Article
Spatial Effect Analysis of Total Factor Productivity and Forestry Economic Growth

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Abstract: This paper takes 31 provinces in China from 2009 to 2018 as the research object. The three-stage data envelopment analysis (DEA) model was used to measure the total factor productivity of forestry, and the entropy method was used to measure the level of economic development and ecological construction. We used the global Moran index to explore the spatial correlation of forestry economic growth, and the local Moran index to explore the spatial agglomeration of forestry economic growth. On this basis, the spatial Durbin model was constructed to explore the spatial spillover effect between forestry total factor productivity and forestry economic growth. The conclusion is as follows: the total factor productivity of forestry in China is increasing continuously, and there are obvious spatial differences. Forestry economic growth has a significant spatial autocorrelation, and an overall upward trend. However, the spatial agglomeration effect was relatively weak and in the beginning stage of its formation. Total factor productivity of forestry has significant direct effect on the growth of forestry economy and forms an indirect spillover effect. Based on this, the countermeasures and suggestions to promote the benign and coordinated development of the forestry economy were put forward.

Keywords: total factor productivity; forestry economic growth; space effect

The report of the 19th National Congress of the Communist Party of China calls for accelerating the reform of the system for promoting ecological progress and building a magnificent China. The phrase “high-quality development” was put forward for the first time, indicating that China’s economy had shifted from a stage of high-speed growth to a stage of high-quality development. The 14th Five-Year Plan calls for giving priority to ecology, promoting green development, comprehensively improving the efficiency of resource use, and promoting high-quality economic development in a coordinated manner. Under the background of the complete cessation of commercial logging of natural forests and the action of ecological protection red line, China’s forestry construction has entered a critical period of quality improvement and transformation. It can be found from the forestry statistical yearbook that the average growth rate of forestry gross output value from 2000 to 2013 is 22.03%, while the average growth rate of forestry gross output value from 2014 to 2018 is obviously slowed down, with an average growth rate of 9%. In other words, the main direction of forestry economic development at present is to accelerate the transformation of forestry economic development model and improve the quality of forestry economic growth. Total factor productivity is an important tool to measure the quality of economic growth, clarify the driving force of economic growth, and explore the contribution level of factors such as technological progress and institutional innovation to economic growth. This can reflect the economic growth brought by other factors after excluding the input of factors. Therefore, it is clear that we must determine whether the economic growth of forestry is driven by factor input or by efficiency improvement.

Therefore, it is of great theoretical significance and practical value to explore the relationship between total factor productivity and forestry economic growth for the forestry economy to achieve high-quality growth.
At present, scholars at home and abroad have clearly and accurately expounded the concept, influencing the factors and research methods of forestry total factor productivity and forestry economic growth. For forestry total factor productivity, scholars use stochastic frontier model (SFA), data envelopment analysis model (DEA), the Cobb–Douglas function and other methods to measure and decompose it, analyze the internal driving force of the forestry total factor productivity change, and explore its spatial pattern and regional differences. The promoting or inhibiting effects of industrial agglomeration, import and export trade, natural disasters, economic development level and other factors on the total factor productivity of forestry were also clarified. The total factor productivity of forestry in China is on the rise, but the growth rate is slightly down, and there is a spatial agglomeration and spatial spillover effect [1–12]. Meanwhile, using grey correlation, principal component analysis, impulse response function, co-integration analysis and spatial econometric methods to explore labor elements (quantity, quality, behavior and resource configuration mode), investment (forestry fiscal expenditure on science and technology, forestry) of investment in fixed assets, the transformation of scientific and technological achievements, forest products import and export trade, regional tourism development, consumer demand, forest resources, forestry, public service marketization process investment, industrial structure upgrade, to the forestry economic growth. It is concluded that these influencing factors can promote the growth of forestry economy [13–22]. However, these influencing factors mainly belong to the category of factor input, and there is little discussion on the relationship between total factor productivity and forestry economic growth. The law of diminishing marginal returns of factor input is the main obstacle to the realization of long-term economic growth, which can only be made up by the improvement of total factor productivity, so as to promote sustainable economic growth. Therefore, in this paper, on the basis of existing research, we aimed to validate forestry economic growth, if there is a correlation in space and integration, and to establish a spatial regression model, to explore the total factor productivity of forestry, the direct effect of forestry economic growth and spatial spillover effect, and to provide certain reference for our country’s forestry industry development and forestry sustainable economic growth.

