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The influence of transportation on regional tourism economic development under the environment of sustainable development: Taking Guizhou Province in China as an example

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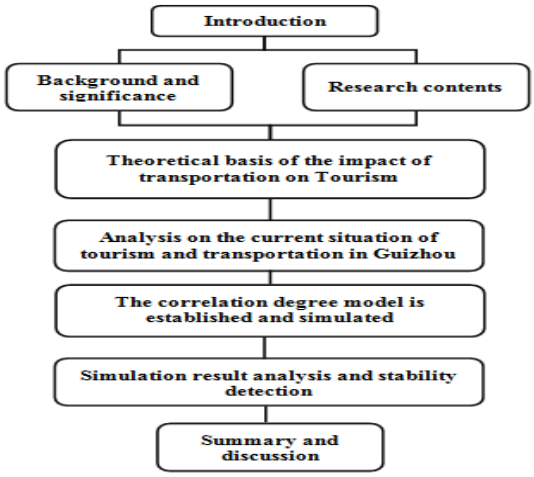
Graphical abstract



Abstract

The regional tourism economy of Guizhou Province (Latitude 26° 38' 49.1964'' N and Longitude: 106° 37' 47.9892'' E) can be developed by improving the transportation situation. The influence of transportation on the regional tourism economy is the main research content here. A correlation model is established to quantify the relationship between the two. Finally, the model experiment results are analyzed and summarized. Growth rate of total tourism revenue has the largest impact after a positive shock in the initial stage and then drops sharply, turning into the largest negative response. There are obvious shocks in the next few times. The impact gradually decreases and finally tends to 0. The impact of the shock disappears after 20 hits. When it is impacted by the total length of transportation lines, the growth rate of total tourism revenue doesn't respond at the initial stage. It then responds negatively. The results indicate that there is a coupling relationship between transportation and tourism. The improvement of transportation serves as a strong booster for the tourism economy and supports the development of tourist attractions. The results are significant for promoting transportation and tourism in Guizhou Province.

Keywords: Sustainable development, transportation construction, Guizhou province, regional tourism, tourism economy, influence mechanism

1. Introduction

After the reform and opening up, the living standards of the Chinese people have been improved. The tourism industry is gradually becoming one of the main consumption areas of residents. The vigorous development of tourism is based on the rapid growth of China's national economy. With the gradual deepening of China's opening to the world, the market economy has become particularly important. The development of China's tourism industry is accelerating. Today, ecotourism is booming. The poverty-stricken areas in Guizhou Province have many original ecological natural landscapes. There are unique geological landforms and ethnic customs. With the support of local government departments, the tourism industry has always occupied the primary position in the economy (Hu and Hou, 2021). In the development of tourism in Southwest China, the tourism industry in Guizhou Province has made great progress. The results achieved are also internationally recognized. Especially in recent years, the tourism industry has begun to take shape due to the obvious improvement of tourism service facilities and transportation conditions. Over than 39 million people call Guizhou home, representing a variety of ethnic groups. 17 of the province's 49 ethnic groups are minorities and have lived there for many years. Bai, Han, Miao, Yi, Dong, Gelao, Tujia, Shui, Hui, and Bouyei are the ten groups.

The role of transportation in the development of the Guizhou tourism economy is the main research content. A correlation model is established to quantify the coupling degree of variables. The branch of Mandarin that is spoken in Guizhou is in the southwest. The pronunciation is very comparable to Northern Chinese because the Han population is the result of the Ming and Qing migrations, only with minimal regional variations in pronunciation and

grammar. The conclusions are drawn through experiments and analysis. There is a coupling relationship between transportation and tourism. Transportation positively impacts the tourism economy.

2. The influence of transportation on tourism economy and the establishment of correlation analysis model

Improving transportation will help the development of the regional tourism economy in Guizhou Province. The role of transportation in promoting Guizhou's tourism economy is studied. The research framework is shown in Figure 1.

