Spatial differentiation and evolution trend of technical efficiency of forestry production in china

Xu Yang

School of Business Administration, Zhongnan University of Economics and Law, Wuhan 430073, China

Abstract: Based on the non-radial super-efficiency SBM model, the technical efficiency of forestry production in 30 provinces (municipalities, autonomous regions) across the country was measured from 2004 to 2018, and the Makov chain was introduced to analyze the evolution trend. The research found that: The average PTE of China's forestry from 2004 to 2018 was 0.516, and the overall level was not high; regional imbalances were prominent, showing a distribution pattern of "high in the south and low in the north" and "high in the east and low in the west". Regions with low and high levels of Forestry PTE have certain characteristics of "path dependence". in the long run, Forestry PTE growth will face greater pressure.

Keywords: Forestry; Production technology efficiency; Makov chain

1 Introduction

Forestry is a basic production sector supported by the state. It not only plays an important role in job creation and green poverty reduction, but also plays an increasingly prominent role in ecological construction. Seeking to obtain the maximum output under a certain factor input, that is, to improve the efficiency of forestry production technology (Forestry PTE), has become a realistic choice for achieving high-quality forestry development. The research of forestry PTE has been widely concerned by scholars. In terms of research content, it is mainly divided into two aspects: First, in terms of measurement and calculation, now it is mainly based on SFA and DEA methods, the SFA result depends on the pre-setting of the production function and the probability distribution of random items, and cannot handle the problem of multiple outputs. The DEA method does not need to set the production function in advance, and can incorporate ecological benefits and economic benefits into the efficiency measurement. It is gradually being widely used by scholars. However, the DEA methods used in the existing literature are mostly radial, that is, the problem of slack variables is not considered, and the results obtained will inevitably deviate from the actual situation. Second, in terms of evolution trend, the existing research on Forestry PTE evolution trend is mostly qualitative, and the results of using Makov chain to explore its long-term evolution trend are very rare.

In view of this, this article intends to expand from the following aspects: First, based on the requirements of ecological civilization construction, aiming at the coupling of forestry ecological benefits and economic benefits, using a non-radial global reference super-efficiency SBM model to measure Forestry PTE; Second, using the Makov chain to analyze the evolution trend of Forestry PTE and grasping the development trend of Forestry PTE.

2 Research methods and Data

2.1 Super efficiency SBM model

This article explores how to maximize the output of ecological and economic benefits under a certain combination of forestry element inputs. Therefore, the super-efficiency SBM model based on the output

angle is used for calculation, as shown in equation (1). In formula (1), δ is the DEA super-efficiency value, λ_j is the weight vector, x and y represent the input and output variables respectively, s and m represent the number of input and output variables, and s+ represents the slack variable of output. When $\delta \geq 1$, the decision-making unit is relatively effective, when $\delta < 1$, the decision-making unit is relatively invalid. The larger the value of δ, the higher the Forestry PTE.

2.2 Makov chain

The Makov chain is a discrete event stochastic process, namely, the index set T corresponds to each period, and the finite state corresponds to the state number of the random variable. Then for all periods t and all possible states j, i and i_k(k= 0,1,2, …,t-2), which satisfies the formula,, which means that the probability of X being in the j state in the t+1 period only depends on the state in the t period.

If the Forestry PTE level is divided into k states, then the transition between Forestry PTE states can be represented by a k×k transition probability matrix P, as shown in equation (2).

In formula (2), P_{ij} represents the transition probability of Forestry PTE belonging to type i in year t and transitioning to type j in year t+1, using maximum likelihood estimation method to obtain, nij is the sum of the number of provinces transferred from type I in year t to type J in year t + 1 in the whole observation period , ni is the sum of the number of provinces belonging to type i in all years. According to the state change, the transfer direction can be defined as three types: upward, downward and steady.

2.3 The selection of indicators

In the calculation of Forestry PTE, labor, land, and capital are selected as input indicators, which are represented by the number of employees in the forestry system at the end of the year, the region of forest land, and the stock of forestry fixed asset investment capital. In the context of the construction of ecological civilization, the output indicators measured by Forestry PTE should balance ecological and economic benefits, which are measured by forest volume and forestry production value respectively. Indicators selection and explanation are shown in Table 1.

Table 1. Selection of input-output indicators

Indicators	Indicators name	Explanation
	labor	number of employees in the forestry systemat the end of the yea
Input indicators	land	area of forest land
	capital	the stock of forestry fixed asset investment capital
Output indicators	ecological benefits	forest volume
	economic benefits	forestry production value

2.4 Data sources

30 provinces (municipalities, autonomous regions) in China are selected as the research objects, excluding Taiwan, Hong Kong, Macau and Tibet. With reference to the research of Ding Zhenmin(2016), 30 provinces (municipalities, autonomous regions) are divided into five forest regions[1], and the time span is selected as 2004-2018. The data related to the value form in the article are all based on 2004, and the corresponding index is used to eliminate the influence of price factors. The original data comes from the "China Statistical Yearbook(2004-2018)", "China Environmental Statistical Yearbook(2004-2018)", "China Forestry Statistical Yearbook(2004-2018)" and some provincial statistical yearbooks.