1. Research Method, Variable Description and Data Source

1.1. Research Methods

1.1.1. Three-Stage DEA Model

In this paper, a three-stage DEA model was used to measure forestry total factor productivity. The key of the three-stage DEA model was to establish the stochastic frontier model by using the redundancy of the input pair of environmental variables to eliminate environmental factors and random noise, so as to make the efficiency more real and accurate. The model expression is [23,24]:

\[
\text{Malmquist Index (three stages): } TFPCH = EFFCH \times TECHCH = PECH \times SECH \times TECHCH.
\]

\( TFPCH \) is the change index of total factor productivity; \( EFFCH \) technical efficiency change index; \( TECHCH \) is technological change; \( PECH \) is pure technical efficiency change; \( SECH \) is the change of scale efficiency.

1.1.2. Entropy Value Method

In this paper, the entropy weight method is used to calculate the comprehensive evaluation index of economic development and ecological construction level. The entropy weight method can reduce the deviation caused by subjective factors in the process of weighting. The calculation steps of this method are as follows [25]:

Standardized initial data:

\[
x_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})}
\]

(1)
Standardized value:

\[ P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \]  

(2)

Information entropy value:

\[ e_j = -K \sum_{i=1}^{m} P_{ij} \ln(P_{ij}) \]  

(3)

Weight:

\[ w_j = \frac{D_j}{\sum_{j=1}^{n} D_j} \]  

(4)

Composite Index:

\[ U_i = \sum_{j=1}^{n} w_j P_{ij} \]  

(5)

1.1.3. Spatial Autocorrelation Test

The global Moran index is used to analyze whether there is spatial autocorrelation, and local Moran index is used to detect the range and location of outliers or clusters. The index calculation formula is as follows [26].

Global Moran index:

\[ I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (x_i - \bar{x})^2} \]  

(6)

Local Moran index:

\[ I_i = \frac{n(x_i - \bar{x}) \sum_{j=1}^{n} w_{ij} (x_j - \bar{x})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \]  

(7)

where \( n \) is the number of regions, \( w_{ij} \) is the element value in the spatial weight matrix of regions \( i \) and \( j \) (take 0 or 1 in the first-order “post-” adjacent relation), and \( x \) is the target variable.

1.1.4. Regression Model of Spatial Panel

The spatial panel model has the advantage of considering the spatial correlation and heterogeneity of specific research objects by incorporating spatial factors into the traditional regression model. Spatial econometric models include spatial autocorrelation regression (SAR), spatial error model (SEM) and spatial Durbin model (SDM). The spatial panel model is expressed as [26,27]

\[ Y = X \beta + WX \delta + \rho WY + \mu + v + \xi \]  

(8)

\[ \xi = \lambda W \xi + \epsilon \]  

(9)

where \( Y \) is the growth of forestry economy (dependent variable vector), \( X \) is total factor productivity, industrial structure, etc. (independent variable matrix), \( W \) is the spatial weight matrix, \( \mu \) and \( v \) are fixed and random effects, \( \xi \) is the residual vector, and \( \delta, \rho \) and \( \lambda \) are the spatial term coefficients.

When \( \lambda = 0, \rho \neq 0, \delta = 0 \), it is a spatial autoregressive model (SAR).

When \( \lambda \neq 0, \rho = 0, \delta = 0 \), it is a spatial error model (SEM).

When \( \lambda = 0, \rho \neq 0, \delta \neq 0 \), it is a spatial Durbin model (SDM).
1.2. Variable Description

1.2.1. Description of Forestry Total Factor Productivity Variables

According to economic theory, the three factors of capital, labor and land play a key role in the production input. Due to the particularity and comprehensiveness of forestry, its output should not only consider economic benefits, but also ecological benefits and social benefits. On the basis of existing studies [28–30], the index system of forestry total factor productivity input was constructed from three aspects of land, capital and labor. Three indexes were selected, including forest land area, per capita forestry investment completion amount and the number of forestry employees. The output index system was constructed from three aspects of economic benefit, ecological benefit and social benefit, and three indexes are selected: total output value of forestry, forest stock volume and average annual wage of forestry workers. The environmental variable index is an exogenous variable that has a significant impact on the input–output relationship. Three indexes were selected: GDP growth rate, urbanization rate and forest pest control rate.

