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Exploring the Economic Benefits of Tourism Enhancement by the Opening of High-Speed Railway in Ethnic Areas Based on Data Envelopment Analysis Methods

Lili Liu[1] and Jianliang Li[1,*]
[1] Business School, Beijing Information Science and Technology University, Beijing, 100000, China
Corresponding authors: (e-mail: eloise912@126.com).

Abstract As an important transportation infrastructure, high-speed railroad has a significant impact on the development of tourism in ethnic areas. Tourism resources in ethnic areas are rich but underdeveloped, and the opening of high-speed railways provides guarantee for tourism convenience and promotes the expansion of the source market. Based on Data Envelopment Analysis (DEA) and Double Difference Method (DID), this study utilizes the panel data of Region B from 2012-2018 to explore the enhancement effect of the opening of high-speed railroads on the economic benefits of the tourism industry in ethnic regions. The study adopts the DEA-BCC model to assess the comprehensive efficiency of the tourism industry, utilizes the DEA-Malmquist index to measure the change in total factor productivity, and employs the PSM-DID method to assess the impact of the opening of high-speed railways on the economic development of tourism. The results of the study show that: the overall comprehensive efficiency of tourism in Region B shows an upward trend, with an average value of 0.45 during 2012-2018, reaching a maximum value of 0.80 in 2018; the Malmquist index analysis shows that the index of total factor productivity change has increased by 0.1% annually, of which the index of technical efficiency change has increased by 0.6% annually, and the index of technological progress has declined by 0.5% annually; the double difference analysis shows that the opening of high-speed rail significantly improves the level of tourism economic development of cities in ethnic areas along the route, and the coefficient of the core explanatory variable is 0.122, and it is significant at the 5% level. The mechanism analysis shows that the high-speed rail promotes the rise of green economic efficiency of urban tourism through the channels of increasing the scale output of tourism, promoting the upgrading of industrial structure and upgrading the level of urban greening. The study confirms that the opening of high-speed railways has an obvious promotion effect on the tourism economic development of ethnic areas, and provides a scientific basis for the tourism policy formulation and transportation infrastructure construction in ethnic areas.

Index Terms high-speed railroad, ethnic areas, tourism economy, data envelopment analysis, double difference, total factor productivity

I. Introduction

In today's society, the change of transportation mode has a profound impact on various fields, tourism is one of them [1], [2]. As an important achievement in the field of modern transportation, high-speed railroad, with its fast, convenient and comfortable features, has brought many opportunities for the improvement of economic benefits of tourism in ethnic areas [3], [4].

For the development of tourism in ethnic areas, high-speed railroad greatly shortens the spatial and temporal distance between cities, enabling people to reach more distant tourist destinations in a shorter time [5], [6]. This gives ethnic regions, which were originally excluded from tourism programs due to their long distances, the opportunity to attract more tourists [7]. Thus, the scope of the tourism market has been expanded to include not only local residents' neighborhood tours, but also to attract more tourists from faraway places [8]. In addition, the comfortable environment and high-quality service of high-speed railways provide tourists with a more pleasant traveling experience [9]. The spacious and neat carriages, stable operation status, and convenient facilities, such as charging sockets and Wi-Fi, increase the comfort of traveling [10]-[12]. At the same time, high-speed railroad stations are usually located near city centers or transportation hubs, which are more conveniently connected to other modes of transportation, and tourists can more easily transfer between multiple modes of transportation, reducing the fatigue and inconvenience of travel [13]-[16]. The opening of high-speed railroads helps to link up scattered tourism resources and form more attractive tourism routes and products [17], [18]. More importantly, with the improved accessibility brought by high-speed railroads, the passenger flow in ethnic areas tends to increase

significantly, which not only directly promotes the development of tourism core industries such as tourist attractions, hotels, restaurants, etc., but also leads to the prosperity of related industries such as shopping, entertainment, transportation, etc. [19]-[22]. The influx of a large number of tourists stimulates consumption, creates more employment opportunities, and injects new vitality into the improvement of the economic benefits of tourism in ethnic areas [23], [24].

