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Tourism Eco-Efficiency and Influence Factors of Chinese Forest Parks under Carbon Peaking and Carbon Neutrality Target

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Abstract: (1) This study aims to solve the problems of sustainable development in the forestry tertiary industry, to address the imbalanced state of natural environmental resources and the forestry industry, to improve ecological and environmental management, and to prepare for carbon peak and carbon neutral goals. (2) Using panel data from forest park tourism in 30 provinces and cities in China from 2010 to 2019, the DEA game cross-efficiency model is adapted to evaluate its tourism eco-efficiency, and the primary factors affecting forestry tourism eco-efficiency are selected; additionally, a panel tobit regression model is established for analysis to find policy entry points for enhancing forestry tourism eco-efficiency through empirical analysis. (3) The results show that transportation network construction and tourism input have a negative impact on the eco-efficiency of forestry tourism in China, while ecological construction, economic level, and environmental regulations are positively correlated with the eco-efficiency of forestry tourism. (4) Therefore, suggestions are made to optimize the allocation of tourism resource inputs and adopt appropriate development models, and to promote the interactive development of forestry industries.

Keywords: eco-efficiency; forestry tourism; the DEA game cross-efficiency model; tobit model

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1. Introduction

In "The Climate Economy and the Future of Humanity" by Bill Gates (2021), it is mentioned that the world emits about 51 billion tons of greenhouse gases into the atmosphere every year, and the worldwide trend towards warming is gradually becoming obvious; accordingly, it has become a broad consensus in the international community to reduce greenhouse gas emissions and slow down the process of climate warming. The Paris Agreement requires the parties to the United Nations Framework Convention on Climate Change to specify the target of national autonomous contribution, promote the early peak of carbon emissions and achieve the goal of carbon neutrality, and control the global temperature rise to within 2 °C by the end of this century. At present, most developed countries have specified carbon neutral timetables, and General Secretary Xi Jinping proposed at the 75th session of the UN General Assembly that China would strive to peak its CO_2 emissions by 2030 and work towards achieving carbon neutrality by 2060. Thus, the goal of carbon peaking and carbon neutrality is a major strategic decision made by China based on its responsibility to promote the building of a community of human destiny and the inherent requirement to achieve sustainable development, demonstrating China's new efforts and contributions to address global climate change and reflecting its firm support for multilateralism in dealing with climate change.

To accelerate the achievement of carbon peaking and carbon neutral targets, it is helpful to enhance the carbon sink potential of forest and grass. Forests are the largest organic carbon reservoir in terrestrial ecosystems [1] and have good carbon sequestration rates and carbon sink potential; many countries are beginning to focus on the role of forest carbon sinks in combating climate change, so continued attention to the speed and quality of forestry development is vital to achieving the dual carbon goal. However, forestry

development models are often limited by natural resource endowments and environmental capacity, and forestry development in the new era should adhere to the concept of green development to achieve a win-win situation in terms of economic, ecological, and social benefits. Forestry tourism is an important branch of forestry production development [2] and has become the third pillar industry of China's forestry industry. However, forestry tourism has many ecological safety hazards which, to a certain extent, reduce the carbon storage and carbon sequestration capacity of forestry ecosystems and damage the productivity of eco-systems; it is certainly a hindrance to the goals of carbon peaking and carbon neutrality. Therefore, it is very important to integrate the concept of sustainable development into forest tourism. An important research perspective on how to measure the sustainable development of forest tourism is tourism eco-efficiency, which was first proposed by German scholars Schaltegger and Sturm in 1990 and later extended to tourism. The meaning of forest tourism eco-efficiency is that the impact on the ecological environment is minimized while the maximum economic benefit can be achieved; the maximum economic output of forest tourism is obtained with the minimum environmental cost and the minimum resource input. Therefore, this paper seeks to accurately measure the eco-efficiency of forestry tourism and find the factors that affect its eco-efficiency, in order to find the policy entry point to enhance the eco-efficiency of forestry tourism and better contribute to the achievement of the dual carbon goal.

Forestry tourism, as a leisure service industry of forestry production, is currently studied from a single perspective. For research on forest park tourism, early domestic and foreign scholars mainly focused on forest tourism product development innovation and tourism resource value assessment. For example, Zandi et al. used the travel cost method to quantitatively evaluate the economic value of forest parks in northern Iran, and Jose et al. analyzed and discussed the development and utilization strategies of forest tourism products from the perspective of biodiversity in tropical areas. Ma et al. [3] responded to the problems of forest tourism products in China with the new development concept and suggested that the development of forest tourism products such as enjoyment-oriented forest leisure and vacation tourism should be promoted as a priority. Li et al. [4] used hierarchical analysis to evaluate the tourism resource value of the Python River National Forest Park.

With the concern about the level of tourism development and depletion of tourism resources, measuring the efficiency and quality of forest park tourism has become the focus of domestic and foreign scholars' research. Foreign scholars focus on the research of sustainable development. An example is Qin's study [5] on the ecological aspects of forest park tourism; they selected Gupo Mountain National Forest Park as the study site, explored the current situation of forest park visitor experience based on field research, and conducted ASEB raster analysis to provide corresponding suggestions for the sustainable development of forest park tourism. Yumi [6] examined the Japanese national forestry management and policy's historical development and critically analyzed its relationship with tourism policy; Ernawati [7] explored sustainable use pathways in places such as Bali through policy analysis targeting ecotourism. Domestic scholars, on the other hand, have focused on economic benefits, which are mainly reflected in the economic efficiency of tourism, and the studies range from regional forest parks to provincial forest parks, such as He et al. [8] who used a dynamic-network DEA model to estimate the efficiency of forestry tourism in Fujian Province, and Zhang et al. [9] who combined efficiency, pure technical efficiency, and scale efficiency, and measured the results of the influence of environmental factors on its efficiency. Xiu et al. [10] explored the factors influencing the development efficiency of 305 national forestry parks in China based on the DEA-tobit model. After the Party's 18th National Congress made the strategic decision to vigorously promote the construction of ecological civilization, scholars began to combine other fields and eco-efficiency themes in their research. For example, Zhang and Hong [11,12] both established linear regression models to study the factors influencing forestry eco-efficiency; Park et al. analyzed the eco-efficiency of Guanshan National Forestry Park from the whole tourism chain based