---

1 That is, the northeast forest region includes 3 provinces including Heilongjiang, Jilin and Liaoning; the southwest forest region includes 2 provinces and 1 municipalities including Sichuan, Chongqing, and Yunnan; the southern forest region includes Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Hubei, Hunan, Guangdong , Guangxi, Hainan, Guizhou, etc. 10 provinces, 1 municipalities and 1 autonomous region; North China forest region includes Beijing, Hebei, Shandong, Tianjin, Henan, Shanxi, Inner Mongolia and other 4 provinces, 2 municipalities and 1 autonomous region; Northwest forest region includes Xinjiang, Gansu, Qinghai, Shaanxi , Ningxia and other 4 provinces and 1 autonomous region.

3 Results and analysis

3.1 The spatial differentiation characteristics of Forestry PTE

The super-efficiency SBM model was used to calculate the Forestry PTE of 30 provinces (municipalities, autonomous regions) across the country from 2004 to 2018. Figure 1 shows the average level of Forestry PTE of 30 provinces (municipalities, autonomous regions) across the country from 2004 to 2018.
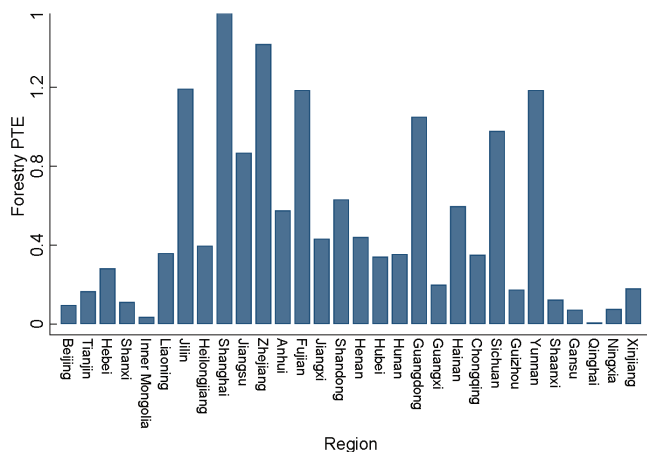
Figure 1. The average level of Forestry PTE of 30 provinces (municipalities, autonomous regions) from 2004 to 2018

From 2004 to 2018, the average Forestry PTE of China was 0.516, and the overall level was not high. As far as the gap between provinces within the same forest region is concerned, the gap within the forest region in North China is relatively large. In the observation period, the highest forest PTE is 0.63 in Shandong, and the lowest is 0.10 in Beijing, which is only about 15.87% of Shandong. The inner gap of southwest forest region is small, the average Forest PTE during the observation period was 1.19 in Yunnan and the lowest was 0.35 in Chongqing, which was only about 29.41% of Yunnan. In terms of the provincial gaps in different forest regions, the Forestry PTE of Zhejiang, Jilin, Yunnan and other places were in the forefront during the observation period, and their average values were about 1.42, 1.19, and 1.19, respectively. The forest PTE of Qinghai, Inner Mongolia, Ningxia and other places has been low, with the average values of 0.01, 0.04 and 0.07 respectively, which is less than 1/20 of Zhejiang and other places. Even Shandong (0.63) and Xinjiang (0.18), which have the highest forest PTE in North

China and Northwest China, have a large gap with Zhejiang and other places. Overall, China's Forestry PTE spatially presents a pattern of "high in the south and low in the north" and "high in the east and low in the west".

3.2 Trend evolution of Forestry PTE

In order to further grasp the future trend of Forestry PTE, this paper uses Markov chain to analyze the characteristics of Forestry PTE transfer probability, and uses natural breakpoint method to divide 30 provinces (municipalities, autonomous regions) into low-level, medium-low-level, medium-level, and medium-high-level and high-level five states. The state transition probability of China Forestry PTE from 2004 to 2018 is calculated based on the Markov chain, the results are shown in Table 2. It can be seen that:

(1) If the Forestry PTE in a certain region is at a low level, the probability of a stable transition in the region after 1, 3, and 5 years is 92.5%, 83.1%, and 77.9%, if the Forestry PTE in a certain region is at a high level, 1 Years later, 3 years later, and 5 years later, the probability of a smooth transition in the region is 87.2%, 84.9%, and 78.3%. The probabilities are all over 75%, which indicates that regions with low and high levels of Forestry PTE show a certain trend of self-reinforcement and have strong "path dependence" characteristics.

(2) If the Forestry PTE in a certain region is at a medium-low, medium or medium-high level, the "path dependence" feature is relatively weak. The probability of a smooth transfer after 5 years is 32.7%, 57.7%, and 39.4%, respectively. Compared with low-level and high-level regions, liquidity has been greatly enhanced.