Transportation infrastructure is an important support for regional economic development, and high-speed railroad, as a core component of modern transportation network, has a far-reaching impact on regional economy. Especially for the resource-rich but inconvenient ethnic areas, the opening of high-speed railway not only changes the regional spatial structure, but also brings new opportunities for the development of local tourism. Ethnic areas are mostly located in the western part of China, with unique natural landscape and cultural resources, and huge potential for tourism, but due to the backward transportation conditions, tourism development has been at a low level. The opening of high-speed rail significantly shortens the time and space distance between the source and the destination, improves the convenience of tourism, and is of great significance in promoting the development of tourism in ethnic areas. At present, domestic and foreign scholars' research on the relationship between high-speed rail and tourism mainly focuses on changes in passenger flow, reconfiguration of tourism spatial pattern, and competitiveness of tourism destinations, etc. However, empirical research on the impact of the opening of high-speed rail on the economic benefits of tourism in ethnic areas is relatively insufficient, especially the lack of systematic analysis from the perspective of efficiency. The development of tourism in ethnic areas is characterized by the problems of abundant but underdeveloped resources, limited source markets, and poor quality of tourism services, and the opening of high-speed rail provides a new way to improve these conditions. However, to what extent the opening of high-speed rail can enhance the economic efficiency of tourism in ethnic areas and what is its mechanism of action, these issues need to be explored in depth. This study selects Area B as a research case, which is an important ethnic area in China with rich tourism resources, and the high-speed rail network has been improving in recent years, providing a good sample for the study. By empirically analyzing the impact of high-speed rail on the economic benefits of tourism in this region and exploring the internal mechanism of high-speed rail to promote tourism development, it can provide a scientific basis for the formulation of tourism development strategies and the construction of transportation infrastructure in ethnic regions.

This study adopts the research framework of “Double Difference Method + Data Envelopment Analysis”, regards the opening of high-speed rail as a kind of “natural experiment”, and combines the Propensity Score Matching (PSM) method to eliminate the sample selection bias, so as to objectively assess the impact of the opening of high-speed rail on the economic development of tourism in ethnic regions. The study uses the DEA-BCC model to measure the comprehensive efficiency of the tourism industry, analyzes the dynamic change of efficiency through the DEA-Malmquist index, and explores the specific mechanism of the opening of the high-speed rail to promote the economic efficiency of the tourism industry. The study selects the panel data of Area B from 2012 to 2018, and uses tourism revenue and the number of tourists as the main indicators to measure the level of tourism development, and verifies the actual effect of the opening of the high-speed railroad by comparing the differences between the cities along the high-speed railroad and those not along the railroad. Meanwhile, robustness tests are conducted through methods such as placebo test and replacement of explanatory variables to ensure the reliability of the study's conclusions. The study focuses on the mechanism of the impact of high-speed rail on the economic benefits of tourism through promoting the innovation of urban tourism science and technology, optimizing the structure of the tourism industry and improving the accessibility of transportation, so as to provide theoretical support for the synergistic development of high-speed rail and tourism in ethnic areas.

II. Research methodology on the economic benefits of tourism from the opening of high-speed railroads

II. A. Modeling

II. A. 1) Double Difference DID

High-speed rail has a significant impact on the tourism development of cities along the route. In order to better assess the impact of high-speed rail on urban tourism development, this paper regards the opening of high-speed rail as a kind of “natural experiment”, and utilizes the double-difference DID method [25] to assess whether high-speed rail before and after the opening of the real impact on urban tourism development. This paper draws on the principle of determining the time node of high-speed rail development, and selects 2012 as the time node of policy implementation, and the sample interval is set as 2012-2018, in which 2012-2015 is regarded as the pre-policy implementation period, and 2015-2018 is regarded as the post-policy implementation period. According to the general steps of DID modeling, two types of dummy variables are constructed first: (1) group dummy variables, the experimental group is the cities where high-speed railways are opened and takes the value of 1. The control group

is the cities where high-speed railways are not opened and takes the value of 0. (2) time dummy variables, according to the time nodes mentioned above, the time in the research sample in 2012 and after takes the value of 1, and the time before 2012 takes the value of 0.

The use of any research method has preconditions that need to be met in order to apply the method, and the cities in the experimental and control groups of the selected samples before applying the DID method should be as similar as possible in all aspects, i.e., the characteristics of the selected experimental group should be as similar as possible to the characteristics of the control group. However, the development of different cities in China is not completely synchronized, and there exists a great deal of heterogeneity in the development of cities, which makes it difficult to be neatly standardized in all aspects. To solve this problem, this paper draws on the propensity score matching method (PSM) to effectively solve the problem of sample selection bias. Based on this, this paper combines PSM, which can eliminate the problem of sample bias, with the DID model, which can solve the endogeneity problem due to the omission of variables, so as to more accurately assess the impact of high-speed rail on urban tourism development.

