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EMPIRICAL ANALYSIS OF TOURISM EFFICIENCY MEASUREMENT IN NORTHERN CHINA BASED ON DEA-MALMQUIST MODEL

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Abstract. *Tourism is a happy industry to realize people's growing needs for a better life, and high-quality development gives tourism governance a new mission of the Times. Using the DEA-Malmquist model, this paper studies the evolution characteristics of tourism productivity index in northern China based on the tourism industry data of nine provinces in northeast and northwest China from 2006 to 2019. The research results show 1) the productivity index of tourism industry in northern China shows a fluctuating change, with a slow growth on the whole, which is mainly driven by scale efficiency and technological progress; 2) Liaoning province in northeast China has the highest total factor productivity with an average of 1.119, while Shaanxi province in northwest China has the highest total factor productivity with an average of 1.176.*
Keywords: Northern China, DEA-Malmquist model, Tourism efficiency

1. **Introduction.** Since the reform and opening up, with the rapid development of tourism, the continuous improvement of the industrial system, and the increasing expansion of the industrial scale, tourism has played a vital role in the development of the national economy. Under the background of the Belt and Road initiative, the economic exchanges at home and abroad increase, and the tourism development in northeast and northwest China also faces new challenges. At the same time, the Western Development Strategy was put forward, and China attaches importance to the development of tourism in northwest China. However, tourism, as an important part of the tertiary industry, has been in the process of regional imbalance, mainly reflected in the strength of the east and weakness of the west [1]. According to the data in The Annual Report of China's Domestic Tourism Development 2018, the development of tourism in northwest China is growing rapidly, while the development of tourism in northeast China is relatively slow, and there is the problem of unbalanced development among provinces [2]. At present, Chinese scholars' research on tourism efficiency mainly focuses on the national level [3,4] and economic zone [5-7] and provincial level [8]. More scholars will choose one province for research [9,10]. The comparative study of tourism efficiency between northwest and northeast China needs to be expanded. The development of tourism in northwest and northeast China is not as good as that in coastal areas, because the tourism infrastructure in coastal areas is relatively sound and the traffic is relatively developed, etc. Therefore, it is of certain reference value to measure and compare the efficiency of the tourism industry in northwest and northeast China, discuss the optimization of the industrial structure of the tourism industry, and put forward countermeasures to improve the efficiency of the tourism industry in northwest and northeast China in the future wave of tourism development to

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obtain greater competitiveness. The DEA-Malmquist model is mainly used to study the efficiency of tourism [11,12], so this paper uses the DEA-Malmquist model to compare the 15-year data of 9 provinces in northwest and northeast China to study the efficiency measure, and analyze the development trend of tourism in northwest and northeast China from 2006-2019, as well as the development advantages and development direction in the future, in order to achieve the goals and tasks of the "14th Five-Year Plan" [13].

This paper mainly studies from three aspects. First of all, based on the existing literature, combined with the characteristics of tourism in northwest and northeast China, the tourism efficiency measurement index system is established. Secondly, based on the data of nine provinces in northern China from 2006 to 2019, the DEA-Malmquist model is used to carry out measurement research, and the total factor productivity index and decomposition index of northern China are obtained. Finally, this paper calculates the annual total factor productivity index and its decomposition index of each province and makes a comparative study, which is also the innovation point of this paper.

2. Research Methods and Data Sources.

2.1. **The mathematical principle of DEA model.** Data Envelopment Analysis (DEA) is a new efficiency analysis method proposed by Charnes et al. [14] using the concept of relative validity in 1978. Its core idea is to determine the boundary of a maximum output or minimum input with the help of mathematical programming model on the condition that the decision-making unit and the "units" with multiple inputs and outputs remain unchanged. The essence is to judge whether DMU is located on the production front. Therefore, data envelopment analysis can also be regarded as a non-parametric statistical method [15].

$$\begin{cases} \text{Min}\left(\ \theta-\varepsilon\quad \left(e_1^T s^- + e_2^T s^+\right)\ \right) & \\ \text{s.t.}\ \sum_{j=1}^{N} X_{ja}\lambda_j + s^- = \theta X_a^N & a=1,2,\ldots,A \\ \sum_{j=1}^{N} Y_{jb}\lambda_j - s^+ = Y_b^N & b=1,2,\ldots,B \\ \lambda \geq 0 & n=1,2,\ldots,N \end{cases} \tag{1}$$

where θ is the comprehensive efficiency, $0 < \theta \leq 1$; ε is the non-Archimedean infinitesimal quantity, s^- is the relaxation variable, $s^- \geq 0$; s^+ is residual variable, $s^+ \geq 0$; λ_j is the weight variable, $\lambda_j \geq 0$; X_{ja} is the input amount of a resource in the j $(j = 1, 2, \ldots, N)$ production unit, and Y_{jb} is the output of b resource in the j production unit.

