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The Tourism Eco-Efficiency Measurement and Its Influencing Factors in the Yellow River Basin

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Abstract: Tourism eco-efficiency is an essential indicator to measure the level of green and sustainable development of tourism. Based on the data of nine provinces in the Yellow River Basin, from 2011 to 2020, this article estimates the changes in tourism eco-efficiency in the Yellow River Basin and explores its internal drivers by establishing multiple input-output index systems using the Global Malmquist-Luenberger (GML) index method. Finally, a panel stochastic Tobit model was applied to identify the key external drivers of its eco-efficiency improvement. The analysis shows that with the continuous promotion of the Yellow River Basin's high-quality development strategy and ecological civilization construction, the tourism eco-efficiency of the Yellow River Basin provinces has been improved in the past decade. Due to the obvious ecological advantages in the upper reaches of the Yellow River Basin and the high level of tourism promotion and economic development in the lower reaches, tourism ecological efficiency in the upstream and downstream areas is commonly higher than in the midstream areas. The improvement of efficiency is the internal core driver of regional tourism eco-efficiency, but the essence of eco-efficiency improvement lies in technological progress. In the analysis of the impact of external drivers on tourism eco-efficiency, tourism economy scale, tourism industry structure, technological innovation, and economic development are the crucial external factors to eco-efficiency enhancement. This work can serve as a guide for the high-level growth of regional tourism industry.

Keywords: eco-efficiency; Global Malmquist-Luenberger (GML) index; spatial differentiation; driving forces; regional tourism; Yellow River Basin

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1. Introduction

As the birthplace of Chinese civilization, the Yellow River Basin has an outstanding role in China and the world. The Yellow River Basin is rich in natural resources, but the fragile ecological environment and over-limited resource carrying capacity have led to a prominent contradiction between economic growth and ecological protection. Exploring the economic and ecological relationship in the Yellow River Basin is of great significance for implementing ecological conservation and quality growth strategies and promoting sustainable development in the Yellow River Basin.

Sustainability acts as a moderator between people's aspirations for a better life and environmental constraints. Over time, the perception of sustainability has gradually changed, with an excessive focus on sustainability obscuring the real contradiction between the well-being of all and environmental protection, and potentially diminishing the importance attached to environmental risks. Ultimately, the key to grasping sustainability lies in the search for a balance between management requirements and a good life [1]. In terms of tourism, not only does its development contribute to environmental change, but the risks posed by climate change can also affect it, either directly or indirectly [2]. The emergence of sustainable tourism has, to some extent, curbed the negative impacts of the tourism development process. Enhancing the regional adaptive capacity can effectively contribute to sustainable tourism development; however, not all adaptation is sustainable [3]. The Complex Approach System provides a unique entry point to look at tourism development from different perspectives of energy flows, originating from finance, people, environment, etc., by considering tourism as an ecosystem. Measuring the efficiency of a complex tourism system can also effectively promote the sustainable development of tourism [4]. The concept of "ecological efficiency" was first introduced by two academics, Schaltegger and Stun, and was subsequently widely used in different research objects [5]. Gossling first introduced ecological efficiency into tourism research in 2002 [6]. Tourism eco-efficiency means generating more economic returns with less investment of resources and minimal environmental damage [7,8], and is an important indicator of the organic harmony between economic development and the environment [9]. As a mainstay industry of the domestic economy, the development of tourism is significant to the qualitative progress of the Yellow River Basin. The natural resource endowment of the Yellow River Basin is not only the basis for tourism development, but the problems of over-intensity of tourism resource development and under-intensive use of tourism resources are also universal. In addition, tourists with different perceptions of the ecological environment have different tourism behaviors, demands and actual experiences [10]. The differences in the use and consumption of tourism resources among these tourists have aggravated the contradiction between tourism and the ecological environment, particularly in the carbon dioxide emissions caused by tourism traffic and in accommodation that exacerbates climate change, which is fundamentally detrimental to the sustainable development of both tourism and the ecology itself [11–13]. The impact of tourism and the ecological environment has therefore been the focus of academic research.

Academic research on tourism eco-efficiency has focused on the definition of concepts [14], establishment of evaluation index [15], construction of measurement methods [16,17], efficiency measurement [5,18], analysis of influencing factors [19,20], and suggestions for countermeasures [21,22]. The aim of this study is to uncover the dynamic relevance between tourism environmental carrying capacity and tourism eco-efficiency through a measurement and regression model and then provide instruction for tourism's sustainable development [23]. Changes in the provincial tourism eco-efficiency in China from 2005–2015 were measured by building a model combining data envelopment analysis and factor decomposition analysis, and then decomposing the growth of tourism into six components [24]. With the continuous development of measurement technology, researchers gradually extend their research objects to regions [25]. Tourism eco-efficiency total factor productivity (TFP) was further estimated and decomposed by introducing the Malmquist index model [26]. The Super-SBM model was used to analyze and characterize the tourism eco-efficiency in China from 2000–2017 [27]. The study of regional tourism ecological efficiency primarily aims to obtain cross regional economic and social exchanges and promote tourism to produce a cluster effect [28]. Other influential work has used regression models to analyze the factors of influence [27,29,30].

In summary, certain results have been achieved in the study of tourism eco-efficiency, but fewer results have been achieved in the study of the temporal and spatial features of tourism eco-efficiency, using the Yellow River Basin as the study area. At the same time, along with the development of tourism, its impact on the climate environment has become increasingly prominent, and there are fewer studies on the introduction of carbon emission-related indicators into the tourism eco-efficiency evaluation system. Tourism, as a pillar industry, from the rough economic model to the clean and efficient model of the transformation and upgrading path exploration, is of great significance.