on the carbon footprint approach. Lin et al. [13] selected East China as the research object and studied its forestry tourism eco-efficiency values based on the Malmquist–Luenberger index method [14]. Lin et al. [15] used the Super-SBM model to measure the eco-efficiency of tourism in 11 prefecture-level cities in Jiangxi Province.

From the perspective of research, existing studies mainly focus on the economic efficiency of forest park tourism and the analysis of the influencing factors; few studies study the ecological efficiency of forest park tourism from the perspective of sustainable development. From the perspective of research method, basically, the traditional DEA efficiency model and super efficiency model are used. The existing research shows that the results obtained from the traditional efficiency measurement method are not unbiased; therefore, this paper adopts the game cross-efficiency model considering non-expected output, which can correct the problems of the traditional DEA model, including the fact that it has multiple optimal solutions for the decision unit and cannot be effectively ranked [16]. From the perspective of the research object, research on the eco-efficiency of forest park tourism is limited to a few provinces or prefecture-level cities in each region, and there are few studies on a larger scale; thus, this paper takes the forest parks in each province of China from 2010 to 2019 as the research object.

2. Materials and Methods

2.1. Tourism Ecological Footprint Model

The introduction of the concept of ecotourism has brought the role of tourism in the conservation of the natural environment into the public eye, leading to the introduction of the ecological footprint approach to tourism accounting. The ecological footprint approach to tourism measures the area of productive surface space required for the resources occupied by tourists to assess their impact on forest ecosystems and the environment. The calculation formula is:

$$EF = R\,(P + I - E)/Y, \tag{1}$$

P represents the total number of annual forest tourism, I represents the number of overseas tourists to Chinese forest parks, E represents the number of Chinese tourists to foreign forest parks, and Y is the ratio of the total number of annual forest park tourism in each province to the total annual forest park area. R represents the equilibrium factor, using the value of Liu et al. [17] based on net primary productivity, and the value of R in this paper is 1.41. The E is ignored due to the small number of Chinese tourists to overseas and the serious data deficiency.

2.2. The DEA Game Cross-Efficiency Model

Improved cross-efficiency models based on traditional CCR models can relate the efficiency of individual decision units to that of the remaining decision units and have the feature of deriving scores through peer assessment. However, the improvements still deviate from the actual results because they use arbitrary scores and therefore rely on a specific set of optimal DEA weights generated by the code, which biases the conclusions of the other decision units. Therefore, Liang et al. [18] combine the ideas of game theory and cross-efficiency to also fully consider the competitive impact of decision units based on their peer assessment. Specifically, the average cross-efficiency value is obtained when the maximum efficiency scores of the decision units themselves are averaged so that each non-unique optimal solution iterates continuously under the specified constraints until a convergence value is obtained, and the final convergence value constitutes a Nash equilibrium point.

If there exists a Decision-Making Unit (referred to as DMU), ($i = 1, \ldots, m$) is the i-th input of DMU_j, ($r = 1, \ldots, s$) is the r-th desirable output of DMU_j, and ($k = 1, \ldots, t$) is the k-th undesirable output of DMU_j. ω, μ, γ correspond to the three types of indicators of weights. The cross-efficiency of DMU_j ($j = 1, \ldots, n$) to DMU_d ($d = 1, \ldots, n$) and the game cross-efficiency of DMU_d to DMU_j is:

$$\alpha_{dj} = \frac{\sum_{r=1}^{s} \mu_{rj}^{d} y_{rj}}{\sum_{i=1}^{m} \omega_{ij}^{d} x_{ij} + \sum_{k=1}^{t} \gamma_{kj}^{d} z_{kj}}, \quad d, j = 1, 2, \ldots, n \tag{2}$$

Therefore, the average game cross-efficiency of DMU_j is:

$$\alpha_j = \frac{1}{n} \sum_{d=1}^{n} \sum_{r=1}^{s} \mu_{rj}^{d^*}(\alpha_d) y_{rj} \tag{3}$$

To solve α_j, set constraints such that each weight is greater than 0 and the weight of the desirable output is greater than the weight of the undesirable output, and consider mainly the following mathematical planning.

$$\begin{aligned}
&Max \sum_{r=1}^{s} \mu_{rj} y_{rj} \\
&\sum_{i=1}^{m} \omega_{ij}^{d} x_{il} + \sum_{k=1}^{t} \gamma_{kj}^{d} z_{kl} - \sum_{r=1}^{s} \mu_{rj}^{d} y_{rl} \geq 0, \quad d = 1, 2, \ldots, n \\
&\sum_{i=1}^{m} \omega_{ij}^{d} x_{ij} + \sum_{k=1}^{t} \gamma_{kj}^{d} z_{kj} = 1 \\
&\sum_{r=1}^{s} \mu_{rj}^{d} - \sum_{k=1}^{t} \gamma_{kj}^{d} \geq 0 \\
&\alpha_d \times (\sum_{i=1}^{m} \omega_{ij}^{d} x_{id} - \sum_{r=1}^{s} \gamma_{kj}^{d} z_{kd}) - \sum_{r=1}^{s} \mu_{rj}^{d} y_{rd} \leq 0 \\
&\omega_{ij}^{d} \geq 0, \quad i = 1, \ldots, m \\
&\mu_{ij}^{d} \geq 0, \quad r = 1, \ldots, s \\
&z_{kj}^{d} \geq 0, \quad k = 1, \ldots, t,
\end{aligned} \tag{4}$$

The steps for solving the game crossover are as follows.

