Gmail S A M <ethan.eryn@gmail.com>

Invitation to review manuscript for Heliyon - Reminder

1 message

Heliyon <em@editorialmanager.com> Thu, Nov 9, 2023 at 6:08 PM
Reply-To: Heliyon <info@heliyon.com>
To: Samuel PD Anantadjaya <ethan.eryn@gmail.com>

Manuscript Number: HELIYON-D-23-50634R1
Title: Non-linear effects of tourism specialization level on tourism green total factor productivity in Chinese Cities

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Abstract:
The global comparable Malmquist model is used to measure the green total factor productivity of tourism in 285 prefecture-level and above cities in China from 2000 to 2020, and then a panel smoothed transformation regression model is used to explore the smoothed transformation effect between tourism specialization level and green total factor productivity of tourism. The results show that (1) the level of tourism specialization can significantly improve tourism green total factor productivity, and technological progress in tourism industry is an important way for tourism specialization level to promote urban tourism green total factor productivity. (2) The effect of tourism specialization level on tourism green total factor productivity presents a non-linear smooth transformation characteristic of increasing marginal effect. After robustness and endogeneity tests, the effect of its influence remains robust. (3) The level of tourism specialization has the same significant
nonlinear promotion effect on tourism green total factor productivity and technological progress. (4) The sub-regional heterogeneity analysis shows that the boosting effect of tourism specialization level on tourism green total factor

productivity is more pronounced in regions with high tourism development and high tourism specialization level. The above findings not only provide a new perspective for understanding and analyzing the green total factor productivity development of tourism in Chinese cities, but also provide a reference for the rational use of tourism specialization level to promote the high-quality development of urban tourism.

Keywords: level of tourism specialization; Technical efficiency; tourism green total factor productivity; global comparable Malmquist model; panel smoothed transformed regression model

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Manuscript Number: HELIYON-D-23-50634R1

Title: Non-linear effects of tourism specialization level on tourism green total factor productivity in Chinese Cities

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Non-linear effects of tourism specialization level on tourism green total factor productivity in Chinese Cities

Revision Number 1
Samuel PD Anantadjaya

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Non-linear effects of tourism specialization level on tourism green total factor productivity in Chinese Cities

--Manuscript Draft--

Manuscript Number:	HELIYON-D-23-50634R1
Article Type:	Original Research Article
Section/Category:	Social Sciences
Keywords:	level of tourism specialization; Technical efficiency; tourism green total factor productivity; global comparable Malmquist model; panel smoothed transformed regression model
Abstract:	The global comparable Malmquist model is used to measure the green total factor productivity of tourism in 285 prefecture-level and above cities in China from 2000 to 2020, and then a panel smoothed transformation regression model is used to explore the smoothed transformation effect between tourism specialization level and green total factor productivity of tourism. The results show that (1) the level of tourism specialization can significantly improve tourism green total factor productivity, and technological progress in tourism industry is an important way for tourism specialization level to promote urban tourism green total factor productivity. (2) The effect of tourism specialization level on tourism green total factor productivity presents a non-linear smooth transformation characteristic of increasing marginal effect. After robustness and endogeneity tests, the effect of its influence remains robust. (3) The level of tourism specialization has the same significant nonlinear promotion effect on tourism green total factor productivity and technological progress. (4) The sub-regional heterogeneity analysis shows that the boosting effect of tourism specialization level on tourism green total factor productivity is more pronounced in regions with high tourism development and high tourism specialization level. The above findings not only provide a new perspective for understanding and analyzing the green total factor productivity development of tourism in Chinese cities, but also provide a reference for the rational use of tourism specialization level to promote the high-quality development of urban tourism.

Dear editor:

Regional Differences, Distribution Dynamics, and Convergence of the Green Total Factor Productivity of China’s Cities under the Dual Carbon Targets

It may be that the research methods are similar, but the research contents are completely different.

Best regards,

Liang

Non-linear effects of tourism specialization level on tourism green total factor productivity in Chinese Cities

Zhenjie Liao [1], Shan Liang [2*]

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Abstract: The global comparable Malmquist model is used to measure the green total factor productivity of tourism in 285 prefecture-level and above cities in China from 2000 to 2020, and then a panel smoothed transformation regression model is used to explore the smoothed transformation effect between tourism specialization level and green total factor productivity of tourism. The results show that (1) the level of tourism specialization can significantly improve tourism green total factor productivity(TGTFP), and technological progress in tourism industry is an important way for tourism specialization level to promote urban TGTFP. (2) The effect of tourism specialization level on TGTFP presents a non-linear smooth transformation characteristic of increasing marginal effect. After robustness and endogeneity tests, the effect of its influence remains robust. (3) The level of tourism specialization has the same significant nonlinear promotion effect on TGTFP and technological progress. (4) The sub-regional heterogeneity analysis shows that the boosting effect of tourism specialization level on TGTFP is more pronounced in regions with high tourism development and high tourism specialization level. The above findings not only provide a new perspective for understanding and analyzing the green total factor productivity development of tourism in Chinese cities, but also provide a reference for the rational use of tourism specialization level to promote the high-quality development of urban tourism.

Keywords: level of tourism specialization; technical efficiency; tourism green total factor productivity(TGTFP); global comparable Malmquist model; panel smoothed transformed regression model

1Introduction

As an important part of the tertiary industry, tourism industry has the characteristics of strong integration and wide industrial correlation, and achieving high-quality and high-efficiency development of tourism is an important mission given to tourism development in the new era [1]. Tourism total factor productivity, i.e., the degree of changes in the efficiency of the allocation and utilization of various factors in the tourism industry during the development process, highlights the benefits of technological progress, management efficiency, service quality, and structural upgrading more than ordinary efficiency [2,3]. From the existing domestic and international literature, as environmental issues have gradually been elevated to an international issue, countries have increasingly emphasized the accuracy of measuring, recording and publishing indicators on environmental issues in national economic accounts. The Fischer indexes used earlier, for example, neglected the output of environmentally harmful by-products in the production process and deviated from the truthfulness and accuracy of productivity growth [4]. Pittman (1983) first introduced environmental pollution as a non-consensual output into regional economic models by measuring and measuring the cost of environmental pollution generated in industrial production and

calculating this pollution cost as a non-consensual contribution variable in the ecological price mechanism [5]. Subsequently, scholars further enriched and improved the green total factor productivity measurement framework by considering both energy consumption and environmental pollution in the green economic efficiency model [6,7]. Domestic scholars earlier proposed the concept of green total factor productivity in order to put energy conservation and emission reduction in a prominent strategic position for improving economic quality, and to reflect more clearly the sustainable development status of regional economy by adding environmental cost indicators [8]. The research on green total factor productivity mainly measures the green total factor productivity of agriculture, forestry, industry and other industries in APEC countries and regions, Chinese provinces and watersheds with the help of data envelopment analysis (DEA), Manquist-Ruengberg (ML) index, EBM model, etc., analyzes the green total factor productivity of each region and industry Productivity stage characteristics and evolution trends of each region and industry, explore the mechanism of resource and environmental factors on the green development of each industry, and then propose feasible paths to promote the green total factor productivity of each industry in each region based on government, industry and public perspectives, and then guide each industry to follow the path of green and sustainable development [9-12]. In addition, since urban construction to achieve green transformation is often closely related to energy conservation, emission reduction and ecological optimization, low-carbon city construction in pursuit of high-quality urban development also gradually incorporates green total factor productivity into the evaluation framework and becomes a new research hotspot [13].

Currently, scholars have conducted few research results on green total factor productivity in tourism, among which a part of researchers focus on the relationship between energy consumption, carbon emission and tourism economic efficiency in tourism industry, while another part of researchers focus on tourism total factor productivity including hotels, travel agencies and tourism transportation [14]. The research on green total factor productivity of tourism is mainly conducted in coastal areas, Yangtze River economic zone and other regions, and the green total factor productivity of regional tourism is studied with the help of DEA-Malmquist model, Super SBM model, SBM-GML index model, etc., to measure the efficiency of regional tourism green total factor productivity(TGTFP), reveal its regional differences, spatial differentiation and evolutionary characteristics, analyze the green development trend of tourism in the region using spatial convergence test, and construct a panel data model to explore the influencing factors and main driving forces of its growth [15-17].