This paper uses the Global Malmquist-Luenberger (GML) index method to estimate the change in tourism eco-efficiency in nine provinces of the yellow river Basin from 2011 to 2020, and decomposes the GML index into technical efficiency (EC) and efficiency improvement (BPC) to explore the internal drivers of ecological efficiency. We then used a panel stochastic Tobit regression model to explore the external influences on tourism eco-efficiency. The study of the spatial differences in tourism eco-efficiency and the drivers of eco-efficiency in the Yellow River Basin can be a reference for the sustainability of tourism development and eco-efficiency improvement in similar regions of the world. The paper is structured as follows. Section 2 introduces the research methodology and data, including the measurement of eco-efficiency, and the analysis of the driving forces. Section 3 contains the relevant indicators and data sources. Section 4 presents the findings of the study. Finally, Section 5 gives findings and outlook (Figure 1).

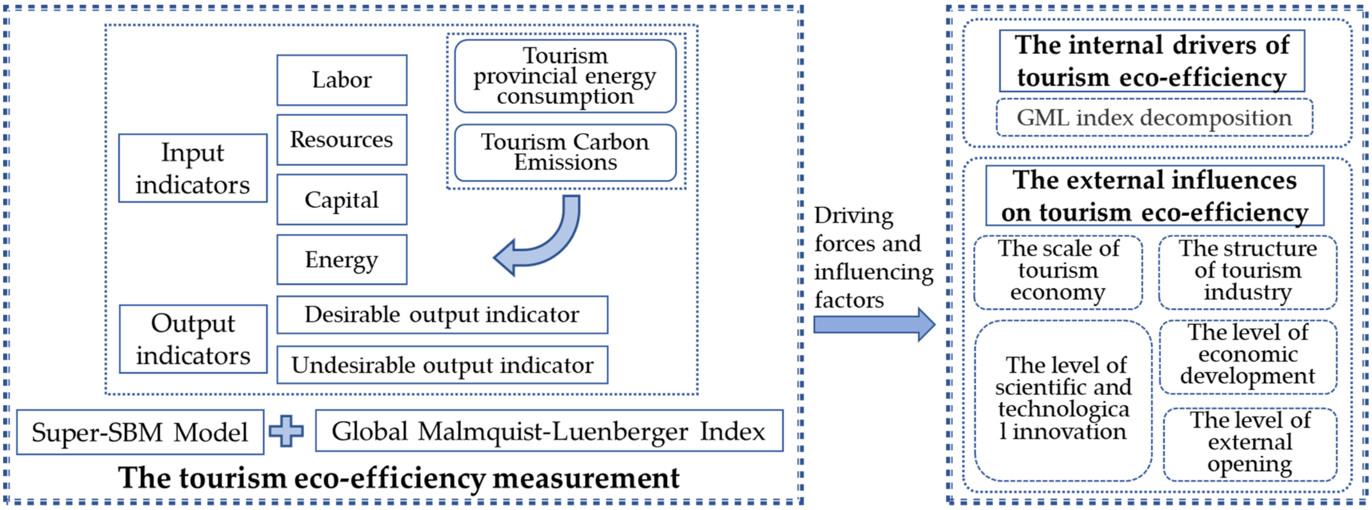

Figure 1. Mechanisms for measuring the eco-efficiency of tourism in the Yellow River Basin.

2. Methods

The energy consumed is an ecological input indicator and CO_2 emissions are a non-expectation output indicator. A non-expectation-SBM model of the Global Malmquist-Luenberger (GML) index was constructed to assess the tourism eco-efficiency in the nine provinces of the Yellow River Basin. Based on Oh's study, the GML index was decomposed into EC (technological progress) and BPC (efficiency improvement) to explore the internal drivers of tourism eco-efficiency in the Yellow River Basin. A panel stochastic Tobit regression method was then applied to identify the external driving factors of tourism ecological efficiency in the Yellow River Basin to reveal effective ways to improve the tourism ecological efficiency.

2.1. Global Malmquist-Luenberger (GML) Index

In this paper, CO_2 emissions are regarded as unexpected outputs. Based on the relaxation-based non-radial Super-SBM model proposed by Tone [31,32], the global Marquist Renberg (*GML*) index method proposed by Oh is used to measure the changes in the tourism ecological efficiency of nine provinces and regions in the Yellow River Basin, from 2011 to 2020, by using the global production frontier to calculate the input-output indicators, including unexpected outputs [33].

$$GML = EC \times BPC \tag{1}$$

A non-angular, non-radial productivity index is constructed based on the premise of the non-desired output-over-efficiency SBM measure model, which is represented as follows.