Based on the above, the hypothetical model of the DID method in this paper is set as equation (1):

$$Y_{it} = \alpha_0 + \alpha_1 du \times dt + \sum_{i=0}^{n} b_i X_{it} + \varepsilon_{it} \tag{1}$$

In order to eliminate the bias of sample selection, this paper is based on the PSM-DID method [26] for robustness assessment, and the main steps are as follows: first, the PSM is used to find the control group with the most similar characteristics to the experimental group. Second, DID regression is performed on the matched experimental and control groups. The specific regression model is shown in equation (2):

$$Y_{it}^{PSM} = \alpha_0 + \alpha_1 du \times dt + \sum_{i=0}^{n} b_i X_{it} + \varepsilon_{it} \tag{2}$$

In equation (2), Y reflects the impact of urban tourism development after the opening of high-speed rail. X is the control variable of the corresponding model, which controls the variables affecting tourism development. α is a constant term. ε_{it} denotes the residual.

II. A. 2) DEA methodology

The DEA method [27] is a non-parametric efficiency evaluation method, which is an analytical method for evaluating the relative effectiveness of decision-making units, mainly using the principles of operations research and mathematical planning models. Based on the DEA-CCR model with constant returns to scale, this assumption does not correspond to the actual situation of economic development, because there are often changes in returns to scale in the actual production of individuals. After that, DEA-CCR model was extended and scholars proposed DEA-BCC model, which is based on the assumption of variable returns to scale, and can decompose the comprehensive technical efficiency (TE) into pure technical efficiency (PTE) and scale efficiency (SE), which can more scientifically measure the relative efficiency of the individuals with different returns to scale.The DEA model can be classified into input-oriented and output-oriented. Input-oriented refers to minimizing inputs at a specific output level, and output-oriented refers to maximizing the amount of outputs at a specific input. In this study, the input-oriented model under the output given condition and the DEA-BCC model with variable returns to scale are used. The details are as follows:

It is assumed that there are n independent evaluation units DMUs, which in this paper means 30 provinces (municipalities and autonomous regions) in China, excluding Tibet, Hong Kong, Macau and Taiwan. Each decision-making unit $DMU\ j\left(j=1,2,\cdots n\right)$ has m kinds of tourism inputs $\left(i=1,2,\cdots,m\right)$ and s kinds of tourism outputs $\left(r=1,2,\cdots,s\right)$, with x_{ij} representing the j th decision-making unit's i th kind of inputs, y_{rj} denoting the r th input quantity of the j th decision cell, the DEA-BCC model [28] is:

$$\min\left[\theta-\varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)\right] = v_d(\varepsilon) \tag{3}$$

$$s.t.\begin{cases}\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{ij0} \\ \sum_{j=1}^{n} y_{rj}\lambda_j - s_i^+ = y_{rj0} \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j, s_i^-, s_i^+ \geq 0 \\ 0 \leq \theta \geq 1 \end{cases} \tag{4}$$

θ is the measured comprehensive technical efficiency (TE) value of China's tourism industry, $\lambda_j \left(\lambda_j \geq 0\right)$ is the weight variable, s_i^- is the slack variable, s_i^+ is the residual variable, and ε is the non Archimedean infinitesimals, $\sum_{j=1}^{n} x_j = x_0 \sum_{j=1}^{n} x_j = y_0$. When $\theta = 1$ and $s_i^- = s_i^+ = 0$, it indicates that the efficiency of the tourism industry in the region is DEA effective, and when $\theta < 1$, it indicates that the tourism industry in the province is non-DEA effective.

In order to further reflect the dynamic efficiency changes of the evaluated units, this paper adopts the Malmquist index to measure China's tourism total factor productivity.DEA-Malmquist incorporates the time dimension, and the change value of total factor productivity in each period is measured by the optimal production boundary (TFPCH). The mathematical expression of the method is:

$$\begin{aligned} TFPCH &= M(x^t, y^t, x^{t+1}, y^{t+1}) \\ &= \left[\frac{D_n^t(x_n^{t+1}, y_n^{t+1})}{D_n^t(x_n^t, y_n^t)} * \frac{D_n^{t+1}(x_n^{t+1}, y_n^{t+1})}{D_n^{t+1}(x_n^t, y_n^t)} \right]^{\frac{1}{2}} \end{aligned} \tag{5}$$