In the first step, solve for the set of average crossover efficiency values defined in Equation (3), such that $\boldsymbol{t = 1, \alpha_d = \alpha_d^1 = \bar{E}_d}$.

In the second step, solve equation (4), such that $\boldsymbol{\alpha_j^{t+1} = \frac{1}{n} \sum_{d=1}^{n} \sum_{r=1}^{s} \mu_{rj}^{d^*}(\alpha_d)\, y_{rj}, \alpha_d = \alpha_d^t}$, where $\boldsymbol{\mu_{rj}^{d^*}(\alpha_d)}$ represents the optimal value of $\boldsymbol{\mu_{rj}^{d}}$ in Equation (4).

In the third step, if there exists a value of j such that $\left|\boldsymbol{\alpha_j^{t+1} - \alpha_j^t}\right| \geq \varepsilon$ (ε is any small positive number) and $\boldsymbol{\alpha_d = \alpha_d^{t+1}}$, then return to the second step, and if all values of j are satisfied $\left|\boldsymbol{\alpha_j^{t+1} - \alpha_j^t}\right| < \varepsilon$, then the iteration stops. At last, $\boldsymbol{\alpha_j^{t+1}}$ is the final average game cross-efficiency value considering the undesirable output.

2.3. The Panel Tobit Model

The panel tobit model was used to measure the degree of explanation of eco-efficiency by the factors influencing eco-efficiency in forestry tourism; the traditional panel model was applied to the case where the dependent variable takes unrestricted values and the efficiency values are scattered between (0,1), so the restricted dependent variable model was used with the following equation.

$$\begin{aligned}
&Y_{it}{}^{*} = \alpha_1 + \alpha_2 X_{it} + \mu_{it} \\
&Y_{it} = Y_{it}{}^{*}, \quad \text{if } Y_{it}{}^{*} > 0 \\
&Y_{it} = 0, \qquad \text{if } Y_{it}{}^{*} \leq 0
\end{aligned} \tag{5}$$

In the formula, $\boldsymbol{Y_{it}{}^{*}}$ is the potential explanatory variable; $\boldsymbol{X_{it}}$ is the explanatory variable; $\boldsymbol{\alpha}$ is the coefficient term; and $\boldsymbol{\mu_{it}}$ is the random disturbance term, which obeys a normal distribution with zero mean [19].

2.4. The Source of Data

The data from 2010 to 2019 are mainly from the China Environment Statistical Yearbook, China Statistical Yearbook, and the statistical yearbooks of provinces and cities.

Since most of the data of Tibet Autonomous Region are missing, the indicator data cover 30 provinces in China.

3. Results and Discussion

3.1. Eco-Efficiency Evaluation of Forestry Tourism

Construction of the Indicator System

The essence of tourism eco-efficiency is to minimize the impact on the ecological environment while maintaining the economic benefits of forestry tourism. This is combined with the concept of green development and the definition of the World Business Council for Sustainable Development on the connotation of efficiency, based on both inputs and outputs to build an efficiency evaluation system, such that the input-output system not only includes both economic and natural resource consumption, but also includes ecological pollution factors, i.e., the output term includes not only the desired outputs but also non-desired outputs. Specifically, input indicators include economic resources input, social resources input, and ecological resources input, among which ecological input is measured by water resources, energy, and land occupation area; desired outputs include economic, ecological, and social benefits, among which ecological benefits are evaluated by increasing afforestation area and transforming forest area; non-desired outputs include wastewater emission, COD emission, sulfur dioxide emissions, solid particle emissions, and forestry fire area, of which forestry fires are the most direct and destructive to forestry ecosystems.

Considering the accessibility of data, the study area covers 30 provinces in China (excluding Hong Kong, Macao, Taiwan, and Tibet Autonomous Region). The 2010 to 2019 data for each province and city are mainly taken from the China Forestry and Grassland Statistical Yearbook, China Environmental Statistical Yearbook, etc. Indicators involving monetary categories are removed from the influence of their price factors, such as annual forest park tourism input funds and total forest park tourism revenue, respectively, with fixed asset investment prices and residential consumer price index deflated to use 2010 as the base period [20,21]. The statistics department did not establish indicators of water and energy consumption in forest parks, so the ratio of forest park output to GDP was used to convert. The three waste indicators in the non-desired output were also not subdivided into forest park units, and considering that in actual production, forest parks mainly discharge industrial three waste by the secondary industry, the value of total forest park revenue as a percentage of total industrial output was calculated, and the value of total industrial three waste indicators in each province and city was converted to forest park three waste emissions.

3.2. Ecological Footprint Measurement

As shown in Table 1, from the temporal dimension, there are up and down fluctuations in the tourism ecological footprint of each province between 2010 and 2019, with most provinces and cities reaching a peak in 2017 and Chongqing reaching a peak of 2.394 million ha in 2010, with no obvious temporal trend in the tourism ecological footprint of each province and region. Comparing 2010 and 2019, 30 provinces and municipalities had tourism ecological footprint values greater than those in 2008 in 2019. In terms of provincial and regional dimensions, the mean tourism ecological footprint values varied widely among the 30 provinces and regions, with the highest and lowest values being Guangdong Province and Tianjin City, at 4.292 million ha and 11,000 ha, respectively, and there was no obvious correlation between the tourism ecological footprints among regions. The mean tourism ecological footprint values of forest parks in Guangdong, Jiangxi, and Jiangsu provinces and regions are at a high level, while the mean tourism ecological footprint values of forest parks in Hainan, Ningxia, and Tianjin are at a low level, and there are significant differences in tourism ecological footprint values between high- and low-level regions. Among them, the tourism ecological footprint level is also low in several provinces of key state-owned forest areas (such as Jilin, Heilongjiang, Inner Mongolia, etc.), which

indicates that their ecological investment planning is in a reasonable and effective category, which is conducive to the further improvement of tourism eco-efficiency.

