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Analysis of the Reciprocal Feedback between Glacier Tourism Development and Regional Economic Growth in Hailuogou

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Abstract: Ice and snow tourism has yielded considerable socioeconomic benefits, especially for the countries and regions that are rich in ice and snow resources. Boosted by the Beijing Winter Olympics, China's ice and snow tourism economy is likely to usher in a period of high-quality development. This study utilized Hailuogou Glacier Forest Park, a relatively well-developed glacier tourism area in China, as the study area. We used data on the regional GDP of Ganzi Prefecture and the comprehensive tourism revenue of Hailuogou scenic area from the period of 1990–2021 to quantitatively analyze the reciprocal feedback relationships between the regional economic growth of Ganzi Prefecture and the development of Hailuogou glacier tourism. The analyses were performed through the construction of a VAR model and through conducting robustness tests using the instrumental variable method. The results show that there is a long-term equilibrium cointegration relationship between regional economic growth in Ganzi Prefecture and tourism development in the Hailuogou scenic area, with each 1% increase in the former driving a corresponding growth of 2.01% in the latter. There is an asymmetric reciprocal feedback relationship between the economic growth of Ganzi Prefecture and the development of tourism in the Hailuogou scenic area. Economic growth in Ganzi Prefecture significantly contributes to the development of glacier tourism in Hailuogou over a longer period of time, with a contribution rate of 49%; meanwhile, the development of tourism in the Hailuogou scenic area has a limited effect on the quality and acceleration of economic development in Ganzi Prefecture, with a contribution rate of 16%. Based on the above results, relevant policy recommendations are proposed to provide a theoretical basis and decision-making reference for the high-quality development of the Hailuogou scenic area in the post-COVID-19 and post-Winter Olympics era.

Keywords: glacier tourism; regional economic growth; reciprocal feeding relationships; VAR model; Hailuogou

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1. Introduction

Tourism has been an industry of importance for local and regional economic growth and development for decades [1–4]. For most countries, tourism should be the main driving force behind regional development, accelerating recent economic activity. It has a positive impact on foreign exchange revenue growth, increasing job opportunities and generating tax revenues [5]. International and regional experiences show that tourism can induce significant positive direct and indirect impacts at the local level through the creation of production and employment, as well as increased wages and capital income [6,7]. Tourism is a significant factor in socio-economic development, as acknowledged in the United Nations World Tourism Organization's (2005) declaration, "Harnessing Tourism to Achieve the Millennium Development Goals." As the primary, and occasionally the only, means of sustainable economic and social development, tourism plays a particularly significant

role in most developing countries, least developed countries (LDCs), and tiny island states. Glacier tourism is an alpine tourism activity that combines sightseeing, experience, fitness, scientific research, popular science, and excitement, with modern glaciers and glacier relic resources as the primary attraction; it is an alpine outdoor activity that is close to nature, challenging to explore, and has the characteristics of providing fitness and physical strength development, recreation, and science education [8]. Over 100 years ago, glaciers began to be developed and utilized as tourism resources globally [9], and have played an important role in many fields, such as in tourism, sports, and economies worldwide. Globally, more than 100 glacier tourism destinations have been successfully developed and operated, with good commercial and economic benefits [8–10].

China has many glaciers at middle and low latitudes. The second glacier inventory shows that there are 48,571 glaciers in China, with a total area of about 5.18×10^4 km^2 [11]. Although China is a country with significant glacier resources, current development is still at a preliminary stage, which is extremely inconsistent with the glacier resources available; this gap is significant compared with other countries. China's glacier resources have great potential for future development. In February 2022, China successfully hosted the 24th Winter Olympic Games and achieved the following goals: "driving 300 million people to participate in ice and snow sports"; "driving income from ice and snow-related industries". The "China Snow and Ice Tourism Development Report (2020)", released in January 2020, pointed out that the number of snow and ice tourism visitors in China during the 2018–2019 snow and ice season reached 224 million, with a snow and ice tourism revenue of approximately CNY 386 billion. In April 2021, the Ministry of Culture and Tourism issued the "14th Five-Year Plan for Culture and Tourism Development" alongside the ongoing development of The National Leisure Programme (2021–2035), which will promote a comprehensive paid leave system, expand holiday consumption, meet mass tourism demands, and continuously increase the potential of tourism. Against the backdrop of these national policies, we will see an increase in people's leisure time, travel demand, the number of visitors to glacier tourism destinations, and the demand for ice and snow tourism; these increases are expected to generate considerable socioeconomic benefits.

With the growth of tourism in many countries and regions, the causal link between economic growth and tourism income has become increasingly important to policymakers. The literature on the relation between tourism and economic growth has been the subject of extensive research for various countries and/or regions. Through reviews of the literature, researchers have found that four basic hypotheses have been formed about the relationship between tourism development and economic growth [12]: the tourism-led economic growth hypothesis (TLGH); the economy-driven tourism growth hypothesis (EDTH); a hypothesis surrounding the two-way interaction between tourism and the economy; and a hypothesis that the relationship has no significant impact. For the TLGH, studies have shown that tourism has long played an important role in promoting economic growth due to its role in creating jobs, increasing foreign exchange earnings, generating tax revenue, stimulating consumption, and promoting regional infrastructure development [13–15]. As pioneers in this field of empirical research, Balaguer and Cantavella Jordá (2002) first proposed the TLGH through cointegration techniques and causality tests [13], and later confirmed the validity of the TLGH in extensive empirical studies at national and provincial levels [16–19]. However, other studies have suggested the opposite, namely EDTH [20–22], with Eugenio Martin et al. (2008) confirming that economic growth in some developed countries has improved the quality of infrastructure and services, which in turn has contributed to tourism expansion [23]. At the same time, studies have also demonstrated a reciprocal relationship between tourism and economic growth [24,25]. Finally, there are cases where studies have found no relationship between tourism and economic growth [26,27].

Due to the considerable socioeconomic benefits of glacier tourism, glacier-tourism-related research began internationally in the 1980s. During this period, the focus was mainly on the direct and indirect economic benefits of glacier tourism and employment from a perspective of livelihood and infrastructure development [28–30]. From the 1990s onward,

there was a clear shift in the perspective of glacier tourism research, mainly from a climate change perspective [31–36]; this perspective focused on the effects of glacier retreats, rising snowlines, and changing precipitation patterns in alpine regions on glacier landscapes [37], as well as tourist seasons, tourist routes [38,39], and related hazards [37,39,40]. Thus, the literature in this field has focused on the economic benefits and sustainable development of the snow and ice tourism industry. Domestic glacier tourism research started late, but it is rich and diverse, and covers aspects such as the economic value of the landscape [41], glacier tourism resource development models [42], economic benefits [43,44], the impact of climate change on glacier tourism [45,46], and the sustainability of glacier tourism [43,47].

