Analysis of the influencing factors on China's forestry economic growth based on grey correlation model

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Abstract

Purpose – The purpose of this paper is to analyze the influence of different factors on forestry production, with an aim to explore the degree of connection between forestry economic growth and influencing factors such as forestry investment, labor input, afforestation area, scientific and technologies progress, and the reform of property-rights regimes.

Design/methodology/approach – According to the data of China Forestry Statistical Yearbook from 1978 to 2017, this paper uses the grey correlation analysis to observe and analyze the factors influencing China's forestry economics growth.

Findings – The results show that capital investment demonstrates the largest impact on the forestry output value, followed by property system, afforestation area, labor input and technologies progress. The correlation coefficients of the above factors are 0.874451654,0.85827468,0.835138412,0.832985604 and 0.825747493. This means that forestry capital investment plays a major role in contributing to forest economic growth; forest property system also plays a positive role in the growth of forestry economy.

Originality/value – This paper uses continuous data collected during 1978–2017, which are quite extensive as compared to data used in the existing research, considering the influencing factors are comprehensive, especially the impact of property right system reform on forestry economic growth.

Keywords Grey correlation model, Forestry economic growth, Influencing factors, China

Paper type Research paper

1. Introduction

Economic growth has always been the focus of economics research. Forestry economic growth is also the emphasized and difficulty point in forestry economy research. Forestry not only serves an important role in public welfare undertakings, it is also one of the important basic industries of China's economy. Since the reform and opening from 1978, forestry economy has been growing rapidly in China, in which the influencing factors driving such growth are worth exploring. As a complex economic system, forestry economy has been influenced in varying degrees such as technology, capital, labor, institution, land and other factors.

Literature research shows a number of studies focusing on the influence on forestry economic growth from the angle of single factor and multiple factors in China. These studies have laid a good foundation and provide a beneficial reference for this study. Existing research has demonstrated only a few influencing factors, as the research data sequence used for analysis was relatively short. In addition, since regression analysis cannot analyze

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the effect degree of forestry economic growth by different influencing factors from the dynamic development trend in different years, the grey correlation analysis method is used for this paper, as it can analyze the changing trend of factors sequence according to its proximity of the curve shape. Based on this model, the following may be analyzed: main and secondary factors, significant and underlying factors, as all could have potential impacts on influencing the forestry total production growth. So, we can also describe that variation trend of influencing factors cause the total forestry production growth by the quantitative comparison of development trend.

Therefore, this paper is mainly based on existing research results. Statistical analysis was carried out on forestry economic growth in China from 1978 to 2017 using the grey correlation model. This paper intends to analyze the influence of different factors on forestry production, with an aim to explore the degree of connection between forestry economic growth and influencing factors such as forestry investment, labor input, afforestation area, scientific and technologies progress, and the reform of property-rights regimes. This paper uses continuous data collected in the last 38 years, which are quite extensive compared to data used in the existing research, considering the influencing factors are very comprehensive and complex, especially the impact of property right system reform on forestry economic growth.

2. Theory frame and literature review

New classical economic growth theory provides an important theoretical basis for this paper. Economic growth theory research suggests that the factors of production consist of labor, capital and technology. The level and quality of economic growth are influenced by investment level and configuration mode of these three factors.

New classical economic growth theory is based on Hador and Solow's theory for the mainstream: the Hador model suggests that savings will determine the speed of economic growth when the capital–output ratio is constant; the Solow model uses the Cobb–Douglas production function by joining technological factors, and the output growth is decomposed into the sum of growth of capital, labor and technology progress (Liu, 2007).

Denison suggests that economic growth factors can be divided into inputs and productivity of production factors. Labor, capital and land investment depend on the inputs of production factors; productivity of production factors depend on resource allocation, scale economy and progress of knowledge. The resource allocation and scale economy also depend on property right system arrangement to a large degree. Yet, the progress of knowledge can be measured by contribution rate of technological progress. Denison's theory of economic growth provides an important theory frame for this paper. The factors that affect the forestry economic growth include forestry capital input, forestry labor input, forest land input, forestry property right system arrangement and forestry technologies progress.

Forestry economic growth is a result of the combination of the above factors. In terms of capital input, forestry has significant positive externalities, as it is both an economic industry and part of the public welfare undertakings. Therefore, national investment has been a main way of forestry investment for a long time with determined direction and efficiency of funds to a large extent; national investment also serves as an important capital investment foundation for forestry economic growth.

In terms of forestry labor input, the labor time of forestry workers is affected seasonally. Labor migration and metastasis, labor quality and behavioral preference, labor resource allocation are due to changes of the forestry work mode and forestry management mode; as a result, these factors could affect the labor of forestry investment, thus influencing forestry economic growth (Cao and Wang, 2012). In terms of forest land input, the forest land area, afforestation area and forest area are growing, with the farmland returning to forest projects and afforestation activities, which provides an important resource base. In terms of forestry technologies progress, the improving level of forestry technical innovation in China will also increase forestry economic growth to some extent. In addition, forestry economic growth is also affected by the influence of system, market, policy and social environment. Moreover, the frequent changes of the forestry property right system in China could have important influence on forestry economic growth.

