Economic analysis of the change of tea production layout in China

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Abstract. In the context of deepening supply-side reform in China, based on the national tea planting area and yield data from 1993 to 2018, combined with GIS technology and spatial center of gravity statistical models, this paper analyzes the characteristics of China's tea development and change in 25 years in detail, and comprehensively analyzes the driving mechanism of the changes. The following conclusions are drawn: China’s tea production space has changed significantly, and the country’s tea planting area and output have been on the rise, but the changes are inconsistent; The continuous westward shift of the center of tea production in China is caused by the joint influence of nature, economy and society, among which resource endowment and policy support are the most important driving forces.

1. Introduction

China is the world's leading producer, consumer and exporter of tea. According to the statistics of the FOOD and Agriculture Organization of the United Nations in 2018, among the 60 tea producing countries in the world, China's tea production ranks first in the world, with 2.616 million tons, accounting for 44% of the world's total production. Tea plantation area accounts for over 62.1% in the world, ranking first in the world. Tea consumption accounted for 36.85 percent of the world's total, reaching 2,119,000 tons, ranking first in the world. Tea exports were 365,000 tons, accounting for 19.7% of the world's total, ranking second in the world. By 2018, the total output value of dry tea in China had exceeded 200 billion yuan for the first time, reaching 215.73 billion yuan, an increase of 20.77 billion yuan or 10.65 percent over the previous year.

As a characteristic agriculture, China's tea industry is an important industry involving more than 80 million tea farmers, more than 70,000 tea enterprises and more than 20 tea-producing provinces and autonomous regions. Tea industry is the pillar industry of economic development in many counties in southern China. Tea income from concentrated producing areas accounts for more than 50% of farmers’ income, and it is one of the important ways to get rid of poverty and become rich in many poor areas in China. It plays an important role in solving the problems concerning agriculture, rural areas and farmers, and has received great attention from relevant departments of the state.

In recent years, as the differences in the economic development levels, production costs, benefits, and technologies of the major tea producing provinces have gradually expanded, tea production is
concentrating in advantageous regions, and the production layout has also changed. At the national level, between 1978 and 2018, the tea plantation area showed a volatile increase (Zheng Xuyuan, 2015), which increased from 1.048 million hectares to 2.28 million hectares, an increase of 1.18 times; tea production continued to increase, from 268,000 tons to 2.616 million Tons, an increase of 876.1%. However, the trend of the tea planting area in various regions is not consistent with the overall situation in the country. In some areas, the tea planting area has declined significantly. At the same time, with the rapid development of my country's tea garden area and tea production, many scholars have raised concerns about overcapacity. Jiang Yongwen (2011) and Guan Xi (2018) unanimously believe that China's tea industry has a certain degree of imbalance in supply and demand, and it is showing a trend of accelerating year by year. In 2018, tea output was 2.61 million tons, domestic sales were 365,000 tons, total consumption was 2.275 million tons, and there was a total of 334,000 tons remaining.

Zhong Funing [5] (2007) analyzed the causes of the change of rice production layout based on the producer behavior theory. Yang Chun [6] (2008) studied the spatial distribution law of grain production by calculating the spatial autocorrelation coefficient of the provincial grain production data. Gu Tianzhu [7] (2017), based on the analysis of statistical data, adopted the production concentration degree, production scale index and regional comparative advantage index to reflect the changes of banana production layout in China from 2003 to 2014.

Although there is no lack of research on crop production change, there is no in-depth study and systematic explanation of the driving force of regional heterogeneity of tea production change. Based on the macro economy increasing downward pressure and tea consumption new normal circumstances, the tea production in China, the development trend of tea "east to the west" and the imbalance of supply and demand of the actual problems, from the supply side, under the premise of fully considering the regional heterogeneity, the pulse of the existing tea production layout, development area of tea production, tea garden incremental control and inventory optimization, constantly optimize the layout of structure adjustment of the national tea production, to realize sustainable development of China's tea industry science has a very important time significance.

