Comparative Advantage and Spatial Agglomeration of Rapeseed in China

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Abstract. Rapeseed is one of the main sources of edible vegetable oil. It is particularly important to clarify the comparative advantages of rapeseed production to optimize the distribution of rapeseed production and improve its competitiveness. Based on the relevant data of rapeseed production in China from 1997 to 2020, this paper calculates the comparative advantage of rapeseed by constructing comprehensive comparative advantage index, resource endowment coefficient and location entropy, then analyzes the spatial agglomeration changes of rapeseed in China by using regional gravity center method and spatial autocorrelation, and further analyzes the driving factors affecting the production of rapeseed in China. The results showed that: (1) The production advantages of rapeseed in China are basically in line with the main production areas, and the Yangtze River Basin production area has obvious comparative advantages and competitiveness in rapeseed production (2). The distribution of rapeseed production shows the characteristics of "westward migration to the south". China's rapeseed production centre of gravity has moved in the same direction as the sown area centre of gravity. (3) There is a significant positive spatial autocorrelation in the spatial distribution of rapeseed production in China.

Keywords: Chinese rapeseed · Comparative advantage · Resource endowment · Space center of gravity · Spatial auto correlation

1 Introduction

Rapeseed is one of the four major oil crops in the world and occupies an important position in agricultural products. China is a major producer of rapeseed in the world. In 2020, 6.8 million hectares of rapeseed would be sown in China, with a total output of 14 million tons. In recent years, with the improvement of people's living standard, rapeseed consumption continues to grow. Although the domestic production and supply level of rapeseed has gradually increased, the growth rate is slow, unable to meet the domestic consumption demand, resulting in a widening gap between supply and demand of rapeseed, increasing external dependence, and a large potential international trade risk. Therefore, identifying rapeseed production advantage regions and describing temporal and spatial changes of rapeseed production has important guiding effects on optimizing production layout of rapeseed crops and ensuring stable production.

R. Lotfi et al. (Eds.): UPRE 2023, AEBMR 253, pp. 246–255, 2023.
https://doi.org/10.2991/978-94-6463-218-7_27

The study of agricultural production layout and comparative advantage has been a hot topic for Chinese and foreign scholars. Basso (2007) analyzed the influence of climate factors on changes in crop production and distribution from the perspective of climate change [1]. Daniel and Killkenny (2009) concluded in their empirical study that the implementation of agricultural subsidies, transfer payments and other policies significantly affected the spatial pattern of agricultural production, among which the increase or decrease of agricultural subsidies had a greater impact on the change of the spatial pattern of agricultural production [2]. Li Shaoting (2021) has studied China's grain production through spatial autocorrelation and believes that China's grain has obvious spatial effect in space, and the promoting effect of agricultural mechanization on grain production is increasing year by year [3]. Saptana (2022) studied the impact of policies on the competitiveness and comparative advantage of Indonesian potatoes. Chinese scholars' research on the change of agricultural production layout and comparative advantage mainly focuses on food crops, cash crops and livestock industry [4]. Cheng Yuanzi et al. (2016) further pointed out that the spatial distribution of rapeseed production in China presents the overall characteristics of "decreasing in the east, shifting to the north and expanding to the west" [5]. Guo Yanjing (2022) analyzed the regional barycenter trajectory of corn production layout in China and its influencing factors, and then analyzed the comparative advantages of corn based on temperature, precipitation and production cost [6]. Huang Weihua et al. (2022) pointed out in their study on spatial layout of citrus production in China that the improvement of irrigation and other infrastructure had a significant positive impact on citrus production agglomeration [7]. According to Feng Tao et al. (2023), among the factors influencing regional comparative advantage of the pig industry in southwest China, economic level is negatively correlated with the comparative advantage of the pig industry, while openness is positively correlated [8]. Liu Shaoxi (2023) believed that policy factors had the greatest influence on the spatio-temporal changes of corn production in the three great plains of China after research, and suggested that differentiated policies should be formulated for major producing areas [9].

At present, there are few studies on regional comparative advantages and agglomeration changes of production spatial layout of rapeseed. Based on this, this paper takes rapeseed production in China from 1997 to 2020 as the research object, uses multiple indexes such as comparative advantage index, resource endowment coefficient and location entropy to study regional comparative advantage of rapeseed in China, and combines regional gravity center method and space autocorrelation method to study the changes of rapeseed planting and production layout in China.