At present, a number of factors influencing the Chinese forestry economic growth have been established in related research. The results of the studies are based on the different perspectives. Tan (1994) identified human resource as an important factor in affecting forestry economic development. Tian (1995) considered that forestry economic development is mainly caused by labor input and technology progress in China. Technological progress is an important factor, as it influences both forestry economic growth and development (Huang *et al.*, 1996). Zhang (1997) stated that forestry economic development mainly depends on assets and labor force growth. Wang (2001) indicated that the influencing factors of forestry economic growth and development stem from national economy and forestry system systematically. Also, the forest resources and labor are driving forces of forestry economic growth in China (Wei and Zhu, 2001). Zhang (2001) considered that investment is very important to promote the forestry economic growth. Gao Shuyuan recognized that the main influencing factors of regional forestry economic development include non-wood forest products consumption, national investment, production data input and human capital investment. The function of policy guidance is important (Cui *et al.*, 2009). Forestry economic growth is closely related to the economic environment and the forestry industry policy (Feng *et al.*, 2010). The capital and labor input play an important role in the process of forestry economic growth. Moreover, the changes of forestry industrial structure have a positive pushing effect on forestry economy, and there are some differences in the contributions of forestry industrial structure change to forestry economic growth (Huang *et al.*, 2010).

With the use of the grey correlation degree analysis method, the influencing factors of forestry economic growth from 1994 to 2009 in China can be analyzed efficiently, and the contribution rate can be compared with the research results of Zhe Yue *et al.*. The results show that Chinese forestry economic growth is mainly affected by fixed investments of forest management, capital construction investment of forest management, average wages of staff and workers and the number of forestry workers, and the influence degree of the first, second and third industry of forestry by each input factors demonstrates significant differences. In addition, institutional change is the process of pursuing the potential benefits and the economic efficiency. Especially the frequent changes of forestry property right system in China also have important influence on forestry economic growth. The relaxation of the forestry property right regulation has a limited contribution for forestry output of Guangdong due to the influence of external factors (Gao and Zhang, 2012). Cao Lanfang *et al.* indicated that labor and land element have a positive and significant impact on forestry economic growth in Hunan, and capital factors are negative, with a significant effect, whereas institutional factors are not significant. The existing research provides the basis of important reference for this paper, but systemic and the normative research remains to be promoted.

Therefore, the analysis of this paper serves an important role, as it can put forward theoretical significance and practical value to advance forestry economic growth strategy, thus finding the major driving factors of forestry economic growth, which can promote our forestry economic growth.

3. Selection of samples and source of data

This paper uses forestry total production (Y) as the dependent variable to reflect the forestry economic growth. According to the data of China Forestry Statistical Yearbook from 1978 to 2017, excluding the impact of price factors, forestry output value can be calculated by current price divided by data of retail price index from 1978. Capital investment (K) refers to forest industry fixed assets investment by the end of each year, which can be calculated by forestry fixed assets investment divided by price index of investment in fixed assets. This method allows the impact of price factors to be excluded. Due to the lack of statistical indicators as well as relevant annual data from the national forestry labor, this study selected the number of forestry workers over the years as the measurement index of labor input (*L*). This paper established afforestation area (land) as measurement index of land input. Forest resources are collected every five years in China due to the lack of continuous forest area. Technological progress contribution rate (*a*) was selected as the measurement index of technological progress level with the Solow Residual Method. It is hard to find direct quantifiable continuous data to construct indicators of system variables (such as privatization index). This paper constructed variables using the assignment method, according to the changing course of the property right system, under the assumption that empowerment of the people improves the forestry managers' motivation, so this situation can promote the growth of forestry economics. Therefore, the assignment method was used to construct this variable on the basis of the analysis of property-rights regimes.

3.1 The growth rate of China's forestry economy in 1978–2017

As shown in Figure 1, the forestry industry of China has grown vigorously. The forestry output value indicates a tendency of rapid growth, with an average annual growth rate of 16.6 percent from 1978 to 2017.The yield increasing rate of forestry output value is positive starting from 1990, and forestry industry continues to grow. Forestry total production has increased significantly over the years; however, its growth slowed down after 2003, as industrial structure improved over time. The second forestry industry became a dominant industry, as a new industry, the third industry development gradually accelerated and the output value and industrial competitiveness gradually enhanced; the proportion of the second and third industries of forestry increased gradually and there were new strides of industrial structure adjustment after 2008.

3.2 Investment status of fixed assets in 1978–2017

As shown in Figure 2, the forestry fixed asset investment demonstrates growth year by year in China from 1978 to 2017. The number of forestry investment has increased steadily since 1990. The economic system reform got into a period of planned commodity economy by taking the reform and opening as the turning point from 1978 to 1995. At the same time,