(x^t, y^t) and (x^{t+1}, y^{t+1}) represent the set of inputs and outputs in periods t and $t+1$, respectively, and $\frac{D_n^t(x_n^{t+1}, y_n^{t+1})}{D_n^t(x_n^t, y_n^t)}$ measures the efficiency of the period $t+1$ relative to the previous period The $\frac{D_n^{t+1}(x_n^{t+1}, y_n^{t+1})}{D_n^{t+1}(x_n^t, y_n^t)}$ measures the change in the technical efficiency of the production activity from period t to period $t+1$, when the optimal production frontier for period $t+1$ is taken as the reference. M denotes the change in efficiency at the production point (x^{t+1}, y^{t+1}) relative to the point (x^t, y^t). A value of M greater than 1 indicates that the total factor productivity of the tourism industry of the unit under study has increased during the current period, corresponding to the previous period. A value of M less than 1 indicates that the total factor productivity of the tourism industry has decreased in the current period, corresponding to the previous period. A value of M equal to 1 indicates that the total factor productivity of the tourism industry remains unchanged in the current period, corresponding to the previous period.

II. A. 3) Selection of variables

In this study, tourism revenue and the number of tourists are selected as the main indicators to measure the impact of high-speed rail on the level of urban tourism development in ethnic areas.YHSR is the time explanatory variable, in which the month of high-speed rail opening is June 30th of the current year and after is regarded as the opening of the next year, and the month of opening is June of the current year and before is regarded as the opening of the current year. Since the official operation of the high-speed rail was put into operation on October 20, 2011, December 20, 2015, and December 24, 2017, respectively, this paper takes 2012, 2016, and 2018 as the time nodes. The dummy variable YHSR is taken as 1 for the years 2012 and later for the cities along the high-speed rail line. YHSR is taken as 0 for the years 2012 and earlier. pHSR is a city dummy variable, i.e., it is taken as 1 for the cities along the high-speed rail line, and it is taken as 0 for the non-city along the rail line. DHSR,it is a double-difference variable, which is the core explanatory variable of the research in this paper.

II. A. 4) Data sources

This paper uses seven years of panel data from 2012-2018 in Region B to study the impact of high-speed rail on the tourism economy of ethnic regions. In this paper, except for the opening time of the high-speed rail, which is collected and organized from several related websites and news reports, the rest of the sample data in this paper

are from the China Regional Economic Statistics Yearbook and China Urban Statistics Yearbook in the relevant years of the Easy Professional Superior (EPS) data platform. Considering the lack of statistical data in some cities and the availability of data, region-wide data are used instead of jurisdictional data.

III. Analysis of empirical results

III. A. Integrated efficiency analysis

Looking at the overall situation in region B, the comprehensive efficiency of the tourism industry during the period of 2012-2018 was at a medium-high level, with an average value of 0.45, as shown in Figure 1, and the value of the comprehensive efficiency reached the highest value of 0.80 in 2018. The lowest value was 0.51 in 2012. The value of the comprehensive efficiency fluctuates between 0.51 and -0.80, with a large change in the overall upward trend. -0.80, with a large range of change and an overall upward trend. On the whole, the comprehensive efficiency of tourism in Area B is still at the level of medium-high efficiency after seven years of development, and the value of resources has been played to a certain extent. With the further opening of high-speed rail, the tourism efficiency of various cities in Region B is expected to continue to improve.