Table 1. Tourism ecological footprint measurement results.

Province	Year										Aver.[1]	Rank
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019		
Beijing	17.0	18.2	25.4	26.7	26.8	27.4	29.6	26.3	81.0	25.4	29.2	21
Tianjin	1.0	1.1	1.1	1.1	1.0	1.1	1.3	1.1	1.3	1.1	1.1	30
Hebei	42.1	38.7	37.6	44.8	51.2	43.6	61.5	63.2	53.4	37.6	47.8	17
Shaanxi	34.3	49.0	75.6	69.2	72.4	70.4	79.1	80.8	79.0	75.6	63.0	14
Inner Mongolia	15.7	14.8	11.2	14.1	15.6	16.3	25.1	26.4	23.2	11.2	17.3	26
Liaoning	93.9	86.3	73.3	69.4	69.7	65.9	65.1	30.5	25.2	73.3	70.6	12
Jilin	40.5	49.8	39.4	37.4	39.8	40.5	49.7	17.9	14.2	39.4	39.0	18
Heilongjiang	35.4	37.9	38.7	38.0	37.5	36.9	43.0	39.0	18.5	38.7	36.5	19
Shanghai	22.2	19.4	19.5	19.3	16.4	15.9	16.8	13.4	14.4	19.5	18.6	25
Jiangsu	176.5	179.0	181.8	162.0	172.9	163.6	168.1	181.2	168.0	181.8	175.9	3
Zhejiang	187.2	170.8	148.9	162.3	182.6	175.6	207.0	183.7	174.2	148.9	172.0	4
Anhui	35.8	47.9	58.4	57.6	59.0	62.2	73.2	76.2	82.3	58.4	56.1	15
Fujian	79.4	80.7	88.0	79.7	73.4	70.8	72.9	67.3	69.1	88.0	75.4	11
Jiangxi	134.0	154.4	207.9	176.6	186.4	211.7	234.9	224.8	173.8	207.9	178.7	2
Shandong	122.3	117.4	135.3	132.0	131.9	127.9	140.1	130.2	110.4	135.3	129.5	6
Henan	88.1	82.5	94.7	83.9	86.4	86.5	96.7	106.9	132.2	94.7	105.6	8
Hubei	45.6	62.5	71.4	68.3	78.7	76.4	74.1	80.0	75.5	71.4	66.1	13
Hunan	95.2	137.2	142.2	124.6	124.1	126.9	145.2	141.0	146.7	142.2	125.3	7
Guangdong	407.7	372.7	356.3	440.6	446.8	543.1	522.2	401.0	563.2	356.3	429.2	1
Guangxi	27.1	26.2	27.9	27.2	27.3	26.7	28.9	28.9	28.7	27.9	27.0	22
Hainan	2.2	14.4	14.1	8.0	7.6	6.5	5.8	16.6	10.0	14.1	8.7	28
Chongqing	239.4	186.9	180.4	173.6	166.2	151.8	137.1	119.8	185.8	180.4	171.6	5
Sichuan	79.3	93.7	95.6	94.4	81.3	89.1	105.6	94.3	80.5	95.6	88.5	10
Guizhou	75.6	78.5	100.2	100.5	99.2	125.3	186.1	189.5	62.4	100.2	102.0	9
Yunnan	19.6	32.9	30.9	34.0	30.1	28.5	30.5	27.9	25.7	30.9	29.4	20
Shanxi	51.4	53.9	39.0	38.9	43.3	49.9	52.6	64.1	38.0	39.0	47.9	16
Gansu	22.1	19.9	21.6	22.8	22.4	26.2	27.2	16.4	17.0	21.6	21.1	23
Qinghai	7.5	8.2	11.9	11.4	9.8	9.2	9.5	8.7	9.2	11.9	9.0	27
Ningxia	3.4	3.0	4.9	6.0	6.3	5.7	7.6	6.5	6.3	4.9	5.2	29
Xinjiang	20.2	22.2	23.6	25.3	30.7	33.5	15.4	14.2	8.7	23.6	20.3	24

[1] Aver indicates the average value.

As shown in Figure 1, the average value of ecological footprint value per capita of tourism in 30 provinces from 2010 to 2019 generally shows a decreasing trend year by year, which indicates that the average area of forest tourism per person is getting smaller and smaller. Theoretically, with the development of forest park tourism and the accelerated development of various types of tourism activities in forest parks, there is bound to be a negative impact on the ecological environment.

Construction of the Indicator System

The inter-provincial forest park tourism eco-efficiency in China is the basis and prerequisite for analyzing the spatial divergence pattern of forest park tourism eco-efficiency in China and studying the sustainable development potential of forest parks. Additionally, incorporating the ecological footprint of forest park tourism in each province of China into the efficiency evaluation index system, and using the game cross-efficiency method of Matlab programming considering non-expected outputs can help to calculate the trend of forest park tourism eco-efficiency increase and decrease in 30 provinces and cities from 2010 to 2019, and the efficiency evaluation system is shown in Table 2.