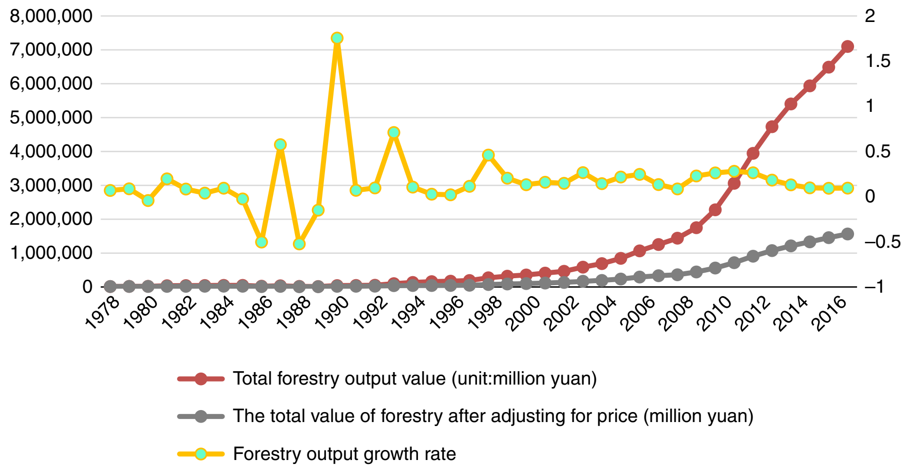

Figure 1.
China's forestry output and its annual growth rate in 1978–2017

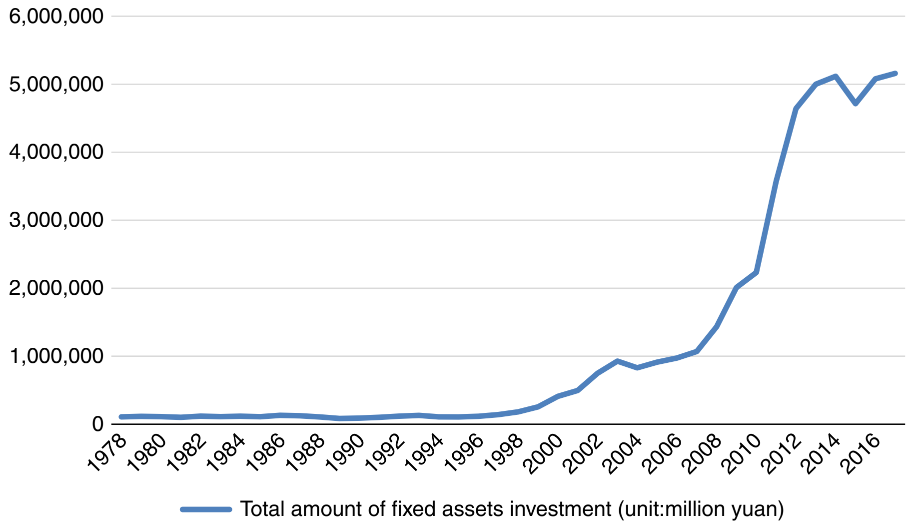

Figure 2.
The completion of forestry fixed asset investment in 1978–2017

the increase of international communication has led to changes to the forestry policy of China based on lessons of experience from advanced country, particularly in the areas of forestry protection and construction. Forestry investment increased steadily over time, whereas a slight increase is observed in forest management.

After 1996, China increased the input of forest management to a large scale. As a result, forestry investments grew rapidly. Fundamental changes took place in forestry structure, resulting in a shift of focus from logging to forest management. This change demonstrates that China's national capital has changed its view.

3.3 The number of forestry workers in 1978–2017

The number of forestry workers shows a trend of decline after the first slow growth from 1978 to 2017 (see Figure 3). Especially, the reason why the number of workers of forestry system has decreased generally since the twentieth century is that the natural forest protection project needs less workers, whereas the ecological public-welfare forests cannot absorb the laid-off workers.

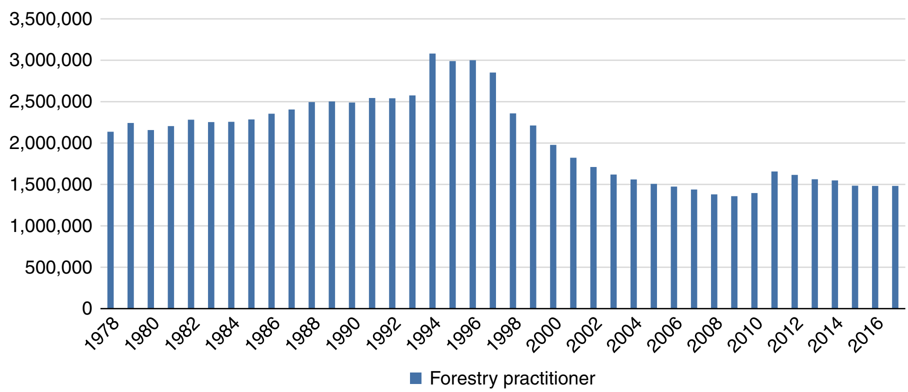

Figure 3.
The number of forestry employees in 1978–2017

3.4 Change of afforestation area from 1978 to 2017

As shown in Figure 4, afforestation area demonstrates a fluctuated rising trend in China from 1978 to 2017. There are significant fluctuations in 1981–1986 and 2001–2005; however, the changes of afforestation area are relatively stable.

The main reason behind the significant increase in 1981 was the national compulsory tree planting campaign. The planting area considerably increased since then. In 2002, the project of returning farmland to forest had contributed to the growth of afforestation areas as it reached a new high tide. In addition, with the improvement of afforestation quality in China, afforestation rate and survival rate increased from year to year. Afforestation area increased as a whole with a steady development momentum.