In summary, for the first, second, and third hypotheses on tourism development and economic growth, most of the literature is focused on clusters of countries and individual countries worldwide; meanwhile, related research in China focuses on the national and provincial levels, with few studies examining regional-scale glacier tourism. Research on glacier tourism has focused on the economic, employment-related, and sustainability benefits of glacier tourism in the context of climate change; there has been a growing variety of research themes, using qualitative analysis as the main research method, and with geography, climatology, and sociology as the main research perspectives. For example, studies on the economic benefits of glacier tourism have focused on the one-way impact of glacier tourism on regional economies, with few quantitative studies on the two-way impact of glacier tourism on regional economic development. Furthermore, while the positive impact of tourism on economic growth is widely acknowledged in the short term, the dynamic interaction between tourism development and economic growth is not adequately addressed in the long term; this is particularly the case in regions where tourism has been developed with specific tourism attractions, which can lead to a neglect of the economic return patterns of tourism. The question of how economies specializing in tourism can sustain long-term growth remains open and requires further research.

In view of this, the study utilized Hailuogou Glacier Forest Park, a relatively well-developed glacier tourism area in China, as the study area; we adopted an econometric analysis method, based on data on Ganzi Prefecture's economic growth and Hailuogou's tourism revenue from 1990 to 2021, to determine whether there is a two-way reciprocal feedback relationship between the glacier tourism industry and regional economic growth and how much the two affect each other in the longer term. The findings are anticipated to serve as a foundation for enhancing the effectiveness and quality of glacier tourism development in the post-Winter Olympics and post-COVID-19 era, as well as serve as a guide for the sustainable growth of the local economy and society with tourism as the leading industry.

2. Study Site

Hailuogou Glacier Forest Park (hereinafter referred to as "Hailuogou Glacier") is located on the southeastern edge of the Tibetan Plateau, on the eastern slope of Mount Gongga (29°29′30″-29°39′20″ N, 101°52′49″-102°15′45″ E) (Figure 1), located in the junction area of Luding, Kangding, and Jiulong in Ganzi Tibetan Autonomous Prefecture of Sichuan Province and Asbestos in Ya'an City. It consists of six scenic spots: Hailuogou, Yanzigou, Muzigou, Nanmenguan Gou, Yajia Ridge, and Moxi Terrace. It holds titles under the "National Grade 5A Tourist Attractions", "National Scenic Scenic Spot", "National Nature Reserve", "National Geological Park", "National Forest Park", China's only "Glacier Forest Park", and the National Ecological Tourism Demonstration Area, among other laurels. The glaciers in Hailuogou cover an area of 31 km^2, including three valley glaciers and eight hanging glaciers and ice bucket glaciers. Among them, Hailuogou No. 1 glacier has the largest area, with its apex at an altitude of 6750 m and its end at an altitude of 2850 m, which is the lowest altitude on earth among glaciers of the same latitude. The glacier tongue is 40–150 m thick and has a variety of glacier landscapes with different shapes and forms. The glacier tongue is 5 km long and extends into the original fir forest, forming rare natural

scenery where the glacier and the original forest coexist; thus, it has become an important resource for the development of tourism in the region.

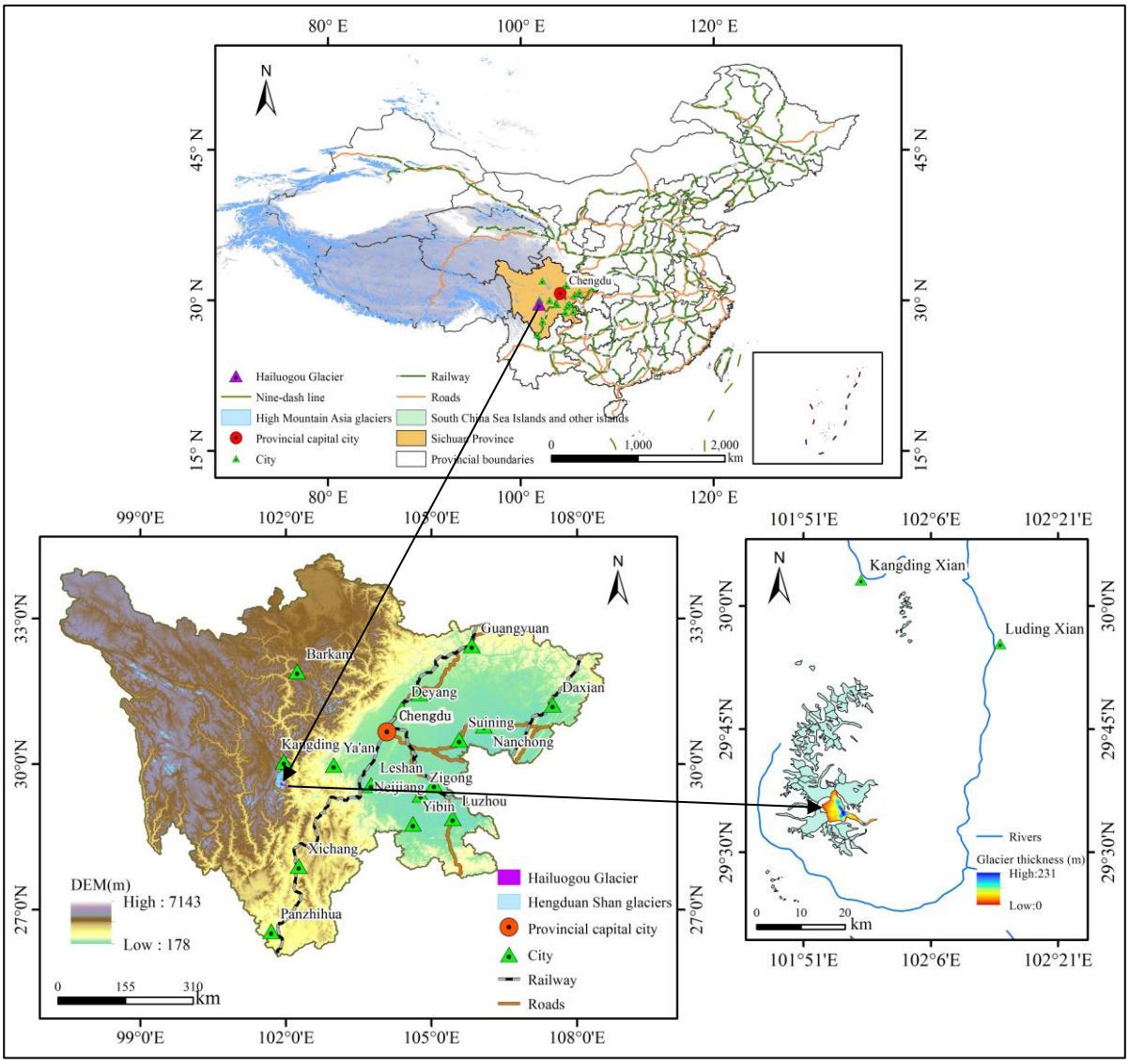

Figure 1. Location map of Hailuogou Glacier Forest Park.