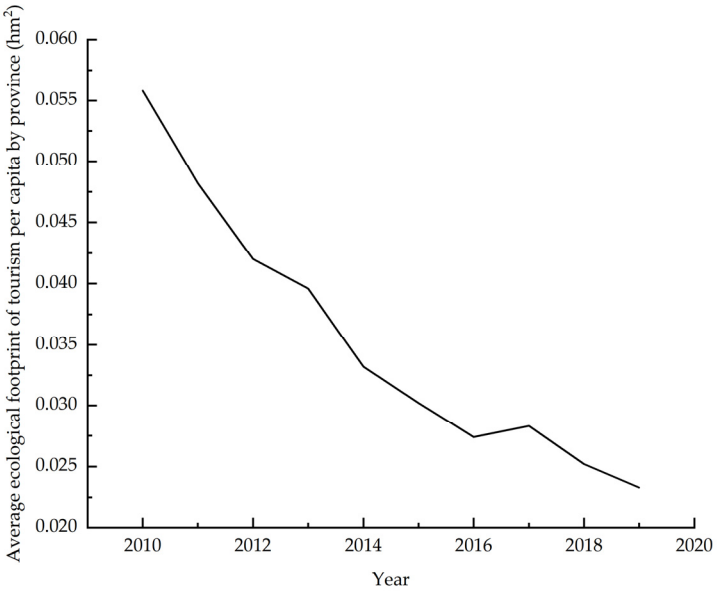

Figure 1. Ecological footprint of tourism per capita (ha/visit).

Table 2. Eco-efficiency evaluation of forestry tourism.

Level 1 Indicators	Level 2 Indicators	Indicator Features
Input Indicator	Resources	Annual forest park tourism input funds (billion yuan)
		Number of forest park employees at the end of the year (persons)
		Tourism ecological footprint (million hm^2)
	Environment	Water consumption (million m^3)
		Energy consumption measured by the quality of standard coal (MT)
		Forest park area (million hm^2)
Output	Desirable	Total tourism revenue of forest parks (billion yuan)
	Undesirable	Forest park wastewater discharge (MT)
		COD emissions from forest parks (MT)
		SO_2 emissions from forest parks (MT)
		Solid particulate emissions from forest parks (MT)
		Forestry fire area (million m^2)

By comparing the mean values of forestry tourism eco-efficiency from 2010 to 2019 in Table 3, it can be found that there are obvious regional differences in tourism eco-efficiency. The mean values of tourism eco-efficiency of forestry parks in Zhejiang and Beijing reach above 0.95, indicating that their inputs and outputs are close to the fully effective level under the premise of balanced development of economic and ecological benefits. The eco-efficiency of forestry park tourism in Jiangsu, Shanghai, Tianjin, Jiangxi, and Chongqing is within the range of 0.8 to 0.9, indicating that the inputs and outputs of these provinces and regions are close to the fully effective level. The eco-efficiency of forestry park tourism in all four of these municipalities is in a relatively high position, indicating that the economic level and ecological policies in economically developed regions are conducive to the improvement of eco-efficiency. In contrast, the mean value of tourism eco-efficiency in Inner Mongolia, Qinghai, Xinjiang, Gansu, and Ningxia regions is lower than 0.3, and there are significant differences in forestry park tourism eco-efficiency between each region.

Table 3. Forestry tourism eco-efficiency distribution table.

Province	Year										Aver.	Rank
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019		
Beijing	0.92	0.99	0.98	0.96	0.92	1.00	0.92	0.86	0.88	0.96	0.94	3
Tianjin	0.10	0.11	0.11	0.11	0.16	0.09	0.13	0.13	0.15	0.13	0.12	29
Hebei	0.36	0.39	0.39	0.38	0.42	0.48	0.64	0.65	0.71	0.80	0.52	15
Shaanxi	0.35	0.47	0.51	0.51	0.57	0.43	0.54	0.55	0.62	0.61	0.52	15
Inner Mongolia	0.27	0.27	0.25	0.25	0.30	0.28	0.19	0.20	0.21	0.22	0.24	24
Liaoning	0.43	0.62	0.62	0.62	0.66	0.56	0.39	0.28	0.32	0.28	0.48	18
Jilin	0.34	0.35	0.35	0.43	0.39	0.40	0.48	0.39	0.23	0.21	0.36	21
Heilongjiang	0.44	0.46	0.48	0.44	0.41	0.32	0.37	0.29	0.28	0.22	0.37	20
Shanghai	0.59	0.44	0.43	0.51	0.56	0.37	0.27	0.26	0.23	0.25	0.39	19
Jiangsu	0.88	0.92	0.89	0.97	0.96	0.97	0.53	0.47	0.54	0.54	0.77	5
Zhejiang	0.99	0.98	0.97	0.97	0.97	0.97	0.93	0.89	0.89	0.90	0.95	2
Anhui	0.48	0.59	0.63	0.64	0.73	0.59	0.47	0.47	0.46	0.47	0.55	13
Fujian	0.72	0.73	0.74	0.83	0.94	0.93	0.53	0.65	0.62	0.61	0.73	7
Jiangxi	0.60	0.57	0.67	0.69	0.75	0.61	0.30	0.30	0.30	0.31	0.51	17
Shandong	0.61	0.88	0.88	0.89	0.94	0.93	0.78	0.62	0.58	0.55	0.77	5
Henan	0.42	0.52	0.59	0.54	0.62	0.58	0.78	0.85	0.87	0.97	0.67	9
Hubei	0.85	0.53	0.60	0.66	0.68	0.74	0.98	0.99	0.99	0.98	0.8	4
Hunan	0.49	0.52	0.60	0.64	0.62	0.65	0.47	0.45	0.46	0.47	0.54	14
Guangdong	0.99	1.00	1.00	1.00	1.00	0.99	0.96	0.88	0.86	0.89	0.96	1
Guangxi	0.15	0.25	0.24	0.25	0.26	0.27	0.44	0.36	0.36	0.30	0.29	22
Hainan	0.32	0.38	0.36	0.32	0.33	0.34	0.19	0.18	0.18	0.21	0.28	23
Chongqing	0.51	0.67	0.84	0.81	0.84	0.81	0.72	0.62	0.55	0.56	0.69	8
Sichuan	0.48	0.73	0.82	0.85	0.76	0.78	0.53	0.57	0.54	0.51	0.66	10
Guizhou	0.55	0.26	0.32	0.35	0.37	0.39	0.91	0.83	0.90	0.92	0.58	12
Yunnan	0.22	0.17	0.18	0.18	0.19	0.18	0.16	0.30	0.28	0.27	0.21	25
Shanxi	0.75	0.65	0.67	0.70	0.72	0.54	0.55	0.55	0.70	0.70	0.65	11
Gansu	0.16	0.14	0.16	0.16	0.18	0.14	0.14	0.12	0.13	0.14	0.15	26
Qinghai	0.11	0.10	0.11	0.10	0.09	0.08	0.19	0.16	0.18	0.35	0.15	26
Ningxia	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	30
Xinjiang	0.14	0.13	0.13	0.11	0.13	0.10	0.16	0.14	0.15	0.10	0.13	28