3.5 The calculation of technological progress contribution rate to forestry from 1978 to 2017

Measuring the contribution rate of technological progress to forestry economic growth is helpful to grasp the potential influence of overall technological progress, in order to clarify the impact of technological progress on economic growth. This is very meaningful for the field of forestry economic development. This paper adopts Solow's residual value method to calculate the contribution rate of technological progress to forestry from 1978 to 2017. The relationship between economic growth and technological progress can be expressed as follows:

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha\frac{\Delta K}{K} - \beta\frac{\Delta L}{L} \tag{1}$$

where Y is the forestry gross output, using the constant price data in 1978; K the material consumption, expressed by completed amount among forestry investment in fixed assets. This index can comprehensively reflect the impact of investment on the forestry production practice; L the labor input index, referring to the number of forestry workers from 1978 to 2017. A is technological level. Capital output elastic coefficient is expressed as α, and β refers to labor output elastic coefficient. Data are from "Statistical Yearbook," "Chinese Forestry Statistical Yearbook" and "China Forestry Yearbook" from the years of 1978 to 2015.

Forestry output growth rate, investment in fixed assets growth rate, forestry workers growth rate of each year from 1979 to 2017 can be calculated by $(\Delta Y/Y)$, $(\Delta K/K)$ and $(\Delta L/L)$, respectively. Based on the least square method, we can conduct the regression estimate via E-Views to solve the two-elastic coefficient, $\alpha = 1.173$ and $\beta = 0.461$.

The speed of technological growth can be calculated by Solow's residual value method. The technological progress contribution rate can be calculated using the speed of technological

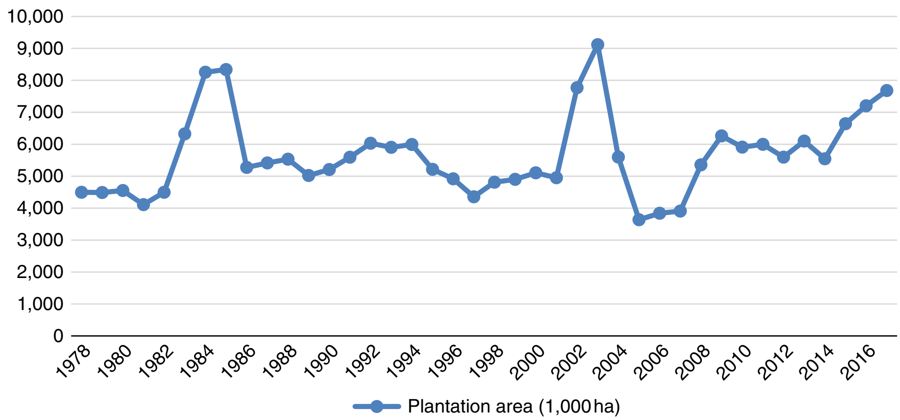

Figure 4.
Afforestation area from 1978 to 2017

growth in every year divided by the speed of forestry production growth (see Table I). During 1978–2017, the technological progress contribution rate in our country has been very unstable, where the average of the speed of forestry technology growth is lower than the speed of forestry output growth. This unstable growth indicates that forestry development does not rely much on technology. Relative to the capital contribution to forestry development, technological development still has a long way to go due to the big gap in technological contribution to forestry. Therefore, it is necessary to take effective measures to further increase the speed of technological progress as well as the contribution rate of technology to forestry output growth.

3.6 Overview of property system changes from 1978 to 2017

Dachang (2001) reviewed the changes in the management of property rights of non-state-owned forests since 1950, and believed that frequent property rights changes

Year	Forestry output growth rate	Technology growth rate	The contribution of technological progress
1978	0.0688	0.1382	2.0087
1979	0.0868	0.1074	1.2371
1980	−0.0433	−0.0596	1.3762
1981	0.1970	0.2122	1.0776
1982	0.0838	0.0915	1.0930
1983	0.0391	0.0365	0.9332
1984	0.0935	0.0913	0.9762
1985	−0.0250	−0.0153	0.6112
1986	−0.5023	−0.4980	0.9913
1987	0.5756	0.5888	1.0229
1988	−0.5231	−0.4973	0.9507
1989	−0.1492	−0.1363	0.9138
1990	1.7553	1.7492	0.9966
1991	0.0700	0.0739	1.0555
1992	0.0964	0.0863	0.8956
1993	0.7096	0.7111	1.0022
1994	0.1051	0.2100	1.9978
1995	0.0272	0.0134	0.4939
1996	0.0206	0.0176	0.8557
1997	0.1144	0.0786	0.6866
1998	0.4600	0.3603	0.7832
1999	0.2046	0.1520	0.7428
2000	0.1324	0.0478	0.3614
2001	0.1596	0.1099	0.6887
2002	0.1480	0.0903	0.6106
2003	0.2657	0.2268	0.8536
2004	0.1441	0.1319	0.9159
2005	0.2174	0.1952	0.8980
2006	0.2468	0.2326	0.9425
2007	0.1335	0.1163	0.8711
2008	0.0855	0.0472	0.5521
2009	0.2291	0.1994	0.8703
2010	0.2630	0.2708	1.0295
2011	0.2805	0.3388	1.2079
2012	0.2642	0.3056	1.1567
2013	0.1828	0.1628	0.8907
2014	0.1307	0.1252	0.9577
2015	0.0977	0.0815	0.8349
2016	0.0926	0.0877	0.9477
2017	0.0754	0.0746	0.9895