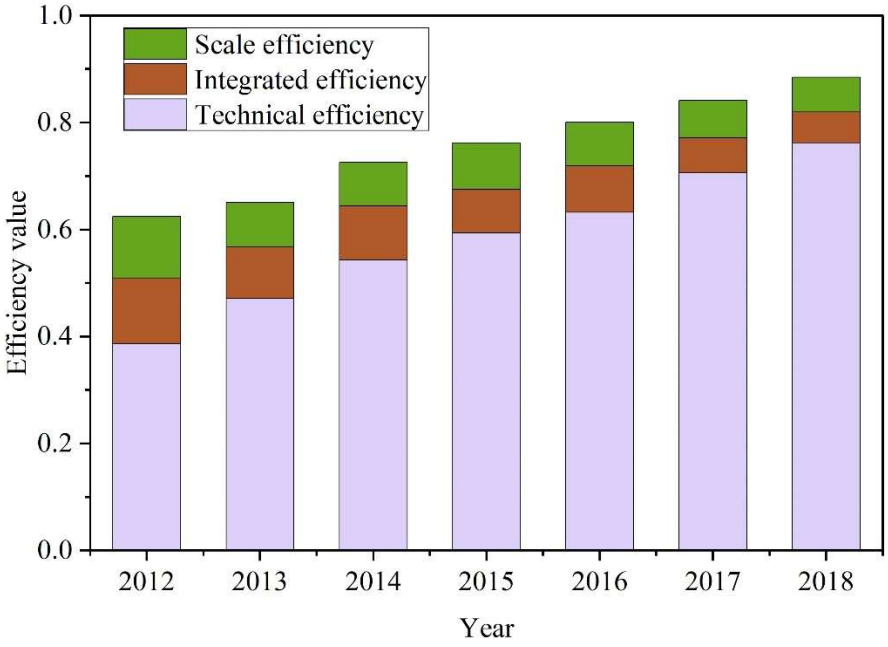

Figure 1: The comprehensive efficiency of tourism in the b region

III. B. Malmquist Index Analysis

The measurement principle of the DEA model shows that the model yields the efficiency value within a defined time frame, i.e., the static value of the target decision unit.The DEA-Malmquist index compensates for the lack of measurement results of the above model by measuring the dynamic efficiency value of the decision unit.In the process of calculating the Malmquist index, the efficiency changes can be decomposed In the process of calculating the Malmquist index, efficiency changes can be decomposed. In this paper, from the dynamic perspective aspect, we utilize the decomposition of total factor productivity (TFPCH) into technical progress index (EFFCH) and technical efficiency change index (TECHCH) as a way to analyze the dynamic changes in the comprehensive efficiency of tourism in region B. The specific results of the calculation are shown in Table 1.

The comprehensive efficiency of tourism in region B fluctuates during the period of 2012-2018, and the TFPCH exhibits an upward state of positive growth in the time period of 2012-2018. Decomposing TFPCH shows that EFFCH rises by 0.6% per year on average, and TECHCH declines by 0.5% per year on average, which shows that the decline in TFPCH is mainly caused by the decline in TECHCH. Further decomposition of EFFCH shows that PECH declines by 0.2% per year on average, and SECH rises by 0.8% per year on average, thus it can be seen that the rise in EFFCH is mainly caused by the rise in efficiency brought about by scale expansion, but at the same time, the insufficient application of pure technology leads to the decline in PECH instead, which has a hindering effect on the rise in EFFCH. From the data results, it can be seen that the decline in total factor productivity stems to a greater extent from the decrease in the technical progress index, while the technical efficiency index, although the overall increase but the decline in the efficiency of pure technology is not conducive to the rise of this index, and

both changes are not conducive to the improvement of total factor productivity. Therefore, it can be seen that although the development of high-speed rail-assisted tourism in Area B has achieved certain results, it still needs to further improve the input and use of advanced technology, and there is much room for development.

Table 1: Malmquist index and its decomposition

Year	EFFCH	TECHCH	PECH	SECH	TFPCH
1	0.944	0.909	0.944	0.911	0.849
2	0.949	0.904	0.943	0.916	0.856
3	0.956	0.900	0.940	0.927	0.874
4	0.964	0.894	0.938	0.935	0.891
5	0.968	0.890	0.936	0.940	0.901
6	0.974	0.884	0.934	0.951	0.906

III. C. Benchmark regression analysis

Tables 2 and 3 show the descriptive statistics of the variables and the results of the baseline regression, respectively, where: ***, ** and * indicate that the statistic is significant at the 1%, 5% and 10% significance levels, respectively, and the value in parentheses is the standard error (below). The coefficient of DHSR,it on the level of tourism economic development is positive at the 5% significance level, indicating that the opening of high-speed rail has a significant promotion effect on the level of tourism economic development of tourist cities. Columns (2) to (8) gradually add the regression results after adding the control variables of tourism reception capacity, economic development level, the degree of government intervention, education level, the level of residents' income, the level of urban greening, and population size. As can be seen from the results, the coefficient of the core explanatory variable DHSR,it is still significantly positive at the 5% level, again indicating that after controlling the relevant factors, the opening of the high-speed railroad still has a positive role in promoting the level of tourism and economic development of cities in ethnic areas. At the same time, the addition of control variables makes the fitting effect of the model gradually improve, and the goodness of fit in column (8) is 0.949, compared with 0.331 in column (1), which is 0.618, and the result is more credible.