Note: Aver indicates the average value. An efficiency value of 1 means that the efficiency is effective, i.e., there is no redundancy in inputs and no shortfall in outputs.

By calculating the annual average value of forest tourism eco-efficiency for each year in each province, city, and autonomous region, we can learn that the average value of forest park tourism eco-efficiency in each province, city, and autonomous region nationwide from 2010 to 2019 is in the range of 0.19 to 1. There is no industry division standard about tourism eco-efficiency values, and in accordance with the principles of science and rationality, this paper defines provinces and cities with forest tourism eco-efficiency values in the range of 0.81 to 1 as the optimal efficiency region, those in the range of 0.61 to 0.8 as the second-best region, 0.41 to 0.6 as the medium efficiency region, and 0.4 and below as the low efficiency region. Six provinces and cities from 2010 to 2014 are in the optimal region; this number increases to nine provinces and municipalities in the optimal region in 2015 to 2019. Ten provinces and municipalities are in the suboptimal region in 2010 to 2014, increasing to 12 provinces and municipalities in the suboptimal region in 2015 to 2019. Nine provinces and municipalities are in the intermediate region in 2010 to 2014, decreasing to seven provinces and municipalities in the intermediate region in 2015 to 2019, and 2010 to 2019 2014 decreases to 4 provinces and municipalities in the medium region. Five provinces and municipalities are in the inefficient region in 2010 to 2014, and six provinces and municipalities are in the inefficient region from 2015 to 2019. The temporal trends of the four types of eco to efficient regions indicate that the overall eco-efficiency of forest park tourism in China has improved. Specifically, Zhejiang, Beijing, Jiangsu, Shanghai, and Tianjin are always in the optimal region, which is mostly attributed to local high-

quality economic development, effective environmental policies, and reasonable tourism investment in forest parks under economic and ecological coordination. Among them, Guizhou and Hubei jumped from sub-optimal to optimal regions, thanks to their emphasis on forest tourism and reasonable development in recent years, indicating that their regions gradually reached the optimal state of low capital investment, low environmental cost, and high expected output. Heilongjiang, Jilin, and Liaoning are the representative provinces of the northeast region, and their eco-efficiency is in a relatively stable middle region, with Jilin's eco-efficiency fluctuating more and Heilongjiang and Liaoning being more stable; the reason for this may be due to their eco-inputs being limited by economic development.

3.3. Analysis of Factors Influencing Eco-Efficiency of Forestry Tourism

3.3.1. Formulating a Hypothesis

In the past, the forestry tourism industry focused more on operational efficiency and ignored the influence of environment and transportation on efficiency. To study the efficiency of forestry ecotourism, factors such as resource input, economic level, environmental regulation, and transportation accessibility should be considered comprehensively [22]. Combining the previous research results, five indicators, namely ecological construction, traffic accessibility, environmental regulation, tourism input, and economic level are selected as the influencing factors. Combined with the current situation of forestry tourism, we comprehensively evaluate the degree of influence factors of forestry tourism. The theoretical analysis and hypotheses for the five explanatory variables are as follows.

(1) Ecological construction. Although China is the world's major contributor to the increase in greening area, there are still deficiencies in forest quality and fragile ecosystems. The ecological benefits brought by planting and renovating forests and other ecological constructions are obviously the most direct, which not only improve the ecological environment, but also can enhance the ecological carbon sink capacity [23].

H1. *The higher the level of forestry ecological construction and protection, the higher the eco-efficiency of forestry tourism.*

(2) Convenience of transportation. Transportation is the basis and premise of tourism development and has an important impact on the development of regional tourism. The more developed the road network is, the more favorable it is for tourists to visit the forest, and the convenience of transportation is not only closely related to the local economic level, but also to the local ecological and geographical environment [24]. The better the natural conditions of forest growth, the lower the cost of forest park management and the higher the quality of the forest park.

H2. *The higher the accessibility and road network density, the higher the eco-efficiency of forestry tourism.*

(3) Capital input. According to the existing research results, it is known that reasonable economic resource input has an obvious positive effect on optimizing the allocation of forest resources and improving the ecological efficiency of forest tourism [25]. However, there is a certain lag in capital input for forest tourism, and it often takes a period of time for the current economic input to fully exert its effect on the output [26,27]. However, due to circumstances such as intermediate output and operational efficiency, the lag period cannot be determined, so the following assumptions are made.