The Hailuogou Glacier in Gongga Mountain is closest to the main sources of visitors, Chengdu and Chongqing, with high accessibility and a lower altitude at the end of the glacier, making it the most accessible marine glacier in the world. As of December 2021, Hailuogou Glacier Forest Park received 2.42 million domestic and foreign visitors, with a comprehensive tourism income of CNY 2.67 billion.

3. Data and Methodology

3.1. Data Source and Processing

Gross Domestic Product (GDP) data and Tourism Revenue (TR) data were used in this study. The GDP data were obtained from the Ganzi Prefecture Statistical Yearbook for a series length of 1990–2021; GDP represents the level of economic growth in Ganzi Prefecture. The TR data were obtained from the Ganzi Prefecture Hailuogou scenic area Administration for a time scale of 1990–2021. TR refers to the total monetary income obtained from the sale of tourism products, tourism commodities, and other labor services in Hailuogou scenic area to domestic and foreign tourists within a certain period of time (here the unit

is a year). All monetary income obtained, i.e., all consumption income including food, accommodation, transportation, shopping, and entertainment, including income from entrance fees, operating hotel accommodation, transportation, sightseeing vehicles and ropeways, catering, cultural services, leisure and entertainment, travel agencies and other booking services, etc. TR is an important indicator of the economic status of tourism in tourist destinations [48] and reflects the level of development of glacier tourism in Hailuogou. In order to eliminate possible heteroskedasticity in the timeseries analysis, the sample data (GDP and TR) were treated using the natural logarithm; the new series after the logarithm method is represented by lnGDP and lnTR, respectively, as the base data for the subsequent analyses. The base map and elevation data of the study area were obtained from the Basic Geographic Information Centre of the National Bureau of Surveying, Mapping and Geographic Information, and the Geospatial Data Cloud website, respectively; the glacier cataloguing data were obtained from the National Scientific Data Centre for Glacial Permafrost Desert. All analyses were conducted using Eviews10 software, which was also used to calculate the results; robustness tests were carried out using Stata 17 SE software.

3.2. Methodology

3.2.1. Vector Autoregressive (VAR) Models

The introduction of vector autoregressive (VAR) models into economics in 1980 by Christopher A. Sims [49,50], a Nobel laureate in economics, has promoted the widespread use of analyses for the dynamics of economic systems. VAR models reflect the regressions of all current variables in a model on a number of lags of all variables, and do not carry any prior constraints. VAR models are used to predict interconnected timeseries systems as well as to analyze the dynamic shocks of stochastic perturbations within the system of variables; thus, the impact of various economic shocks on the formation of economic variables can be explained using VAR models [51]. Specifically, the unconstrained vector autoregressive model (VAR(p)) introduced here has the following mathematical expression:

$$y_t = \Phi_1 y_{t-1} + L + \Phi_p y_{t-p} + Hx_t + \varepsilon_t,\ t = 1, \ldots, T \quad (1)$$

where y_t is a k-dimensional column vector of endogenous variables; x_t is a d-dimensional column vector of exogenous variables; p is the lag order; and T is the number of samples. k $\times$ k-dimensional matrices Φ_1, ..., Φ_p and k $\times$ d-dimensional matrix H are the coefficient matrices to be estimated. ε_t is a k-dimensional column vector of random perturbations that can be correlated contemporaneously; however, this cannot be performed with their own lagged values or with the variables on the right-hand side of the equation. Assuming that $\sum$ is the covariance matrix of ε_t, a (k $\times$ k)-positive definite matrix, Equation (1) can be expanded and expressed as follows:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ M \\ y_{kt} \end{bmatrix} = \Phi_1 \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ M \\ y_{kt-1} \end{bmatrix} + L + \Phi_p \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \\ M \\ y_{kt-p} \end{bmatrix} + H \begin{bmatrix} x_{1t} \\ x_{2t} \\ M \\ x_{kt} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ M \\ \varepsilon_{kt} \end{bmatrix},\ t = 1, \ldots, T \quad (2)$$

Equation (2) is a VAR(p) model containing k timeseries variables, consisting of k equations.

3.2.2. Overview of the VAR Model Analysis Process

A seven-step process is required to analyze the relationship between glacier tourism development and regional economic growth using a VAR model, as follows:

① Smoothing tests: In classical econometrics, one important assumption when modelling timeseries data is that the data are stationary. Unsteady data series often lead to large deviations in the results of some statistical tests, and even to "spurious regression" problems. Therefore, in this study, the augmented Dickey–Fuller unit root test (ADF) was used to test the smoothness of the data series of two variables before the VAR model was

constructed [52]. ADF is a test which can be used to determine the smoothness of the data series of the two variables [52]. If the ADF test value is less than the critical value at some significance level, then the series is considered to have no unit root and is smooth; thus, the original hypothesis is rejected; otherwise, the original hypothesis is accepted and the series is considered to have a unit root, i.e., a non-smooth series.

② Cointegration test: The Engle and Granger cointegration (E-G two-step method) method was used to test the cointegration relationship between the two variables [53]. According to the cointegration theory proposed by Engle and Granger, two variables should be considered to be cointegrated, and there is a long term equilibrium relationship if some linear combination of the two variables remains in a steady state.

③ Determination of the model order: When constructing the VAR model, the optimal lags need to be determined. In this study, the optimal lags were determined based on the Akaike information criterion (AIC) [54], the Schwarz criterion (SC) [55], the likelihood ratio (LR) [56], the final prediction error criterion (FPE) [57], and the Hannan–Quinn criterion (HQ) [58], to determine the optimal lag order of the VAR model.

④ Model stability test: After determining the order of the VAR model, for a VAR model with lag length, p, and k endogenous variables, the AR-characteristic polynomial has $p \times k$ roots. A VAR model is considered stable if the modulus of the inverse of all roots of the constructed VAR model is less than 1, i.e., if the modulus of the inverse of all roots lies within the unit circle.