In summary, the scope of existing literature on green total factor productivity in tourism is mainly focused on the more economically developed regions of China, with fewer studies involving Chinese cities; in terms of research content, most of the literature still focuses on measuring green total factor productivity, lacking insight into the dynamic evolutionary trends and the influencing factors behind them.

2 Theoretical analysis and research hypothesis

The higher TGTFP indicates that the same tourism input can obtain more tourism output, and the tourism economic growth mode tends to be more intensive and endogenous. According to established studies, TGTFP can be decomposed into tourism technological change (TTC) and tourism technical efficiency change (TEC) [18]. Tourism technological progress refers to the overall outward movement of the production frontier representing the most advanced production technology, and the continuous improvement of the technology level makes more output with the given production factor input, which is expressed as the growth of tourism revenue or tourism number; tourism technical efficiency refers to the

increase of coordination among various resource factors under the existing technology level, such as institutional innovation, improving resource matching rate and scale efficiency, etc. To make the potential of the established technology level can be released to a greater extent. There is a strong intrinsic link between the level of tourism specialization and TGTFP, and the higher the level of specialization, the higher the regional pure technical efficiency is promoted through economies of scale, which effectively promotes the improvement of TGTFP. The specific mechanism of action is shown in Figure 1.

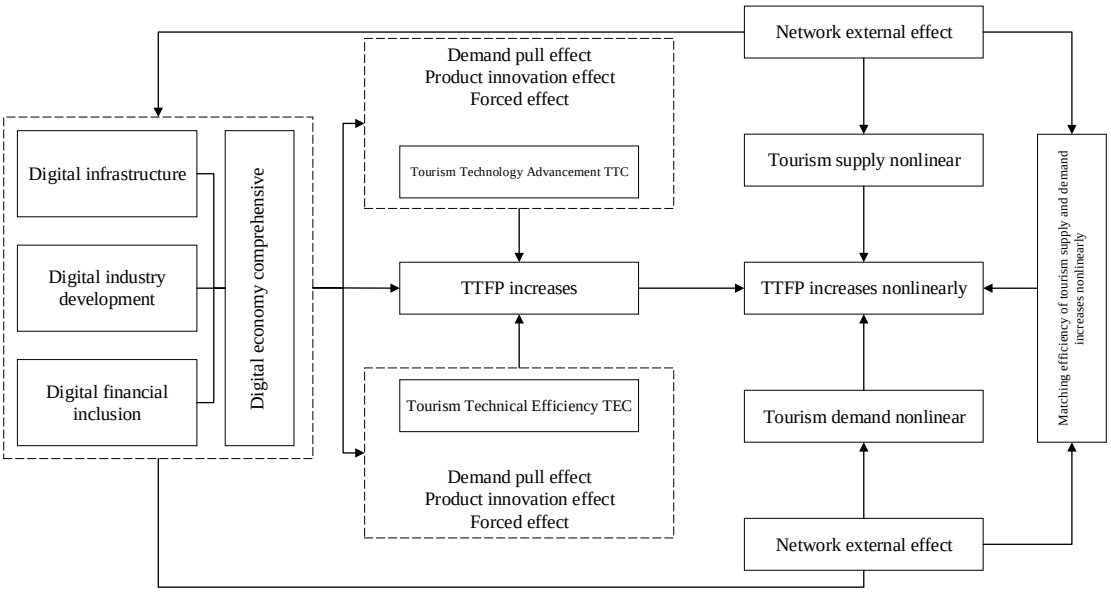

Fig. 1 Nonlinear impact mechanism of specialization level on tourism total factor productivity

3 Econometric models, variable measures and data sources

3.1 Research Methodology

In this paper, a panel smooth transition regression (PSTR) model is used to investigate in depth the asymptotic evolution of the relationship between the level of tourism specialization and TGTFP.The PSTR model is obtained by extending the panel threshold model (PTR) proposed by Hansen [19]. Compared with the traditional linear model, the PSTR model can effectively overcome the problem of biased parameter estimates due to endogeneity, especially by allowing the model parameters to make slow and smooth nonlinear transitions with the transition variables. In this paper, we first construct the PSTR model [20] with univariate two mechanisms (i.e., the existence of a transformation function) as shown in Eqs. (1) and (2).

$$Y_{i,t} = \varepsilon_i + \alpha_0 X_{it} + \alpha_0' X_{it} \theta(q_{it};\gamma,c) + \varepsilon_{i,t} \tag{1}$$

$$\theta(q_{it};\gamma,c) = \left(1+\exp\left(-\gamma \prod_{j=1}^{m}(q_{i,t}-c_j)\right)\right)^{-1} \tag{2}$$

In Eq. (1), *i is the* city and *t is the* time; $Y_{i,t}$ is the explained variable, $X_{i,t}$ is the vector of explanatory variables, and $\varepsilon_{i,t}$ is the error term. In Eq. (2), the transformation function $\theta(q_{i,t};\gamma,c)$ *is the* logistic function, which is a continuous function about the transformation variable $q_{i,t}$ and takes values in [0,1]. γ *is the*

smoothing parameter, which determines the transformation speed; *c* is the *m* dimensional vector of position parameters. It can be seen that the estimated coefficients of the variables in the PSTR model consist of a linear part α_0 and a nonlinear part $\alpha_0'\theta(\cdot)$ together, and the model exists in two mechanisms, when $\theta(\cdot)=0$, the model is in the low mechanism, and when $\theta(\cdot)=1$, the model is in the high mechanism, and the $X_{i,t}$ coefficient is monotonically smoothly transformed between α_0 and $\alpha_0+\alpha_0'$ as the value of the transformation function moves smoothly between 0 and 1.

3.2 Variable measures and descriptions

3.2.1 Urban TGTFP measure

(1) Indicator system construction

Based on the completeness and consistency of data, this paper takes 285 prefecture-level and above cities in China from 2000 to 2020 as the research object to measure TGTFP. At present, a more mature index system for measuring tourism total factor productivity has been formed internationally, and combined with the definition of total factor productivity in economics, tourism input indicators are mainly selected from four perspectives: labor, capital, energy and resource inputs [21-23].

①Labor input, distinguished from other industries, the labor force in tourism industry is mainly concentrated in star-rated hotels, travel agencies and scenic spots and other service sectors. Among them, the statistical scope of tourism workers in 2000-2020 is star-rated hotels, travel agencies and tourist attractions.

②Capital input, using physical capital stock as capital input is the most ideal variable data, considering the availability of tourism data and the scientific nature of data processing methods, this paper uses the original value of fixed assets in tourism at the end of each year in each province as an approximate proxy, and the statistical scope of each year is the same as the statistical scope of the number of people employed in tourism. Also, considering that the GML index measurement is presented in the form of a ratio, capital input is not adjusted here with 2000 as the base period [24].

③Resource input, the number of star-rated hotels and travel agencies are mainly selected as important indicators of tourism resource input.

④Energy inputs, which are characterized using energy consumption. Tourism output indicators include the desired output indicators along with the non-desired output indicators. Expected output indicators are selected to reflect the total tourism economy and the scale of tourism economy in terms of total tourism revenue and total tourism receipts. The non-desired output is expressed by CO_2 emissions. For the measurement of energy consumption and carbon emissions, the "bottom-up" method is chosen, by calculating the energy consumption and carbon emissions of three major tourism industries, namely tourism transportation, tourism accommodation and tourism activities, and then adding them up.

(2) TGTFP measurement method

In this paper, we use MaxDEA 8Ultra software to measure urban TGTFP using the global referenceable Malmquist (GRM) model, which is a GRM index model with the frontier (global frontier) constructed jointly for all periods as the reference frontier to avoid the non-transferability of non-global indices and potential linear programming shortcomings such as the unsolvable problem, and the formulas can be found in existing studies [25,26]. The final TGTFP index and its product decomposition terms TEC index and TTC index are obtained. Among them, TEC index represents the technical efficiency change; TTC index represents the technical progress. Since the indices obtained from the calculation are the rates of change of TGTFP, technical efficiency and technical progress, referring to the previous practice [27,28],

TGTFP, TEC and TTC of the base period cities are assumed to be 1, and then cumulatively multiplied with the corresponding year indices to obtain TGTFP, TEC and TTC from 2000 to 2020.