Table I. Contribution rate of forestry science and technology progress will have negative effects on forest management and farmers' livelihoods in the long run. Yin reviewed the impact of institutional changes on China's rural forestry sector since the 1980s from the perspective of institutional economics. It was confirmed that property rights and marketization as institutional innovations had promoted the improvement of forestry productivity and the development of forestry economy. During these 40 years, China's forestry property rights system reform has undergone tremendous changes. Since the 3rd session of the 11th congress of the Communist Party of China in 1978, the plenary session has implemented the new policy of reform and opening up, which initiated the new rural reform process. From1978 to 1981, it was called the stage of forestry restoration development after the "Cultural Revolution." On March 8, 1981, the central committee of the Communist Party of China and the state council promulgated the "Resolution on Several Issues about Forest Protection and Forestry Development" policy, following which a series of forestry reform was launched in response, including stabilizing mountain and forest rights, delimitating hilly lands, and determining the forestry production contract responsibility system. In 1985, China's collective forest areas abolished timber purchases and opened up the timber market. The timber could be sold freely. Obviously, these decisions stimulated the enthusiasm of forestry management and achieved some good results. However, the inability to support the demand, as well as the suspicion to new policies, led to the destruction and deforestation of nearly half of the forest resources. As a result, the central committee of the Communist Party of China and the state council issued the "Instructions about Strengthening the Southern Forest Area Resources Management and Stopping Deforestation" policy on June 30, 1987, which pointed out that the ones not get the timber forest would never be distributed. Hence, the proposed forestry reform policies were not fully implemented.

In 1993, a legal basis for the reform of forest ownership was provided, which was "Decisions on Building Socialist Market Economic System by Central Committee of the Communist Party of China." Thus, the flow speed of woodland resources increased, resulting in various business patterns such as partnerships, joint stock cooperative, leasing management, trans-ownership and inter-trade joint venture. These different management patterns contributed to the rapid development of the forestry economy. In 1998, the new revised "Forest Law of the People's Republic of China" and the "Land Administration law of the People's Republic of China" standardized and supported the transformation of forest land use rights. In 2002, the "Rural Land Contract Law of the People's Republic of China" further clarified that the forest land attributing period is 30–70 years.

As China enters the twenty-first century, non-public forest has developed rapidly and marketing transformation of forest right has sprung up, making the trend of ownership marketing much more clear and presenting diversification development by the woodland management. All aspects' forces have been encouraged to take part in the building of forest ecology and forest industry. In order to empower farmers, make farmers rich, and increase the enthusiasm of farmers for afforestation, the central committee of the Communist Party of China and the state council issued "Decisions on Speeding up Forestry Development" on June 25, 2003, which were initiated by the system of forestry ownership. In response, the Fujian province started a new forest right reform policy in June, 2003. The central committee of the Communist party of China and the state council issued "Opinions on Comprehensively Promoting the Reform of Collective Forest Rights System" on June 8, 2008, which signified the reform of property system, and this reform was executed in all regions of China. This reform clarified the property system, eased the operating rights, insured forest farmers' usufruct, and propelled reasonable circulation of forestry property system via the combination of the reform of forestry property system and rural taxes and dues, as well as the reform of institutions and social security system. Meanwhile, the relations of forestry production were clearer than before, and forestry productive market was much free.

The forestry property system reform at this stage demonstrated systematization and universality, which led to profound effects. In 2018, "Central No. 1 Document" proposed to continue to deepen the reform of the collective forest rights system.

According to the data of State Forestry Administration, the total area of national approval forest was 2.701bn hectare, 98.97 percent of the total area of collective forest lands. In total, 2,100m copies (87.84m households) of forest right certificate had been issued in our country, and the license issuing area was up to 2.641bn hectares in total, 97.65 percent of the area around the collective forest right system reform.

On November 23, 2009, the China Forestry Property Exchange was opened in Beijing and the International Trade Research Center for Forest Products of the State Forestry Administration was established. At present, China has established a number of large-scale forest rights exchanges, which provide forestry property rights trading, forestry carbon trading, and forest tenure mortgage loans. In addition, all parts of China actively cultivate new types of forestry management entities. By the end of 2016, the number of new types of forestry management entities had reached 231,500. In 2018, there were 348 national forestry professional cooperatives and demonstration institutions, and 439 national-level farmers' forestry cooperative cooperatives.

System changing is a process to deny the old system (Wei and Zhang, 2000). Summarizing the practice in forestry property system reform since the reform and opening up, it was found that property right system changes and economic system reform were closely connected in our country. They supported each other and impacted each other as well. The following hypothesis can be formulated:

H1. The reinforcement of woodlands privatization caused by property system changes had a positive effect on forestry economic output.

If the degree of woodlands privatization was enhanced, the assignment would be +1, otherwise the assignment would be −1. Then the property system as a virtual variable placed them into model ; the details are as follows: 1978–1981; 1, 2, 3, 4: 1982–1987; 5, 6, 7, 8, 9, 10; 1988–1992: −1, −2, −3, −4, −5; 1993–2002: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10; 2003–2017: 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25.

