it}$ in the DID model, to improve the explanatory coefficient R2, the control variable – investment in fixed assets is added [8]. The introduction of fixed asset investment is mainly because the regional industrial structure passed by the Lanzhou–Urumqi high-speed railway is dominated by traditional industries, and the transformation and upgrading process is slow. The opening of a high-speed railway will not immediately change the nature of the industrial structure, so the impact of the high-speed railway opening on the industrial structure is not great. In addition, the population structure is mainly based on the resident population, and the amount of population in and out does not change much, so it has little impact on its control.

The completed DID model is:

$$y_{it} = \beta treat_{it} \times time_{it} + \beta_j \times X_{it} + \alpha_i + \varepsilon_{it} \quad (6)$$

where X_{it} is the control variable added to the model that affects the explained variable; β is the effect of high-speed railway, and the higher the value, the greater the effect of the opening of high-speed railway; β_j is the coefficient of influence of the control variable on the explained variable; α_i is a fixed effect, and the city does not change greatly over time, so the influence of the control variable on the explained variable can be verified more simply. ε_{it} is a random error term.

3. Analysis of regional accessibility and economic development effects along the Lanzhou–Urumqi high-speed railway

3.1. Research area

The research area included Gansu, Qinghai, and Xinjiang provinces. There are 31 stations on the Lanzhou–Urumqi high-speed Railway. Seven stations, namely Lanzhou West Railway Station, Xining Railway Station, Zhangye West Railway Station, Jiayuguan South Railway Station, Jiuquan South Railway Station, Hami Railway Station, and Urumqi Railway Station, are selected to study the regional accessibility along the Lanzhou–Urumqi high-speed railway. These stations have the common feature of large passenger flow, so the analysis results are representative. Five stations, Lanzhou West Railway Station, Jiayuguan South Railway Station, Xining Railway Station, Zhangye West Railway Station, and Urumqi South Railway Station, are selected to study the impact of the Lanzhou–Urumqi high-speed railway on the regional economy. The passenger flow of these five stations is relatively large, including the starting station, the terminal station, and the intermediate station, which have a certain representativeness. In addition, five regions with similar economic development status and short spatial distances without high-speed railways were selected as the control group, namely Baiyin City, Jinchang City, Wuwei City, Changji City, and Haidong City.

3.2. Data processing and description

The operation time of the Lanzhou–Urumqi high-speed railway from 2012 to 2014 and 2017 to 2019 is selected for the study, in which 2012–2014 is the research period before the opening, and 2017–2019 is the research period after the opening. The data of each city in the study were obtained from its statistical yearbook, and the GDP growth rate of the explained variable was calculated. For consistency, GDP data are converted into pairs. The data of the shortest travel time between cities along the route mainly refer to the official website of railway 12306. The change in the average travel time of the cities along the Lanzhou–Urumqi high-speed railway before its opening is shown in **Table 1**. The change in the average travel time of the cities along the Lanzhou–Urumqi high-speed Railway after its opening is shown in **Table 2**. The weighted average travel time of the Lanzhou–Urumqi high-speed Railway before and after operation is shown in **Table 3**.

Table 1. Average travel time of cities along the line before the operation of the Lanzhou–Urumqi high-speed railway

	Urumqi	Hami	Jiayuguan	Jiuquan	Zhangye	Xining	Lanzhou
Urumqi	0						
Hami	300	0					
Jiayuguan	665	355	0				
Jiuquan	723	396	19	0			
Zhangye	836	498	122	112	0		
Xining	935	625	262	223	132	0	
Lanzhou	1 112	802	439	447	335	162	0

Table 2. Average travel time of cities along the line after the operation of the Lanzhou–Urumqi high-speed railway

	Urumqi	Hami	Jiayuguan	Jiuquan	Zhangye	Xining	Lanzhou
Urumqi	0						
Hami	171	0					
Jiayuguan	370	183	0				
Jiuquan	393	201	12	0			
Zhangye	458	273	72	66	0		
Xining	586	399	189	175	107	0	
Lanzhou	662	475	265	251	182	72	0

Table 3. Comparison between the weighted average travel time of cities along the line after the operation of the Lanzhou–Urumqi high-speed railway

City	Weighted average travel time/min			Accessibility coefficient	
	Pre-operation	Post-operation	Decrement	Before opening	After opening
Urumqi	865.46	518.65	346.81	1.58	1.61
Hami	485.20	304.27	180.93	0.88	0.96
Jiayuguan	425.19	242.46	182.73	0.78	0.77
Jiuquan	466.37	259.04	207.33	0.85	0.82
Zhangye	466.29	247.83	218.46	0.85	0.79
Xining	494.37	292.94	201.43	0.90	0.93
Lanzhou	686.65	387.51	299.14	1.25	1.22