3.2.2 Level of tourism specialization

With reference to the literature [29,30], the level of tourism specialization is expressed as the ratio of the share of the output value of an industry in the regional GDP to the corresponding share in the region, calculated by the formula .

$$S_{it} = \frac{T_{it}/G_{it}}{T_t/G_t} \tag{3}$$

Where, S_{it} denotes the level of tourism specialization of city *i in period t;* T_{it} and T_t denote the total tourism revenue (including domestic tourism revenue and inbound tourism revenue) of a city and the whole China in period *t, respectively*; G_{it} and G_t denote the gross product of a city and the whole China in period *t, respectively*. The larger the value of S_{it} , the stronger the degree of tourism industry agglomeration in the city and the more significant the industry pillar effect, and the lower the opposite.

3.3 Model Setting

This paper empirically tests the non-linear relationship between the two by constructing a PSTR model of the level of tourism specialization affecting TGTFP, with the following econometric model settings:

$$Y_{i,t} = \varepsilon_i + \alpha_0 DE_{it} + \alpha_0' DE_{it}\theta(DE_{it};\gamma,c) + \beta_0 Z_{it} + \varepsilon_{i,t} \tag{4}$$

In equation (4), $Y_{i,t}$ is the explanatory variable, and TGTFP, TEC, and TTC are used as explanatory variables, respectively, to explore whether the level of tourism specialization can promote urban TGTFP enhancement and to identify the main ways to promote TGTFP. The level of tourism specialization (*TS) is the* core explanatory variable and the transformation variable, $Z_{i,t}$ is a set of control variable vectors, and $\theta(TS_{i,t};\gamma,c)$ is the transformation function with the level of tourism specialization as the transformation variable. The choice of the transformation variables is mainly based on the consideration that the utility of the effect of the level of tourism specialization on TGTFP changes with the development of the level of tourism specialization.

Relevant control variables: in order to more accurately analyze the effect of the level of tourism specialization in the process of green total factor productivity development of urban tourism, the following control variables were also included with reference to relevant research results [31-33]: tourism industry size (TomDp), total tourism industry revenue over gross regional product; industrial structure upgrading (IndPd), the proportion of value added of the third sector to value added of the second sector; Economic development level (GdpRt), the growth rate of regional GDP; government efficiency (GovFy), the ratio of GDP to fiscal expenditure; science and education development level (SciEd), the ratio of government fiscal expenditure on research and education to GDP; and marketization level (MarKDex), obtained from the FanGang marketization index.

3.4 Data sources

This paper uses the tourism input and output data of 285 Chinese cities from 2000 to 2020, to calculate the city TGTFP, TEC, and TTC from 2000 to 2020, and combines the relevant data for 285 prefecture-level Chinese cities from 2000 to 2020 and above cities in China from 2000 to 2020, and the study of tourism specialization level-total green factor productivity of tourism was conducted to form a balanced panel observation of 256 cities-years. The data sources for each indicator are CEIC database, China City

Statistical Yearbook, China Tertiary Industry Statistical Yearbook, China Regional Economic Statistical Yearbook, and the statistical yearbooks and statistical bulletins of relevant prefecture-level cities. In order to eliminate the influence of price fluctuations, all price indicators in this paper are deflated based on the consumer priceindex (CPI) in 2000 as the base period, and the stock of tourism fixed assets is adjusted by the fixed asset price index with 1999 as the base period. For individual missing data, linear interpolation is used to complete the paper.

4 Analysis of empirical results

4.1 Tourism specialization level and TGTFP measurement results

In order to visualize the spatio-temporal evolution characteristics of tourism specialization level and TGTFP, this paper intercepted five time periods of 2000, 2005, 2010, 2015 and 2020, and divided the tourism specialization level and TGTFP values into seven categories. (1) Figure 2 shows the spatio-temporal distribution of tourism specialization level. In terms of time, the level of tourism specialization in most Chinese cities has increased significantly from 2000 to 2020. (2) Figure 3 shows the spatio-temporal distribution of TGTFP. In terms of time evolution, most cities have gained significant growth in TGTFP compared to the base period. Spatially, there is a certain degree of spatial misalignment between urban TGTFP patterns and tourism economic growth, as shown in regions such as Beijing, Shanghai, Guangzhou, Hangzhou, and Chongqing, which do not rank prominently in TGTFP despite their high levels of tourism economic development. This suggests that tourism economic growth is not a sufficient condition to promote TGTFP.