Table 2: Variable definitions and descriptive statistics

Variable name	Variable meaning	Mean	Standard deviation
Qit	Tourism economic development level	10.243	1.114
YHSR	Time virtual variable	0.206	0.405
PHSR	Urban virtual variable	0.53	0.496
DHSR,it	Double difference variable	0.203	0.403
a5A	Virtual variables for tourism resources	0.681	0.467
Ustation	High iron station virtual variable	0.732	0.448
Rroad	Degree of traffic	34.718	14.993
Iscience	Tourism technology innovation	0.78	1.954
Sindustry	Tourism industry structure	0.418	0.103
Lhotel	Tourist service level	3.732	0.743
PGDP	Economic development level	10.452	0.708
Gfinance/GDP	Government intervention level	0.193	0.092
Eschool	Education level	1.56	1.063
Wincome	Income level	10.679	0.465
Vpark	Urban greening	2.382	0.451
Npeople	Population scale	6.016	0.655

III. D. Parallel trend test

Before conducting the HSR opening, it is necessary to verify that there is no significant difference between the development trend of the experimental group and the control group before the opening of the HSR, i.e., the parallel trend hypothesis is satisfied. Figure 2 shows the results of the parallel trend test, and the occurrence points of the horizontal axis are the time points before and after the intervention of the high-speed rail opening. 0 is the time point at the time of the intervention. -3,-2,-1 are the time points before the intervention, which are used to test whether the trend of changes in the experimental group and the control group before the intervention is the same.1,2,3 are

the time points after the intervention, which are used to test whether the trend of the experimental group and the control group will be different after the intervention.

Table 3: Benchmark regression

Variable	Qit							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DHSR,it	1.331***	1.372***	0.130*	0.131**	0.121*	0.122*	0.122**	0.122**
	(19.373)	(15.271)	(1.993)	(2.096)	(1.954)	(1.965)	(2.224)	(2.221)
Lhotel		0.176	0.21***	0.18***	0.15***	0.15***	0.21***	0.194***
		(0.6073)	(3.415)	(3.156)	(2.861)	(2.841)	(3.356)	(3.354)
PGDP			0.413	0.441	0.448	0.401	0.62***	0.63***
			(1.376)	(1.51.)	(1.562)	(1.533)	(2.933)	(2.985)
Gfinance/GDP				0.732	0.842	0.799	0.521	0.542
				(1.194)	(1.385)	(1.295)	(0.901)	(0.935)
Eschool					0.162**	0.160**	0.151***	0.153***
					(2.651)	(2.611)	(2.962)	(3.043)
Wincome						0.122	0.092	0.092
						(0.961)	(0.745)	(0.752)
Vpark							-0.191*	-0.192*
							(-1.961)	(-1.974)
Npeople								0.055***
								(3.631)
Constant term	9.975***	9.311***	4.255	3.946	3.664	2.942	1.465	1.035
	(729.544)	(8.512)	(1.545)	(1.412)	(1.345)	(0.923)	(0.645)	(0.412)
Sample size	600	600	600	600	600	600	600	600
Fitting excellence	0.331	0.335	0.941	0.941	0.942	0.942	0.945	0.949

To test the parallel trend hypothesis, 2012-2018 was selected as the observation period, and whether or not HSR was introduced was used as the basis for distinguishing the control group from the experimental group. To avoid the problem of multiple covariates, the period before the opening of HSR is chosen as the base period. The regression coefficients of the opening of high-speed rail on the tourism economic development of cities in ethnic areas are small and insignificant before the occurrence of the shock by the opening of high-speed rail, indicating that there is no systematic difference in the evolutionary trend of the tourism economic development of cities along the high-speed rail and those not along the high-speed rail before the opening of the high-speed rail with the same time-varying trend, which satisfies the precondition of the parallel trend. And the policy effect began to appear 1 year after the opening of the high-speed rail, the regression coefficient of the opening of high-speed rail on the level of tourism economic development of the cities along the nationalities is significantly positive and shows a continuous upward trend, indicating that the opening of the high-speed rail contributes to the development of the tourism economy of the cities along the line. This shows that the multi-period double difference model used in this paper to assess the effect of the opening of high-speed rail on the development of tourism economy in cities along the ethnic areas is effective.