2. Data sources and research methods

2.1. Data sources and processing
In this study, data from the whole country and 17 tea-producing provinces from 1993 to 2018 were mainly used, including the actual area of tea gardens at the end of the year, the area of tea picking this year and the yield of tea leaves. The data are all derived from the provincial database of China Agriculture, Rural Areas and Farmers Database. The area and yield unit adopt The Chinese national standard. The area is 1000 ha, the yield is ton, and the data are kept to two decimal places.

2.2. Research methods
Geographic Information System (GIS) is characterized by the dynamic integration of time and space, which enables the visualization of research results. Using the spatial gravity center statistical model and spatial autocorrelation analysis method of Huang Xiujie et al. [8] for reference, this study systematically analyzed the dynamic evolution law of the spatial layout change of Chinese tea production from 1993 to 2018.

The specific research method is to establish a statistical model of the spatial center of gravity of tea production, use ArcGIS software to describe the spatial center of gravity coordinates of main tea production areas, and then combine with the map to explain the migration track, direction and distance of the center of gravity of tea production.

Assume major tea producing areas in China is composed of n is the area, among them, the first is the area I barycentric coordinates (Xi, Yi), Mi for the subdomain some properties of number value (e.g., area, production), is China's tea production areas geographical spatial coordinates mean t period.
(Xi, Yi) is the area some properties of the production center of gravity. The calculation formula is as follows:

\[ X = \sum_{i=1}^{n} \frac{M_i X_i}{\sum_{i=1}^{n} M_i}, \quad Y = \sum_{i=1}^{n} \frac{M_i Y_i}{\sum_{i=1}^{n} M_i} \]

The inter-annual spatial location movement distance of tea planting area and tea yield center within the main producing areas is calculated as follows:

\[ D_{ij} = R \times \sqrt{(X_i - Y_i)^2 + (X_j - Y_j)^2} \quad (i > j) \]

Where, D I-j represents the distance (Km) that the center of gravity moves from the j year to the I year; (Xi, Yi) and (Xj, Yj) represent the geographical coordinates of the center of gravity in the I and j years respectively. The unit longitude length in the latitude direction varies, but the distance of the center of gravity is usually not very large, which is ignored in this paper. The constant R is 111.13, which represents the coefficient of the surface spherical longitude and latitude coordinates converted into the plane distance.

3. Analysis of the temporal and spatial changes of tea production in China from 1993 to 2018

3.1. Overview of tea production in China

After the reform and opening up, during the 25 years from 1993 to 2018, China's tea industry gathered and expanded in terms of production scale. It can be seen from Figure 1 that the planting area and yield of tea in China are on the rise. By the end of the year, the area of actual tea plantations had increased from 1,170.7 thousand hm² in 1993 to 2,985.8 thousand hm² in 2018, an increase of 1.5 times. During this period, there were three stages of changes. From 1993 to 2002, the area of tea plantation did not increase significantly and was in a relatively stable state. But from 2003 to 2015, the tea plantation area in China began to expand rapidly, increasing by 1585 thousand hm². The tea plantation area decreased by 68.6 thousand hm² in 2016, but reached the historical peak in 2018. During this period, the area of tea picking this year is consistent with that of the actual tea garden at the end of the year.

In terms of the growth of national tea production, it increased from 599,900 t in 1993 to 2,610,400 t, an increase of 3.4 times. The change of national tea yield also went through three stages, from 1993 to 2003, the change range was very small, with an average annual growth rate of 2.5%. From 2004 to 2014, the national tea production increased rapidly, with an average annual growth rate of 9.64%. The period from 2015 to 2018 is a period of rising volatility, with an average annual growth rate of 5.09%.

From 1993 to 2018, the yield per unit area of Tea in China grew rapidly, from 6, 5855.21 kg·hm⁻² in 1993 to 12, 2369.82 kg·hm⁻², an increase of about 1.16 times. It can be seen from Figure 1 and figure 2 that the change trend and speed of tea yield per unit area (tea yield/picking area) are inconsistent with the growth trend of tea planting area and tea picking area. This is related to the improvement of tea varieties, planting technology and other factors.

Figure 1. Changes of tea planting area, picking area and tea yield in China from 1993 to 2018.
3.2. Changes in the space-time pattern of tea production in China

In order to further explore the evolution pattern of Tea production in time and space in China, tea plantation area and tea yield in the four years of 1993, 2000, 2009 and 2018 were selected to analyze their evolution trend in specific key years.