H3. *The higher the economic resource input, the higher the forestry tourism eco-efficiency.*

(4) Economic level. The relationship between eco-efficiency and regional economic development above shows that regions with high-quality economic development, effective environmental policies, and coordinated economic and ecological development also have higher tourism eco-efficiency, and combined with the results of existing literature, it is found that there is a correlation between real GDP and eco-efficiency [28]. Among them, Sun et al. [29] used the SBM super-efficiency model regional eco-efficiency and found that regions with high economic levels tend to be eco-efficient when other variables are close.

Qian et al. [30] used the SBM model to measure the green economic efficiency of each province and region in China, and the results showed that the quadratic term of GDP per capita showed an obvious "U" relationship with the green economic development efficiency. However, the time span of this paper is small, so the following assumptions are made.

H4. *The higher the income and economic level of the population, the higher the eco-efficiency of forestry tourism*.

(5) Environmental regulation. The government's goal is to reduce environmental pollution and continuously improve environmental quality based on the economic level. The Porter hypothesis argues that moderate environmental regulation stimulates technological innovation, and improved production methods increase business profits, which compensates for the increased production costs caused by environmental regulation [31] and affirms the coordinating role of the government to achieve a "win-win" situation for economic growth and environmental protection.

H5. *The better the forestry control inputs and environmental regulation, the higher the forestry tourism eco-efficiency*.

3.3.2. Model Setting and Indicator Interpretation

In order to analyze the factors influencing the eco-efficiency of forestry tourism in China, the data are derived from the China Statistical Yearbook, China Forestry and Grassland Statistical Yearbook, and the statistical yearbooks of each region. Based on data integrity, relevant data of 30 provinces and cities in China from 2010 to 2019 are selected, and their influencing factors are studied and analyzed in combination with the results of the cross-efficiency value measurement of the game above. The total number of observed samples is 300 and the explanatory variables are ecological construction, transportation accessibility, tourism input, economic level, and environmental regulation, totaling five categories, and the explained variables are efficiency. Based on the selected five categories of ecological construction, accessibility, tourism input, economic level, and environmental regulation, a panel Tobit model is established.

$$FTE_{it} = \alpha_0 + \alpha_1 lnEC_{it} + \alpha_2 lnCL_{it} + \alpha_3 lnTL_{it} + \alpha_4 lnEL_{it} + \alpha_5 lnER_{it} + \mu_{it}, \quad (6)$$

where *FTE* is the eco-efficiency value of forestry tourism; *EC*, *CL*, *TL*, *EL*, and *ER* represent ecological construction, accessibility, tourism inputs, economic level, and environmental regulation, respectively; is the regression coefficient of the explanatory variables; i represents the province, $i = 1, 2, \ldots, n$; t represents the year, and the year interval is from 2010 to 2019; is the disturbance variance, which indicates the remaining unexplained part. To make the indicator series smooth and eliminate heteroskedasticity, the indicators were logarithmicized.

The meaning of ecological construction is conducive to the green and sustainable development of forestry construction inputs, such as afforestation, reforestation, and other means, so the forestry park coverage area is used as a measure. Transportation convenience is one of the most basic indicators of the tourism industry; if the traffic road network is developed [32], it is easy to reach tourist attractions, which is more favored by consumers, based on the availability of data to take the road density to characterize the convenience of transportation. Tourism input in the economic level is the most direct way of resource input, usually used for forestry park infrastructure, technical management, and pollution prevention, etc. The economic level greatly affects the residents' willingness to consume leisure tourism and the construction of local forestry park infrastructure. In order to avoid the interference of factors such as population and development scale, this paper uses GDP per capita to compare the economic level. Regarding environmental regulation, its meaning is to adopt a series of constraints on the production activities of enterprises and other economic agents involving the emission of pollutants, so as to restrain the damage to the environment while rapidly developing the economy. Combined with the basis of previous

research, the ratio of investment in environmental pollution control of forestry tourism to total industrial output value is used to express environmental regulation.

3.3.3. Forestry Tourism Eco-Efficiency Panel Tobit Analysis

The panel model was first subjected to the Hauseman test, which tested whether mixed effects or random effects were used, and the test statistic rejected the original hypothesis, so random effects were used. The results of the panel tobit measure were calculated using stata software and the results are shown in Table 4.

Table 4. Forestry tourism eco-efficiency distribution table.

Influencing Factors	Coefficient Estimates	Standard Error	Z-Statistics	*p*-Value
lnEC	0.2740	0.0660	4.15	0.000 ***
lnCL	−0.1000	0.0510	−1.94	0.019 **
lnTL	−0.0200	0.0120	−1.74	0.081 *
lnEL	0.1720	0.0320	5.46	0.000 ***
lnER	0.0930	0.0330	1.62	0.105
Constant	1.6240	0.2550	−5.74	0.000 ***

Note: ***, ** and * denote significance at 1%, 5%, and 10% significance levels, respectively.

The Tobit model was used to obtain the degree and direction of the effect of the five indicators on efficiency. The adjusted R^2 is 0.604, which indicates the goodness of fit of the model estimation, and this goodness of fit is in line with the requirements at the econometric level because the sample is a panel data of 30 provinces, which is a small sample data.

Transportation accessibility has a negative impact on the eco-efficiency of forestry tourism in China, with the *p*-value rejecting the original hypothesis at the 95% level of significance. In economic theory, well-developed transportation facilitates the transportation and circulation of various materials, which helps to reduce transportation costs and increase economic benefits, and theoretically increases the operational efficiency of forest tourism, but in ecological theory, the improvement of the road network also makes the region bear heavier traffic pressure, which leads to the increase of harmful gas emissions to a certain extent, and the convenient transportation facilities also attract more tourists, and the tourism behavior brings pollution emissions and damage to the soil, which also leads to the decrease of ecological efficiency to a certain extent. Tourism inputs also have a negative impact on the eco-efficiency of forestry tourism in China, with the *p*-value rejecting the original hypothesis at the 90% level of significance. This suggests that the investment in tourism has not achieved the effect of enhancing eco-efficiency and that there is redundancy in the investment funds. This result seems to be a little different from the economic theory. According to the research results of related literature [33], it is believed that there may be two kinds of perturbation factors: (1) most of the invested capital acts on those projects that need long-term construction, and it is difficult to produce effective output in the short term. Some studies show that there is a promotion effect of capital investment on forest eco-efficiency with a lag of several periods. (2) The production elasticity of capital in the forest tourism industry is small. Although forest tourism requires a large amount of capital investment, the increase of tourism income is small.