⑤ Granger causality test: The Granger causality test is essentially a test of whether the lagged variables of a variable can be introduced into the equation of other variables; a variable is said to have Granger causality if it is affected by the lags of other variables [59,60]. In this study, based on the results of tests ① and ②, we tested whether the two smooth data series variables constitute Granger causality in the presence of a cointegration relationship.

⑥ Impulse response function analysis: As VAR models contain many parameters with an economic significance that is difficult to interpret, attention is usually focused on the impulse response function. If there is a cointegration relationship between two variables that constitutes at least a one-way Granger causality, then the dynamics of the system when the model is subjected to some kind of shock can be analyzed by means of an impulse response function (IRF) [50].

⑦ Variance decomposition analysis: The importance of different structural shocks is further evaluated by analyzing the contribution of each structural shock to the change in the endogenous variables through variance decomposition (VD) [50]. The impulse response function describes the impact of one unit of shock to an endogenous variable in the VAR system on other variables, which is a description of the absolute effect; meanwhile, the variance decomposition analyzes the contribution of each variable update toward the impact of the variables in the VAR system, comprising a description of the relative effect.

4. Findings

4.1. VAR Model Construction

(1) ADF Smoothness Test

The trend changes of the two variables, lnGDP and lnTR, are shown in Figure 2. Both lnGDP and lnTR show a continuous upward trend and have different means at different time periods, so the original data series was initially judged to be nonstationary. However, as the two have roughly the same growth trend, there may be a cointegration relationship between them. The ADF was further used to test the smoothness of the original data series, and the results are shown in Table 1.

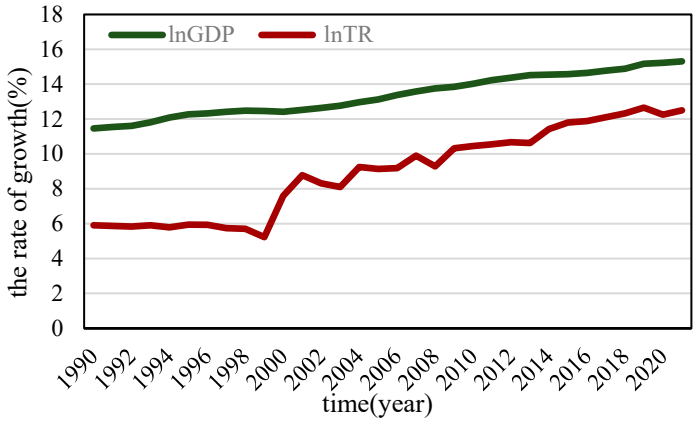

Figure 2. Sequence trend change diagram.

Table 1. Results of stationarity test of each variable.

Variables	Inspection Type (*c*, *t*, *m*)	ADF Value	Critical Value			*p*-Value	Result
			1%	5%	10%		
ln*GDP*	(*c*, *t*, 1)	−2.4119	−4.2967	−3.5684	−3.2184	0.3664	non-stationary
ln*TR*	(*c*, *t*, 0)	−3.1412	-4.2846	−3.5629	−3.2153	0.1149	non-stationary
dln*GDP*	(*c*, 0, 0)	−3.4481	−3.6702	−2.9640	−2.6210	0.0170	stationary
dln*TR*	(*c*, 0, 1)	−5.2211	−3.6793	−2.9678	−2.6230	0.0002	stationary
ε_t	(*c*, 0, 0)	−2.6940	−2.6417	−1.9521	−1.6104	0.0088	stationary

Note: The test type is (*c*, *t*, *m*), where *c* denotes the intercept term, *t* denotes the trend-containing term, *m* denotes the lag order, and *d* denotes the first-order difference of the variable order difference.

Table 1 shows that the ADF test values of the lnGDP and lnTR data series were all greater than the critical values of 1%, 5%, and 10%, and the corresponding *p*-values were 0.3664 and 0.1157, respectively; neither of these results rejects the hypothesis of the existence of a unit root, so the original data series was not smooth. After subjecting the data series to first-order difference treatment, the ADF test values of the variable dlnGDP (indicating the economic growth rate of Ganzi Prefecture) were all less than the critical values of 5% and 10%, corresponding to a *p*-value of 0.0170; the ADF test values of the variable dlnTR (indicating the growth rate of the comprehensive tourism revenue of Hailuogou scenic area) were all less than the critical values of 1%, 5%, and 10%, corresponding to a *p*-value of 0.0002. The first-order difference form of each variable was considered to be a smooth series and was recorded as a first-order single-integer series I(1).

(2) E-G cointegration test

From the ADF test, it could be seen that the two series of lnGDP and lnTR were first-order single-integer series I(1), so the cointegration relationship of I(1) was able to be further tested. Least-square regressions were estimated with lnTR as the explanatory variable and lnGDP as the explanatory variable, and the results are shown in Table 2.

Table 2. Regression estimation results of cointegration equation.

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
c	−17.8795	1.5372	−11.6309	0.0000
ln*GDP*	2.0085	0.1146	17.5327	0.0000

The following regression equation was obtained from Table 2:

$$\ln TR = -17.8795 + 2.0085 \ln GDP + \varepsilon_t \quad (3)$$

This equation fits well, with a good test coefficient of R^2 = 0.9111. f = 307.3968 > $F_{0.05}$(1,29) = 4.18 passes the significance test, indicating that the regression equation has good explanatory significance. The ADF unit root test was performed on the residual series, ε_t. If the residuals are a smooth random series, it can be judged that there is a cointegration relationship between the two series of lnTR and lnGDP.

The t-statistic of the unit root test for the residual series, ε_t (Table 1), is −2.6940, which is smaller than the corresponding critical values at the 1%, 5%, and 10% significance levels. Therefore, the original hypothesis that there is a unit root for the residual series, ε_t, is rejected and the residual series, ε_t, is considered to be smooth; this finding indicates that there is a long-term stable equilibrium relationship between the comprehensive tourism revenue of Hailuogou scenic area and the economic growth of Ganzi Prefecture. The equation regression coefficient gives the elasticity relationship between the growth of the comprehensive tourism income of Hailuogou scenic area and the economic growth of Ganzi Prefecture. Equation 3 shows that for every 1% increase in Ganzi's regional GDP, the comprehensive tourism income of Hailuogou scenic area increases by 2.01% accordingly, and Ganzi's regional economic growth has a more significant impact on the development of Hailuogou glacier tourism.