China with a total of 22 provinces (cities) in tea tree planting, 1993-2018, JiangSu, ZheJiang, AnHui province of FuJian JiangXi HuBei HuNan GuangDong GuangXi, HaiNan, HeNan SiChuan GuiZhou YunNan 17 provinces of GanSu, ShaanXi, over 95% of the total area of the country's tea planting area in this article defined the 18 provinces as the major tea producing areas in China's existing four big tea area, in order to facilitate calculation, this paper defined in FuJian, GuangDong GuangXi belongs to southern China in HaiNan tea area, GuiZhou, SiChuan southwest YunNan belongs tea area, AnHui, JiangSu province HuNan, HuBei, JiangXi, ZheJiang belongs to JiangNan tea district, Gansu Shaanxi Henan belongs to Jiangbei tea district.

Firstly, from the perspective of large regions in China, the tea production pattern of the four major tea regions has changed greatly. It can be seen from Figure 3 and Table 1 that in 1993, the tea planting area in Jiangnan tea District ranked the first in China, accounting for 50.10% of the country; the tea area in southwest China accounted for 27.64%; the tea area in South China ranked the third, accounting for 17.68%; and the tea area in North China accounted for the least, only 4.58%. From 2000 to 2009 to 2018, the planting area of Jiangnan tea district decreased year by year, accounting for only 34.26%, and the southwestern tea district surpassed Jiangnan and became the first in China, accounting for 44.79%. The planting area of tea in South China also showed a decreasing trend year by year, which was 17.68%, 19.10%, 15.69% and 11.92%, respectively. Although jiangbei tea district occupies the lowest proportion in the whole country, its proportion is increasing year by year, being 4.58%, 5.42%, 8.31% and 9.03% respectively. Generally speaking, tea areas in the southwest and Jiangnan regions account for nearly 80% of the tea in China, while those in the southwest and Jiangbei regions show an increasing trend year by year, while those in the South and Jiangnan regions are vice versa.

However, from the dimension of tea yield, the change trend and planting area are different. The planting area of Jiangnan Tea area occupies more than average in China, and its output naturally ranks the first, accounting for 53.05%, 46.58%, 40.32% and 45.10% respectively. However, the yield of the second largest tea area in southwest China is not as high as that in South China. Different from the growing area, the yield of tea leaves shows a trend of fluctuation and decline, which is 23.17%, 22.85%, 28.64% and 18.77% respectively. However, although the tea planting area in South China decreased year by year, the tea yield increased year by year, which was 22.24%, 28.24%, 26.68% and 29.41%, respectively, which was related to the tea research, scientific and technological development level, excellent germplasm resources and other factors. The change of tea yield in Jiangbei tea area...
was consistent with the change of planting area, showing an increasing trend year by year, which was 1.55%, 2.33%, 4.26% and 6.72% respectively.

![Figure 3. The spatial pattern of tea plantation area and tea yield in China from 1993 to 2018.](image)

**Table 1. Proportion of tea production and planting area in the four major tea areas from 1993 to 2018.**

| Region                | Ratio category | Year   |
|-----------------------|----------------|--------|
|                       |                | 1993   | 2000   | 2009   | 2018   |
| South China Tea District | Yield         | 22.24% | 28.24% | 26.78% | 29.41% |
|                       | Area           | 17.68% | 19.10% | 15.69% | 11.92% |
| Southwest Tea District | Yield         | 23.17% | 22.85% | 28.64% | 18.77% |
|                       | Area           | 27.64% | 27.92% | 38.08% | 44.79% |
| Jiangnan Tea District  | Yield         | 53.05% | 46.58% | 40.32% | 45.10% |
|                       | Area           | 50.10% | 47.55% | 37.91% | 34.26% |
| Jiangbei Tea District  | Yield         | 1.55%  | 2.33%  | 4.26%  | 6.72%  |
|                       | Area           | 4.58%  | 5.42%  | 8.31%  | 9.03%  |