$$GML_0^{T,T+1} = \frac{\rho_0^{T+1}\left(x_0^{T+1}, y_0^{g,T+1}, y_0^{b,T+1}\right)}{\rho_0^{T}\left(x_0^{T}, y_0^{g,T}, y_0^{b,T}\right)} \times \left[\frac{\rho_0^{g}\left(x_0^{T+1}, y_0^{g,T+1}, y_0^{b,T+1}\right)}{\rho_0^{T+1}\left(x_0^{T+1}, y_0^{g,T+1}, y_0^{b,T}\right)} \times \frac{\rho_0^{T}\left(x_0^{T}, y_0^{g,T}, y_0^{b,T}\right)}{\rho_0^{g}\left(x_0^{T}, y_0^{g,T}, y_0^{b,T}\right)}\right] \tag{2}$$

where $GML_0^{T,T+1}$ represents the change in the full factor of tourism eco-efficiency from T to $T+1$ in different provinces. $\rho_0^T(x_0^T, y_0^{g,T}, y_0^{b,T})$, $\rho_0^{T+1}\left(x_0^{T+1}, y_0^{g,T+1}, y_0^{b,T+1}\right)$ denote the province's efficiency values in periods T, $T+1$ periods; $\rho_0^g\left(x_0^T, y_0^{g,T}, y_0^{b,T}\right)$ is the efficiency value based on the global production technology in each period and the input-output values in period T; $\rho_0^g\left(x_0^{T+1}, y_0^{g,T+1}, y_0^{b,T+1}\right)$ is the efficiency value based on the global production technology in each period and the input-output values in period $T+1$ of the efficiency values. $\frac{\rho_0^g\left(x_0^{T+1}, y_0^{g,T+1}, y_0^{b,T+1}\right)}{\rho_0^{T+1}\left(x_0^{T+1}, y_0^{g,T+1}, y_0^{b,T}\right)}$ reflects how close the frontier $T+1$ is to the global frontier, $\frac{\rho_0^T\left(x_0^T, y_0^{g,T}, y_0^{b,T}\right)}{\rho_0^g\left(x_0^T, y_0^{g,T}, y_0^{b,T}\right)}$ reflects the proximity of the frontier T to the global frontier. If $GML_0^{T,T+1} = 1$, it indicates no change in green total factor production efficiency; if $GML_0^{T,T+1} < 1$, it indicates a decrease in green total factor production efficiency; $GML_0^{T,T+1} > 1$, it indicates an increase in green total factor production efficiency.

2.2. Panel Tobit Regression Analysis

The panel Tobit regression model was initiated by Tobin and primarily addresses the construction of a finite or truncated dependent variable. This paper uses a panel stochastic Tobit regression model, in which tourism eco-efficiency is the explanatory variable and each influencing factor is the explanatory variable, to identify the driving factors affecting the spatial differentiation of regional touristic and ecological efficiency. This model is represented as follows.

$$Y_{it} = \alpha_i + \beta_1 x_{1it} + \beta_2 x_{2it} + \beta_3 x_{3it} + \beta_4 x_{4it} + \beta_4 x_{4it} + \varepsilon_{it} \quad (3)$$

where: i denotes the ith province; t denotes t periods; Y_{it} is the explanatory variable, which is the tourism eco-efficiency value; X_{it} is the explanatory variable; β_{ki} is the coefficient which is to be evaluated and ε_i is a random parameter of error.

3. Indicators and Data Resources

3.1. Eco-Effienciency Indicators

According to existing studies [34–37], the construction of an index system for evaluating the ecological benefits of tourism in the Yellow River Basin includes not only input indicators such as natural resources, labor, capital input and energy consumption, but also unexpected output factors, such as ecological and environmental pollution (Table 1). There is not yet a unified measurement index for selecting input and output factors. Therefore, a specific indicator system should be selected according to the practical input and output procedures of tourism promotion and the existing research results.

Table 1. An evaluation index system for the ecological benefits of tourism in the Yellow River Basin from 2011 to 2020.

Indicator Type	Indicators Name	Indicator Characterization
Input indicators	Labor	Number of employees in the tourism industry
	Resources	Tourism Resource Endowment
	Capital	Investment in fixed assets in tourism
	Energy	Provincial energy consumption in the tourism sector
Output indicators	Desired output indicators	Total Tourism Revenue
	Non-desired outputs indicators	Tourism Carbon Emissions

Input indicators: The number of employees in tourism, tourism fixed asset investment, tourism resource endowment, energy consumption in tourism provinces and regions are selected as input elements. Among them, tourism fixed asset investment characterizes the capital input. As provinces and regions have not produced relevant statistics, the whole society fixed asset investment and tourism share are used for conversion. Tourism resource endowment characterizes the resource input, the number of A-class scenic spots and the number of world heritage sites are selected for the assessment; tourism provincial energy consumption characterizes the energy input. Previous research has found that the carbon emissions from tourism transportation account for more than half of the total carbon emissions created by tourism [34]. The energy consumption of hotel lighting systems, air conditioning systems, home appliance systems, etc., generated in tourism accommodation renders the carbon emission of accommodation activities the second sector in terms of carbon emission [35,36]; carbon emissions from tourism activities rank third [37]. Coal, natural gas, oil, etc., are the main energy consumption resources of tourism activities, leading to greenhouse gas emissions, mainly CO_2. Considering the proportion of energy consumption in different tourism sectors, and ignoring the energy consumption generated by catering, shopping, waste and other links, the tourism transportation, accommodation, and activities with high carbon emissions in the tourism industry are estimated [38].

Output indicators: The total regional tourism revenue is chosen as the desired output indicator, and regional tourism carbon emission is taken as the non-desired output indicator. The measurement of tourism carbon emission indicators mainly focuses on tourism transportation, tourism accommodation and tourism activities, and the bottom-up method is used to measure the carbon emission generated by tourism.

3.2. The Panel Tobit Regression Model Indicators

To further investigate the influencing factors of certain differences in the tourism ecological efficiency of the Yellow River Basin from 2011 to 2020, scale effect, industrial structure, technical innovation, and other factors should be considered as the influencing factors of tourism ecological efficiency. According to the published literature, we selected the scale of tourism economy, the structure of tourism industry, the level of scientific and technological innovation, the level of economic development and opening to the outside world as the influencing factors, and comprehensively consider their impact on tourism ecological efficiency. Specific indicators and explanations are as follows.