2.2. **Malmquist production index model.** Malmquist total factor productivity index was proposed by scholar Malmquist in 1953. Fare et al. [16] improved this algorithm in 1994. In the case of constant return to scale, the formula of Malmquist productivity index from t period to $t+1$ period is

$$M(Y_{t+1}, X_{t+1}) = \frac{d^{t+1}(X_{t+1}, Y_{t+1})}{d^t(X_t, Y_t)} \sqrt{\left[\frac{d^t(X_{t+1}, Y_{t+1})}{d^{t+1}(X_t, Y_t)} * \frac{d^t(X_t, Y_t)}{d^{t+1}(X_t, Y_t)}\right]} \tag{2}$$

When $M > 1$, the total factor productivity index increases; When $M = 1$, it means that the total factor productivity level remains unchanged; When $M < 1$, it means that the total factor productivity level decreases. Formula (2) can be further decomposed into

$$M(Y_{t+1}, X_{t+1}, Y_t, X_t) = \sqrt{\left[\frac{d^t(X_{t+1}, Y_{t+1})}{d^t(X_t, Y_t)} * \frac{d^{t+1}(X_{t+1}, Y_{t+1})}{d^{t+1}(X_t, Y_t)}\right]} \tag{3}$$

In the formula (Y_{t+1}, X_{t+1}) and (Y_t, X_t) represent the input and output of t and $t+1$; d^t and d^{t+1} represent the distance function between t and $t+1$. In Formula (3), the first part of the right part represents the change rate of technical efficiency, while the second part represents the change rate of technological progress, which can be decomposed into scale efficiency and pure technical efficiency.

Therefore, the final decomposition formula is

$$\text{TFPCH} = \text{EC} * \text{TECH} = \text{PEC} * \text{SECH} * \text{TECH} \tag{4}$$

In the formula, TFPCH is the total factor productivity, which can be decomposed into EC and TECH, which are the change rate of technical efficiency and technological progress, respectively [17].

2.3. **Variable selection and data source.** This paper selects Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang as the research object. Based on the experience of previous scholars, the measurement index of this paper is established. Choose the number of star hotels (home), the total number of travel agencies (home), tourism practitioners (ten thousand), the original value of fixed assets of star hotels (ten thousand yuan) as investment indicators; total tourism income (100 million yuan) and total number of tourists (ten thousand people) are output indicators [18]. In the measurement, the total tourism income and the original value of fixed assets of star hotels are smoothed to eliminate the impact of price fluctuations. The relevant data in this paper are collected according to the China Tourism Statistical Yearbook (2007-2020) and the national economic and social development statistical bulletin of each province.

3. Empirical Analysis of Tourism Efficiency Measurement in Northern China.

3.1. **Time variation characteristics of total factor productivity index and decomposition of tourism industry in northern China.** Table 1 shows the total factor productivity index and decomposition index of tourism industry in Northern China from 2006 to 2019. On the whole, the total factor productivity index in northern China shows a wavy change, but the wavy change shows a trend of gradual improvement.

First of all, a higher growth rate shown in northern China has achieved great development, for tourism from 2008 to 2010, the growth rate reached 14.1%, this kind of situation

Table 1. Total factor productivity index and decomposition index of tourism industry in northern China from 2006 to 2019

Year	TFPCH	TECH	EC	PEC	SECH
2006-2007	1.113	1.156	0.963	1.001	0.962
2007-2008	1.148	1.282	0.896	0.958	0.935
2008-2009	1.167	1.218	0.958	0.995	0.963
2009-2010	1.308	1.419	0.922	1.032	0.893
2010-2011	1.169	1.211	0.965	0.985	0.980
2011-2012	1.223	1.193	1.025	0.996	1.030
2012-2013	1.424	1.298	1.097	1.055	1.040
2013-2014	0.878	0.943	0.931	0.972	0.958
2014-2015	1.013	0.920	1.101	1.081	1.018
2015-2016	1.308	1.252	1.044	1.006	1.038
2016-2017	1.211	1.235	0.981	1.050	0.934
2017-2018	1.219	1.322	0.922	0.865	1.065
2018-2019	1.306	1.105	1.183	1.097	1.078
The mean	1.183	1.188	0.996	1.005	0.990

is likely to be due to the Shanghai World Expo held, and large of world-class attracted a large number of tourists from home and abroad, also effectively led to the growth of the tourist customers in eastern. However, at the same time, it also has a certain degree of diversion effect on tourists in northeast and northwest regions, and promotes the high-quality development and optimization of tourism [19]. Secondly, the growth rate of total factor productivity index in 2013 reached 20.1%, and the total factor productivity in this year reached the highest level. This is precisely because China's tourism industry has entered the "mass tourism" stage, during which people's desire to travel keeps rising, and the development of the domestic tourism market is relatively optimistic.