Secondly, from the provincial perspective, the overall pattern of tea planting area in China has changed greatly in the past 25 years, showing the characteristics of geographical agglomeration. The yield of tea leaves is not coupled to the change in area. Can be seen from the figure 4, the planting area of 120000 hm2 provinces are: Yunnan, Zhejiang, Hunan, Fujian, Anhui, Guizhou, Sichuan, Hubei and Shaanxi, since 1993, Guizhou, Sichuan, Hubei and Shaanxi tea growing area of expansion, most notably in Guizhou in just 25 years tea growing area expanded 8.45 times, Shaanxi expanded by a factor of 3.38, Sichuan and Hubei expansion of 2.42 and 2.12 times respectively, among the Chinese tea in Guangdong province. However, Hainan province is shrinking. Zhejiang, Fujian and Hunan, the traditional tea-growing provinces relying on the expansion of natural endowment resources, see a slowdown in the growth of tea planting area and return to normal development. However, the tea production ranks among the top five in China. However, Guizhou and Shaanxi, which have the most obvious expansion in area, produce less than 100,000 tons of tea. The underlying reasons need to be further studied and discussed.
Third, according to the basic data of planting area and yield of Tea in China from 1993 to 2018, the center of gravity of tea production and its moving distance were calculated by formula, and the center of gravity movement path of planting area and yield of tea in China was obtained by Arc GIS software (Figure 5).

From 1993 to 2018, the center of gravity of China's tea plantations fell between 111.97°-109.71° East longitude and 28.34°-28.66° North latitude. In 1993, the center of gravity of tea garden area was located in Taojiang County, Yiyang City, Hunan Province. In 2018, the center of gravity moved to Baojing County, Yiyang City, Hunan Province, and the center of gravity shifted to the northwest by 253.75km. The change of zonal direction of the area center of gravity was small, which showed northward migration. The meridional change is more obvious, which is manifested as a continuous eastward shift. The moving distance of the center of gravity of tea plantation from east to west is greater than that from south to north, indicating that the planting area of tea plantation in the east and west direction of China changes greatly. From 2000 to 2009, the center of gravity moved to the maximum distance of 159.29 km (Table 2). This indicates that the tea planting area in western China developed rapidly during this period, and the growth rate was higher than that in eastern China.

From 1993 to 2018, the center of gravity of Tea production in China was located in the east-south of the center of gravity of tea garden area, generally falling between 113.07°-110.64° e and 28.12°-28.17° N. It is also true that the meridional change is greater than the zonal change. In 1993, the center of tea output was above the fields of Changsha, Hunan province. In 2018, it moved west to Xupu County, Huai Hua, Hunan, where it moved 270.17km to the west (Table 2). From the perspective
of the movement distance of the center of gravity, the most obvious changes occurred from 2000 to 2009 and from 2009 to 2018, with the movement distance of more than 100km to the west and south, indicating that the tea yield in the southwest tea region grew rapidly.

![Figure 5. 1993-2018 China tea garden area and tea production center of gravity transfer path.](image)

### Table 2. The distance between the area of Chinese tea gardens and the center of gravity of tea production from 1993 to 2018.

| Year | Xm    | Ym    | Area moving distance | Xc    | Yc    | Output moving distance |
|------|-------|-------|----------------------|-------|-------|------------------------|
| 1993 | 111.97| 28.34 | 0.00                 | 113.07| 28.12 | 0.00                   |
| 2000 | 111.82| 28.50 | 23.98                | 112.87| 28.03 | 24.32                  |
| 2009 | 110.40| 28.63 | 159.29               | 111.95| 28.26 | 104.65                 |
| 2018 | 109.71| 28.66 | 76.85                | 110.64| 28.17 | 146.67                 |

### 4. Analysis of driving mechanism of Chinese Tea production changes

#### 4.1. Resource endowment factors

From the above analysis, it can be found that the tea plantation area in southwest China is expanding most rapidly, and one of the most important reasons is that the tea provinces in west China have obvious advantages in resource endowment. Different resource endowments among regions will determine the different distribution characteristics of tea production among regions. Topographic conditions, climatic conditions, agricultural population resources and other factors will affect the location conditions and production costs of tea production in different regions, thus affecting the layout of tea production. The proportion of mountainous area and the quantity of agricultural labor force are the two most prominent important factors in the resource endowment. The poor mountainous areas have abundant land resources, sufficient supply of production factors and low land cost. Therefore, tea can become the dominant variety of agricultural production in mountainous areas, with obvious regional advantages and development potential.