4. Grey correlation analysis of China's forestry economic growth influencing factor

Based on two systems or a measure of connection between two factors, the grey correlation analysis can quantitatively describe and compare system's development trends. Its basic idea is to determine whether its connection is close or not, according to similar degree of geometric shape of sequence curves. The closer it gets to the curve, the greater is the degree of correlation between corresponding sequences, and the reverse could be true (Cui *et al.*, 2009). The basic modeling steps of the grey correlation analysis are as follows.

4.1 To determine reference and comparative sequence

(1) The reference sequence was taken as the generating factor for comparison. According to the data from the "China Forestry Statistical Yearbook," the "China Statistical Yearbook" and the "China Forestry Yearbook" from 1978 to 2015, the index of forestry gross output (Y) had been regulated as the generating sequence of grey correlation analysis of forestry economic system. Moreover, it acted as a measure of output indicators, which can be calculated by this method: Current Price/Retail Price Index. The "Retail Price Index" took the retail price in 1978 as a basis, denoted as $x0(k)$ ($k = 1, 2, \ldots, 34$).

(2) The "sub-factors," compared with the reference sequence as a comparative sequence, are denoted as xi(k) ($i = 1, 2, 3, 4$).They were capital investment (K); labor input (L); afforestation area (land); technological advancement contribution rate (a); and property system variables (SD) for property ownership.

4.2 Non-dimensionalization for initial value of each sequence

Due to different units within the data set, the results are hard to compare or hardly correct since we are using the gray correlation analysis (Cui *et al.*, 2009). Thus, all initial data must be processed by the non-dimensionalization process. There are different ways to fulfill non-dimensional destination such as initial value, average method, and so on. Average and initial treatment can eliminate the influence of index dimension and magnitude order while including all the information in the original data. Since this paper involves mainly time series data, it adopts the methods of initial value, meaning that data of a same sequence are divided by the first data set to get a new sequence. This new sequence indicated a numerical value of each moment with respect to the first moment of a multiple sequence, as shown in Table II.

4.3 Correlation coefficient calculation

Correlation coefficient reflects how tightly two contrast sequences from different groups are related at some point. The correlation coefficient's calculation formula of reference and comparative sequence is as follows:

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho * \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho * \max_i \max_k |x_0(k) - x_i(k)|} \tag{2}$$

where ρ is resolution ratio, generally taking 0.5. ξi (k) as the correlation coefficient between kth element of comparative column x_i and the kth element of reference sequence x_o (see Table III).

4.4 To solve related degree

Related degree can be calculated by the following two comparative sequences:

$$\gamma_i = \frac{1}{n} \sum_{k=1}^{n} \xi_i(k) \tag{3}$$

where γ_i is the related degree of comparative number of columns x_i and reference number of columns x_0. The related degrees of L, k, l, and, a, SD are 0.8197, 0.8601, 0.8218, 0.7998, 0.8233, respectively.

4.5 Correlation order

According to related degree γ_i, the order of each factor impact on target value and forestry gross output can be done. Namely: capital investment, the changes of property system, afforestation area, labor input and technological progress (see Figure 5), and the correlation coefficients were 0.8601, 0.8233, 0.8218, 0.8197, 0.7998.

The results showed that from 1978 to 2017, the average related degree between capital investment and forestry gross output is the largest, followed by property system and afforestation area, with labor and technology factors being much lower than others. This meant that nearly 30 years of Chinese forestry growth were mainly driven by capital investment and property system changes; meanwhile, the labor input had been continuously decreasing. The advancement of property system's revolution could provide guidance in the tendency of woodlands privatization to a certain degree, as demonstrated from the