3.3. Empirical analysis

3.3.1. Empirical results of accessibility

It can be seen from **Table 3** that after the opening of the Lanzhou–Urumqi high-speed railway, the average travel time of all cities along the line has decreased by 43% on average. Except for Hami, which has decreased by 37.29%, the average travel time of other regions is more than 40%. Therefore, it can be seen that Hami has the lowest accessibility degree and Zhangye has the highest accessibility degree. From the perspective of accessibility coefficient, after the opening of the Lanzhou–Urumqi high-speed railway, Urumqi, Hami, and Xining are higher than before the opening of the three cities, while other regions are lower than before the opening of the railway. It can be seen that the accessibility degree of these regions is still not coordinated with the overall development level in the same region, and corresponding adjustments need to be made. Overall, the opening of the Lanzhou–Urumqi high-speed railway has greatly improved the accessibility of cities along the line.

3.3.2. Empirical process based on the DID model

Before analyzing the impact of the opening of high-speed railways on the economy, we should first test the stationarity of explained variables and control variables. The ADF test method is selected, and the stationarity test is shown in **Table 4**.

Table 4. Stationary test

Variate	*P*-values (Fisher-ADF)	Stationarity
*RT*GDP	0.0000	Steady
lnGDP	0.0401	Steady
ln*IS*	0.0035	Steady

It can be seen from the test results that the *P*-values are all less than 0.05, indicating that the data is stable and there is no need to delay the first order of revalidation. The explained variables GDP and GDP growth rate were analyzed by regression and differentially before and after adding control variables.

When the GDP growth rate is taken as the explained variable, the impact of the high-speed railway on it is analyzed. When the GDP growth rate is taken as the explained variable, the regression results without the introduction of fixed asset investment are shown in **Table 5**.

As can be seen from **Table 5**, when the control variable fixed asset investment IS is not introduced, the equation results are more significant, the constant term is 0.117 8, the coefficient of regional and time variables are negative, respectively, -0.155 and -0.104, and the coefficient of interaction between regional and time variables is 0.04, thus obtaining the regression equation

Table 5. Regression without fixed asset investment when the GDP growth rate is used as the explained variable

GDP growth rate	Coefficient	Standard error	*t*	*P* >*t*
Interaction term	0.0400	0.0493	0.81	0.421
Treatit	-0.1550	0.0311	-0.50	0.620
Timeit	-0.1040	0.0278	-3.74	0.000
Constant term	0.1178	0.0219	5.38	0.000

Note: *treat* as a regional factor; *time* is the time factor; *P*>*t* is the probability of a false error that rejects the null hypothesis.

$$y_{it} = 0.1178 - 0.155treat_{it} - 0.104time_{it} + 0.04treat_{it} \times time_{it} + \varepsilon_{it} \quad (7)$$

The analysis results show that when the control variables are not added, the interaction term of the regional and time variables has strong significance, and the coefficient is positive, indicating that the opening of high-speed railway has a positive impact on the GDP development of Northwest China and is conducive to promoting the overall economic development.

When the GDP growth rate is taken as the explained variable, the regression result of introducing fixed asset investment is shown in **Table 6**.

Table 6. Regression with fixed asset investment when the GDP growth rate is used as the explained variable

GDP growth rate	**Coefficient**	**Standard error**	***t***	***P*** **>*t***
Interaction term	0.037	0.048 0	0.77	0.446
Treatit	-0.023	-0.030 1	-0.75	0.458
Timeit	-0.111	0.274 0	-4.06	0.000
IS	0.074	0.047 0	1.59	0.118
Constant term	-0.077	0.126 0	-0.61	0.544

It can be seen from **Table 6** that after the introduction of control variables, the constant term is -0.077, the coefficient of regional and time variables are negative, respectively -0.023 and -0.111, the coefficient of regional and time variables interaction is 0.037, and the coefficient of control variables is 0.074, thus the regression equation is obtained:

$$y_{it} =- 0.077 - 0.023treat_{it} - 0.111time_{it} + 0.037treat_{it} \times time_{it} + 0.074IS + \varepsilon_{it} \quad (8)$$

After adding control variables, it is observed that the regional and time variables still have strong significance, and the coefficient is negative at this time, indicating that the effect of adding fixed asset input on the high-speed railway has a lag. Overall, the opening of high-speed railways has a positive effect on economic development.

When GDP is taken as the explained variable, the influence of high-speed railways on it is analyzed, and the regression and differential-difference analysis are carried out before and after the addition of control variables, and a conclusion is drawn. Through the Hausman test, it is concluded that the random effects model is more suitable for this study. The regression results without introducing fixed asset investment when GDP is the explained variable are shown in **Table 7**.