#### 4.2. Economic and social factors

Farmers are rational economic men and have decision-making behaviors aiming at profit maximization. Tea planting and picking as a typical labor-intensive crop, the opportunity cost of planting is increasing year by year, and there is a huge difference between the level of economic development and non-agricultural employment opportunities among different regions. Economic factors have become an important criterion for tea growers' production. For example, Zhejiang and Guangdong, both traditional tea-producing provinces, are economic development zones along the east coast. Non-agricultural employment opportunities increase year by year with the continuous...
advancement of the national reform and opening up process. In addition, tea picking, processing and production require a large amount of labor input, which greatly increases the cost of tea production, resulting in lower economic benefits than other industries. All kinds of economic and social factors are influencing the change of tea production layout.

4.3. Technical progress factors
The development of agricultural technology has a profound impact on tea production. On the one hand, advanced production technology can break through the restrictions of natural factors on tea production, so that some areas with insignificant resource advantages can also produce tea, thus changing the production layout of tea. On the other hand, the innovation of production technology, such as biotechnology, tea garden digital management, fertilizer slow-release technology and so on, can help reduce the dependence on labor, reduce the production cost of tea, improve the quality of tea, and increase the economic benefits of tea production. However, the development level of agricultural technology in various tea-producing provinces is not uniform, and the acceptance level of tea farmers is limited. As a result, the yield level of tea leaves per unit area in various tea-producing provinces varies greatly, which affects the distribution of tea production in China.

4.4. Policy factors
The state policy support for agricultural industry will increase the enthusiasm of tea farmers to grow tea, thus expanding the planting area of tea. Taking Fujian Province as an example, Fujian Provincial Party Committee and provincial government attach great importance to the development of tea industry in Fujian province with hundreds of billions of yuan due to its rich tea history and cultural heritage and other soft functions, and have successively issued "Eight Measures to revitalize tea quality" and "Regulations of Fujian Province on Promoting Tea Industry Development" to safeguard the sustainable development of Fujian tea industry. This is also one of the indispensable key factors for the stable development of Fujian tea industry in the past 25 years.

5. Conclusions and suggestions
Based on the national tea planting area and yield data from 1993 to 2018, combined with GIS technology and spatial center of gravity statistical model, this paper analyzes the characteristics of China's tea development and change in 25 years , and comprehensively analyses the driving mechanism of the changes. And the following conclusions are drawn: China’s tea production space has changed significantly, and the development characteristics of various tea areas are different; the national tea planting area and output are increasing, but the changes are inconsistent; the Chinese tea garden area and output center of gravity continue to move west, indicating that the growth rate of tea in Southwest tea area is higher than that in other regions. The change of China's tea production space layout is caused by the common influence of nature, economy and society, among which resource endowment and policy support are the most important driving forces.

Tea is one of the three major drinks in the world. Since the 21st century, tea has become a kind of fashionable life drink and lifestyle, and the demand for tea has been increasing year by year. The westward shift of the focus of tea production will help to take advantage of the comparative advantages of land and human resources in the west. However, there are still shortcomings in the western region, such as low level of scientific and technological development and blind expansion, which need to be paid attention to by all parties. It is necessary to comprehensively overcome the key issues such as insufficient use of new tea technologies, so as to increase the yield of tea in the southwest tea areas. In addition, mountain resources are the most important factor affecting tea production layout. In addition to make rational use of large mountainous resources in the western production areas, giving full play to the advantages of resources, harnessing and improving the planting conditions in mountainous areas, paying attention to the agricultural infrastructure construction, increasing investment in manpower, capital, etc., and providing good conditions for planting tea in mountainous areas. However, while expanding the tea planting area, it is necessary to
pay attention to the protection of land resources, not to over-reclamation, to guide tea farmers to cultivate scientifically, and to establish ecological tea plantation parks. For the steady development of Jiangnan Tea District and South China Tea District, it is primary task for Chinese tea to go global by leveraging the advantages of all parties and jointly creating a shining "Chinese tea" brand.

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