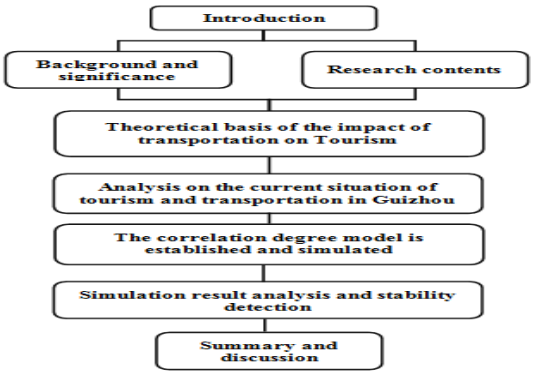


Figure 1. Research Methodology

3. Basic theories related to the transportation system and tourism economic development

The development of the regional tourism economy is inseparable from all aspects of resource support. Many scholars have paid attention to this problem, and there have been many research contributions in related fields (Shpak *et al.*, 2021). Sustainable development is a core value for accomplishing human growth objectives even while trying to preserve the capacity of nature's systems to provide the environmental services and resources that the society and economy rely on (Bai *et al.*, 2021; Zhang and Bai, 2020). Some scholars pointed out that the important stages of regional tourism cooperation development were: raising questions, clarifying directions, and implementing them. Later, some scholars applied the principles of organizational relations to forestry management and service work, business associations, and tourist associations for in-depth research. They discussed the behavior, motivation, and restrictive effects of cooperation from both theoretical and practical aspects (Bai *et al.*, 2021). Guizhou, the poorest province in China, has a total area of about 176,000 km2, making it slightly shorter than Uruguay and Cambodia. Guizhou, which is in the country's southwest, is bounded to the north by Sichuan, to the east by Hunan, to the south by Guangxi, and to the west by Yunnan. China must first strive for the best combination of interests in the region according to the basic principles of the socialist market economy. Therefore, tourism will have more cooperative launch points (Zhang and Bai, 2020). Among the various resources, transportation resources have brought a very far-reaching impact on the tourism economy. Many modern means of transportation provide people with convenient conditions for traveling. Tourism moves towards industrialization. The benefits brought by tourism are gradually recognized by people (Zhou and Chen, 2021). Every breakthrough in transportation technology pushes the travel industry to a new stage.

All forms of transportation within the territory are included in the transportation system. It is not restricted to the routes of transportation methods, but rather reflects the region's efficient and advanced level of transportation. (Liu *et al.*, 2020). Many studies reveal that transportation expenses greatly impact tourism. Expenses on transportation in travel account for the majority of travel expenses. The transportation expenses in travel are related to the economic development of the tourism industry in the target area (Ling *et al.*, 2020). Transportation plays an important role in tourists' choice of travel goals and methods. Transportation also impacts the development of China's travel destination areas. The developed water, land, and air transportation routes in China are demonstrated in Figure 2.

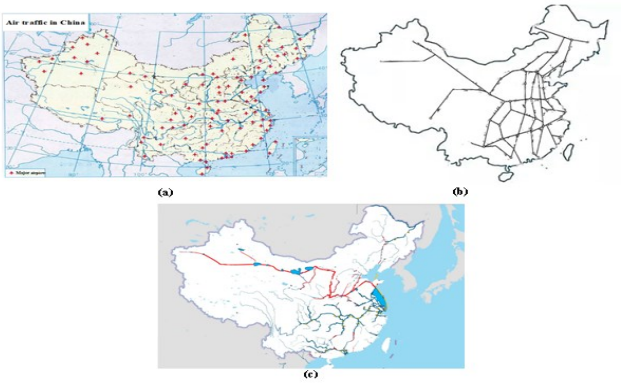


Figure 2. China's transportation map (a: route traffic; b: high-speed railway and highway traffic; c: water traffic)