Year	k	x0 y	x1 l	x2 k	x3 Land	x4 a	x5 SD
1978	1	1.0868	1.0498	1.0682	0.9984	0.6158	2
1979	2	1.0397	1.0098	1.0229	1.0124	0.6851	3
1980	3	1.2445	1.0320	0.9380	0.9141	0.5364	4
1981	4	1.3488	1.0684	1.1002	0.9998	0.5441	5
1982	5	1.4014	1.0547	1.0268	1.4066	0.4646	6
1983	6	1.5325	1.0562	1.0816	1.8356	0.4860	7
1984	7	1.4943	1.0698	1.0137	1.8541	0.3043	8
1985	8	0.7437	1.1020	1.2058	1.1730	0.4935	9
1986	9	1.1717	1.1261	1.1501	1.2041	0.5092	10
1987	10	0.5588	1.1678	0.9862	1.2306	0.4733	−1
1988	11	0.4754	1.1713	0.7793	1.1172	0.4549	−2
1989	12	1.3098	1.1651	0.8290	1.1584	0.4961	−3
1990	13	1.4016	1.1911	0.9357	1.2442	0.5254	−4
1991	14	1.5367	1.1893	1.0962	1.3412	0.4459	−5
1992	15	2.6270	1.2055	1.1995	1.3129	0.4989	1
1993	16	2.9032	1.4422	0.9994	1.3328	0.9945	2
1994	17	2.9822	1.3993	0.9855	1.1597	0.2459	3
1995	18	3.0435	1.4043	1.0710	1.0941	0.4260	4
1996	19	3.3917	1.3349	1.3026	0.9686	0.3418	5
1997	20	4.9519	1.1039	1.6694	1.0700	0.3899	6
1998	21	5.9653	1.0354	2.3567	1.0899	0.3698	7
1999	22	6.7548	0.9258	3.7834	1.1354	0.1799	8
2000	23	7.8331	0.8534	4.5838	1.1016	0.3429	9
2001	24	8.9920	0.8009	6.9159	1.7283	0.3040	10
2002	25	11.3809	0.7583	8.5611	2.0281	0.4249	11
2003	26	13.0205	0.7305	7.6554	1.2450	0.4559	12
2004	27	15.8510	0.7055	8.4209	0.8090	0.4471	13
2005	28	19.7634	0.6902	8.9813	0.8538	0.4692	14
2006	29	22.4018	0.6735	9.8723	0.8691	0.4336	15
2007	30	24.3164	0.6461	13.2322	1.1909	0.2749	16
2008	31	29.8871	0.6357	18.5575	1.3928	0.4332	17
2009	32	37.7482	0.6536	20.5901	1.3144	0.5125	18
2010	33	48.3359	0.7755	32.9835	1.3337	0.6013	19
2011	34	61.1048	0.7561	0.4285	1.2445	0.5759	20
2012	35	72.2719	0.7316	0.4615	1.3567	0.4434	21
2013	36	81.7168	0.7253	0.4722	1.2334	0.4768	22
2014	37	89.6967	0.6949	0.4351	1.4774	0.4156	23
2015	38	1.0868	1.0498	1.0682	0.9984	0.6158	24
2016	39	97.9984	0.6940	0.4687	1.6021	0.4183	25
2017	40	105.3885	0.6941	0.4762	1.7082	0.4274	26

Table II. Reference and comparative sequence after non-dimensionalization

years 1978–2017. Based on the analysis results as well as the actual situation, the property system's revolution had a strong contribution to the development of forestry.

From the view of dynamic changes, years changing, correlation degree of forestry funding was always keeping on one level with a little bit fall. The falling range associate degree of labor input was far greater than capital factor. The impact of the land element, afforestation area, on forestry economic growth had been reducing. The associate degree of technology slightly decreased in volatility, and system factors fluctuated greatly. At the beginning of liberation, private property rights showed a highly degree with a gradual decline, falling to the lowest around 1978. During 1978–2003, a twist occurred with an increase followed by a decrease. Starting in 2003, woodlands privatization had demonstrated a rapid development.

Year	l	k	Land	a	SD
1978	1.0000	1.0000	1.0000	1.0000	1.0000
1979	0.9998	1.0000	1.0000	0.9900	0.9739
1980	1.0000	1.0000	1.0014	0.9926	0.9450
1981	0.9959	0.9936	0.9946	0.9848	0.9242
1982	0.9944	0.9948	0.9941	0.9827	0.9018
1983	0.9929	0.9920	1.0019	0.9799	0.8793
1984	0.9901	0.9904	0.9952	0.9775	0.8596
1985	0.9912	0.9897	0.9939	0.9745	0.8372
1986	0.9927	0.9901	0.9923	0.9949	0.8020
1987	0.9996	0.9999	1.0013	0.9858	0.7911
1988	0.9872	0.9909	0.9870	0.9985	0.9559
1989	0.9853	0.9936	0.9876	1.0000	0.9314
1990	0.9974	0.9897	0.9986	0.9825	0.8860
1991	0.9960	0.9900	0.9984	0.9812	0.8611
1992	0.9929	0.9906	0.9976	0.9766	0.8366
1993	0.9697	0.9694	0.9730	0.9549	0.9540
1994	0.9689	0.9594	0.9676	0.9594	0.9742
1995	0.9663	0.9575	0.9622	0.9427	1.0000
1996	0.9651	0.9580	0.9596	0.9450	0.9726
1997	0.9565	0.9556	0.9498	0.9365	0.9545
1998	0.9210	0.9318	0.9210	0.9077	0.9700
1999	0.9009	0.9255	0.9023	0.8890	0.9704
2000	0.8848	0.9379	0.8888	0.8720	0.9645
2001	0.8650	0.9325	0.8693	0.8567	0.9667
2002	0.8451	0.9559	0.8603	0.8375	0.9712
2003	0.8078	0.9409	0.8267	0.8033	0.9892
2004	0.7841	0.8930	0.7909	0.7807	0.9708
2005	0.7466	0.8576	0.7472	0.7438	0.9217
2006	0.7005	0.8057	0.7013	0.6985	0.8531
2007	0.6724	0.7811	0.6733	0.6705	0.8188
2008	0.6532	0.8014	0.6574	0.6503	0.8008
2009	0.6038	0.7978	0.6088	0.6028	0.7217
2010	0.5458	0.7226	0.5487	0.5455	0.6284
2011	0.4837	0.7443	0.4851	0.4835	0.5323
2012	0.4247	0.4240	0.4251	0.4247	0.4482
2013	0.3838	0.3834	0.3842	0.3835	0.3943
2014	0.3548	0.3547	0.3547	0.3548	0.3585
2015	0.3336	0.3335	0.3340	0.3335	0.3335
2016	0.3140	0.3141	0.3146	0.3140	0.2540
2017	0.2985	0.2986	0.2991	0.2985	0.2405