(3) As far as the direction of transfer is concerned, regions where Forestry PTE with low-medium and medium-level have a greater probability of downward transfer after 1, 3, and 5 years, which means that if a place is in the above two states ,Forestry PTE tends to decline. In regions with a medium-high level, whether it is 1 year, 3 years or 5 years later, the probability of upward transition is greater, which means that Forestry PTE tends to rise .

(4) In terms of the transfer range, when T=1, the elements on the off-diagonal line are closely arranged on both sides of the diagonal line, which means that in the two adjacent years of the observation period,

Forestry PTE can only achieve transitions between adjacent states, and the possibility of achieving cross-state transitions or declines is minimal. When T=3, the arrangement of the elements on the off-diagonal line is relatively uniform, and when T=5, the arrangement of the elements on the off-diagonal line is more uniform, indicating that as the interval lengthens, Forestry PTE can achieve a across-state rise or fall. However, the probability of a cross-state decline is higher than the probability of a transition, which shows that in the long run, the improvement of Forestry PTE is facing greater pressure.

Table 2. Markov transition probability results of Chinese PTE

	State	Low	Medium-Low	Medium	Medium-High	High
	Low	0.925	0.075	0	0	0
	Medium-Low	0.164	0.685	0.151	0	0
T=1	Medium	0	0.133	0.781	0.086	0
	Medium-High	0	0	0.160	0.620	0.220
	High	0	0	0.012	0.116	0.872
	Low	0.831	0.169	0	0	0
	Medium-Low	0.313	0.437	0.250	0	0
T=3	Medium	0.021	0.202	0.649	0.128	0
	Medium-High	0	0.025	0.150	0.575	0.250
	High	0	0	0.041	0.110	0.849
	Low	0.779	0.221	0	0	0
	Medium-Low	0.346	0.327	0.288	0.038	0
T=5	Medium	0.026	0.231	0.577	0.167	0
	Medium-High	0	0.030	0.121	0.394	0.395
	High	0	0.017	0.050	0.150	0.783

4 Conclusions and discussion

4.1 Conclusions

From 2004 to 2018, the average Forestry PTE of China was 0.516, and the overall level was not high. The problem of regional imbalance is a prominent feature of China's forestry development. The overall spatial pattern is "high in the south and low in the north" and "high in the east and low in the west". Forestry PTE has strong "path dependence" characteristics when it is in a low-level and high-level state, but as the interval grows, the mobility of Forestry PTE between different states increases.

4.2 Discussion

In the reality that the total amount of forestry resources in China is relatively insufficient and the quality is not high, it is urgent to find a new driving force to promote forestry development to solve the problem of insufficient motivation of traditional growth methods and achieve forestry transformation and upgrading and sustainable development. The improvement of Forestry PTE has become the key to the high-quality development of forestry economy. This paper uses a non-radial super-efficiency SBM model to measure forestry PTE, and then creatively introduces the Makov chain method to explore its spatial differentiation characteristics and evolution trends from multiple perspectives of qualitative and quantitative, clarifying the past and grasping the future. This deepens its theoretical and practical significance. Through research, this article believes that: First, it is necessary to open up the "two mountains" transformation channel of forest resources, accelerate the promotion of the value realization of forest ecological products, and use ecological capital operation thinking to realize the double transformation and double promotion of "green water and green mountains" and "golden mountains and silver mountains". The second is that the state should continue to increase its support for regions with backward forestry development, and steadily promote major forestry projects such as the "Three Norths" Shelterbelt and "Beijing-Tianjin Sand Source Control" to achieve an effective connection between ecological protection and the supply of ecological products. The third is to further strengthen the links between provinces, promote the low-level provinces of Forestry PTE to fully integrate resources, learn advanced technology and management experience, so as to give full play to their "late development advantages.

5 Declaration of competing interest

The authors declare no conflict of interest.

References

[1] Cui XH, Bao QF. Evaluation of Inner Mongolia Forestry Production Efficiency Based on Panel Data[J]. Issues of Forestry Economics, 2016, 36(2): 188-192.

[2] Leejy. Using DEA to measure efficiency in forest and paper companies[J]. Forest Products Journal,2005,55 (1):58-66.

[3] Li L, Xu ZJ, Cao YK. Production efficiency calculation of state-owned forest industry enterprises in forest areas of Heilongjiang Province——Based on three-stage DEA model[J]. Forestry Economics. 2012(4): 51-55.

[4] Jiang Y, Guan SY. Analysis of the temporal and spatial evolution and agglomeration characteristics of China's forestry total factor productivity[J]. East China Economic Management, 2018, 32(2): 117-121.

[5] Guan J, Cao YK, Zhu ZF. The spatial correlation network structure of China's forestry total factor productivity and its influencing factors[J]. Commercial Research, 2019(9): 73-81.

[6] Chen SH, Jin ZN, Teng YH. Forestry total factor productivity analysis-based on data from nine major forestry provinces[J]. Ecological Economy, 2013(10): 81-84.

[7] Liu QQ, Jiang H. China Forestry Total Factor Productivity Measurement[J]. Statistics and Decision, 2017(4): 146-149.