Table 7. Regression without fixed asset investment when the GDP is used as the explained variable

GDP growth rate	**Coefficient**	**Standard error**	***t***	***P*** **>*t***
Interaction term	0.009	0.178	0.05	0.961
Treatit	0.272	0.116	2.35	0.022
Timeit	0.038	0.081	0.47	0.638
Constant term	2.622	0.525	49.95	0.000

It can be seen from **Table 7** that the coefficients of the interaction terms of the time variable and the regional variable before the control variable is added are all positive, which are 0.038, 0.272, and 0.009, respectively, thus the regression equation can be obtained:

$$y_{it} = 2.622 + 0.272treat_{it} + 0.038time_{it} + 0.009treat_{it} \times time_{it} + \varepsilon_{it} \quad (9)$$

Before the introduction of fixed assets, the regional variables all show a significant state, and the coefficients before and after are positive, that is, the opening of high-speed railway has a positive effect on the cities along the line. When GDP is taken as the explained variable, the regression result of introducing fixed asset investment is shown in **Table 8**.

Table 8. Regression with fixed asset investment when the GDP is used as the explained variable

GDP growth rate	Coefficient	Standard error	*t*	*P >t*
Interaction term	-0.025	0.057	-0.44	0.660
Treatit	0.191	0.034	5.56	0.000
Timeit	-0.043	0.041	-1.04	0.302
IS	0.843	0.045	18.57	0.000
Constant term	0.411	0.121	3.41	0.001

As can be seen from **Table 8**, after adding the control variable, the regional variable is 0.191, which is positive, while the interaction term of the time variable and the two is negative, which are -0.043 and -0.025 respectively. The regression equation is:

$$y_{it} = 0.411 + 0.191treat_{it} - 0.043time_{it} - 0.025treat_{it} \times time_{it} + 0.843IS + \varepsilon_{it} \quad (10)$$

After the introduction of fixed assets, regional variables and control variables are significant, while time variables and interaction coefficient symbols are negative. The reason for this phenomenon is that the high-speed railway has a long-term effect on economic development with lag. In addition, **the** Lanzhou–Urumqi high-speed railway has just opened in 2014 and China is in the opening stage of the "13th Five-Year Plan" in 2017. Various economic factors are steadily adjusting and advancing, and the negative time variable is consistent with reality. In addition, the economic growth rate of the experimental group and the control group converged during this period, which was conducive to narrowing the gap and promoting coordinated development [9].

Through the above empirical research, we can obtain: Before the opening of the high-speed railway, the accessibility level among the regions along the route was poor. With the opening of the high-speed railway, the accessibility level on the whole continues to improve, but there are still some differences in the accessibility coefficient. Urumqi and Lanzhou, because the accessibility coefficient is greater than 1, indicates that the accessibility level is higher than the regional average level, while other regions are less than 1, indicating that the accessibility level is lower than the average level. The opening of **the** Lanzhou–Urumqi high-speed railway is conducive to improving inter-regional accessibility, speeding up the flow speed of various factors between regions, and promoting economic development, which further shows that the degree of accessibility indirectly affects economic development, and the two show a positive correlation.

4. Conclusion

(1) Through regression analysis, it is found that the GDP growth rate of the control group is lower than that of the experimental group along the high-speed railway, regardless of whether the control variables are added. This conclusion is also consistent with the reality, that high-speed railway construction is usually selected in the relatively large passenger flow and relatively strong economic strength of the region, its own development potential, coupled with the completion of high-speed railway, is more conducive to economic growth. On the whole, the opening of high-speed railways has a positive effect on economic development.

(2) The opening of the Lanzhou–Urumqi high-speed railway has greatly improved the accessibility of cities along the line, but the comprehensive improvement of accessibility is different, showing a trend of greater impact on intermediate stations and less impact on departure stations and terminal stations. Urban

location, inter-city spatial distance frequency of transportation, and economic contact affect the weighted average travel time. The widening of the urban accessibility gap along the Lanzhou–Urumqi high-speed railway leads to the deepening of the marginalization of cities with few benefits of accessibility in the future and intensifies the siphon effect and Matthew effect under the situation of regional imbalance.

(3) After the opening and operation of the Lanzhou–Urumqi high-speed railway, the improvement of accessibility can promote the improvement of urban investment, consumption, industrial structure, and residents' income level to varying degrees, which is an important driving factor for regional economic spatial agglomeration and the key to improving regional economy.

Disclosure statement

The authors declare no conflict of interest.

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