2 Research Methods

2.1 Comprehensive Comparative Advantage Index

Comprehensive comparative advantage index (AAI) combines efficiency comparative advantage index and scale comparative advantage index, which can reflect the superiority degree of a certain crop production in a region more comprehensively. The specific calculation formula is as follows:

$$SAI_{it} = \frac{GS_{it}/GS_I}{GS_t/GS} \quad (1)$$

$$EAI_{it} = \frac{AP_{it}/AP_i}{AP_t/AP} \quad (2)$$

$$AAI_{it} = \sqrt{EAI_{it} \times SAI_{it}} \quad (3)$$

Here, SAI_{it}, EAI_{it} and AAI_{it} respectively represent scale comparative advantage index, efficiency comparative advantage index and comprehensive comparative advantage index in t years of i province, and GS_{it}/GS_I represents the proportion of rapeseed sown area in oil crop sown area of i province in t years. GS_t/GS represents the proportion of the national rapeseed sown area in the oil crop sown area in t year. AP_{it} and AP_i represent the yield level of rapeseed seed and oil during t period in region i, respectively. AP_t and AP respectively represent the unit yield levels of rapeseed and oil seed crops in China during t period. If $AAI_{it} > 1$ it indicates that the province has comprehensive comparative advantage. If $AAI_{it} < 1$, it indicates that the province does not have scomprehensive comparative advantage. The larger the value, the more obvious the advantage.

2.2 Coefficient of Resource Endowment

In order to better reflect the change of regional comparative advantage of rapeseed in the Yangtze River Basin, this paper combines the resource endowment coefficient and comprehensive comparative advantage index. The resource endowment coefficient is a reflection of the comprehensive factors of a country or a region and a comprehensive evaluation of the quality of natural resources of a country or a region. Calculation formula:

$$EF_{it} = \frac{V_{it}/V_i}{Y_{it}/Y_i} \quad (4)$$

EFit represents the resource endowment coefficient of t period in region i, Vit and Vi represent the rapeseed yield of t period in province i and t period in China, respectively. Yit and Yi respectively represent the agricultural output value of rapeseed during t period in i province and t period in China. It is generally believed that if $0 < EF_{it} < 1$, it indicates the lack of comparative advantage in rapeseed resource endowment this region. if $1 < EF_{it} < 2$, it indicates that rapeseed resource endowment in this region has a strong comparative advantage.

2.3 Location Entropy

The Location Entropy Index is commonly used to analyze the degree of specialization and regional distribution of industrial development in a certain region. g_{it}/G_t represents the ratio of total yield of rapeseed to oil crops in province i, P_{it}/P_t represents the ratio of total yield of rapeseed to oil crops in different periods in China.

$$LQ_{it} = \frac{(g_{it}/G_t)}{(P_{it}/P_t)} \quad (5)$$

2.4 Regional Center of Gravity Method

The shift of regional center of gravity of rapeseed in different periods reflects the change of spatial distribution of rapeseed production. By calculating the annual rapeseed production center of gravity, the regional center of gravity method can describe the variation distance and direction of rapeseed seeding area, yield and unit yield level, and directly and dynamically reflect the spatial distribution characteristics of rapeseed production in the Yangtze River Basin. The calculation formula of gravity center coordinates is as follows:

$$\overline{L_t} = \sum_{i=1}^{N} Y_{it} L_i / \sum_{i=1}^{N} Y_{it} \quad (6)$$

$$\overline{B_t} = \sum_{i=1}^{N} Y_{it} B_i / \sum_{i=1}^{N} Y_{it} \quad (7)$$

Type: $(\overline{L_t}, \overline{B_t})$ said I province rapeseed production center of gravity location latitude and longitude values values, Y_{it} said I province first t in rapeseed production or area. $N = 1, 2 \ldots n$ is the number of regions. Production center of gravity moving distance formula:

$$D = R \times \sqrt{(\overline{L_i} - \overline{L_j})^2 + (\overline{B_i} - \overline{B_j})^2} \quad (8)$$

D is the moving distance between the centers of gravity of rapeseed production. R is a constant, taking 111.11 km, whose function is to convert the latitude and longitude of a sphere into a plane distance; These are the values of latitude and longitude in year i and year j.

3 Analysis of Regional Comparative Advantages of Rapeseed in China

Comprehensive comparative advantage combines scale comparative advantage index and efficiency comparative advantage index to measure regional production comparative advantage more comprehensively. Table 1 shows the calculated results of comprehensive comparative advantage of rapeseed in China from 1997 to 2020. It can be seen from the results that the average comprehensive comparative advantage of rapeseed in each province during 1997–2020 is Qinghai, Shanghai, Tibet, Guizhou, Hunan, Yunnan, Sichuan, Zhejiang, Hubei, Jiangsu, Shanxi, Anhui, Jiangxi, Gansu, Chongqing. The comprehensive comparative advantages of rapeseed in all provinces and cities during the investigation period remained stable on the whole with little fluctuation, and the provinces and cities with advantages kept their advantages. The changing trend of comprehensive comparative advantage is consistent with the changing trend of scale comparative advantage and efficiency comparative advantage. The production advantage of rapeseed basically conforms to the main producing areas of Chinese rapeseed. The producing areas of Yangtze River Basin have obvious comparative advantages in rape production Although Inner Mongolia is located in the advantageous producing areas of spring rapeseed, it does not have obvious comprehensive comparative advantage.