Table III.
Correlation coefficient

5. The conclusion and enlightenment

The capital investment (*K*), labor input (*L*), afforestation area (land), technological advancement contribution rate (*a*) and property system variables (SD) were placed into the forestry economic growth model in the study. The grey correlation model was used to analyze the related input factors impact on forestry economic growth. Every input factor had different degree influences on Chinese forestry output value. The results showed that Chinese forestry economic growth was mainly driven by capital investment and property system; particularly, the correlation of forestry investment in fixed assets and forestry production was the largest. On the one hand, it states that the investment in fixed asset played a particularly important role in the rapid growth of China's forestry economy. On the other hand, it showed the lower impact factors in today's forestry industry development. This suggested that human and material resources still relied on a great deal of investment

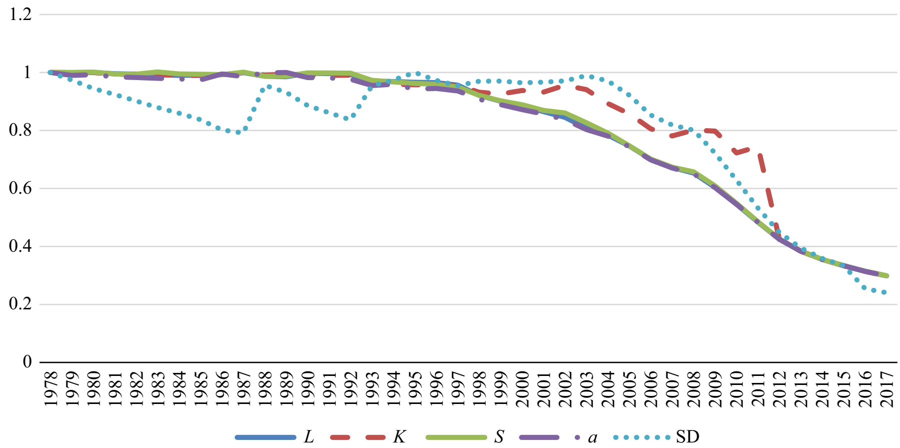

Figure 5.
Correlation factors and forestry output value

to maintain rapid growth of extensive development. Therefore, the forestry economic growth mode must be changed to the new developmental state.

In regard to funds investment, China's forestry economic growth depended heavily on national capital investment in the long term. Forestry played an important role in public welfare from the ecological and environmental perspective. Therefore, it is imperative to invest forward to strengthen the construction of ecological engineering. Forestry is also an important economic industry. Even with the implementation of the forest land tenure reform policy, the following questions still need to be addressed: how to give full play to market capacity? How to complete forestry financial system? How to explore diversified investment and financing channels to attract social assets entering forestry?

With respect to property system, the correlation of property system and forestry output growth was larger than others, indicating that property system's reform had an important impact on forestry economic growth. As a new round of forest rights reform was being implemented, the tendency of woodlands' using right privatization was obvious. This could stimulate operator's enthusiasm for operating, promote the application and popularization of forestry science and technology, and raise the management efficiency of the woodlands. In the future, we need to further investigate and adjust the coordinated reform policy of property system and forest management socializing service system. At the same time, we need to further consider the continuity of property system and the relative stability of policies. It is more advantageous for farmers to form long-term rational expectations in order to make long-term sustainable operation behavior choices, and eventually contribute to a steady growth of forestry economy. In addition, we need to further examine the following: how to effectively promote state-owned forest tenure reform as well as how to promote management efficiency of state-owned forest farm and forest region?

In terms of forest land area, the forest land area had the growth potential because of short-term grain for green and entering-city farmers. However, in the long run, the new added woodland area was affected by the constraints of the inherent territory. This meant its increasing potential is limited. Therefore, the improvement of output capacity of unit forest area is much more important for further forestry economic growth. Furthermore, it is crucial to address other issues such as how to scientific manage the large areas of man-made forest, how to transform the low-yield forest of our country, and how to improve the level of forest ecosystem, sustainable forest management and production efficiency.

With regard to the labor part, due to the limitation of existing statistical data, this study could only select forestry staff number as a measure index, which had some defects, as there is no way to consider the labor input of individual forest operators. Therefore, the impact of labor input on forestry economic growth will be underestimated to a certain extent. Research shows that China's forestry economic growth is still in the labor-intensive and extensive growth stages. With the advancement of technological progress and forest land circulation, large-scale forest land and intensive and precision management will become a trend in the long run. Labor input impact on forestry economic growth will continue to diminish. Thus, education must be enhanced, and comprehensive quality and unit output must be improved with respect to forestry labor. In the context of green economy and ecological civilization, the development of the green forestry industry can lead to additional forestry-related jobs while continuously strengthening forestry operator's management motivation and performance.

In terms of technological progress, although China's forestry sector had achieved some technological breakthrough and progress in recent decades, the level of contribution of forestry technological progress to economic growth was low with limitation in the percent conversion and practice of forestry technology. This is especially true in the context of woodland fragmentation and diversification of substitution income; many forest areas lack investment in technology, as technological impact on forestry economic growth is relatively small. Therefore, further development in science and technology need to be in place for the forestry sector in order to advance the transformation of forestry economic growth mode.

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