(1) the scale of the tourism economy: X_1 is characterized by the total tourism revenue of each province. According to the results of Lenzen, the relationship between tourism ecological efficiency and tourism income conforms to the inverted "U" curve; that is, the increase in tourism income can promote the level of tourism ecological efficiency to some extent. However, when it increases to a certain extent, the efficiency gradually declines [39,40]. Therefore, the tourism economic scale was selected as an indicator for further exploring the impact of economic scale on the tourism ecological efficiency of the Yellow River Basin.

(2) the structure of the tourism industry: X_2 is expressed by the proportion of total tourism revenue to the output value of tertiary industry. The optimization of industrial structure is conducive to the improvement of tourism ecological efficiency [41]. A reasonable industrial structure can promote industrial agglomeration, achieve the scale effect of tourism through exchanges and cooperation between different industries, reduce the heavy pressure on resources and environment, and improve tourism ecological efficiency. In contrast, the environmental pressure caused by the industrial agglomeration of a single industrial structure is greater, which is not conducive to the improvement of tourism ecological efficiency.

(3) the level of technological innovation: X_3 is characterized by the number of patent applications in each province and region to show the influence of scientific and technological progress on the eco-efficiency of tourism in the Yellow River Basin. On the premise of a certain tourism income, the higher the technical level, the lower the energy consumption and the higher the efficiency. In other words, the promotion of technological innovation can drive the sustainable development of tourism [41].

(4) the level of economic development: X_4 is expressed by the gross domestic product (GDP) per capita. According to existing research, there is a correlation between ecological efficiency and regional economic development [42,43]. According to the existing research, there is a correlation between ecological efficiency and regional economic development. Areas with high-quality economic development tend to have more effective environmental policies and carry out tourism activities reasonably under the coordination of economy and environment, often leading to a higher tourism ecological efficiency.

(5) The level of external opening: X_5 is expressed by the amount of actual foreign capital utilization. A higher level of regional opening to the outside world can not only bring a certain amount of foreign investment, but can also introduce advanced management concepts and technologies to reduce resource consumption and environmental pollution, thus improving the tourism ecological efficiency [44].

To ensure the smoothness of the data, the data are logarithm zed before the regression processing.

3.3. Data Sources

This paper measures the eco-efficiency of tourism in the Yellow River Basin from 2011 to 2020 by establishing an input-output indicator system. The data selection were extracted from the public data resources based on government departments. The details of the data sources and calculation methods are shown in Table 2. The linear interpolation was used to compensate for a small amount of individual missing data.

Table 2. Data source: Evaluation indicators of tourism eco-efficiency in the Yellow River Basin based on the input-output method.

Indicators	Indicator Characterization	Calculation Method	Data Resource
Labor	Number of employees in the tourism industry	/	China Tourism Statistical Yearbook
Resources	Tourism Resource Endowment	Sum of A-level scenic spots and world heritage sites	China Tourism Statistical Yearbook, the United Nations Educational, Scientific, the Cultural Organization (UNESCO) official website
Capital	Tourism industry fixed asset investment	Investment in fixed assets × (Total Tourism Revenue/Tertiary industry output × 100%)	China Statistical Yearbook, China Tourism Statistical Yearbook
Energy	Tourism provincial energy consumption	$C = C_{trans} + C_{acco} + C_{activities}$ $C_{trans} = \sum(Q_i \times w_i \times \alpha_i)$ $C_{acco} = q \times s \times T \times \beta$ $C_{activities} = \sum(P_k \times \gamma_k)$	China Tourism Statistical Yearbook
Desirable output indicators	Total Tourism Revenue	/	China Tourism Statistical Yearbook
Undesirable output indicators	Tourism Carbon Emissions	Bottom-up approach: $E = E_{trans} + E_{acco} + E_{activities}$ $E_{trans} = \sum(Q_i \times w_i \times p_i)$ $E_{acco} = q \times s \times T \times m$ $E_{activities} = \sum(P_k \times n_k)$	China Tourism Statistical Yearbook

Note: C is for total energy consumption; C_{trans} is for tourism transport energy consumption; C_{acco} for energy consumption in tourist accommodation; $C_{activities}$ represents the energy consumption of tourism activities; α_i for energy consumption factor; β for accommodation energy consumption factor; γ_k represents the energy consumption factor for different activities; E_{trans} is carbon emissions from tourism traffic; E_{acco} is for carbon emissions from tourist accommodation; $E_{activities}$ is carbon emissions from tourism activities; p_i represents the carbon emission factor for tourism traffic; m represents the carbon emission factor of the accommodation; n_k represents the carbon emission factor for different activities; Qi represents the passenger turnover of rail, road and water transport; w_i is the proportion of tourists in the passenger turnover; P_k refers to person times of various tourism activities; q is the number of beds; s is the room occupancy rate; T is the number of days in a year.

The external influences on tourism eco-efficiency in the Yellow River Basin were measured through a panel Tobit regression model. The total revenue data was obtained from the Tourism Statistical Yearbook of each province; the proportion of total tourism revenue and tertiary industry was calculated through the data of the China Statistical Yearbook and China Tourism Statistical Yearbook; the number of patent applications was obtained from the China Science and Technology Statistical Yearbook; the gross domestic product (GDP) per capita and the amount of actual foreign investment utilized were obtained from the China Statistical Yearbook.