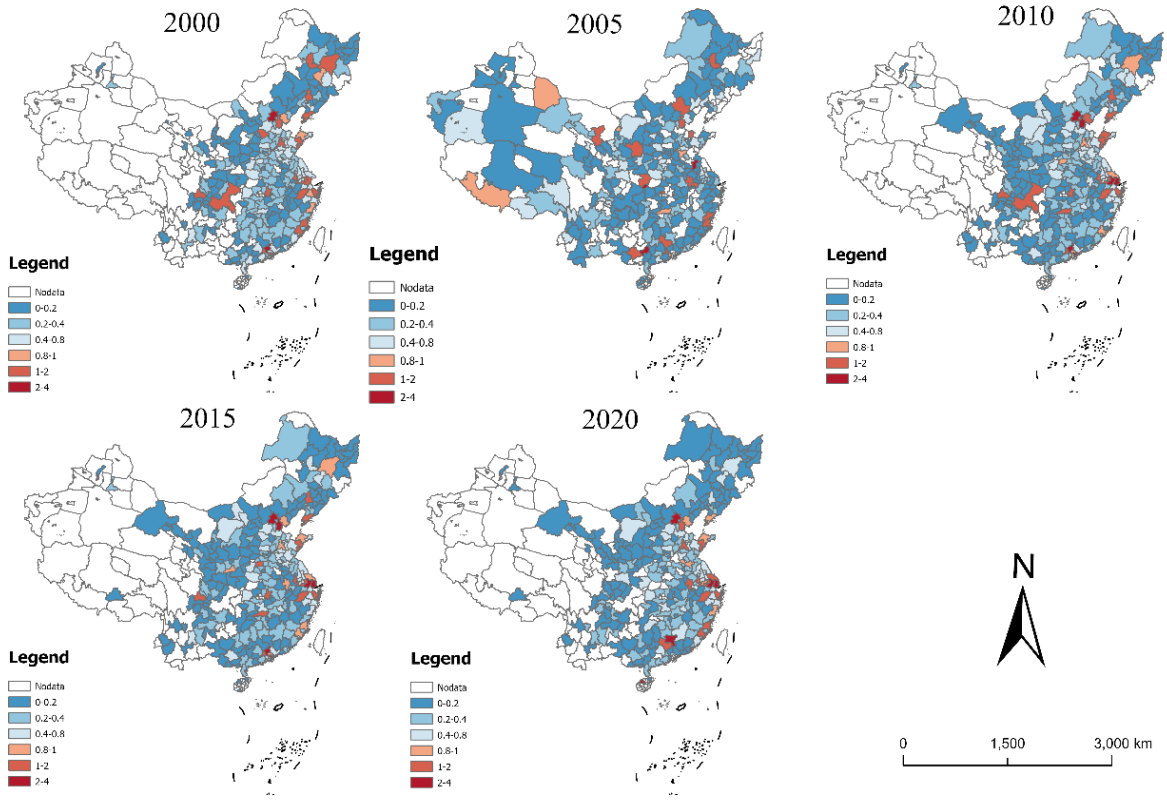

Fig. 2 Distribution of tourism specialization level

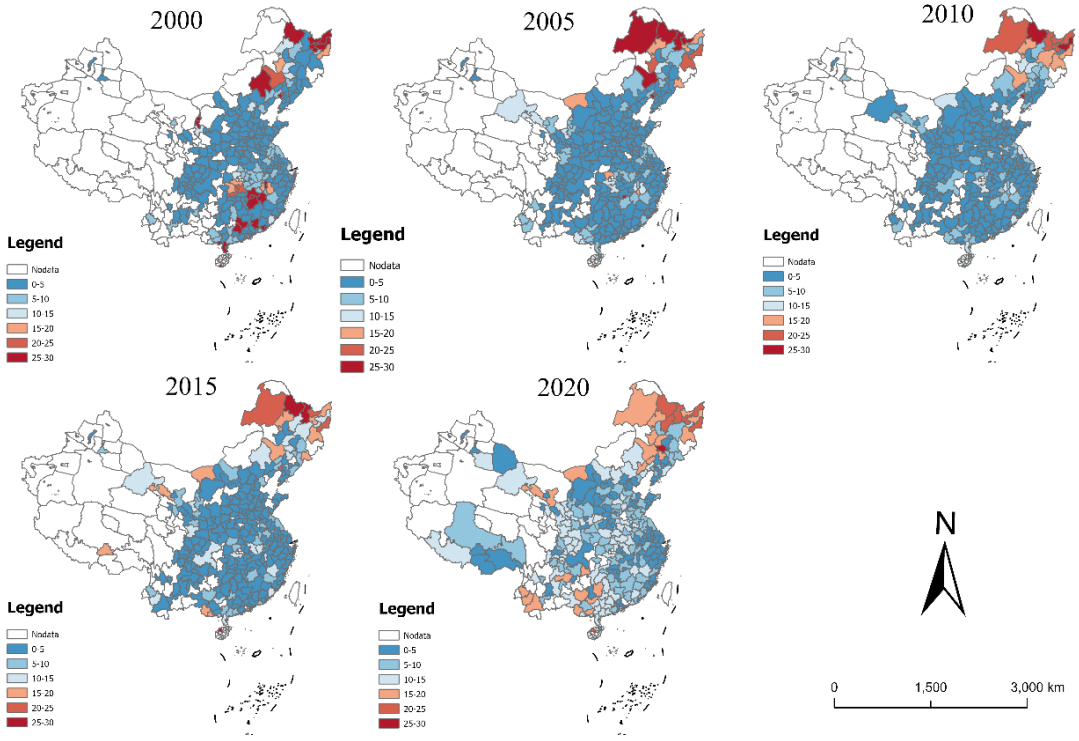

Fig. 3 Distribution of TGTFP

4.2 Model nonlinearity test

A nonlinearity test was first performed on equation (4) to verify the presence of a nonlinear mechanism transformation effect. Since the model contains unidentified parameters γ and c, it is not possible to perform a traditional nonlinearity test on the model. González et al. suggest following Luukkonen et al. [34] by making the null hypothesis of homogeneity H0:γ=0 and replacing it with a first-order Taylor expansion of the transformation function at γ=0. Then, the auxiliary regression equation and the linear fixed effects model are estimated separately, and the two models are tested based on the residual sum of squares to construct statistics for testing, using the LM that obeys the χ2 distribution and the LMF test statistic that obeys the F distribution.

$$LM = \frac{TN(SSR_0 - SSR_1)}{SSR_0} \tag{5}$$

$$LM_F = \left[\frac{(SSR_0 - SSR_1)}{mk}\right] \Big/ \left[\frac{SSR_0}{TN - N - mk}\right] \sim F(mk, TN - N - mk) \tag{6}$$

In equation (6), T is the length of time, N *is the number of* cross sections, k is the number of exogenous variables, and SSR_0 and SSR_1 are the residual sums of squares for accepting and rejecting the original hypothesis, respectively. The models with TGTFP, TEC and TTC as explanatory variables were tested for nonlinearity in turn, and the results are shown in Table 1. The results show that when m=1 and m=2, the *LM*, LM_F and their robust forms of model 1, model 2 and model 3 reject the original hypothesis of linearity at the 0.01 level; when m=3, only model 3 passes the 0.01 significance test, model 2 does not pass the significance test, and Model 1 only passed the 0.05 significance test. Therefore, when the number of location parameters is m=1 and m=2, there is a non-linear effect of tourism specialization level on TGTFP, TEC and TTC with tourism specialization level as the transition variable, and the PSTR model can

be used for parameter estimation. Further, according to González et al. view [35], the value of *m* in the case where the original hypothesis is rejected more strongly should be chosen as the number of location parameters, and in a comprehensive judgment, the number of location parameters should be chosen as 1 for model 1, model 2 and model 3, i.e., m=1.

Tab. 1 Test for nonlinearity of the PSTR models

Variables	Model 1			Model 2			Model 3		
	m=1	m=2	m=3	m=1	m=2	m=3	m=1	m=2	m=3
	0.315*	-1.234	2.018**	-0.879	-0.049	-0.672*	0.993*	0.501*	0.695***
LM	0.042	0.071	0.003	0.109	0.12	0.032	0.026	0.06	0
	0.221	0.029	0.987***	0.043*	0.91	0.118	0.399	0.002	3.491***
LMF	0.183	0.165	0	0.035	0.489	0.237	0.098	0.642	0
	0.098	0.002	0.42	0.885	0.326	0.042	0.011	0.129	46.053***
HAC	0.024	0.123	0.997	0.083	0.221	0.134	0.508	0.347*	0
	0.31*	0.032*	0.008**	0.721	0.152	0.003**	0.444**	0.097	3.206***
HACF	0.091	0.021	0.002	0.357	0.817	0.041	0.05	0.603	0

4.3 Model parameter estimation

The PSTR model parameters were estimated using nonlinear least squares (NLS), where the slope coefficient γ of the transformation function and the location parameter c were estimated using the grid search method. To enhance the robustness of the results, the panel fixed effects model is also estimated as a comparison (Table 2). The estimated coefficients of the level of tourism specialization for TGTFP, TEC, and TTC in the linear estimation of the ordinary panel fixed model in Table 2 are 0.712, -0.067, and 0.520, respectively.The omission of the nonlinear relationship between the level of tourism specialization on TGTFP, TEC, and TTC leads to an impact effect that tends to underestimate the linear impact effect of the level of tourism specialization, while overestimating the overall impact effect of the level of specialization, and therefore, the impact effect of the level of tourism specialization lies between the low and high mechanisms. Therefore, the PSTR model better portrays the dynamic effects of tourism specialization level on TGTFP, TEC, and TTC compared to the linear estimation of the ordinary panel fixed model.

Tab. 2 Estimation results of the PSTR models and panel linear model

Variables	Model 1			Model 2			Model 3		
	PSTR		FE	PSTR		FE	PSTR		FE
	Linear	Nonlinear		Linear	Nonlinear		Linear	Nonlinear	
TS	0.305**	-0.109	0.712***	1.209***	-0.865	-0.067	0.107	0.347***	0.520**
	(0.097)	(0.132)	(0.083)	(0.184)	(0.212)	(0.068)	(0.103)	(0.057)	(0.144)
TomDp	1.112***	-0.032	0.498**	1.654***	-0.207	0.418**	-0.039	0.252**	0.723**
	(0.251)	(0.336)	(0.212)	(0.468)	(0.538)	(0.168)	(0.257)	(0.149)	(0.326)
IndPd	-0.124	-0.001	0.366***	0.796***	-0.458	-0.039	0.023	0.252***	0.645***
	(0.078)	(0.118)	(0.065)	(0.164)	(0.182)	(0.049)	(0.074)	(0.041)	(0.103)
GdpRt	0.927***	-0.015	0.341**	1.244***	-0.112	0.718***	-0.033	0.333**	0.897***
	(0.197)	(0.302)	(0.178)	(0.391)	(0.449)	(0.143)	(0.219)	(0.127)	(0.278)
GovF	0.245**	-0.124	0.685***	1.309***	-0.842	-0.068	0.062	0.246***	0.603***
	(0.092)	(0.1380	(0.076)	(0.189)	(0.208)	(0.056)	(0.084)	(0.046)	(0.115)
SciEd	1.324***	-0.049	0.567*	1.618***	-0.346	-0.259	-0.484	-0.361	0.486**

	(0.266)	(0.408)	(0.235)	(0.517)	(0.584)	(0.16)	(0.114)	(0.127)	(0.161)
MarKDex	-0.069	0.035	0.409***	0.983***	-0.615	-0.129	-0.224	0.063	0.024
	(0.083)	(0.125)	(0.069)	(0.173)	(0.192)	(0.37)	(0.316)	(0.066)	(0.045)
γ		-0.072	-		0.435***	-		0.372***	-
		(0.1)	-		(0.055)	-		(0.124)	-
C		-0.065	-		0.285**	-		0.253***	-
		(0.068)	-		(0.14)	-		(0.048)	-