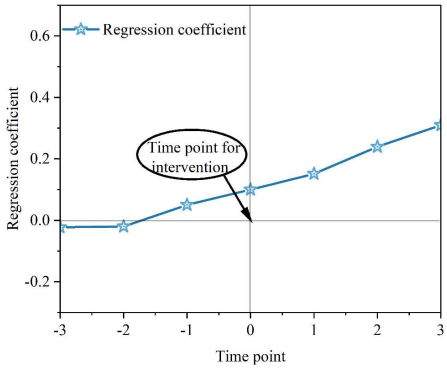

Figure 2: Parallel trend test results

III. E. Robustness Tests

In this study, domestic tourist arrivals and total tourist arrivals are used as alternative indicators of tourism economic development for robustness testing. After regression analysis, if the results of empirical analysis are still significantly positive, the robustness of the above results can be proved. After replacing the explanatory variables for regression analysis, the results of regression analysis are shown in Table 4. The coefficients of the core explanatory variables DHSR,it for the number of domestic tourists and the total number of tourists are both significantly positive at the 1% level, and the coefficients of the core explanatory variables DHSR,it are generally significant and do not change much when comparing with the results of the original benchmark regression. This further confirms the robustness of the variables and also ensures the credibility of the regression results. Meanwhile, the regression analysis after replacing the variables shows that the number of tourists in the cities of ethnic areas along the high-speed rail line have been increased to some extent after the opening of the high-speed rail. From the DHSR,it coefficient, the coefficient of the total number of tourists is not as high as the coefficient of the number of domestic tourists, and the coefficient of the number of domestic tourists is 0.162, which may be due to the fact that at present the high-speed rail is developing rapidly, and the attraction for the international travelers is not enough, and the number of inbound tourists fails to be significantly increased. The high-speed railway should actively maintain its own advantages while increasing the number of inbound tourists through convergence with other connections, thus greatly enhancing the tourism economic development of cities in ethnic areas along the route in general.

Table 4: Robustness test results

Variable	Ⅰ Replace the interpreted variable		Ⅱ Primary regression
	Number of domestic tourists	Total number of tourists	Tourism economic development level
DHSR,it	0.162***	0.154***	0.123**
	(2.815)	(2.811)	(2.224)
Lhotel	0.273***	0.275***	0.194***
	(6.132)	(6.171)	(3.354)
PGDP	0.542***	0.542***	0.631***
	(2.811)	(2.824)	(2.987)
Gfinance/GDP	-0.512	-0.495	0.542
	(-0.925)	(-0.902)	(0.936)
Eschool	0.135**	0.138**	0.154***
	(2.635)	(2.667)	(3.042)
Wincome	-0.022	-0.026	0.092
	(-0.225)	(-0.267)	(0.752)
Vpark	-0.185*	-0.181*	-0.193*
	(-1.932)	(-1.885)	(-1.977)
Npeople	0.055***	0.057***	0.056***
	(3.495)	(3.535)	(3.632)
Constant term	1.385	1.394	1.031
	(0.592)	(0.592)	(0.425)
Sample size	600	600	600
Fitting excellence	0.962	0.963	0.944

In order to completely rule out the possible problems of omitted variables and random errors in the identification process, a placebo test was performed on the study data. The results of the placebo test are shown in Figure 3, where the distribution of the regression coefficients of the sham experimental group obtained from 500 Monte Carlo simulations shows that the regression coefficients of the randomly sampled policy experimental group constitute a kernel density curve, which has a normal distribution at zero. The regression coefficients of the actual policy experimental group are also significantly different from those of the randomly sampled regression coefficients, with the vast majority having p-values greater than 0.1 and non-significant regression results, which suggests that inaccurate results of the benchmark regression due to omitted variables or random errors happen to be very small probability events from a counterfactual perspective. Therefore, we can reasonably exclude the possibility that the benchmark regression results are due to unobservable factors.

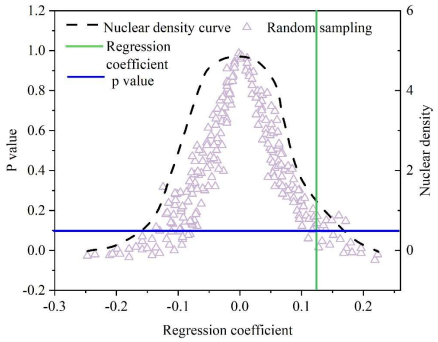

Figure 3: Placebo test results

III. F. Mechanisms of inquiry

The previous analysis shows that the opening of high-speed rail significantly improves the economic efficiency of urban tourism in economically driven neighboring ethnic areas, and a series of robustness tests confirm the reliability of this conclusion. Then, how does the opening of high-speed rail promote the economic efficiency of urban tourism? In order to explore this formation mechanism, the impact mechanism of high-speed rail opening to promote the green economic efficiency of urban tourism in ethnic areas and its dynamic evolution will be analyzed:

$$\text{Overall effect: } MED_{it} = \beta_0 + \beta_1 HSR_{it} + X_{it}\xi + \mu_i + \lambda_t + \varepsilon_{it} \tag{6}$$

$$\text{Dynamic effects: } MED_{it} = \beta_0 + \sum_{k=-6, k\neq 0}^{6} \beta_k HSR_{it}^{k} + X_{it}\xi + \mu_i + \lambda_t + \varepsilon_{it} \tag{7}$$