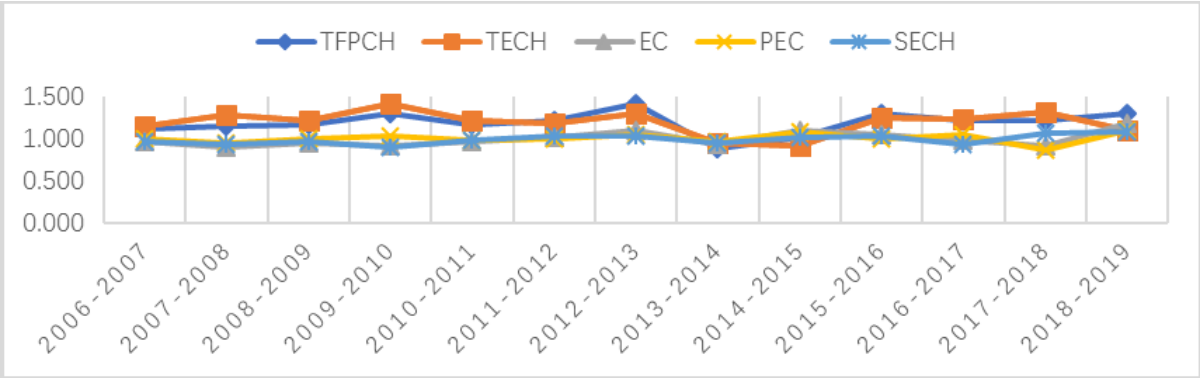

FIGURE 1. Time variation characteristics of total factor productivity index and decomposition index of tourism industry in north China from 2006 to 2019

It shows the time trend of total factor productivity index and decomposition index of tourism industry in northern China. It can be seen from the figure that during 2006-2019, the total factor productivity showed a trend of rising first and then falling again. Except for 2013-2015, the fluctuation range was relatively stable, with an average growth rate of 18%. Total factor productivity experienced two peaks and one trough. When there is a big event, the total factor productivity will fluctuate greatly, and the fluctuation is relatively stable in the rest of the time, which shows that the tourism industry is easily disturbed by external factors. Since the implementation of the Belt and Road policy, the overall development level of tourism in the northern region has improved, but there is still a certain gap between the development of tourism and the coastal areas.

3.2. **The difference and evolution characteristics of tourism total factor productivity index in northern China.** In this paper, the nine provinces studied are divided into two regions, northwest (including Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang) and northeast (Inner Mongolia, Liaoning, Jilin and Heilongjiang), and the difference of total factor productivity index between the two regions is compared. Table 2 shows the calculation results of total factor productivity of tourism in Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang from 2006 to 2019.

It can be seen from the table that the total factor productivity of these five provinces showed an increasing trend from 2006 to 2019, and it can be concluded that Shaanxi province has the fastest growth, while Qinghai province has the slowest growth. It can be seen that the average annual growth rate of Shaanxi province is 17.6%, the average annual growth rate of Gansu province is the second with an average annual growth rate of 13.5%, followed by Xinjiang with an average annual growth rate of 12.6%, Ningxia with a total factor growth rate of 9.5%, and Qinghai province with the lowest average annual growth rate of 3.9%. Ningxia and Qinghai have the lowest growth rate, which may be mainly due to the fact that transportation and the local tourism infrastructure is not perfect. For Ningxia and Qinghai provinces, they should improve the utilization of local tourism