4.3.1 Smoothing transformation effect of tourism specialization level on TGTFP

The estimation results of model 1 in Table 2 show that the estimated coefficient α0 of the linear part of the level of tourism specialization of TGTFP is 0.305; the estimated coefficient α0′ of the nonlinear part is -0.109, which is significant at the 0.05 level. It indicates that there is a significant positive contribution of tourism specialization level to TGTFP. Combined with the conversion function, when the conversion function $\theta(TS;\gamma,c)$=0, the effect of the level of tourism specialization on urban TGTFP influence is 0.305, and the model is in the low mechanism. When the transformation variable tourism specialization level is at the value of position parameter c -0.065, $\theta(TS;\ \gamma,c)$=0.5, the tourism specialization level impact effect on TGTFP is 1.735 (i.e. α0+0.5α0′), and the model is in the middle of the low-high mechanism. When $\theta(TS;\gamma,c)$=1, the tourism specialization level impact effect on TGTFP is 2.568 (i.e., α0+α0′), and the model is in the high mechanism. The effect of the level of tourism specialization on urban TGTFP effect is between the low and high mechanisms, centered on the location parameter c = -0.065, with a smooth transition rate of γ = 19.310 between [0.305, 2.568]. In other words, the impact of the level of tourism specialization on urban TGTFP is dynamic and nonlinear, with smooth transitions in the relationship between the level of tourism specialization and TGTFP when the level of tourism specialization is at different stages of development. Initially, the impact of lower levels of tourism specialization on TGTFP is insignificant and needs to reach a certain scale to effectively promote TGTFP, and as the level of tourism specialization continues to increase, the impact of tourism specialization on TGTFP becomes more significant and the marginal effect increases subsequently. Specifically, when the level of tourism specialization is low, the impact effect is in the low impact state, and when the level of tourism specialization crosses the threshold value of -0.065, the impact effect of tourism specialization level starts to gradually shift from the low impact state to the high impact state, and finally continues to be in the high impact state. This may be due to the fact that the initial investment in the level of tourism specialization takes up a large amount of resources, but does not immediately produce an effective return on tourism development, or the return is much lower than the level of investment. Only after reaching the inflection point of tourism specialization level growth, the development of tourism specialization level will significantly affect TGTFP and gradually promote TGTFP to a deeper level. Therefore, this paper argues that in the coming period, relevant government departments should continue to enhance the level of tourism specialization, so that the level of tourism specialization can better play a positive role in promoting the green total factor productivity of regional tourism.

In addition, the model in this paper contains other control variables, taking the TGTFP estimation in Table 2 as an example: tourism industry development (TomDp) has a significant contribution to TGTFP, indicating that the higher the share of tourism industry, the higher the TGTFP, which may be due to the high share of regional tourism in the national economy, which is more likely to receive financial and technological support from the government. At the same time, under the influence of agglomeration

economy, enterprises are able to reduce talent search costs, strengthen technological linkages and spillover effects, promote technological progress and organizational management improvement, and thus increase total factor productivity. The level of economic development (GdpRt) has a promoting effect on TGTFP, which indicates the high importance of accelerating urban industrial transformation and upgrading and vigorously developing national economy to improve TGTFP; the influence of government efficiency (GovFy) on tourism total factor turns from positive to negative, which indicates that moderate government intervention has a significant positive promoting effect on tourism. Although industrial structure upgrading (IndPd), science education (SciEd) and marketization level (MarKDex) did not pass the significance test, the coefficients were positive overall, indicating a positive effect on TGTFP.

4.3.2 Smoothing conversion effect of the level of tourism specialization on the TEC

The PSTR model estimation results for model 2 in Table 2 show that the estimated coefficient α0 for the linear part of the level of tourism specialization of TEC is 0.045 and the estimated coefficient α0′ for the nonlinear part is 0.430, and neither of them passes the significance test at the 0.1 level, it shows that the effect of the level of tourism specialization on TEC is not significant during the study period. The effect of the level of tourism specialization on the technical efficiency of tourism is completely different from its effect on TGTFP and TTC. The possible reason for this is that although the development of the level of tourism specialization has broken the information asymmetry between (potential) tourists and destinations, alleviated the imbalance between the supply and demand of tourism labor, and improved technical efficiency to some extent; however, most tourism enterprises have not been able to keep up with the development needs of the professional era in terms of organizational management and corporate culture, and at the same time, the large OTA (online travel agency) platform as the representative of the monopoly behavior and long-tail economic thinking, service thinking is not conducive to the regional tourism industry technical efficiency, under the combined positive and negative effect of the impact of the level of tourism specialization, their forces on technical efficiency offset each other, resulting in the impact of tourism technical efficiency is not significant. Therefore, we should conform to the concept of high-quality tourism development, combine the external constraints of relevant macro and micro factors, clarify the shackles of the positive effect of tourism specialization level to play, explore the mode and channel of tourism specialization level to promote the technical efficiency of tourism industry, so that the development dividend of tourism specialization level can better contribute to the improvement of overall efficiency of tourism industry.

4.3.3 Smoothing transition effect of the level of tourism specialization on TTC

The impact of the level of tourism specialization on the technological progress of the tourism industry is very similar to the trend of its impact on the green total factor productivity of tourism. The results of model 3 estimation in Table 2 show that the estimated coefficient α0 of the linear part of the level of tourism specialization for TTC is 0.107 and the estimated coefficient α0′ of the nonlinear part is 0.347, which is significant at the 0.01 level, indicating that there is a positive contribution of the level of tourism specialization to the technological progress of tourism. The positive effect of the level of tourism specialization on the technological progress of the tourism industry shifts smoothly between [0.107, 1.531]. When the level of tourism specialization crosses the location parameter c = 0.253, the impact effect of the level of tourism specialization begins to gradually shift from a low impact state to a high impact state, and eventually continues in a high impact state during the study period. The slope coefficient γ of model 3 smoothed between impact effect mechanisms is 68.300, indicating that the model transitions between

low-high mechanisms relatively quickly. The reason for the nonlinear effect of technological progress is mainly due to the fact that the higher the level of urban tourism specialization, the more it can exert the power of its network externalities, which in turn forms a stronger product innovation effect, demand pull effect and push back effect, prompting the accelerated expansion of the production frontier surface of urban tourism through the paths of innovative tourism products and business types, precise marketing, and push back tourism industry transformation and upgrading, promoting Tourism industry technological progress, and further realize the promotion of TGTFP continues to increase. The level of tourism specialization has led to the expansion of the production frontier surface of urban tourism, which is more reflective of the comprehensive promotion of the level of tourism specialization to improve the quality and efficiency of urban tourism.

Taken together, TGTFP is an important indicator of regional tourism quality improvement and efficiency, and it is crucial to identify its driving mechanism. Looking at the three models, from the fixed effects estimated coefficients, the estimated coefficients of tourism specialization level on TGTFP and TTC are 0.712 and 0.520, respectively, and both pass the 0.01 significance level, while the estimated coefficient on TEC is only -0.067 and does not pass the significance test. Based on the quantitative relationship between TGTFP, TEC, and TTC (TGTFP is the product of TEC and TTC), as far as linear estimation is concerned, it can be initially identified that the effect of the level of tourism specialization on TGTFP is mainly achieved by influencing the technological progress in tourism. In addition, the trend of the smoothed transformation of PSTR estimates shows that as the level of tourism specialization deepens, the estimated coefficient of the level of tourism specialization on TGTFP becomes larger and the estimated coefficient of TTC becomes larger, profoundly indicating the synergy of the two smoothed transformation mechanisms, in contrast, the estimated coefficient of the level of tourism specialization on TEC has an increasing trend, but none of them pass the significance test. It further suggests that the intensification of the driving effect of the level of tourism specialization on TGTFP comes through the promotion of technological progress in tourism. Both linear and non-linear estimation results suggest that the boosting effect of the level of tourism specialization on TGTFP is mainly achieved from the boosting of technological progress in the tourism industry, rather than the technical efficiency of the tourism industry.