1.2.2. Variable Description of Spatial Econometric Model

The explained variable forestry economic development level was expressed by the total output value of forestry economy (Y). The core explanatory variable was the forestry total factor productivity (FTP). The total factor productivity of forestry was calculated by the three-stage DEA model, and the cumulative processing was conducted. In reference to existing literature [31–35], control variables were selected, including industrial structure upgrading (ISU), economic development level (EDL), ecological construction level (ECL), transportation development degree (TDD) and population density (POP).

Among them, the industrial structure was upgraded to the ratio of the output value of forestry tertiary industry to that of forestry secondary industry; the economic development level index system was built from economic scale, economic structure and economic potential three aspects to build, the per capita GDP, per capita national finance income, per capita social investment in fixed assets, the second industry output value proportion, the proportion of the tertiary industry output value, per capita gross domestic product (GDP) growth rate, per capita expenditure on education, and science and technology spending nine indicators; the ecological construction level index system was from the level of ecological protection and ecological pressure three aspects to build, per capita water resources, proper hazard-free treatment rate of green coverage, forest coverage, living garbage, environmental pollution control investment as a share of GDP and per capita wastewater emissions, sulfur dioxide emissions per capita and per capita electricity consumption of eight indicators; the transportation development degree was expressed by the ratio of highway mileage to total population in each province. The population density was expressed by the ratio of the total population of each province to the land area.

1.3. Data Sources

Data came from China Statistical Yearbook and China Forestry and Grassland Statistical Yearbook.

2. Empirical Results and Analysis

2.1. Total Factor Productivity of Forestry

Since the external environmental influence and random factors were not excluded in the first stage of forestry total factor productivity measurement, there was a large gap between the actual output and the optimal output under the existing input level, so the measurement results were somewhat deviated from the real level. To this end, it is necessary to determine the external environmental variables that affect the input redundancy, and calculate the impact of the external environmental variables through the second-stage SFA model. The slack variables of forest area, forestry employees and forestry investment were taken as dependent variables, and the disease and insect pest control rate, urbanization rate and GDP growth rate were taken as independent variables to establish regression.
equations. The SFA results of environmental indicators on input redundancy are shown in Table 1. γ-test value, likelihood value and likelihood ratio (LR) all show that the SFA model has passed the test as a whole, indicating that the model is suitable for SFA analysis. The environmental variables have the most significant influence on the redundancy of forestry investment completion, followed by the redundancy of forestry employees. By comparison, the environmental variables have a weak influence on the redundancy of forest land area.

Table 1. SFA results of environmental indicators on input redundancy from 2009 to 2018.

|                        | Redundancy of Forestry Area | Redundancy of Forestry Practitioners | Redundancy of Forestry Investment |
|------------------------|-----------------------------|-------------------------------------|----------------------------------|
| Constant               | −187.13                     | 0.69                                | 1,091,976.30 ***                 |
| Forestry pest and disease control rate | −0.17                       | 0.00                                | −19,905.30 ***                   |
| Urbanization rate      | 2.04                        | −0.03 ***                           | 11,337.06 ***                    |
| GDP growth rate        | −0.33                       | 0.00                                | −25,251.33 ***                   |
| Sigma-squared          | 468,024.99 ***              | 26.54 ***                           | 3,270,009,800,000 ***            |
| Γ                      | 0.99 ***                    | 0.99 ***                            | 0.85 ***                         |
| Log likelihood         | −1870.59                    | −333.01                             | −4663.86                         |
| LR                     | 898.22 ***                  | 1200.30 ***                         | 279.91 ***                       |

Note: *, ** and *** indicate that they are valid at the significance level of 0.10, 0.05 and 0.01, respectively.

The SFA model was used to adjust the three input variables, and the Malmquist index model was used to calculate the total factor productivity of forestry in 31 provinces (autonomous regions and municipalities directly under the central government) of China from 2009 to 2018, as shown in Tables 2 and 3. Overall, the total factor productivity of China’s forestry is on the rise, but the growth rate is slightly down, and both technical efficiency and technological progress play a leading role. In addition, the total factor productivity of forestry has obvious spatial difference, the eastern region > the central region > the western region. By 2018, only Inner Mongolia, Shandong, Jiangsu, Qinghai, Ningxia and Xinjiang showed a trend of decline.