TABLE 2. Tourism productivity index in northwest China from 2006-2019

Year	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang	On average
2006-2007	1.091	1.039	0.997	1.058	1.206	1.078
2007-2008	1.129	1.007	0.895	1.138	0.993	1.032
2008-2009	1.213	1.119	1.182	0.899	1.004	1.083
2009-2010	1.284	1.197	0.934	1.114	1.071	1.120
2010-2011	1.250	1.166	1.092	1.073	1.018	1.120
2011-2012	1.198	1.107	1.100	1.075	1.132	1.122
2012-2013	1.156	1.179	1.237	1.164	1.122	1.272
2013-2014	1.113	1.280	0.957	0.814	0.930	1.019
2014-2015	0.917	0.992	0.943	0.862	1.043	0.951
2015-2016	1.316	1.169	1.014	1.068	1.221	1.158
2016-2017	1.214	1.282	0.914	1.280	1.126	1.263
2017-2018	1.356	1.158	1.139	1.172	1.161	1.197
2018-2019	1.051	1.054	1.106	1.016	1.107	1.067
The mean	1.176	1.135	1.039	1.095	1.126	1.114

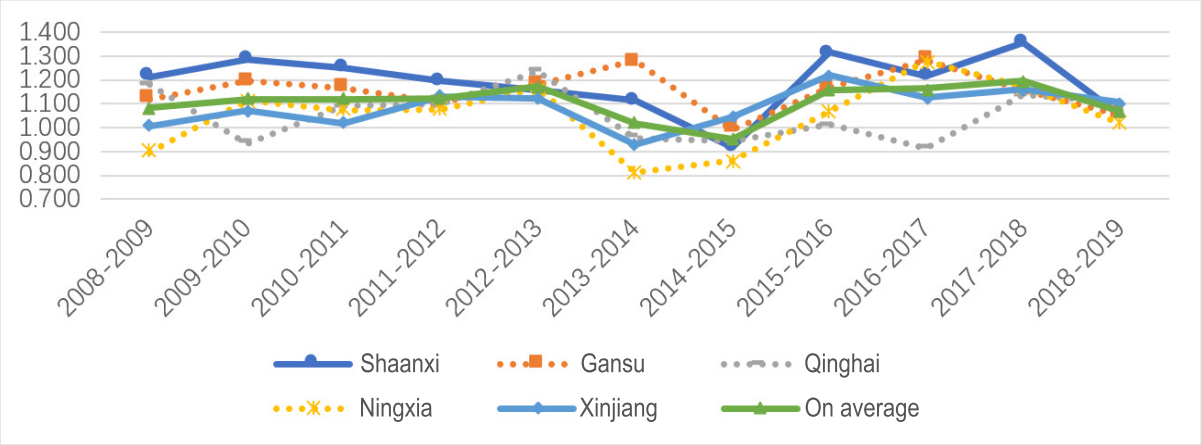

FIGURE 2. Tourism productivity index line chart of northwest China from 2006 to 2019

resources, and develop tourism products in line with local characteristics, and the local government should also actively build local tourism infrastructure.

It shows the time line chart of total factor productivity index of Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. As can be seen from the figure, the productivity indexes of these five provinces have the same fluctuation changes. From 2008 to 2009, the total factor productivity indexes of these five provinces have increased significantly, which may be due to the economic recovery after the financial crisis. From 2014 to 2018 the total factor productivity fluctuation is bigger, but on the whole is present a growth trend. Total factor productivity fell in all five provinces, but by a relatively small margin. This shows that the tourism industry in West Belgium has been less affected by the COVID-19 outbreak, in 2019.

It shows the calculation results of total factor productivity indexes of Inner Mongolia, Liaoning, Jilin and Heilongjiang from 2006 to 2019. It can be seen from the table that total factor productivity shows an overall trend of growth. Liaoning province recorded the highest growth rate of 11.9 percent. Inner Mongolia recorded the lowest total factor productivity growth rate of 8.5 percent. There is little difference in the average annual growth rate of total factor productivity in these four provinces, indicating that the development of tourism in northeast China is correlated. In the northeast, Liaoning province

TABLE 3. Tourism productivity index in northeast China from 2006 to 2019

Year	Inner Mongolia	Liaoning	Jilin	Heilongjiang	On average
2006-2007	1.080	1.155	0.967	1.170	1.093
2007-2008	1.170	1.213	1.029	1.139	1.138
2008-2009	1.139	1.184	1.015	1.017	1.089
2009-2010	1.189	1.217	1.187	1.102	1.174
2010-2011	1.166	1.184	1.136	1.159	1.161
2011-2012	1.082	1.178	1.127	1.252	1.160
2012-2013	1.158	1.134	1.237	1.149	1.170
2013-2014	0.919	1.003	1.126	0.843	0.973
2014-2015	1.045	0.977	1.120	0.953	1.024
2015-2016	1.114	1.284	1.122	1.103	1.156
2016-2017	1.040	1.136	1.183	1.151	1.128
2017-2018	1.045	1.479	1.164	1.273	1.240
2018-2019	1.004	0.944	1.029	1.077	1.014
The mean	1.085	1.119	1.101	1.092	1.099