(3) Determination of the optimal lag order of the VAR model

Table 3 shows the calculated *LR*, *FPE*, *AIC*, *SC*, and *HQ* values for VAR models of orders 0–7. The lags marked with "*" are the lags filtered by the corresponding criteria. According to the principle of determining the optimal lag of the model by taking the lag corresponding to the smallest value at the same time, the optimal lag order of the VAR model is 4. Therefore, the VAR model was constructed with the optimal lag order of 4, which is denoted as VAR(4), The model is as follows:

$$\begin{bmatrix} \mathrm{dln}GDP \\ \mathrm{dln}TR \end{bmatrix}_t = \begin{bmatrix} 0.015 \\ 1.356 \end{bmatrix} + \begin{bmatrix} 0.294 & 0.044 \\ -2.498 & -0.281 \end{bmatrix} \begin{bmatrix} \mathrm{dln}GDP \\ \mathrm{dln}TR \end{bmatrix}_{t-1} + \begin{bmatrix} 0.220 & 0.044 \\ -2.819 & -0.468 \end{bmatrix} \begin{bmatrix} \mathrm{dln}GDP \\ \mathrm{dln}TR \end{bmatrix}_{t-2} + \begin{bmatrix} 0.019 & 0.032 \\ 3.884 & -0.127 \end{bmatrix} \begin{bmatrix} \mathrm{dln}GDP \\ \mathrm{dln}TR \end{bmatrix}_{t-3} + \begin{bmatrix} -0.018 & 0.037 \\ -5.103 & -0.253 \end{bmatrix} \begin{bmatrix} \mathrm{dln}GDP \\ \mathrm{dln}TR \end{bmatrix}_{t-4} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (4)$$

Table 3. Selection criteria for optimal lag order of VAR model.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	3.6624	NA	0.0030	−0.1387	0.0406 *	−0.1127
1	8.7664	8.9276	0.0027	−0.2305	0.0640	−0.1524
2	12.0885	5.2599	0.0029	−0.1740	0.3168	−0.0438
3	14.2286	3.0318	0.0035	−0.0191	0.6681	0.1633
4	25.0259	13.4966 *	0.0021 *	−0.5855 *	0.2980	−0.3511 *
5	25.4354	0.4436	0.0030	−0.2863	0.7936	−0.0002
6	29.7855	3.9876	0.0032	−0.3155	0.9607	0.0231
7	31.1424	1.0177	0.0048	−0.0952	1.3774	0.2955

Note: * indicates the lag order chosen for the corresponding criterion.

The points in the unit circle in Figure 3 indicate the mode of the inverse of the AR-characteristic roots, and the horizontal and vertical coordinates indicate the unit values; if all these points fall within the unit circle, then the VAR(4) model is smooth. The VAR(4) model established here, with four lags of two variables, has eight characteristic roots; the mode of the inverse of each characteristic root falls within the unit circle, indicating that the constructed VAR(4) model passes the stability test; therefore, the impulse response function and variance decomposition analyses can be performed.

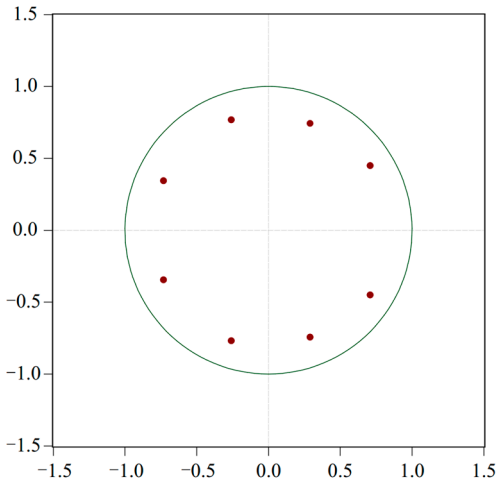

Figure 3. Discriminant diagram of VAR model stability.

(4) Granger causality test

Granger causality tests were conducted on the constructed VAR(4) model to determine the causal relationship between dlnGDP and dlnTR. The test results are shown in Table 4; the results show that the model is stable, so the impulse response function and variance decomposition analyses were able to be performed.

Table 4. Granger causality test.

Null Hypothesis	Number of Lag	Obs	*F*-Statistic	*p*-Value	Conclusion
dln*TR* does not Granger Cause dln*GDP*	4	27	1.1299	0.3737	accept
dln*GDP* does not Granger Cause dln*TR*	4	27	4.1811	0.0144	refuse

As can be seen in Table 4, for the first hypothesis—"dlnTR is not the Granger cause of dlnGDP"—its F-Statistic is 1.1299 at the 5% significance level, corresponding to a concomitant probability p-value of 0.3737; this is greater than the 5% test level, so the original hypothesis cannot be rejected and dlnTR is not the Granger cause of dlnGDP. dlnGDP is not the Granger cause of dlnGDP. For the second hypothesis—"dlnGDP is not the Granger cause of dlnTR"—its F-Statistic is 4.1811 at the 5% significance level, and the *p*-value is 0.0144, which is less than the 5% test level; therefore, the original hypothesis is rejected and dlnGDP is the Granger cause of dlnTR. In summary, the Ganzi economic growth rate is the Granger cause of the Hailuogou comprehensive tourism income growth rate; however, the Hailuogou comprehensive tourism income growth rate is not the Granger cause of the Ganzi economic growth rate. There is a one-way Granger cause between the two by Ganzi economic growth rate to Hailuogou comprehensive tourism income growth rate. It shows that the economic growth of Ganzi Prefecture has a certain influence on the improvement of glacier tourism development in Hailuogou; however, the growth of the comprehensive income of tourism in the Hailuogou area does not necessarily influence the economic development of Ganzi Prefecture.

4.2. Analysis of the Asymmetric Relationship between the Economic Growth Rate of Ganzi Prefecture and the Growth rate of the Comprehensive Tourism Revenue of Hailuogou Scenic Area

The analyses in Subsections (3) and (4) show that the VAR(4) model passed the smoothness test and that there is a one-way Granger cause of the economic growth rate of Ganzi Prefecture—the growth rate of the comprehensive tourism income from the Hailuogou area. Therefore, this section analyzes the impact of Ganzi Prefecture's economic growth rate (dlnGDP) and the Hailuogou comprehensive tourism income growth rate

(dlnTR) on themselves and on each other, respectively, through impulse response functions (Figure 4).