4. Results

4.1. The Overall Evolution of Tourism Eco-Efficiency in the Yellow River Basin

The non-expectation output of the SBM-GML model was used for the calculation of tourism eco-efficiency in the nine provinces of the Yellow River Basin, between 2011–2020, and the spatial and temporal distribution of tourism eco-efficiency was analyzed.

During this 10 year period, the GML index values of the nine provinces in the Yellow River Basin were all higher than 1 (Figure 2), and the tourism eco-efficiency improved in general. The upper reaches of the Yellow River Basin had the highest mean GML index value, at 1.23l Ningxia was the highest among the nine provinces and regions, at 1.48; Qinghai had the lowest tourism eco-efficiency value at 1.08. The overall GML index for the Yellow River Basin was 1.20, with Sichuan, Ningxia, Inner Mongolia, and Henan all above the overall average, indicating some regional differences in eco-efficiency.

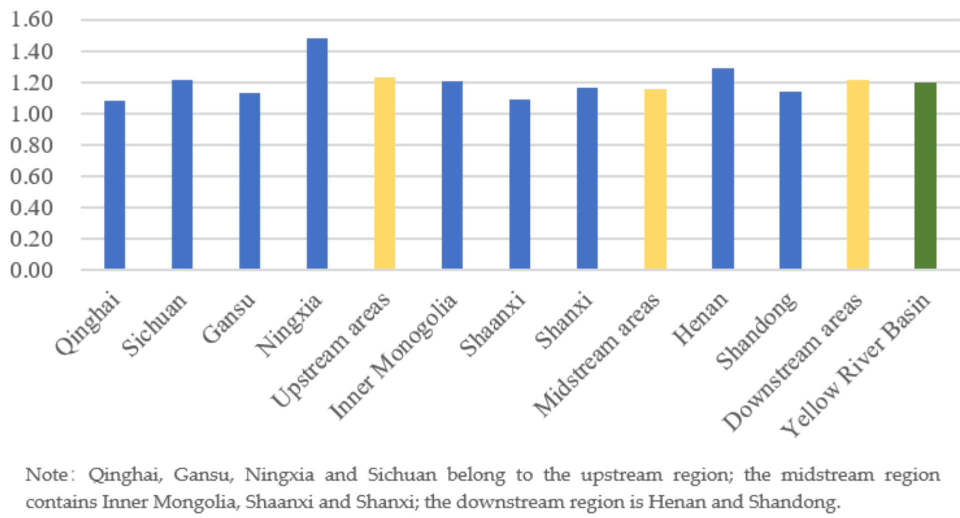

Figure 2. Average GML index by provinces and districts, 2011–2020.

To compare the changes in the tourism eco-efficiency of each region, the GML index of the Upper, Middle and Lower Yellow River Basin over the ten-year period is presented, as shown in Figure 3. Considering that the mean values of tourism eco-effectiveness in the Yellow River Basin and the upstream, midstream and downtown areas are 1.20, 1.23, 1.16 and 1.22, respectively, it can be found that the tourism eco-effectiveness in the Yellow River Basin and its regions is fluctuating and increasing, and the measures to optimize the tourism input-output structure and reduce environmental damage have achieved initial results. In terms of growth, the tourism eco-efficiency of the Yellow River Basin has increased from 0.95 in 2011–2012 to 1.40 in 2019–2020, with the upstream region maintaining a steady growth, the GML index peaking at 2.21 and the lowest value at 0.95, a difference of approximately 1.26. The increase in efficiency is mainly due to the obvious advantages of tourism resource endowment in the upstream region, which has a greater compensatory effect on CO_2 emissions. CO_2 emissions have a greater compensatory effect, coupled with the conscious implementation of environmental protection measures, causing tourism eco-efficiency grow steadily. The central region's tourism eco-efficiency shows a trend of rising first and then declining, with efficiency values distributed between 0.87 and 1.54 during the decade, gradually declining from 2016 to 2020, mainly because tourism in the midstream region is more resource-consuming and sloppy. The GML index is higher in the lower reaches compared to the upper and middle reaches, with efficiency values mostly greater than one over the last decade. Henan and Shandong are large tourism provinces, which carry out tourism reception activities on a large scale, bringing corresponding economic benefits with a higher proportion of resource inputs. The input-output pattern is relatively stable, and it is difficult to make a high breakthrough in eco-efficiency as there is less room to reduce energy dependence and CO_2 emissions. Overall, it appears that the Yellow River Basin has seen a significant increase in tourism eco-efficiency over the decade, with an increasing emphasis on ecological impacts. As the birthplace of Chinese civilization, the Yellow River Basin's superior ecological environment has, to some extent, contributed to tourism eco-efficiency, and a better balance has been achieved between environmental protection and economic development. However, there are still problems with the overall level of performance being insufficient, and the promotion of optimizing the structure of the tourism industry and reducing energy consumption has not been effective. It is consequently essential to investigate the internal growth dynamics of tourism ecological efficiency and to identify the sources of the dynamics of efficiency growth.