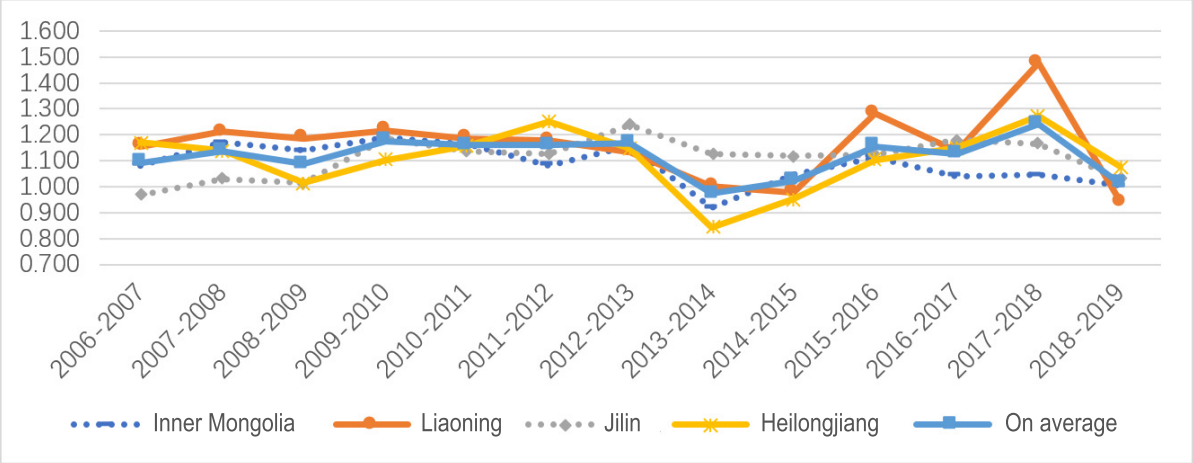

FIGURE 3. Line chart of tourism productivity index in northeast China from 2006 to 2019

has the best tourism development. The main reason is that Liaoning province has a relatively superior geographical location, a relatively comfortable climate environment, and there are many coastal cities in Liaoning province.

Figure 3 shows the time trend of total factor productivity index in Inner Mongolia, Liaoning, Jilin and Heilongjiang. As can be seen from the figure, the total factor productivity index of the four northeastern provinces, except Liaoning province, is relatively stable without big fluctuations. Liaoning province fluctuated the most from 2013 to 2019, with a significant decline in total factor productivity in 2019, indicating that the tourism industry in Liaoning province was greatly affected by the COVID-19 outbreak. Tourism is more vulnerable to large-scale events and adverse weather conditions, and tourism economy is more vulnerable to external conditions.

4. **Conclusion.** To sum up, this paper uses the DEA-Malmquist model to measure the tourism efficiency of nine provinces in northern China from 2006 to 2019. The results show that 1) the total factor productivity of tourism industry in northern China shows a fluctuating change and a slow growth in general. The change rate of total factor productivity index is the same as that of technological progress. Both comprehensive technical efficiency and technological progress can cause the change of total factor productivity.

Technological progress fluctuates greatly and is the main factor causing the change of total factor productivity. 2) From the perspective of spatial and regional differences, the growth rate of total factor productivity in northwest China is larger, while the growth rate of total factor productivity index in northeast China is slower. The average annual growth rate of total factor productivity in northwest Shaanxi, Gansu and Xinjiang provinces is higher than that in Liaoning province. 3) Tourism is more vulnerable to local climate conditions and emergencies, and the impact of total factor productivity index on emergencies in northeast China is greater than that in northwest China. When large-scale events are held, they will have a relatively short-term promotion effect on tourism efficiency. To sum up, this paper believes that to promote the development of tourism, it is necessary to strengthen the investment in tourism technology, at the same time to create tourism products in line with local characteristics, a large amount of investment in scientific and technological innovation, so as to ensure the rapid development of tourism. For the northwest region, the government should pay attention to the construction of transportation and tourism infrastructure in the northwest region, and the northeast region should increase the construction of tourism brand to create a unique tourism brand.

There are also many shortcomings in the research of this paper. Due to problems in data collection, the established measurement index is not comprehensive enough to fully reflect the efficiency of tourism. Therefore, in the future research, the research idea should be more detailed and realistic, and more attention should be paid to the in-depth study of tourism efficiency.

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