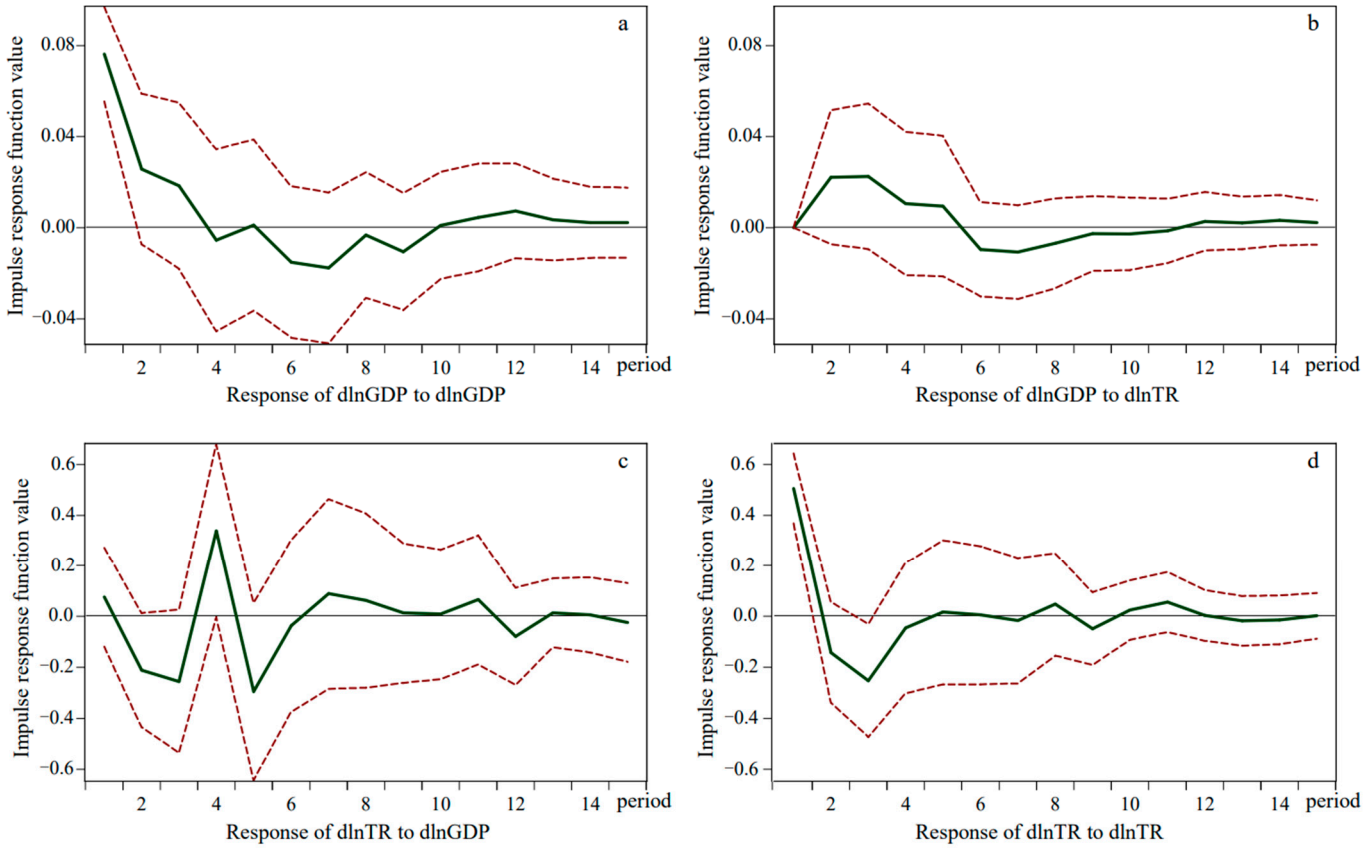

Figure 4. Results of impulse response function of VAR(4) model. The solid green line indicates the movement of the variable after a shock, and the top and bottom red lines indicate deviation bands of plus or minus two times the standard deviation. Subfigures a and b indicate that the economic growth rate of Ganzi Prefecture is subject to shocks from itself and the growth rate of the comprehensive tourism revenue of the Hailuogou scenic spot, respectively. Subfigures c and d show that the growth rate of comprehensive tourism revenue of Hailuogou scenic spot is affected by the economic growth rate shock of Ganzi Prefecture and its own shock, respectively.

(1) Shocks to the economic growth rate in Ganzi: In the current period (annual-scale data are used in the text—the forecast unit is a year), the economic growth rate of Ganzi Prefecture immediately reacts to the standard deviation of new interest rate shocks, with the shock value reaching 0.08 in period 1; then, it continuously fluctuates down to about −0.02 in period 7, and fluctuates up in period 8, until a weak positive shock effect is maintained for a long time after period 10 (4a). This indicates that the economic growth rate of Ganzi has a positive shock effect on itself over a longer period of time. Figure 4b shows that dlnGDP is subject to a positive shock from dlnTR, which starts to rise in period 1 and reaches a maximum of 0.02 in period 2; after this, the shock effect decreases continuously to −0.01 in period 6, and then rises slightly in period 7 and remains relatively stable thereafter. It can be seen that dlnTR has a positive effect on dlnGDP in the first five periods, a short negative shock in periods 6–8, and is not statistically significant after period 9; these results indicate that the shock effect of dlnTR on dlnGDP is insignificant in the long term. Overall, in the long term, Ganzi's economic growth rate is mainly influenced by its own internal structure; meanwhile, in the short term, it is influenced by both its own internal structure and the growth rate of comprehensive tourism income from the Hailuogou scenic area, and this effect is positive.

(2) The shock to the growth rate of comprehensive tourism revenue in the Hailuogou scenic spot is shown in Figure 4c. dlnTR is shocked by dlnGDP in the first six periods, creating a "W" shape shock, in periods 1–3 of the negative shock; however, in the fourth period, the highest value of positive shock is reached at nearly 0.4; then, in the fifth period, a second negative shock peak is reached (-0.3); a positive shock can be observed in periods 7–11, and a plateau can be seen after period 12. It can be seen that the period of response to the growth rate shock of Hailuogou tourism revenue is relatively long. dlnTR responds quickly to a standard deviation of its own new interest shock in the current period; this reaches a value of 0.5 in period 1, followed by a short negative shock of −0.3 in periods 2–4, and then remains stable for a long time from period 5 onwards and converges to 0 (Figure 4d). This indicates that the shock effect of the combined tourism growth rate of the Hailuogou scenic area on itself is not persistent.