Table 2. Estimated results of forestry total factor productivity in the three stages of 2018 (after adjustment).

| Firm               | Effch | Techch | Pech  | Sech  | Tfpch |
|--------------------|-------|--------|-------|-------|-------|
| Beijing            | 1.034 | 1.109  | 1.036 | 0.999 | 1.147 |
| Tianjin            | 1.05  | 1.106  | 1.044 | 1.006 | 1.161 |
| Hebei              | 0.983 | 1.123  | 0.986 | 0.997 | 1.103 |
| Shanxi             | 1.016 | 1.106  | 1.01  | 1.006 | 1.124 |
| Inner Mongolia     | 0.953 | 1.057  | 1.004 | 0.95  | 1.007 |
| Liaoning           | 0.976 | 1.12   | 0.974 | 1.001 | 1.093 |
| Jilin              | 0.992 | 1.047  | 0.988 | 1.004 | 1.039 |
| Heilongjiang       | 1.007 | 1.027  | 1.004 | 1.003 | 1.034 |
| Shanghai           | 1     | 1.11   | 1     | 1     | 1.11  |
| Jiangsu            | 1.009 | 1.173  | 1     | 1.009 | 1.184 |
| Zhejiang           | 1     | 1.148  | 1     | 1     | 1.148 |
| Anhui              | 1.059 | 1.119  | 1.061 | 0.998 | 1.185 |
| Fujian             | 1.016 | 1.109  | 1.016 | 1     | 1.127 |
| Jiangxi            | 1.028 | 1.095  | 1.025 | 1.003 | 1.125 |
Table 2. Cont.

| Firm       | Effch | Techch | Pech | Sech | Tfpch |
|------------|-------|--------|------|------|-------|
| Shandong   | 1.038 | 1.165  | 1.029| 1.009| 1.209 |
| Henan      | 1.003 | 1.114  | 0.999| 1.003| 1.117 |
| Hubei      | 1.055 | 1.1   | 1.052| 1.002| 1.16  |
| Hunan      | 1.009 | 1.106  | 1.007| 1.002| 1.116 |
| Guangdong  | 1     | 1.146  | 1    | 1    | 1.146 |
| Guangxi    | 1.046 | 1.081  | 1.03 | 1.015| 1.131 |
| Henan      | 1.045 | 1.114  | 1    | 1.045| 1.164 |
| Chongqing  | 1.063 | 1.12   | 1.06 | 1.002| 1.19  |
| Sichuan    | 1.003 | 1.04   | 1    | 1.003| 1.042 |
| Guizhou    | 1.054 | 1.085  | 1.046| 1.007| 1.143 |
| Yunnan     | 1.005 | 1.045  | 1.011| 0.994| 1.05  |
| Xizang     | 1     | 1.061  | 1    | 1    | 1.061 |
| Shanxi     | 1.009 | 1.097  | 1.008| 1.002| 1.107 |
| Gansu      | 1.01  | 1.1    | 1.011| 0.999| 1.112 |
| Qinghai    | 1.043 | 1.113  | 0.973| 1.072| 1.161 |
| Ningxia    | 0.979 | 1.111  | 0.898| 1.09 | 1.087 |
| Xinjiang   | 1.008 | 1.105  | 1.017| 0.992| 1.114 |
| Mean       | 1.015 | 1.101  | 1.009| 1.007| 1.118 |

Table 3. Decomposition results of forestry total factor productivity in three stages from 2009 to 2018 (after adjustment).

| Year | Effch | Techch | Pech | Sech | Tfpch |
|------|-------|--------|------|------|-------|
| 2010 | 1.007 | 1.111  | 1.02 | 0.987| 1.119 |
| 2011 | 1.023 | 1.188  | 0.951| 1.076| 1.215 |
| 2012 | 1.015 | 1.131  | 1.04 | 0.976| 1.148 |
| 2013 | 1.095 | 1.016  | 1.084| 1.01 | 1.112 |
| 2014 | 0.948 | 1.146  | 0.983| 0.964| 1.087 |
| 2015 | 1.046 | 1.08   | 1.009| 1.036| 1.13  |
| 2016 | 1.03  | 1.041  | 1.015| 1.015| 1.072 |
| 2017 | 0.995 | 1.117  | 1    | 0.995| 1.111 |
| 2018 | 0.986 | 1.091  | 0.982| 1.004| 1.077 |
| Mean | 1.015 | 1.101  | 1.009| 1.007| 1.118 |