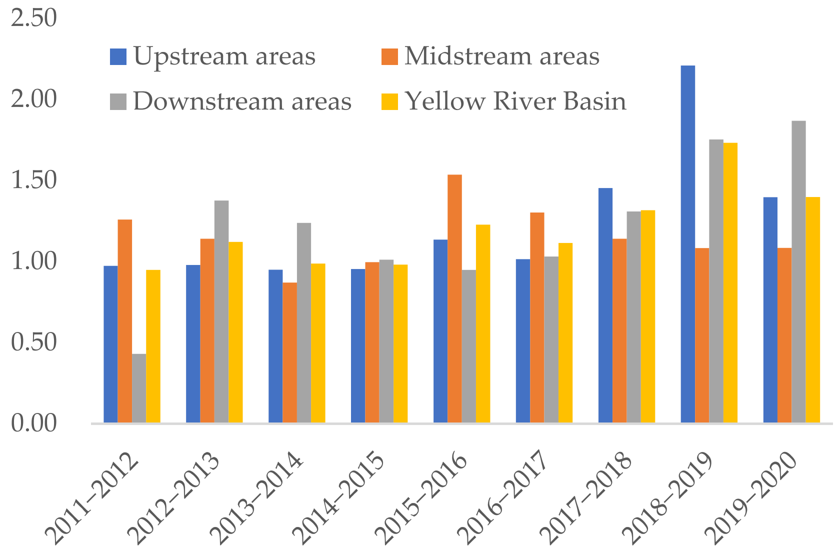

Figure 3. GML Index in Upper and lower reaches of Yellow River Basin.

4.2. Analysis of the Internal Driving Forces of Tourism Eco-Efficiency

To further analyze the internal influencing factors of the tourism and ecological efficiency in the Yellow River Basin, the GML index of intertemporal changes in tourism and ecological efficiency was decomposed into EC (technical progress) and BPC (efficiency improvement), according to Equation (1). Figure 4 shows the mean values of the GML index and decomposition index for the nine provinces and cities in the Yellow River Basin. The GML index is greater than one for all nine provinces, indicating that the tourism eco-efficiency of the Yellow River Basin provinces has improved to some extent. Regionally, the GML indices for the upstream, midstream and downstream of the Yellow River Basin are 1.23, 1.16 and 1.22, respectively. The technological progress index is generally lower than the improvement in the efficiency index, and more notably, the EC for the downstream is below one and the BPC is above one, suggesting that efficiency improvement has a more significant pull on tourism eco-efficiency, relative to technological progress.

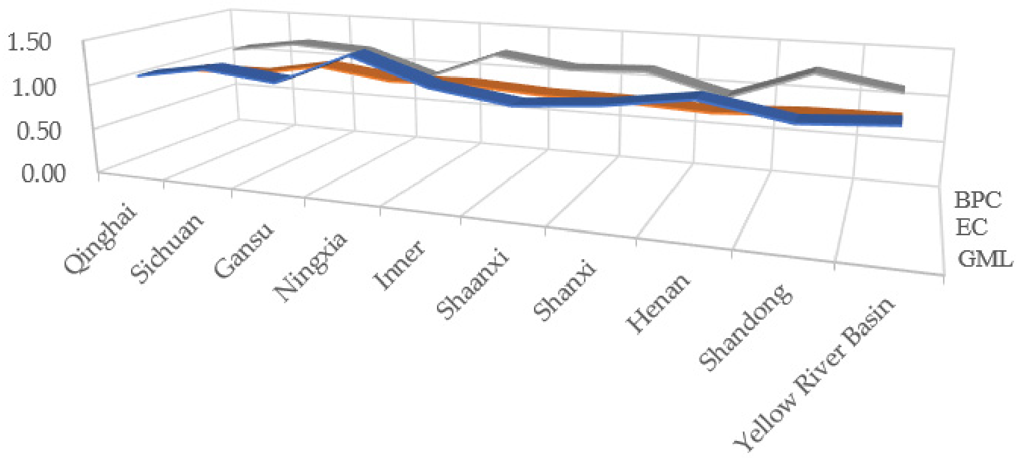

Figure 4. Mean values of the GML index and its decomposition for tourism eco-efficiency.

The mean values of GML, EC and BPC, obtained by decomposing the GML index for the nine provinces of the Yellow River Basin, are 1.20, 1.03 and 1.13, respectively, indicating that the overall tourism efficiency has improved across the Basin and that the internal factors causing this improvement are primarily efficiency gains, while technological progress has also contributed to energy and eco-efficiency improvements, although their effect is not as strong as that of efficiency gains (Figure 5). For further analysis, the mean values of the GML, EC and BPC indices for each period in the Yellow River Basin were plotted in a bar chart, as shown in Figure 2. As can be seen from the graph, only the mean values of the GML indices for the five stages of 2012–2013, 2015–2016, 2017–2018, 2018–2019 and 2019–2020 are higher than one, indicating that the tourism eco-efficiency has improved during this period; the results of the decomposition of the GML indices indicate that the eco-efficiency has improved among the five stages of tourism. It reflects the fact that the improvement of the eco-efficiency of tourism in the Yellow River Basin relies more on efficiency gains and gradually shifts to being driven by both technological advances and efficiency gains after 2018–2019. Efficiency improvement is mainly reflected in the improvement of the internal management, organization and control of enterprises, but the essence of eco-efficiency improvement lies in relying on technological progress, without which it is difficult to obtain breakthrough improvements in the tourism eco-efficiency [45].

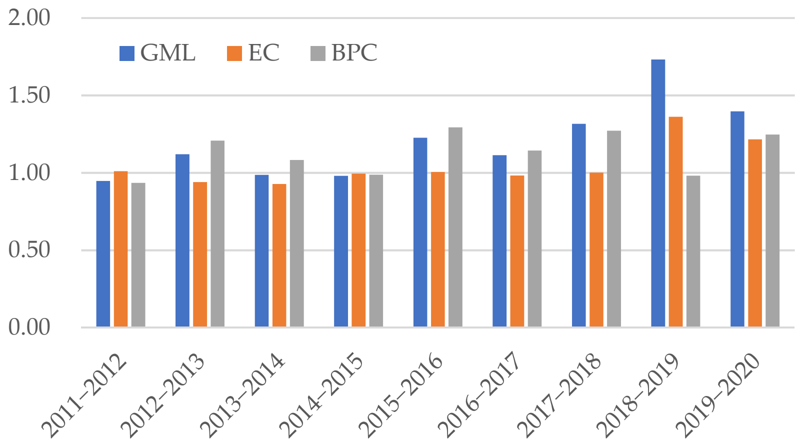

Figure 5. Mean values of the GML index and its decomposition for the eco-efficiency of tourism in the Yellow River Basin.