In summary, there is an asymmetrical relationship between the economic growth rate of Ganzi Prefecture and the growth rate of comprehensive tourism income in the Hailuogou area, as evidenced by the following: (1) The longer duration of the shock response period is caused by the economic growth rate of Ganzi Prefecture. The length of the shock response period for the economic growth rate of Ganzi Prefecture on itself and the growth rate of comprehensive tourism income in Hailuogou are the 10th and 12th periods, respectively; meanwhile, the length of the shock response period for the growth rate of the Hailuogou comprehensive tourism income on the economic growth rate of Ganzi Prefecture and on itself are the 7th and 5th periods, respectively. (2) The shock effect caused by the economic growth rate of Ganzi Prefecture is much larger than that caused by the growth rate of the Hailuogou comprehensive tourism income. The vertical axis shock function values in Figure 4b,c show that the maximum value of the dlnTR–dlnGDP shock is about 0.02 and the maximum value of the dlnGDP–dlnTR shock is about 0.4, with a difference of 20 times between the two. It can be seen that the economic growth of the Ganzi region can significantly contribute to improvements in the comprehensive tourism income of Hailuogou.

4.3. Quantitative Analysis of the Relationship between the Economic Growth Rate of Ganzi Prefecture and the Growth Rate of Hailuogou Comprehensive Tourism Revenue

The analyses in the previous section show that there is a significant asymmetric relationship between economic growth in the Ganzi region and tourism development in the Hailuogou scenic area; this subsection will further quantify this asymmetric relationship through a variance decomposition analysis.

In terms of the results of the variance decomposition of the economic growth rate of Ganzi Prefecture (Table 5), the impact effect of the Hailuogou comprehensive tourism growth rate on the economic growth rate of Ganzi Prefecture, which is influenced by 100% of its own fluctuation shock in period 1, starts to appear in period 2; the shock intensity of dlnTR on dlnGDP is 7.061% at the beginning of the shock, and increases to 12.795% in period 3. It is worth noting that, from period 3 onwards, the shock intensity continues to increase until it reaches 16% in period 7, and after period 7, the shock intensity remains stable at around 16%; meanwhile, the shock intensity of dlnGDP to itself remains constant at around 84% from period 7 onwards. Overall, the shock intensity of the Hailuogou comprehensive tourism growth rate to the economic growth rate of Ganzi Prefecture is weak, and the contribution of the growth rate of Hailuogou comprehensive tourism to the economic growth rate of Ganzi Prefecture is relatively low in the long run. This is consistent with the previous conclusion that the shock effect of the Hailuogou comprehensive tourism growth rate on the economic growth rate of Ganzi Prefecture is insignificant.

Table 5. Variance decomposition table of economic growth rate of Ganzi Prefecture and tourism comprehensive income growth rate of Hailuogou scenic spot.

Period	Variance Decomposition of dln*GDP*			Period	Variance Decomposition of dln*TR*		
	S.E.	dln*GDP*	dln*TR*		S.E.	dln*GDP*	dln*TR*
1	0.0762	100.0000	0.0000	1	0.5114	2.2256	97.7744
2	0.0834	92.9389	7.0611	2	0.5714	15.5156	84.4844
3	0.0883	87.2053	12.7947	3	0.6748	25.4483	74.5517
4	0.0891	86.0217	13.9783	4	0.7563	40.2823	59.7177
5	0.0896	85.0683	14.9317	5	0.8119	48.1441	51.8559
6	0.0914	84.5547	15.4453	6	0.8128	48.2490	51.7510
7	0.0937	84.0003	15.9997	7	0.8178	48.8458	51.1542
8	0.0940	83.5713	16.4287	8	0.8216	48.9825	51.0175
9	0.0946	83.7131	16.2869	9	0.8232	48.8251	51.1749
10	0.0947	83.6485	16.3515	10	0.8236	48.7866	51.2134

In terms of the results of the variance decomposition of the growth rate of the Hailuogou comprehensive tourism income (Table 5), the dlnTR is affected by the impact of the economic growth rate of Ganzi Prefecture in period 1, with a shock intensity of 2.226%; after period 1, the shock intensity shows a continuous strengthening trend, maintaining a steady state of about 49% after period 7, with the largest contribution occurring in period 8, with a contribution rate of 48.98%. dlnTR is affected by its own structural shock. The strength of dlnTR, as influenced by its own structural shock, gradually decreases from period 1 to period 7, until it plateaus at about 51% after period 7; this indicates that dlnGDP has a strong shock strength on dlnTR. This is consistent with the results of the previous paper, stating that the "economic growth rate of Ganzi Prefecture is the Granger cause of the growth rate of tourism revenue in Hailuogou". This means that the economic growth rate of Ganzi Prefecture and the growth rate of Hailuogou tourism revenue can help to explain the future growth rate of tourism revenue in Hailuogou.

The above results are mainly due to the fact that the regional economic growth in Ganzi Prefecture is the result of the combined effect of primary, secondary, and tertiary industries. Tourism is only a part of the tertiary industry; furthermore, the Hailuogou scenic area is only one of the tourist attractions in Ganzi Prefecture, and its comprehensive tourism revenue in 2021 only accounted for 6.8% of the comprehensive tourism revenue in Ganzi Prefecture. However, this does not mean that the effect of the Hailuogou comprehensive tourism revenue on the regional economic development in Ganzi Prefecture will disappear in the later years. In fact, tourism and the economy have a two-way interaction that promotes a positive relationship, with socioeconomic development, the continuous improvement of people's living standards as well as the construction of roads and other infrastructure (the total mileage of roads in Sichuan Province at the end of 2020 ranks first in the country), and the gradual introduction of relevant national leisure tourism policies, the ongoing (post-Olympic era) ice and snow tourism interest provides an unprecedented opportunity for the rapid development of glacier tourism in Hailuogou.

4.4. Robustness Tests

To further substantiate the findings in this paper, the instrumental variables approach was used for robustness testing. In terms of the logic of the interaction between the development of Hailuogou glacier tourism and the regional economic growth in Ganzi, the VAR model describes the process of change in the endogenous variables; the historical observations of the variables in the VAR model used here are influenced by important exogenous factors, such as "national and regional policies and investments". However, due to insufficient theoretical understanding and unobservable variables, it is not possible to list all the missing variables in the actual modelling; some important explanatory variables may have been missed. Failure to take these omitted variables into account when analyzing the findings of this study could lead to a "misinterpretation" of the model; therefore, this

two-way relationship in the paper creates a possible endogeneity problem in the estimation which cannot be ignored in empirical economic analysis. In addition to finding external instrumental variables, the use of lagged terms of endogenous variables as instrumental variables is also very common in various disciplines of economics. In this study, the lagged explanatory variable lnGDP was selected as the instrumental variable to test whether there is an endogeneity problem; the regression results are presented inTable 6.

Table 6. Robustness test results.

Variables	**ln*GDP***
ln*TR*	0.490 ***
	(17.61)
constant	8.982 ***
	(34.44)
observations	31
R-squared	0.901

z-statistics in parentheses. *** $p < 0.01$.