Figure 2 is the current situation of China's transportation development. The figure mainly shows the main routes of air routes and land routes. In the research on the transportation system and tourism development, most of the research is on the impact of specific transportation forms and transportation routes on the tourism industry (Han and Su, 2021). The relationship between aviation and tourism development is studied. The development of foreign aircraft is early, and the main mode of travel in Europe and the United States is mostly aircraft. The research results of expressway planning and tourism development generally include the theoretical study of tourism highways, the relationship between highways and tourism development, and the empirical analysis of the accessibility of scenic spots (Kai and Fuchs, 2021). Meanwhile, the research results of the impact of expressway network development on tourist demand include international tourism cooperation, development and utilization of marine tourism resources, and water tourism management (Zhao and Yu, 2021). With the rapid development of China's transportation, the development of China's transportation and tourism has also become a hot topic. Figure 3 displays the framework of promoting the integration of transportation and tourism.

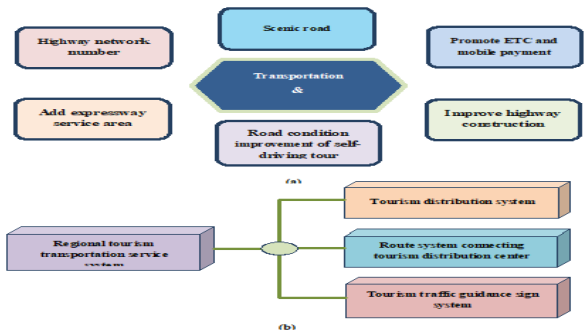


Figure 3. Framework of promoting the integration of transportation and tourism (a: integration point; b: integration system)

Figure 3 is the main points and system framework of China's transportation to promote the development of global tourism. In recent years, concepts such as "low-carbon tourism" and "smart tourism" have emerged (Wei *et al.*, 2021). It is necessary to accelerate the planning and construction of national tourist scenic routes and tourist transportation systems. Creating a natural landscape with extensive influence has become the only way to develop the tourism economy at present. The functions of tourism service facilities along highways, service areas, passenger transport hubs, and cruise yacht terminals should be improved. The construction of relevant transportation infrastructure for red tourism, rural tourism, vacation leisure tourism, self-driving tourism should be supported. Also, the integrated development of general aviation and tourism should be promoted (Li *et al.*, 2021). It is essential to improve the transportation distribution system of key tourist attractions, encourage the development of customized tourism transportation services, and enrich cruise tourism services. As a result, a pattern of benign interaction between traffic and tourism is formed.

In terms of transportation in the traditional sense, there are many research results on air transportation and highways. In recent years, the research results on highways have become abundant (Yang *et al.*, 2021). The construction of transportation and the development of the tourism economy are closely related. They are usually studied using methods such as the coefficient method and gravitational modeling. Transportation planning impacts the entire tourism pattern (Akbari and Ha, 2020). Most of the current research starts from the perspectives of travel flow, travel cost, transportation accessibility, transportation and tourism harm, and product structure.

4. Current situation of tourism development in Guizhou

Guizhou Province is a region rich in red tourism resources. Guizhou Province has amazing natural beauty, tiny imprints left by the wheel of Chinese history, and the sacred spirit of the Red Revolution. Guizhou Province is located in southwest China, adjacent to Chongqing, Sichuan, Hunan, Yunnan, and Guangxi (Papatheodorou, 2021). Guizhou is a major transportation hub in Southwest China. There are many plateaus and hills (Wets, 2020). Guizhou Province mainly includes six cities, Guiyang City, Zunyi City, Anshun City, Liupanshui City, Bijie City, and Tongren City. It also consists of three ethnic autonomous prefectures, Qiandongnan, Qiannan, and Qianxinan (Sharkhuu *et al.*, 2020). The distribution of major scenic spots and the scenery in Guizhou are shown in Figure 4.