This study argues that high-speed rail enhances the green economic efficiency of urban tourism by promoting urban tourism science and technology innovation, tourism industry structure and transportation accessibility, and then enhances the green economic efficiency of urban tourism. Specifically, the following variables are selected: columns (2) to (8) are the results of gradually adding control variables such as tourism reception capacity, economic development level, government intervention level, education level, residents' income level, urban greening level, and population size.

The results of the overall effect test are shown in Table 5, which shows that the opening of high-speed rail significantly enhances the tourism reception capacity of the station cities, and positively affects the green economic efficiency of the tourism industry by increasing the scale output of the tourism industry. Overall, from the perspective of the overall effect, the opening of high-speed rail enhances the green economic efficiency of tourism by virtue of the scale effect of promoting tourism development.

The opening of high-speed rail has an obvious effect on the urban greening level and population scale of the city. The increase of urban greening level and population scale means that the technological level continues to progress, which on the one hand is conducive to the reduction of pollution and the overall green and efficient development of the city. On the other hand, it helps to enhance the overall tourism attraction of the city, improve the output of tourism, and then enhance the green economic efficiency of urban tourism. All in all, the opening of high-speed rail promotes the green tourism economic efficiency of the city by virtue of increasing the output of tourism scale, promoting the upgrading and transformation of industrial structure, and upgrading the greening level of the city, etc. The derivation of the mechanism in the previous section has been empirically tested accordingly.

Table 5: Overall effect test

	Qit							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HSR	0.1101***	0.0934***	1.9425***	0.9604***	0.1681**	0.0772**	8.2902***	0.5343***
	(4.5631)	(4.3205)	(5.6322)	(3.6951)	(2.2772)	(2.2772)	(4.3004)	(5.8543)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Urban fixation effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Observed value	600	600	600	600	600	600	600	600
Adjust-R2	0.7700	0.8012	0.8459	0.8745	0.9054	0.8115	0.6021	0.7156

IV. Conclusion

The opening of high-speed rail produces a significant increase in the economic efficiency of tourism in ethnic areas. Based on the results of DEA analysis, the overall comprehensive efficiency of the tourism industry in Region B shows an upward trend, with an average value of 0.45 during 2012-2018, reaching a maximum value of 0.80 in 2018, which is 0.29 higher than that of 2012.The analysis of the Malmquist index shows that the index of total factor productivity change is in a fluctuating upward state, and the index of technical efficiency change rises by 0.6% per year, with the index of pure technical efficiency rising by 0.6% per year, which indicates that efficiency improvement mainly comes from scale expansion. Among them, the pure technical efficiency index decreased by 0.2% annually and the scale efficiency index increased by 0.8% annually, indicating that the efficiency improvement mainly comes from scale expansion. Double difference analysis confirms that the opening of high-speed rail has a significant promotion effect on the level of tourism economic development of cities along the ethnic areas, and the coefficient of the core explanatory variables is 0.122, and it is significant at the 5% level. The placebo test and regression analysis after replacing the explanatory variables further verify the robustness of the findings.

The high-speed rail promotes the economic benefits of tourism through various channels: improving the tourism reception capacity and expanding the scale output of tourism; promoting the upgrading of the structure of the tourism industry and optimizing the allocation of resources; and upgrading the level of urban greening and the population scale to enhance the attractiveness of urban tourism. However, the development of tourism in Region B still faces problems such as insufficient application of technology, and the annual average decline of the technical progress index is 0.5%, which restricts the improvement of total factor productivity. In order to give full play to the promotion of high-speed rail to the tourism industry in ethnic areas, it is necessary to strengthen the connection between high-speed rail and other modes of transportation and improve the regional transportation network; increase the investment in tourism science and technology innovation and improve the level of technology application; and strengthen regional cooperation to achieve resource sharing and complementarity of advantages.

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