2.2. Spatial Correlation Analysis

In this paper, the global Moran index was used to investigate the spatial correlation effect of forestry economic growth in 31 provinces (autonomous regions and municipalities directly under the central government) during the period of 2009–2018, as shown in Table 4 and Figure 1. Moran index was greater than 0, and p values were all less than 0.01. Therefore, forestry economic growth has significant spatial relevance. From the perspective of dynamic trend, spatial autocorrelation intensity is on the rise and reaches the highest value in 2018.
### Table 4. Global Moran index from 2009 to 2018.

| Year | Global Moran Index | p   |
|------|--------------------|-----|
| 2009 | 0.2767             | 0.009|
| 2010 | 0.3815             | 0.002|
| 2011 | 0.3969             | 0.001|
| 2012 | 0.3848             | 0.002|
| 2013 | 0.3741             | 0.003|
| 2014 | 0.3886             | 0.002|
| 2015 | 0.4303             | 0.002|
| 2016 | 0.4544             | 0.001|
| 2017 | 0.475              |      |
| 2018 | 0.4938             |      |

#### 2.3. Spatial Agglomeration Analysis

Spatial agglomeration reflects the spatial characteristics of the development level of the forestry economy, which is not only closely related to the status of forestry industry, the basis of ecological environment and the level of economic development in each region, but is also due to the existence of a certain spatial interaction between regions, so as to form spatial agglomeration.

In order to explore whether the development level of forestry economy has a spatial agglomeration effect, the local Moran index of the growth of forestry economy in 31 provinces (autonomous regions and municipalities directly under the central government) in 2018 was calculated, as shown in Table 5. The results of local Moran index show that at the significance level of 0.1, Anhui, Chongqing, Zhejiang, Hunan, Guizhou, Guangxi, Guangdong, Fujian and Jiangxi show a “high-high” agglomeration feature. Hebei, Beijing and Tianjin showed a “low-low” agglomeration feature. Shanghai presents the characteristics of “low-high” agglomeration feature. Xinjiang presents “high-low” agglomeration, while other provinces do not show the agglomeration characteristics. The spatial agglomeration effect of the development level of forestry economy in China is relatively weak and is in the beginning stage of formation. The southeast region has a high level of economic development, which can attract more talents, capital and technology. It has great potential for resource development and a high utilization rate, thus realizing the improvement of spatial agglomeration. The northeast, central and western core agglomeration areas are rich in forest resources, but due to the influence of terrain, extensive production mode and other factors, the level of economic development is low, the overall level of ecological construction is not high, and there is no good interaction effect.
Table 5. Local Moran index in 2018.

| Area            | Local Moran Index | p    |
|-----------------|-------------------|------|
| Beijing         | 0.2677            | 0.011|
| Tianjin         | 3.1945            | 0.022|
| Hebei           | 0.577             | 0.004|
| Shanxi          | 0.4598            | 0.152|
| Inner Mongolia  | 0.2               | 0.124|
| Liaoning        | 0.0953            | 0.3   |
| Jilin           | −0.1217           | 0.314|
| Heilongjiang    | −0.0112           | 0.406|
| Shanghai        | −0.8049           | 0.096|
| Jiangsu         | 0.194             | 0.219|
| Zhejiang        | 0.5788            | 0.034|
| Anhui           | 0.3989            | 0.024|
| Fujian          | 1.5508            | 0.002|
| Jiangxi         | 1.0196            | 0.001|
| Shandong        | 0.019             | 0.467|
| Henan           | −0.03             | 0.456|
| Hubei           | 0.2438            | 0.136|
| Hunan           | 0.6118            | 0.002|
| Guangdong       | 0.8795            | 0.01  |
| Guangxi         | 0.921             | 0.03  |
| Henan           | 0.5917            | 0.192|
| Chongqing       | 0.0911            | 0.076|
| Sichuan         | −0.0731           | 0.232|
| Guizhou         | 0.5401            | 0.063|
| Yunnan          | 0.0963            | 0.236|
| Xizang          | 0.1652            | 0.327|
| Shanxi          | 0.0041            | 0.197|
| Gansu           | 0.218             | 0.159|
| Qinghai         | 0.4912            | 0.172|
| Ningxia         | 0.1865            | 0.206|
| Xinjiang        | −0.1517           | 0.037|