4.4 Decomposition of the effect of tourism specialization level on TGTFP

In order to further refine the effect analysis of tourism specialization level-TGTFP enhancement, this paper uses the four dimensions of tourism resource endowment, economic development level, marketization degree and industrial structure in the tourism specialization level indicator system as independent variables for empirical testing, and further explores the specific factors of tourism specialization level on urban TGTFP, TEC and TTC. The estimation results of model 4 in Table 3 show that the estimated coefficient $\alpha 0$ for the linear part of tourism resource endowment (TRS) is 3.881; the estimated coefficient $\alpha 0'$ for the nonlinear part is 7.199, which passes the significance test of 0.05. It indicates that there is a significant positive contribution of professional infrastructure to TGTFP. When professional infrastructure crosses the location parameter c=0.101, its effect on TGTFP is smoothly transformed from low mechanism to high mechanism, and reaches the maximum value of high mechanism 11.080 when $\theta(TS;\gamma,c)$=1, indicating that the effect of professional infrastructure on TGTFP always has positive promotion effect, and the improvement of professional infrastructure will not only promote urban tourism space specialization and intelligent transformation and upgrading, but also through the improvement of network coverage level to realize the effective matching of tourism information and improve tourism total factor productivity.

Therefore, with the gradual improvement of professional infrastructure, the marginal effect of its effect on TGTFP enhancement increases. The estimated coefficients of both linear and nonlinear parts of professional infrastructure on tourism technical efficiency do not pass the significance test, indicating that the effect of urban professional infrastructure on tourism technical efficiency is not significant, which is basically consistent with the trend of TEC model in Table 2. The results of model 5 estimation in Table 3 show that the positive effect of professional infrastructure on tourism technical progress shifts smoothly between [0.355, 6.707]. When the level of tourism specialization crosses the location parameter c= 0.126, the impact effect of the level of tourism specialization begins to gradually shift from a low impact state to a high impact state and eventually persists in a high impact state during the study period.

Tab. 3 Estimation results of the PSTR models for the digital economy in different dimensions

Variables	Model 4		Model 5		Model 6		Model 7		Model 8		Model 9		Model 10		Model11	Model11
	TGTFP		TTC		TGTFP		TTC		TGTFP		TTC		TGTFP		TTC	
	Linear	Non-linear	Linear	Non-linear	Linear	Non-linear	Linear	Non-linear	Linear	Non-linear	Linear	Non-linear	Linear	Non-linear	Linear	Non-linear
TRS	-0.044	0.716***	-0.051	0.737***												
	(0.07)	(0.195)	(0.057)	(0.127)												
EC					0.057	-0.048	-0.041	-0.037								
					(0.106)	(0.297)	(0.086)	(0.194)								
MA									-0.017	0.182**	0.236**	0.197***				
									(0.071)	(0.058)	(0.17)	(0.047)				
SAI													0.192**	0.197***	0.395***	0.748***
													(0.111)	(0.039)	(0.146)	(0.374)
	0.377***	-0.322	0.338***	-0.335	-0.036	-0.033	-0.013	-0.029	0.21***	0.181***	0.178***	0.951***	1.002***	-0.352	-0.35	-0.329
γ	(0.118)	(0.131)	(0.099)	(0.111)	(0.042)	(0.035)	(0.115)	(0.143)	(0.029)	(0.035)	(0.029)	(0.165)	(0.204)	(0.082)	(0.099)	(0.082)
	0.861***	-0.198	-10.015	0.758***	20.820***	30.998	-0.012	-0.015	0.193***	0.165***	0.346***	0.341***	0.312***	-10.156	-0.126	43.23
c	(0.244)	(0.275)	(0.035)	(0.076)	(0.094)	(0.053)	(0.064)	(0.052)	(0.064)	(0.079)	(0.073)	(0.088)	(0.073)	(0.185)	(0.229)	(0.592)

From the estimation results of model 6 and model 7 in Table 3, the non-linear estimation part of economic development level (EC) on both TGTFP and TTC is significantly positive, indicating that the professional industry development has a significant contribution to the improvement of both green total factor productivity and technological progress in tourism. This may be because the accelerated application of big data, cloud computing, mobile communication and smart terminals in tourism industry not only promotes the optimal allocation of tourism factor resources and the transformation and upgrading of tourism industry, but also improves the ability of accurate marketing of tourism products and achieves a more balanced supply and demand structure through the Internet, which promotes the technological progress of tourism industry and thus enhances the green total factor productivity of tourism.

From the estimation results of model 8 and model 9 in Table 3, the linear and nonlinear estimated coefficients of the degree of marketization (MA) on the PSTR models of TGTFP and TTC are positive, and the estimated coefficients of the nonlinear part pass the significance tests of 0.05 and 0.01, respectively, indicating that the degree of marketization has a significant positive effect on TGTFP and technological progress. The degree of marketization directly determines the level of tourism specialization and the ability of tourism industry integration, and the deep integration of expertise and tourism industry promotes tourism product innovation and business model innovation, promotes tourism industry technological progress, and enhances TGTFP. At the same time, with the increase of enterprises with market-oriented degree, it changes and intensifies the competitive market environment, forcing the tourism industry to transform and upgrade, which in turn accelerates the transfer of capital to innovative and developmental tourism enterprises, and thus promotes the technological progress of regional tourism industry and the improvement of TGTFP. From the estimation results of model 10 and model 11 in Table 3, the linear and nonlinear estimated coefficients of industry structure (SA) on the PSTR models of TGTFP and TTC are both positive, and the estimated coefficients of the nonlinear part also pass the significance tests of 0.05 and 0.01, respectively, indicating that industry structure has a significant positive effect on TGTFP and technological progress. The main reason is that the industrial structure can broaden the financing channels of tourism enterprises and alleviate the problem of financing constraints of tourism enterprises, which makes tourism enterprises have enough funds to carry out tourism technology innovation and promote technological progress, thus improving TGTFP. In addition, the estimated results of industrial structure on tourism technical efficiency (TEC) are insignificant, probably because, although industrial structure can stimulate behaviors such as online booking and payment, which improve tourism convenience and satisfaction while reducing transaction costs for (potential) tourists and improving tourism technical efficiency; however, precisely because of the low transaction costs, resulting in a higher probability of (potential) tourists to abort the transaction, tourism enterprises unilaterally suffer default losses, the positive and negative effects cancel each other out, resulting in an insignificant effect of industry structure on tourism technical efficiency. Taken together, the results of the PSTR model estimation show that the four sub-dimensions of the level of tourism specialization (tourism resource endowment, level of economic development, degree of marketization, and industry structure) have a significant positive driving effect on the improvement of green total factor productivity of urban tourism and technical progress of tourism, but not on the technical efficiency of tourism. This proves the important finding that the level of tourism specialization contributes to the improvement of urban TGTFP by driving technological progress and also proves the high robustness of the findings of

this paper from the perspective of replacing the core explanatory variables.

4.5 Robustness tests

The robustness tests in this paper mainly consider the measurement error of the explanatory variable (TGTFP). Specifically, first, referring to Jiang et al [36], the number of tourism employees in each provincial administrative region multiplied by the share of tertiary industry employees in the provincial administrative region to which the city belongs is used to obtain the number of tourism employees in each city, which is used as an indicator for the robustness analysis of tourism human capital and re-measure the explanatory variables (model 12 and model 13 in Table 4); second, referring to Yang et al [37] (model 14 and model 15 in Table 4); third, referring to the treatment of tourism resource indicators in established studies [38], we assign weights of 2 and 1 to world-class and national tourism resources, respectively, and then multiply them by the corresponding number of resources and then summed up and used as the robustness analysis variables for tourism resource inputs (Model 16 and Model 17 in Table 4). Finally, the model estimation results after replacing the explanatory variables show that the effect of tourism specialization level on TGTFP maintains a good robustness.