Among the other three indicators, ecological construction and economic level have a significant positive effect on efficiency. The promotion of economic levels often means increased consumption for the tertiary sector, which requires additional spiritual supplements in addition to basic material needs. Firstly, government finances can give more support to forest tourism, with a wide range of financing channels and various financing methods, which can promote sustainable and healthy development of the tourism sector. Secondly, the general population's income is also higher than the average, which can be invested more in the new ecotourism mode of forest tourism. While the effect of environmental regulation on efficiency does not pass the significance test, this seems to contradict the theory, because the higher the degree of environmental regulation by local governments,

the less over-expansion of tourism and destruction of ecological resources and the more beneficial for sustainable tourism industry. The reason for this may be that environmental regulations have a lagging effect on the eco-efficiency of forest tourism, and it is difficult to produce significant effects in the short term.

4. Discussion

This paper establishes an index system of eco-efficiency of forest park tourism based on both input and output aspects, which is in line with the principles of scientificity and rationality, but there are still deficiencies in the selection of indicators for output aspects; the positive output indicators only consider the economic level benefits, not the ecological level benefits, and the selection of undesirable output indicators is also incomplete. Furthermore, there are also outputs such as solid waste from tourists in actual forest park tourism activities. Secondly, the quantitative analysis of ecological efficiency impact factors should be added to make the analysis more complete.

In addition, there are three main contributions of this paper. First, an innovative perspective is adopted to study the long-term development of tourism in forests from the perspective of ecological protection and pollution reduction based on the context of carbon peaking and carbon neutrality. Second, a game cross-efficiency model that considers non-desired outputs is used, which can correct the problem of traditional DEA models with multiple optimal solutions for decision units that lead to ineffective ranking and the existence of invalid decision units. It has been shown that the results obtained from traditional efficiency measurement methods are not unbiased. Third, the current research on the eco-efficiency of forest park tourism is only limited to a few provinces or prefecture-level cities in each region, and few studies have been conducted on a large scale, so this paper takes the forest parks in each province of China from 2010 to 2019 as the research object.

The findings of this paper suggest four perspectives, including optimizing the allocation of input resources, improving public awareness of ecological protection aspects such as forest carbon sinks, policy innovation for forestry industry development, and paying attention to coordinated development among regions, to ensure steady and coordinated development of economy and ecology, and to motivate all sectors of society to actively participate in forest carbon sink initiatives.

5. Conclusions

The overall eco-efficiency of inter-provincial forestry tourism in China has improved from 2010 to 2019, and the average value of tourism eco-efficiency of 30 provinces and municipalities has increased from 0.63 in 2010 to 0.69 in 2019. However, nearly 70% of provinces have still not reached the optimal state of less capital input, less environmental cost, and more expected output. Among the factors affecting the eco-efficiency of forestry tourism, accessibility and tourism inputs have inhibiting effects on the eco-efficiency of forestry tourism in China, and ecological construction and economic level have significant promoting effects on the efficiency. To solve the above problems, three policy recommendations are proposed.

First, optimize the allocation of tourism resource inputs and adjust the investment structure so that resource inputs and tourism can develop synergistically to maximize the desired output share and improve the overall forestry tourism eco-efficiency with the smallest amount of inputs. In the process of forestry tourism development, find a balance point between the emission of environmental pollutants, various economic inputs, and the increase of forestry tourism production. Adopt a suitable development model in combination with local geographical conditions and develop more forestry tourism experience projects that are suitable for the time and place.

Second, use effective publicity to raise public awareness and demand for forestry leisure tourism. Make full use of news, popular science, special reports, new media, and other forms and means of publicity to actively promote the scientific knowledge of forest

carbon sinks, explain the work and practice in forest carbon sinks, and do a good job of popularizing knowledge and policy interpretation of forest carbon sink actions. Enhance the professionalism of practitioners and raise the awareness and action of all people to participate in addressing climate change, ecological protection and restoration, and biodiversity conservation. Promote the mutual promotion and development of the forestry tertiary industry and the remaining two forestry industries and explore the diversification of the forest tourism integration model to drive the economic development of the surrounding villages and link the inter-regional economic development.

Third, actively explore policy innovation and establish incentive mechanisms for forest carbon sink actions. Promote the establishment of an accounting and assessment system for the value of forest ecological products, and enrich green ecological financial products such as forest and grass carbon sinks. On the premise of not adding new hidden debts, encourage financial institutions to innovate financial products and services, support social capital to participate in forest carbon sink actions according to the law and regulations, mobilize the government, society, enterprises, organizations, and individuals to participate in forest and grass carbon sink actions, and establish a diversified input mechanism for forest carbon sink actions.

Fourth, pay attention to inter-regional differences in ecological efficiency and achieve the coordinated development of forest tourism. The economic lead in the development of ecotourism has not been reflected, and the economic siphon effect has instead further stretched inter-regional ecotourism differences. At the provincial level, the shift from a sloppy to an intensive economic development model should become the premise and basis for the development of ecotourism in each province and region. Furthermore, it is important to give full play to the role of economic factors as a leader at the level of environmental protection by strengthening economic exchange and cooperation to form a sustainable development model of tourism with economic synergy as the main focus.

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