2.4. Spatial Spillover Effect Analysis

According to the results of the global Moran index, the development level of the forestry economy has a significant spatial dependence, so spatial factors should be introduced in the establishment of a regression model. In this paper, spatial autoregressive model and spatial lag model are established, respectively, to explore whether a spatial spillover effect only comes from independent variables or errors. According to the results of LM test and R-LM test, it can be concluded that the spatial autoregressive model is superior to the spatial error model, and the assumption of no spatial lag and no spatial error cannot be rejected. Therefore, the spatial Durbin model should be established. According to the results of LR and Wald test, the spatial Durbin model cannot be simplified into spatial error model or spatial lag model, which indicates that it is reasonable to choose the spatial Durbin model to explore the spatial spillover effect of forestry economic development level. This paper uses the Hausmann test to judge whether the spatial econometric model should choose a fixed effect or random effect. According to the Hausmann test results, the fixed effects of the spatial autoregressive model, spatial error model and spatial Durbin model are all superior to random effects, so the analysis should be conducted based on the fixed effects (Table 6).

According to the results of the spatial autoregressive model, the spatial coefficient of total forestry output value is 0.7340, and it passes the significance test of 1%. It shows that there is a strong spatial dependence between the total forestry output value of this province and the total forestry output value of neighboring provinces. If the total output value of forestry in neighboring provinces increases by 1%, the total output value of forestry in this province will increase by 0.734%.
According to the results of spatial Durbin model, the regression coefficient of total factor productivity of forestry is 0.1636, indicating that there is a positive correlation between total output value of forestry and total factor productivity of forestry. The regression coefficient of forestry industrial structure is −0.0003, which indicates that the total output value of forestry is negatively correlated with the total output value of forestry. The regression coefficients of the ecological construction level and highway density are positive, while the regression coefficients of the population density are negative, and both have passed the significance test of 10%. As can be seen from the spatial lag variables, the spatial interaction coefficient of total factor productivity of forestry, economic development level and transportation development degree all passed the significance test of 1%.

2.5. Decomposition of Spatial Spillover Effect

Since the spatial Durbin model contains spatial lag terms of variables, the regression results generated by the operation cannot accurately estimate the influence of explanatory variables on the explained variables in the local area and adjacent areas [27]. Therefore, the marginal effect is further divided into the direct effect (local effect) and indirect effect (spillover effect), as shown in Table 7.
Table 7. Marginal effect decomposition of spatial Durbin model.

| Variable | Direct Effect | Indirect Effect | Total Effect |
|----------|---------------|----------------|--------------|
| FTP      | 0.1587 ***    | −0.3750 *      | −0.2163      |
| ISU      | −0.0003 **    | −0.0003        | −0.0005      |
| EDL      | 0.3330        | 7.2099 ***     | 7.5429 ***   |
| ECL      | 0.8024 ***    | −0.7638        | 0.0387       |
| TDD      | 0.0059 **     | 0.0873 ***     | 0.0932 ***   |
| POP      | −0.2528 ***   | −0.54158 *     | −0.7943 **   |

Note: *, ** and *** indicate that they are valid at the significance level of 0.10, 0.05 and 0.01, respectively.

The direct effects of forestry total factor productivity, forestry industrial structure, ecological construction level, traffic condition and population-scale on the total output value of forestry were 0.1587%, −0.0003%, 0.8024%, 0.0059% and −0.2528%, respectively, and passed the significance test of 5%. This means that the improvement of the forestry total factor productivity has a significant promoting effect on the increase in forestry total output value. This is because the forestry total factor productivity, as one of the important indicators to measure the quality of forestry economic growth, means technological progress, institutional innovation and improvement of resource allocation, thus promoting the increase in forestry total output value. The optimization and upgrading of forestry industrial structure has a slight hindering effect on the increase in forestry total output value. This is because under the background of the complete cessation of commercial logging in natural forests, the forestry industry is gradually moving towards a service-oriented process, and the structure of the forestry industry is constantly adjusted and in an unstable state, which leads to the “structural deceleration” effect and restrains the growth of the forestry economy. However, in the long run, the optimization of industrial structure and economic growth are mutually driving forces, and the continuous optimization of the forestry industrial structure can improve the total output value of forestry.