Tab. 4 Results of robustness check

Variables	Model 12		Model 13		Model 14		Model 15		Model 16		Model 17	
	TGTFP		TTC		TGTFP		TTC		TGTFP		TTC	
	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear
TRS	-0.029	-0.016	0.88*	0.307	0.324**	0.78***	-0.014	0.175***	1.011***	-0.118	-0.022	0.177***
	(0.035)	(0.052)	(0.175)	(0.029)	(0.073)	(0.103)	(0.157)	(0.088)	(0.226)	(0.253)	(0.034)	(0.028)
γ	0.281***		-0.291		0.789***		-0.018		0.167***		1.01***	
	(0.071)		(0.080)		(0.101)		(0.153)		(0.085)		(0.219)	
c	-0.105		-0.011		-0.033		0.172***		0.239***		-0.250	
	(0.246)		(0.034)		(0.051)		(0.028)		(0.070)		(0.078)	

Tab. 5 Estimation results of the PSTR models for transform variable lagged

Variables	TGTFP			TEC			TTC		
	PSTR		FE	PSTR		FE	PSTR		FE
	Linear	Nonlinear		Linear	Nonlinear		Linear	Nonlinear	
TS	-0.035	-0.022	0.18***	0.232**	-0.271	0.786***	-0.017	0.164***	1.002***
	(0.036)	(0.054)	(0.030)	(0.076)	(0.086)	(0.107)	(0.163)	(0.091)	(0.234)
γ	-0.083	-0.009	-	0.237**	0.799***	-	0.164***	-0.077	-
	(0.263)	(0.055)	-	(0.076)	(0.105)	-	(0.089)	(0.257)	-
c	-0.036	0.168***	-	-0.234	-0.022	-	1.007***	-0.017	-
	(0.037)	(0.030)	-	(0.085)	(0.159)	-	(0.229)	(0.037)	-

Tab. 6 Estimation results of the PSTR models for transform variable and independent variable lagged

Variables	TGTFP			TEC			TTC		
	PSTR		FE	PSTR		FE	STR		FE
	Linear	Nonlinear		Linear	Nonlinear		Linear	Nonlinear	
TS	-0.022	0.867	0.236***	-0.223	-2.13	-0.026	0.235**	-0.217	0.81***
	(0.037)	(0.055)	(0.030)	(0.076)	(0.086)	(0.057)	(0.229)	(0.258)	(0.031)
γ	-0.013	-0.067***	-	-0.022	-0.022	-	0.188***	-0.023	-
	(0.105)	(0.160)	-	(0.089)	(0.229)	-	(0.259)	(0.038)	-
c	0.167***	1.013***	-	-0.067	0.227**	-	-0.203	4.765	-

	(0.105)	(0.160)	-	(0.089)	(0.079)	-	(0.089)	(0.187)	-

4.6 Endogeneity test

Measurement error, omitted variables, and reciprocal causality are important factors contributing to endogeneity. The possible endogeneity issues have been dealt with accordingly in the previous paper. First, for measurement error, this paper adopts the global referable Malmquist model to measure TGTFP, TEC and TTC, and constructs a comprehensive index system to measure the development level of tourism specialization level using the improved entropy weight TOPSIS method to weaken the influence of data quality on the estimation results; second, for the endogeneity caused by omitted variables, this paper adds tourism industry development, Second, to address the endogeneity caused by omitted variables, this paper adds control variables such as tourism industry development, external linkage degree, industrial structure upgrading, economic development level, science and education development level, government efficiency and marketization level to control them. The endogeneity arising from mutual causality is the key to be addressed in this study, i.e., the level of tourism specialization promotes the growth of TGTFP, which in turn has the potential to promote the level of tourism specialization. For this reason, drawing on Gong et al [39], the PSTR model is re-estimated by choosing the level of tourism specialization with a one-period lag as the switching variable, weakening the risk of endogeneity of the switching variable (Table 5). Considering that the remaining explanatory variables may also have endogeneity problems, we also tried to replace all explanatory and transformation variables with lagged one-period values (Table 6), and the results show that the estimation results of the above two types of model parameters are relatively close, and although the location parameters and estimated values are different, the overall regression results are still largely consistent with the model results in Table 2. It can be judged that H1 and H2 still hold after dealing with endogeneity.

4.7 Heterogeneity analysis

4.7.1 Heterogeneity analysis of sub-tourism development levels

There may be heterogeneity in the impact of tourism specialization level on TGTFP in regions with different levels of tourism development. For this reason, this paper divides the total sample into high tourism development regions and low tourism development regions according to whether they are successfully selected as excellent tourism cities in China, and the estimation results are shown in Table 7. In terms of model significance, high tourism development areas are more significant than low tourism development areas; in terms of model estimated coefficients, the positive effect of tourism specialization level on TGTFP shifts smoothly between [0.796, 2.564] in high tourism development areas, while the estimated effect interval of the model in low tourism development areas is [1.835, 2.459] , suggesting that the level of tourism specialization contributes more significantly to TGTFP in high tourism development areas compared to low tourism development areas, and the panel fixed effects model supports this result. The reason is that, on the one hand, compared with non-excellent tourism cities, excellent tourism cities have more abundant tourism attractions and facilities, which provide external conditions for residents to carry out tourism consumption activities, and specialization will better reach potential customers with tourism products and services, which effectively realize the "realization" of potential tourism consumption demand and thus increase TGTFP. On the other hand, the level of tourism specialization can promote the effective allocation of tourism resources, capital, talents and other factors, realize the close cooperation between tourism market players and related industries, further expand the scale of tourism industry, and strengthen the scale effect of regional production;

at the same time, excellent tourism cities generally have a stronger spirit of tourism industry innovation, and are more likely to apply professional technology to the regional tourism industry At the same time, excellent tourism cities generally have a stronger spirit of tourism industry innovation, and are more likely to apply their expertise to many aspects of regional tourism industry, such as product innovation, organization and management, and publicity and promotion, to enhance tourism specialization, which in turn is conducive to giving full play to the development dividend effect of tourism specialization in tourism industry and promoting tourism productivity, thus, tourism specialization has a more prominent promotion effect in high tourism development regions.

Tab. 7 Difference in tourism industry development level

Variables	High tourism development areas			Low tourism development areas		
	PSTR		FE	PSTR		FE
	Linear	Nonlinear		Linear	Nonlinear	
TS	0.805***	-0.023	0.164***	1.014	-0.059	0.186***
	(0.038)	(0.057)	(0.031)	(0.079)	(0.089)	(0.105)
γ	-0.013	-0.027	-	0.181***	0.225	-
	(0.038)	(0.057)	-	(0.031)	(0.079)	-
c	-0.01	-0.026	-	0.18***	0.221	-
	(0.090)	(0.057)	-	(0.038)	(0.031)	-

4.7.2 Heterogeneity analysis of the level of sub-tourism specialization

The previous empirical analysis has shown that the impact of the level of tourism specialization on TGTFP gradually increases with the level of tourism specialization. It is hypothesized that there may be heterogeneity in the impact of tourism specialization level on TGTFP in cities with different levels of tourism specialization development. To this end, this paper divides the total sample into high tourism specialization level regions and low tourism specialization level regions according to the median annual TS as the boundary, and the estimation results are shown in Table 8. Among them, the positive effect of tourism specialization level on TGTFP is smoothly transformed between [0.928,2.767] in the high tourism specialization level region and the non-linear estimation part passes the significance test of 0.05. In contrast, the non-linear estimated partial coefficient of the level of tourism specialization on TGTFP is not significant in the low tourism specialization level areas and the estimated coefficient of the panel fixed effects model is also not significant.

Tab. 8 Difference in digital economy development level

Variables	Areas with high tourism specialization			Areas with low tourism specialization		
	PSTR		FE	PSTR		FE
	Linear	Nonlinear		Linear	Nonlinear	
TS	-0.012	-0.026	0.72	0.18***	0.224**	-0.199
	(0.038)	(0.057)	(0.031)	(0.080)	(0.090)	(0.105)
γ	-0.026	0.157***	-	1.014	-0.041	-
	(0.038)	(0.057)	-	(0.031)	(0.080)	-
c	-0.017	-0.018	-	0.784	0.186	-

	(0.105)	(0.161)	-	(0.088)	(0.228)	-

This suggests that the level of tourism specialization has a more significant contribution to TGTFP in regions with a high level of tourism specialization compared to regions with a low level of tourism specialization. The possible reason for this is that the level of regional tourism specialization is highly correlated with the level of macroeconomic development, and the accessibility of finance and the inefficiency of its services in low tourism specialization level regions compared to high tourism specialization level regions are severely constrained by financial resources, resulting in low motivation for regional tourism investment development and product innovation. Meanwhile, the limited tourism information dissemination channels in areas with low tourism specialization level, the high cost of reaching potential consumers with tourism products and services, and the low disposable income in areas with low tourism specialization level largely inhibit tourism consumption demand, thus, the role of tourism specialization level on TGTFP is constrained. In contrast, in regions with a high level of specialization, the deep development of industrial structure not only effectively alleviates the financing constraints of tourism enterprises, but also provides convenient and efficient transaction conditions for potential consumers, effectively promoting the conclusion of transactions; professional and technical development provides technical support for tourism product innovation, while the Internet's almost zero-cost diversified three-dimensional publicity speeds up the transmission of tourism information among consumers, significantly activates tourism consumption potential, therefore, the level of tourism specialization has a more obvious role in promoting TGTFP in areas with high tourism specialization.