Overall, the GML index was generally below one from 2011–2015 and above one from 2015–2020, suggesting that the provinces in the Yellow River Basin have been paying increasing attention to eco-efficiency in tourism in recent years, with obvious results. The mean value of the eco-efficiency in tourism in 2018–2019 is 1.73, the highest in history, which is growing faster, but there is still more room for improvement. Continuing to deepen the structural reform of the tourism industry and improving the efficiency of energy reuse remain urgent issues in the Yellow River Basin.

4.3. Analysis of External Influences on Tourism Eco-Efficiency

The tourism eco-efficiency of the Yellow River Basin from 2011 to 2020 was taken as an explained variable; the scale of the tourism economy, the structure of the tourism industry, the level of science, technology innovation, economic development, and external openness were taken as the independent variables. According to Formula (2), the Tobit regression analysis was conducted through the Stata software. To study the influencing factors of tourism's eco-effects and to determine the best-fitting model, mixed OLS, fixed effects (FE), random effects (RE) and Tobit regression models were run, respectively, and the corresponding results are shown in Table 3. Firstly, the mixed OLS panel regression model was run, and the coefficients of all variables were found to be significant. This was followed by a fixed effects regression analysis, which showed that the coefficients on tourism industry structure (X_2), technological innovation (X_3) and external openness (X_5) were significant; the F-test results showed that the fixed effects model fitted significantly better than the mixed OLS regression model. The random effects regression model was then used to fit the coefficients of tourism economic scale (X_1), tourism industry structure (X_2), science and technology innovation level (X_3) and economic development level (X_4), and the LM test results showed that the random effects model was better than the mixed OLS regression model. According to the Hausman test, the p-value was 0.26, and the original hypothesis of "using the random effects model" was accepted, and the random effects model was judged to be better than the fixed effects model. An LR test was conducted, and the result was 0.002, which concluded that the panel random Tobit model was optimal. Therefore, the regression results of the panel random Tobit model are used to explore the factors influencing tourism eco-efficiency.

Table 3. Results of panel regression models.

	(1) OLS	(2) FE	(3) RE	(4) Tobit
Variables	y	y	y	y
X_1	−0.91 ***	−0.85	−0.93 ***	−0.43 ***
	(−4.99)	(−1.49)	(−3.94)	(−3.51)
X_2	3.24 ***	2.66 *	3.17 ***	1.55 ***
	(4.42)	(1.71)	(3.54)	(3.44)
X_3	0.38 ***	0.48 ***	0.39 ***	0.15 **
	(3.54)	(2.90)	(3.06)	(2.38)
X_4	0.48 **	0.73	0.70 **	0.43 ***
	(2.17)	(0.91)	(2.44)	(2.66)
X_5	0.10 *	0.27 **	0.11	0.06
	(1.81)	(2.18)	(1.56)	(1.59)
Constant	−0.91 ***	−0.85	−0.93 ***	−0.43 ***
	(−4.99)	(−1.49)	(−3.94)	(−3.51)
F test (p-value)	2.99 (0.01)			
LM test (p-value)			3.30 (0.03)	
Hausman (p-value)		7.66 (0.26)		
LR test (p-value)				8.64 (0.00)

Note: *, ** and *** were shown to be significant at 0.1, 0.05 and 0.01 levels.

From the above results, there is some variation in the factors selected to influence the different regression models, but overall, they adopt the test of significance, suggesting that the ecological benefits of tourism in the Yellow River Basin are influenced by a combination of factors. The scale of the tourism economy has a significant negative impact on the tourism eco-efficiency of the Yellow River Basin, passing the 1% significance test, i.e., for every 1% rise in tourism economy scale, the ecological benefit of tourism declines by 0.43 percentage-points. As a result of expanding the scale of tourism, the chances of environmental pollution and ecological damage will increase, ultimately making no positive output, while reducing tourism eco-efficiency. The tourism industry structure passed the significance test and had a significant positive effect on tourism eco-efficiency, with an estimated coefficient of 1.54. The reason for this is that the Yellow River Basin is constantly adjusting its industry structure, with the guidance of high-quality development, thus promoting the improvement of tourism eco-efficiency. Technological innovation has a significant positive effect on tourism eco-efficiency, contributing to the economic development of tourism and eco-efficiency. It should not be overlooked that for the tourism industry, the role of technology is to enhance the experience of tourism services, update tourism products and facilitate communication, but these are of secondary importance to tourism. What the traveler gains from tourism is more about the encounter with different cultures, experiencing the impact of nature, history and humanity, and the environment is another important part of the cultural transmission of tourism [13]. Technology is therefore more of an accelerant for tourism eco-efficiency, with the level of technological innovation contributing to the improvement of tourism eco-efficiency to a certain extent, compared to the size of the tourism economy and the structure of the industry, rather than being the most important influencing factor. Innovation in science and technology not only includes innovation in tourism models, but also iterations of technology and products that enhance service levels and promote environmental behaviors, encouraging the tourism industry to invest actively in research and development, prompting tourism enterprises to actively carry out the transformation of advanced achievements such as big data and human co-intelligence, and to continuously promote the development and application of low-carbon technology products, empowering tourism industry development with science and technology and improving tourism eco-efficiency. The economic development is found to be directly relevant under the 1% significance test, with an estimated coefficient of 0.43. This reflects that the scale of the tourism economy is expanding with economic development and improving the living standards of the people, accompanied by continuous investment in green infrastructure and green innovation, so that the economy, society and ecology reach an organic balance, reflecting that the green development of the travel industry depends on the prosperity of the regional economy. The level of external openness has a positive effect on tourism eco-efficiency, but it does not pass the significance test. The inflow of foreign capital has, to a certain extent, promoted the progress of science and technology, the training of talents and the renewal of management concepts, and has a positive effect on the ecological impact of tourism. However, while the Yellow River Basin has a low external opening level and a weak level of foreign investment attraction, it has obvious advantages in its own natural resource endowment, which can compensate, to a certain extent, for the lack of foreign investment.