With the improvement of the ecological construction level, the forest ecosystem can be effectively managed, and the development and utilization level of forest resources can be improved, thus driving the growth of forestry economy. The improvement of traffic and transportation level has positive influence on the development of forestry economy. With the aging of the population in China, the increase in regional population has a restraining effect on the growth of forestry economy.

The indirect effects of the forestry total factor productivity, forestry industrial structure, economic development level, traffic condition and population scale on the total output value of forestry are −0.3750%, 7.2099%, 0.0873% and −0.54158%, respectively, and all of them pass the significance test of 10%. It is verified that the growth of the forestry economy is open and external economy exists, and the progress of forestry technology, system innovation and resource allocation among regions can be well spilled over to other provinces to drive or restrain the growth of the forestry economy in the surrounding areas. The improvement of forestry total factor productivity in neighboring provinces will hinder the improvement of forestry total output value in the province. This is because the neighboring provinces will actively seek the optimization and upgrading of the forestry industrial structure while increasing the total factor productivity of forestry, and the middle and low-end forestry industries will be transferred to the surrounding areas, so as to further improve the local forestry factor structure and resource allocation, so that the “first-mover advantage” of the neighboring provinces can be retained. The improvement of the economic development level of a neighboring province can drive the development level of forestry economy of this province. This is because the spatial spillover effect is mainly manifested in the flow of elements and the spillover of knowledge. When the economic development level of neighboring provinces improves, their levels of science and technology, education, investment, innovation and other aspects will be improved and spread to the surrounding areas, thus promoting the development of the forestry industry in the province. The developed degree of traffic and transportation in neighboring
provinces has a positive effect on the development of the forestry economy in the province, and the increase in regional population has an inhibiting effect on the growth of the forestry economy.

3. Conclusions and Suggestions

Taking 31 provinces in China from 2009 to 2018 as the research object, this paper constructed a spatial econometric model to explore the spatial spillover effects of forestry total factor productivity and other factors on forestry economic growth. The following conclusions were drawn:

(1) The total factor productivity of forestry in China is constantly improving and has great potential for future development. The growth of the total factor productivity of forestry is constantly promoted by technological progress, pure technical efficiency and scale efficiency.

(2) The growth of the forestry economy shows positive spatial autocorrelation, the agglomeration state is obvious, and the overall trend is rising, but the spatial agglomeration effect is relatively weak, and it is in the beginning stage of formation.

(3) The total factor productivity of forestry has a significant positive effect on the growth of the forestry economy, but has an inhibiting effect on the development of the forestry economy in neighboring provinces; the upgrading of industrial structure has a significant negative impact on the growth of forestry economy, but has no significant impact on the development of forestry economy in neighboring provinces. The influence of economic development level on the growth of forestry economy is not significant but has a significant positive influence on the development of the forestry economy in neighboring provinces. The level of ecological construction has a significant positive effect on the growth of forestry economy but has no significant effect on the development of forestry economy in neighboring provinces. The degree of traffic development and population density have significant influence on the development of forestry economy in both local and neighboring provinces.

Based on the above research, the following suggestions are put forward to promote the benign and coordinated development of the forestry economy:

(1) Unswervingly promote the high-quality development of forestry, focusing on increasing investment in forestry science and technology innovation, and improving the contribution rate of science and technology to the growth of forestry economy;

(2) To further innovate forest product varieties, improve the quality of forest products, extend the processing chain of forest products, optimize the configuration structure of production factors, and constantly promote the improvement of total factor productivity of forestry;

(3) Adhere to the combination of policy guidance and market demand, attach importance to the optimization and upgrading of forestry industrial structure, vigorously develop economic forest and other non-wood products, and actively develop modern forestry service industry;

(4) Rational management of forest resources can maximize forest growth rate and forest savings, and give full play to its role in the whole process of achieving carbon peak and carbon neutrality in China;

(5) Adhere to the national overall planning and the combination of regional advantages and regional characteristics, create a good cross-provincial exchange and cooperation environment, expand the forestry industry market boundary, release the kinetic energy of forestry economy, and form industrial linkage with neighboring regions to achieve mutual benefit and a win–win situation.

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