5 Conclusion and Policy Recommendations

5.1 Research findings

Research on the relationship between the level of tourism specialization and high-quality tourism development is still at the stage of theoretical exploration. Therefore, based on Chinese city-scale panel data from 2000 to 2020, this paper innovatively analyzes the mechanism of the role of tourism specialization level on TGTFP, empirically examines the nonlinear relationship between tourism specialization level and urban TGTFP, TEC, and TTC using a nonlinear panel smoothed transformation regression model, and portrays in detail the dynamic transformation mechanism between them. The dynamic transformation mechanism between the two is detailed, so as to obtain estimation results that are more consistent with the economic reality. The main findings are as follows.

First, the overall trend of tourism specialization level and TGTFP is steadily increasing during the study period, and spatially, tourism specialization level has a significant spatial distribution characteristic of high in the east and low in the west, while there is a certain degree of spatial misalignment between urban TGTFP pattern and tourism economic growth. Second, due to the existence of network effects, the effects of tourism specialization level on both TGTFP and technological progress show non-linear characteristics of increasing marginal effects, and the significance of the estimated coefficients strengthens with the increase of tourism specialization level. When the level of tourism specialization crosses the threshold, the effect of tourism specialization level on TGTFP and TTC is in the high mechanism, and the increase of tourism specialization level strengthens its marginal contribution to TGTFP and TTC, while the smooth transition between the low-high mechanism is centered on the location parameter. Third, the level

of tourism specialization has a positive contribution to TGTFP and technological progress, and an insignificant effect on tourism technical efficiency, indicating that tourism technological progress is an important way for tourism specialization level to promote urban TGTFP. The sub-dimensional variables of tourism specialization level such as tourism resource endowment, economic development level, marketization degree, and industry structure also have significant positive promoting effects on TGTFP and tourism technical progress, but the effects on tourism technical efficiency are not significant. Moreover, the robustness test and endogeneity test prove that the research findings are robust and reliable. Fourth, the sub-regional heterogeneity analysis shows that the promotion effect of tourism specialization level on TGTFP is more significant in high tourism development regions and high tourism specialization level regions.

5.2 Policy Recommendations

Under the new development pattern, promoting the transformation of tourism from resource-driven to innovation-driven has become an important way to realize the high-quality development of tourism. This study not only enriches the theoretical innovation of tourism development under the concept of high-quality development, but also provides reference and reference for promoting the quality and efficiency of the whole tourism industry chain. It is necessary to make full use of the window of opportunity where the impact effect of tourism specialization level is at the stage of increasing marginal effect, to promote the transformation and upgrading of tourism industry with tourism specialization level, and to improve the green total factor productivity of tourism.

(1) Promote the deep integration of "specialization + tourism", and innovate tourism products and services supply system. First, use big data to aggregate multi-source cultural and tourism resource information, create a professional sharing platform for cultural and tourism resources, give full play to the resource matching ability of professional technology, realize the efficient flow and matching of tourism resources, capital, technology and talents, and lay the resource foundation for innovative tourism product content production. Second, actively promote the construction of new infrastructure for tourism specialization, promote the specialization and wisdom transformation of traditional scenic spots, venues and hotels and other tourism spaces, and enhance the level of tourism wisdom services. Finally, encourage cultural tourism enterprises to use professional technology to develop interactive and immersive tourism formats and products, realize the interactive integration of online new cultural tourism and offline scenes, create an innovative tourism ecology that meets diversified needs, and improve green total factor productivity in tourism.

(2) Improve the Internet marketing system to effectively enhance the efficiency of dynamic matching between demand and supply. First, with the help of professional new media industry, we can form a diversified three-dimensional tourism promotion and marketing model through short video-based new media communication and community interaction and sharing platforms to enhance the visibility and brand influence of products and services and stimulate the increase of demand. Secondly, using professional technology to tap into the big data formed by user-generated content (UGC) and draw consumer portraits, identify consumer behavior and consumption habits, pinpoint consumer needs, improve and innovate tourism products and services based on them, and improve the relevance and effectiveness of tourism marketing and communication. Finally, to promote the construction of professional infrastructure and industrial

structure, not only to open up the information "artery" of economic and social development, to realize the effective docking of universal tourism supply and dynamic demand, but also to optimize the service process, reduce transaction costs, and improve the operational efficiency of tourism.

(3) Strengthen institutional innovation in tourism under the concept of high-quality development to improve the technical efficiency of tourism. The backwardness of organizational management system and the attempted monopoly of Internet enterprises may be the two main reasons why the level of tourism specialization is difficult to promote the improvement of tourism technical efficiency. In this regard, on the one hand, it is necessary to strengthen the management system and organizational culture innovation of tourism enterprises and related enterprises to realize their resonance and coordination with the development of tourism specialization level; on the other hand, it is necessary to be alert to the monopoly tendency of head tourism platform enterprises, introduce anti-monopoly related policy documents, strengthen the application of professional technology in platform governance and supervision, and build a "regulatory hand" of the government and "professional hand" of platform enterprises. On the other hand, we should be alert to the monopolistic tendency of the head tourism platform enterprises, introduce anti-monopoly-related policy documents, strengthen the application of professional technology in platform governance and supervision, and build an anti-monopoly supervision model that efficiently combines the "regulatory hand" of the government and the "professional gatekeeper" of the platform enterprises, so as to promote the healthy development of the tourism market, avoid the reduction of technical efficiency caused by the diseconomies of scale of the oligopolistic enterprises, and reverse the situation that the level of tourism specialization has no significant impact on the technical efficiency of tourism.

(4) Pay high attention to the heterogeneous characteristics of the impact effect of the level of tourism specialization and promote the coordinated development of green total factor productivity of tourism in different types of cities. Considering that the impact effect of tourism specialization level on TGTFP in cities with low tourism development still needs to be improved, a dynamic and differentiated tourism specialization development strategy should be implemented. On the basis of promoting the sustainable development of areas with developed tourism and high tourism specialization level, we make up for the shortcomings of tourism specialization level development in relatively backward areas, improve information transparency, service accessibility, resource allocation efficiency and income level, promote better integration of tourism specialization level and tourism industry, and then enhance the synergistic development of TGTFP in each region.

5.3 Discussion

It is worth noting that there are still some issues to be explored in depth in this study: first, only the level of tourism specialization is used as a transformational variable to examine the non-linear relationship between the level of tourism specialization and TGTFP, TEC, TTC, etc. resulting from changes in its state variables. In the future, institutional variables (policy support and degree of marketization, etc.) can also be considered as transformation variables to identify the effect of urban institutional heterogeneity on the efficiency enhancement effect of tourism specialization level. Second, although this paper analyzes in depth the mechanism of the effect of tourism specialization level on urban TGTFP, but limited to the space, the mediating effect model test is not done in the empirical aspect, and the subsequent research can continue to improve. Third, the

level of tourism specialization has the spatial and temporal compression effect caused by the efficient information transmission function, which accelerates the interaction and association of tourism industry between regions, resulting in the level of tourism specialization can act on neighboring regions through spatial spillover effect, and the future can verify whether there is spatial spillover effect between the level of tourism specialization and TGTFP, TEC and TTC. In addition, due to the lack of tourism statistics at the city level, it is difficult to characterize the input and output factors of tourism production completely and precisely. It is hoped that with the establishment and improvement of tourism satellite accounts, more direct indicators will be selected for more precise measurement in the future.

Author Contributions:

Conceptualization: Zhenjie Liao, data curation: Shan Liang, formal analysis: Zhenjie Liao, writing—original draft: Zhenjie Liao, software: Shan Liang, writing—review and editing: Zhenjie Liao and Shan Liang. All authors have read and agreed to the published version of the manuscript.

Data Availability: The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Funding: This study received support from the following sources: a grant from the Guangzhou Huashang College(No.2022HSKT02); a grant from the Guangzhou Huashang College(No.2021HSXK10); the Philosophy and Social Sciences of Guangzhou in the 14th Five-year Period(2023GZGJ314).

Conflicts of Interest: The authors declare no conflict of interest.

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