From Figure 4, Guizhou Province is rich in natural tourism resources, such as primitive natural environment, unique karst mountainous landforms, profound Chinese history, and strong ethnic customs. In Guizhou Province, there are six 5A-level scenic spots, 63 4A-level scenic spots, 99 3A-level scenic spots, one world cultural heritage site, and several national best tourist cities (Makhutov *et al.*, 2021; Ayeratharasu Rajasekharan and Porchelvan, 2022). These are enough to illustrate the huge potential of tourism in Guizhou Province.

Figure 4. Scenery and main attractions distribution in Guizhou (a: distribution of main scenic spots; b: scenery in Guizhou; c: crafts in Guizhou; d: intangible cultural heritage in Guizhou)

Guizhou Province has unique tourism conditions. Weather affects outdoor activities. Suitable weather conditions are also a special tourism resource for a region (Qin *et al.*, 2022; Luo *et al.*, 2022). Weather is a major factor in attracting tourists who need a vacation. The number of tourists in the country and the number of tourists in Guizhou from 2017 to 2021 are counted. Figure 5 shows the specific results.

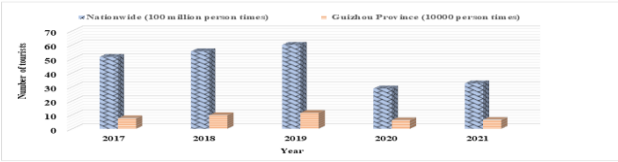


Figure 5. National tourist arrivals and Guizhou province tourist arrivals

From Figure 5, in the scope of national tourism, tourism in Guizhou Province occupies a certain position. Guizhou Province has mostly cloudy and rainy weather and belongs to the plateau subtropical monsoon climate. In most places, there is no extreme heat in summer and no severe cold in winter. The hottest month in most parts of the country is July, with average temperatures around 22-26 degrees. The climate of Guizhou Province is different from the hot and dry climate in the eastern region of the same latitude in China (Chowdhury and Endres, 2021). When Guizhou is the coldest, the average outdoor temperature is only about -6℃-8℃. Therefore, sightseeing and tourism activities can be carried out basically throughout the year in Guizhou Province. It has become a potential area for developing holiday sightseeing tourism activities in the plateau area of China. Mostly the local people from china, Indian people, North East country peoples, Western peoples and Asian peopled are visited to see the aesthetics and other natures in Guizhou Province. Especially in

summer, Guizhou Province has become a summer resort for many tourists. The increase in tourist arrivals has brought an increase in economic income (Chen *et al.*, 2020). Statistics are made on the national tourism revenue and Guizhou tourism revenue from 2017 to 2021. Figure 6 displays the specific results.

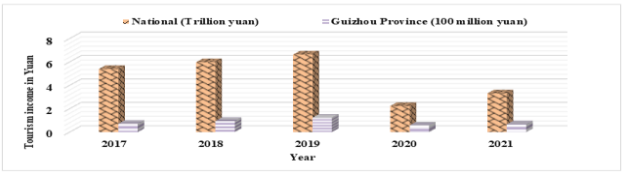


Figure 6. National tourism income and Guizhou Province tourism income

Before the high-speed railway is opened in Guizhou Province, the basic facilities are not yet complete. The facilities for accommodation and reception, transportation, environmental conservation and sanitation, and proper safety technical machinery are not perfect. From Figure 6, the development scale of tourism in Guizhou Province has been greatly improved after the high-speed railway is opened to traffic. The scale of its tourism development is further expanding, and it has formed an important pillar industry that drives the Gross Domestic Product of Guizhou Province (Long, 2020). The total tourism revenue has also increased significantly, and it has formed an important part of facilitating the growth of the national economy (Serova *et al.*, 2021). However, the transportation level of Guizhou Province must be improved in an all-around way to give full play to the local pleasant climatic conditions and the advantages of geographical resources with beautiful mountains and rivers. Figure 7 demonstrates the current traffic coverage in Guizhou Province.