In terms of the external influencing factors of tourism eco-efficiency in the Yellow River Basin, the scale of the tourism economy, the structure of the tourism industry, the level of scientific and technological innovation, the level of economic development and opening to the outside world all have a positive or negative impact on tourism eco-efficiency to varying degrees. The scale of the tourism economy, the structure of the tourism industry and the level of economic development are the main influencing factors driving eco-efficiency improvement, reflecting the role of the economic level in driving tourism eco-efficiency improvement. Since its reform and opening, China’s level of economic development has continued to rise, enabling the rapid development of the economy and tourism industry in the Yellow River Basin. Consequently, the development of the tourism economy has driven a continuous increase in tourism eco-efficiency. The level of technological innovation has taken a secondary role in the improvement of tourism eco-efficiency, with tourism focusing more on the cultural and spiritual experience, and the development of technology playing a secondary role in promoting tourism. Combined with the analysis of the internal drivers of tourism eco-efficiency, the pull of technological forces on tourism eco-efficiency will continue to expand in the future, with technology empowering tourism economic development and energy consumption structure improvement, to promote sustainable tourism development.

5. Conclusions and Perspective

This article analyses the tourism eco-efficiency of nine provinces in the Yellow River Basin in the years 2011–2020, systematically describes the characteristics of tourism eco-efficiency in time and space, dissects the inner drivers and outer influences affecting tourism eco-efficiency, and draws several key results.

Between 2011 and 2020, the tourism eco-efficiency of the nine provinces in the Yellow River Basin were generally on an upward trajectory, with a high growth potential, a high level of tourism eco-efficiency in the upstream and downstream regions, and a relatively stable eco-efficiency in the midstream region. The rapid growth of the tourism industry in the Yellow River Basin has not caused uncontrollable damage to the ecological and geographical environment. On the contrary, as China's economy enters the 'new normal' and the strategy of high-quality development in the Yellow River Basin is put forward, the ecological and economic development of tourism continues to grow, and the effectiveness of energy saving and emission reduction, optimization of resource allocation and technological upgrading continues to emerge. The Malmquist index decomposition shows that the efficiency enhancement drives the optimization and enhancement of ecological benefits more than technological enhancement. Therefore, the technological capacity of the tourism industry should be vigorously promoted to facilitate the breakthrough growth of the ecological benefits in the Yellow River Basin tourism industry.

The results of the analysis of the external influencing factors show that there is a significant negative influence of the tourism economic scale, and a significant positive influence of the tourism industry structure, science and technology innovation level and economic development level, on tourism eco-efficiency. Therefore, the tourism industry in the Yellow River Basin should reduce the level of regional economic development, strengthen the exchange and cooperation of industrial clusters at the provincial level, and build a low-cost and high-efficiency tourism complex; co-ordinate and accelerate industrial optimization and upgrading, promote industrial structure adjustment, change the rough and loose management mode, carry out supply-side reform according to the new era of tourism market demand, and promote the rationalization and efficiency of tourism structure; and continuously increase investment in technological innovation The important driving force behind the long-term development of the Yellow River Basin is to ensure continuous investment and efficient allocation of technological factors in the tourism industry, focusing on the application of high technology, such as big data, cloud computing and artificial intelligence, to ensure that the efficiency of technological factor investment is enhanced in order to achieve efficiency growth.

The high-quality growth of tourism in the Yellow River Basin is highly significant for the economic development of China. A study of the evolution of the ecological benefits of tourism in the Yellow River Basin over space and time, as well as the inner driving forces and outer influences, will go some way to filling the gaps in the existing research and provide direction for the future high-quality development of tourism in the Yellow River Basin.

China is the largest source country and the largest destination for tourism in the world. The rapid expansion of tourism in China, as well as the huge scale of cross-regional tourism activities, has raised concerns about the ecological environment of tourism. The development of ecotourism can effectively reduce regional pollution, promote the transformation of the Yellow River Basin tourism industry to an ecotourism development model and further improve its tourism-ecological benefits [46]. The rapid development of tourism in China and the huge scale of cross-regional tourism activities reflect the comprehensive nature of the ecological benefits and the driving forces. Currently, countries and regions with fast-growing tourism industries are facing eco-efficiency issues. The input-output evaluation index system for energy consumption and carbon emissions from tourism constructed in this paper can serve as a reference for tourism management agencies and practitioners in the same type of countries and regions to clarify tourism eco-efficiency and assess it, so that tourism can become a high-quality and sustainable industry.

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