From the results in the Table 6, there is a significant positive correlation between lnTR and lnGDP; therefore, we tested the endogeneity of the instrumental variables further. For the original hypothesis, H0, we found that the variables were exogenous, the Durbin(score) chi2(1) was 29.5443 (p=0.0000), and the Wu–Hausman F(1, 28) result was 568.293 (p=0.0000); based on the endogeneity test results, the p-value was less than 0.01. Therefore, the original hypothesis was rejected, with the indication that there was some endogeneity problem between the variables. There may be some degree of mutual causality between lnGDP and lnTR, with lnTR influencing lnGDP while also being inversely influenced by lnGDP. This indicates that the regression results are robust.

5. Discussion and Conclusions

In this study, using Hailuogou Glacier Forest Park as the study area, we analyzed the reciprocal feedback relationships between the growth rate of Ganzi regional economy and the growth rate of the Hailuogou scenic area comprehensive tourism income; this was achieved through the construction of a VAR model using data from 1990 to 2021. The model passed the robustness test. We obtained the following conclusions (here, GDP indicates the level of economic growth in Ganzi; TR reflects the level of development in Hailuogou glacier tourism):

(1) There is a long-term, stable equilibrium relationship between the level of regional economic growth in Ganzi Prefecture and the level of glacier tourism development in the Hailuogou scenic area. This equilibrium relationship is an elastic one, i.e., every 1% increase in Ganzi's GDP will lead to a 2.01% increase in the comprehensive tourism income of the Hailuogou scenic area; these results indicate that Ganzi's regional economic growth has a relatively significant positive impact on the development of tourism in the Hailuogou scenic area.

(2) There is an asymmetrical dependency between the economic growth rate of Ganzi Prefecture and the growth rate of the Hailuogou comprehensive tourism income: the impact of the economic growth rate of Ganzi Prefecture on itself and on the growth rate of Hailuogou comprehensive tourism lasts longer and contributes more significantly, at approximately 84% and 49%, respectively; the contribution of the growth rate of Hailuogou comprehensive tourism to itself and to the economic growth of the Ganzi Prefecture region is approximately 51% and 16%, respectively. The economic growth of the Ganzi Prefecture region can significantly contribute to the development of glacier tourism in Hailuogou; meanwhile, the development of glacier tourism in Hailuogou has a limited impact on the quality and acceleration of the economic development in Ganzi Prefecture.

Based on the above conclusions, our team found, after several surveys of the Hailuogou scenic area, that post-COVID-19 pandemic tourism competition may be a greater challenge

for the future of the Hailuogou scenic area than the inevitable factors such as climate warming and the COVID-19 pandemic. In the recent decades of China's booming tourism industry, homogenization and low level are common problems in current tourism scenic spots, particularly in Hailuogou scenic area. The specific problems are as follows: low level of development, single tourism product, and lack of experience; the high price of entrance fee and the secondary charges of the scenic area, which exceed expectations; inconvenient transportation, and the scenic area being far away from tourists' starting point, and tourists only staying in one-stop. Combining these objective problems with our model-based conclusions, the current level of tourism development in the Hailuogou scenic area is not yet a good driver of economic growth in the Ganzi Prefecture region. The primary issue facing the Hailuogou scenic area concerns the means with which to recognize problems and future trends, transform negative impacts into new growth points and new highlights through comprehensive quality improvement, improve the scientific and technological content of tourism, increase visitors' sense of experience and satisfaction, improve the taste and reputation of the scenic area, and develop a domestic super-class glacier tourist destination model, to this end, we provide the following recommendations: (1) Carry out three-dimensional planning and build a long-term development strategy for the scenic area. Specific measures are re-planning and transformation of the glacier scenic area; construction of a "subtropical-Arctic" ecological experience sightseeing area with a vertical vegetation spectrum; integration of the geological landscape, featuring rich glacier landscape area viewing content. (2) To shape a high-quality brand image, carry out the quality improvement project with science popularization as the primary connotation. Specific measures are to utilize the fact of glacier changes, to carry out targeted science popularization activities, to correspond exactly to the physical objects-photos interpretation, and to make science popularization interpretations clear and precise; make full use of the public image of national scientific research institutions, such as the State Key Laboratory of Cryosphere Science of the Northwest Institute of Ecological and Environmental Resources of the Chinese Academy of Sciences, and organically combine science popularization with observational studies conducted by these institutions to enhance the grade and credibility of science popularization in the scenic area. (3) Mining and integration of rich natural, scientific and educational, and "red" tourism resources, to create a professional mid-to-high-end "glacier+" study tour. (4) Break the management rule of "one view, many doors", and improve the overall management level, to create a national first-class scenic spot. Specific measures are management system reform and strengthening of the professional management team. The above recommendations can be implemented to create a good reputation and high-quality tourism brand image, enhance the experience and satisfaction of tourists, so as to retain tourists, and then release more consumption potential, enhance the direct consumption power and industrial development power, strengthen the Hailuogou glacier tourism Rosto guidelines, which can enhance the development of the Hailuogou glacier tourism to Ganzi Prefecture regional economic growth spillover capacity, provide more jobs for the destination community, and create more tax revenue for the local government.

With the success of the Beijing Winter Olympic Games, China has fulfilled its promise of "driving 300 million people to participate in snow and ice sports"; accordingly, they have driven the rapid growth of the snow and ice tourism economy. As an important part of the ice and snow tourism economy, glacier tourism will continue to see rapid development. China is rich in glacier resources, holding considerable economic potential in glacier tourism value. This study utilized Hailuogou Glacier Forest Park, a relatively well-developed glacier tourism area in China, as a case study. We quantified the reciprocal feedback relationships between Hailuogou glacier tourism development and economic growth in Ganzi Prefecture based on an econometric approach, which to some extent makes up for the shortcomings of existing qualitative studies, enriches the scientific research on the cryosphere, and, moreover, verifies the hypothesis that a two-way interaction exists between tourism and economic growth. However, as an exploratory study, there were

some shortcomings. In the initial development of the model, the study relied on relevant economic theory to suggest that tourism will, to some extent, contribute to local economic growth; furthermore, we suggest that the increase in local income brought about by local economic growth may indirectly contribute to local tourism. For example, it may contribute by bringing about infrastructure development and thus promoting tourism; however, our investigation of this potential was limited by the availability of data on infrastructure input variables. Thus, it was not possible to add infrastructure inputs as new endogenous variables in the VAR model to determine their influence on tourism. Accordingly, we were unable to validate the following hypothesized driving mechanism: "economic growth in Ganzi brings about the development of infrastructure, which in turn drives the level of tourism development in Hailuogou".

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