Figure 7. Traffic coverage in Guizhou province

Figure 7 reveals that the convenient transportation in Guizhou Province makes self-driving tourists the main force of tourism consumption in Guizhou. Since December 2014, the first high-speed railway in Guizhou Province, the Guizhou-Guangzhou high-speed railway, opened to traffic, a new chapter in the transportation of Guizhou has been opened. Tourism has opened the "high-speed rail era". The travel capacity increases with the transportation advantages. The convenience of transportation has brought about changes in the tourism market. The number of special trains from Guangzhou, Changsha, Kunming, Wuhan, Shanghai, and other places to Guizhou for summer vacation, folk tours, leisure tours, health tours, and other tourist routes is increasing. Guizhou Province has formed a three-dimensional transportation system connecting high-speed, high-speed rail, air passenger transport, and waterway shipping from county to county (Qi *et al.*, 2020). The improvement in traffic has made it no longer a long way for tourists to appreciate Guizhou's landscapes. According to incomplete statistics, self-driving travel accounts for 46.8% of domestic tourist travel in Guizhou Province in 2021. During the National Day holiday, the proportion of self-driving tourists in attractions accounts for 55.1%.

5. Model design and data processing of the impact of transportation on Guizhou's economic development

The important influencing factors of correlation are studied from a systematic macroeconomic perspective to illustrate the impact of transportation on the development of the tourism economy in Guizhou. When analyzing the relationship of multi-factor indicators, the gray correlation degree analysis and the other methods are generally considered (Li *et al.*, 2021; Li *et al.*, 2022). Common analytical methods are often applied to large samples but require extensive data processing. Moreover, they have disadvantages such as large estimators and possible anomalies. The grey correlation analysis is usually applied to small samples or uncertainty statistics. This method can find the relationship between the factors and sort them.

The period for tourism economic and social development is limited. The survey period of the key indicators of tourism economic and social development that can be selected in Guizhou is also less than 30 years. Therefore, the resulting number of samples is 27. A sample size of less than 30 indicates that this is a small sample of data. It is appropriate to use the grey correlation analysis.

The research mainly adopts grey correlation analysis and the Value-Adder Reseller model. Vector autoregressive models are studied in two parts (Du *et al.*, 2021). Under the VAR model, the comprehensive urban rail transit project and the development factors of the Guizhou tourism economy are firstly studied. Secondly, it studies the special urban rail transit projects (divided into three categories of railways, highways, and inland waterways) and the factors of tourism economic development in the Sichuan-Chongqing region. In addition, special urban rail transit projects are divided into railways, highways, and inland waterways. Research on VAR model construction and analysis are carried out respectively (Wang *et al.*, 2020; Liu *et al.*, 2020). In the research, the indicators of tourism economic development level in the Sichuan-Chongqing region (represented by Y), transportation infrastructure construction indicators (represented by X), economic development level indicators (represented by P), and tourism resources sharing and endowment indicators (represented by S) are the main variable. The data is processed by the initial value method. The equations are as follows:

$$X_i^{'} = \frac{X_i(k)}{X_i(1)} \tag{1}$$

$$k = 1,2,\ldots\ldots,m \tag{2}$$

$$i = 1,2,\ldots\ldots,n \quad (3)$$

In Eq. (1), X_i is the correlation factor set. X_i is the comparison sequence. The equation for calculating the grey correlation coefficient is concluded as:

$$\xi_i(k) = \frac{m + \rho M}{\Delta_i(k) + \rho M} \quad (4)$$

$$\Delta_i(k) = \left| x_0(k) - x_i(k) \right| \quad (5)$$

$$\Delta_i = \left(\Delta_i(1), \Delta_i(2), \ldots, \Delta_i(n) \right) \quad (6)$$

In Eq. (4), ρ is the relative difference between the comparison curve *X* at the kth point and the reference curve x_0, generally 0.5.

The two-level maximum *M* and minimum difference *m* are expressed as:

$$M = \max_i \max_k \Delta_i(k) \quad (7)$$

$$m = \min_i \min_k \Delta_i(k) \quad (8)$$

The equation for calculating the grey correlation degree is:

$$r_i = \frac{1}{N} \sum_{k=1}^{N} \xi_i(k) \quad (9)$$

In Eq. (9), $\mathbf{r_i}$ is the correlation degree, which is the correlation degree of the average value of the correlation coefficient of each period to the parent sequence.

The VAR model (vector autoregression model) provided by sims is used to conduct experiments to further study the internal influence mechanism of the development of the transportation and tourism economy in the dynamic relationship. Eq. (10) is the general form of a vector autoregressive model.

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-i} + B_1 x_{t-1} + \ldots + B_p x_{t-j} + \varepsilon_t \quad (10)$$

In Eq. (10), y_t is the dimensional endogenous variable. *A* and *B* are the dimensions of *i*i* and *j*j* and the coefficient matrix to be estimated, respectively. *i* and *j* are the lag orders of endogenous and exogenous variables, respectively.

6. Analysis of results

6.1. Analysis of the experimental results of the model of the impact of transportation on the economic development of Guizhou

The VAR modeling of the impact of transportation on Guizhou's economic development is generally carried out with specific indices as representative variables in empirical research. Descriptive data are shown in Figure 8.

From Figure 8, Differences in absolute values between variables are reduced, thereby offsetting the negative effects of differences in different regions across the entire range of values (Xiao *et al.*, 2020; Zhang *et al.*, 2020). Therefore, the problem of heteroscedastic function will also be well solved. The signals expressed by the descriptive statistics of the four variables after logarithmic processing and the descriptive statistics of the absolute number of gray correlation variables are the same. After the first-order difference is carried out, it is found that the average value of the net income of tourists and the traffic routes is negative. This reveals that in the historical development of Guizhou's regional economy, both the net income of tourists and the construction of transportation infrastructure have declined year on year. It is inferred that the transportation design, reconstruction, and data statistics of the area are disturbed after the administrative jurisdiction is redrawn. Therefore, the total length of traffic lines doesn't show a normal year-on-year increase, but a substantial decrease.

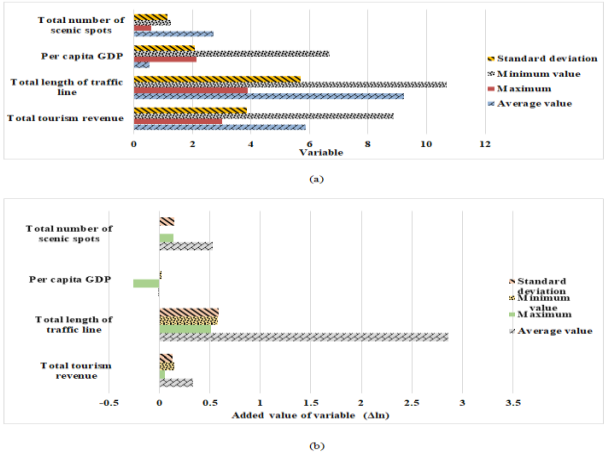


Figure 8. Model description results of the impact of transportation on Guizhou's economic development (a: variable description; b: variable incremental description)

6.2. Data stationarity test results analysis

The unit root test is a common method for testing stationarity. This part uses the Augmented Dickey-Fuller unit root test method to judge whether the data of each variable is stable. Figure 9 displays the test results.

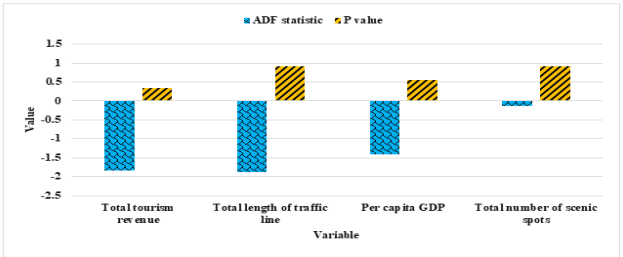


Figure 9. Unit root test results

From Figure 9, all root values are below 1. There are no eigenvalues other than 1. The VAR model passes the stability test. The total tourism revenue, the total length of transportation routes, the per capita GDP, and the total number of tourist attractions are all stationary sequences containing constant terms. All four variables pass the stationarity check. The next step is to test the stability of the VAR model.

Checking the stability of the model is convenient for the next step of impulse response analysis. The specific stability test results are demonstrated in Figures 10 and 11.

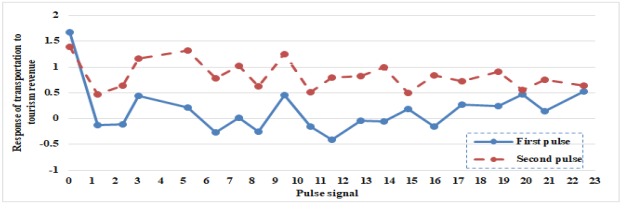


Figure 10. Impulse response function diagram of the impact of traffic conditions on tourism economic development

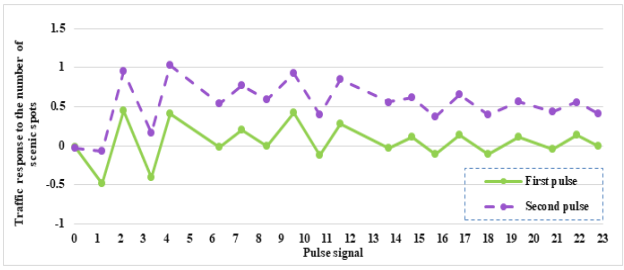


Figure 11. Impulse response function diagram of the impact of traffic conditions on the development of tourist attractions

From Figure 10, the growth rate of total tourism revenue has the largest impact after a positive shock in the initial stage and then drops sharply, turning into the largest negative response. There are obvious shocks in the next few times. The impact gradually decreases and finally tends to 0. The impact of the shock disappears after 20 hits. When it is impacted by the total length of transportation lines, the growth rate of total tourism revenue doesn't respond at the initial stage. It then responds negatively. After about 4 times, it gradually changed from a negative to a positive response. From the 5th time onwards, the long-term weaker positive response phase is entered. It weakens after reaching a relative high in positive utility for the 10th time. It tends to stabilize in small and slow fluctuations but maintains a positive effect. The result means that the development of transportation positively affects the development of Guizhou's tourism economy.

From Figure 11, after the traffic situation gives a shock in the initial period, the total tourism revenue responds positively in the second period. The response reaches the maximum in the fourth period, and then gradually declines and stabilizes, maintaining a positive effect most of the time. After the development of tourist attractions has an impact on the total tourism revenue, the total tourism revenue first has a negative response. It then rises to a relative maximum positive response and maintains a long-term state of small fluctuations in the form of alternating positive and negative responses. It also maintains a weak positive effect after 12 times and finally reaches stability. The result implies that the development of transportation promotes the development of Guizhou tourism.

7. Conclusions

Tourism is an important driving force for the development of the national economy and has become a key indicator reflecting the structure of China's national economy. In the development of tourism in Southwest China, the achievements of the tourism industry in Guizhou Province are internationally recognized. Transportation is an important factor to make the tourism economy develop faster, so sustainable development is taken as a precondition in this paper. Guizhou Province is selected as the research case. A series of studies on the impact of transportation on the regional tourism economy. Firstly, the current tourism and traffic conditions in Guizhou Province are explained based on the relevant theories of the impact of traffic on tourism. Secondly, a correlation model is established to quantify the coupling development relationship. Finally, the model experiment results are analyzed and summarized, and conclusions are drawn. There is a coupling relationship among traffic, total tourism revenue, and the number of tourist attractions. Therefore, traffic improvement will serve as a strong booster for the development of the tourism economy and support the development of tourist attractions. This paper is of great significance to the development of regional tourism economic theory and the process of promoting the development of transportation and tourism in Guizhou Province.

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