Table 1. Comprehensive comparative advantages of rapeseed in China from 1997 to 2020

Province	1997	2010	2020	Province	1997	2010	2020
Beijing	0.000	0.000	0.216	Hubei	1.304	1.357	1.337
Tianjin	0.000	0.000	0.393	Hunan	1.351	1.452	1.497
Hebei	0.259	0.225	0.347	Guangdong	0.184	0.149	0.135
Shanxi	0.350	0.299	0.618	Guangxi	0.706	0.282	0.330
Inner Mongolia	0.524	0.657	0.577	Hainan	0.000	0.000	0.000
Liaoning	0.086	0.038	0.055	Chongqing	1.330	1.379	1.398
Jilin	0.000	0.000	0.011	Sichuan	1.327	1.374	1.436
Heilongjiang	0.595	0.127	0.079	Guizhou	1.422	1.453	1.371
Shanghai	1.477	1.483	1.509	Yunnan	1.286	1.369	1.481
Jiangsu	1.263	1.352	1.185	Tibet	1.490	1.568	1.593
Zhejiang	1.455	1.442	1.431	Shaanxi	1.257	1.281	1.273
Anhui	1.239	1.204	1.158	Gansu	1.048	1.132	1.187
Fujian	0.426	0.366	0.329	Qinghai	1.478	1.556	1.594
Jiangxi	1.205	1.211	1.188	Ningxia	0.117	0.065	0.602
Shandong	0.204	0.138	0.139	Xinjiang	0.819	0.749	0.632
Henan	0.585	0.637	0.418				

Table 2 reflects the change of resource endowment coefficient of rapeseed in China. The research shows that the resource endowment coefficient of Anhui, Jiangxi, Hubei, Hunan, Sichuan, Guizhou, Tibet, Gansu and Qinghai are all greater than 2 during the investigation period, and they have comparative advantages in rapeseed production. Among them, the resource endowment coefficient of Qinghai is around 8 all the year round, which has a strong comparative advantage. Compared with 1997, the resource endowment coefficients of Sichuan and Hubei both exceeded 3, indicating that the comparative advantages of rapeseed production in both places were expanding. The resource endowment coefficient in coastal areas is declining, which can be attributed to the development of other industries in developed areas. Secondly, from the perspective of region, since 1997, provinces and cities with comparative advantages have shifted from decentralization to agglomeration. The comparative advantage of rapeseed production in Qinghai-Tibet Plateau and Yangtze River Basin is obvious.

In order to measure the comparative advantage of rapeseed in China more comprehensively, this paper introduces the locational entropy method from the perspective of competitiveness to measure the competitiveness of each region in rapeseed production in China, as shown in Table 3, the locational entropy value of the Yangtze River basin is greater than 1 during 1997–2020, which has obvious comparative advantage and competitiveness. Among them, Jiangsu, Hubei, Hunan, Chongqing and Yunnan show an increasing trend in locational entropy. In addition, the comparative advantages of rapeseed in Tibet, Shaanxi and Qinghai are also more obvious.

Table 2. 1997–2020 Changes of resource endowment coefficient of rapeseed in China

Province	1997	2010	2020	Province	1997	2010	2020
Beijing	0.000	0.000	0.002	Hubei	2.997	3.417	3.525
Tianjin	0.000	0.000	0.003	Hunan	4.940	2.284	3.472
Hebei	0.060	0.033	0.085	Guangdong	0.019	0.013	0.011
Shanxi	0.065	0.038	0.275	Guangxi	0.369	0.031	0.049
Inner Mongolia	0.455	0.702	0.852	Hainan	0.000	0.000	0.000
Liaoning	0.002	0.001	0.003	Chongqing	0.990	1.550	1.644
Jilin	0.000	0.000	0.000	Sichuan	1.899	2.800	3.445
Heilongjiang	0.073	0.004	0.000	Guizhou	2.650	2.482	1.398
Shanghai	1.757	0.370	0.238	Yunnan	0.466	0.793	0.954
Jiangsu	1.340	1.399	0.637	Tibet	2.201	3.577	2.488
Zhejiang	1.288	0.902	0.825	Shaanxi	1.160	0.951	0.682
Anhui	2.881	2.445	1.725	Gansu	1.125	1.238	1.217
Fujian	0.073	0.042	0.027	Qinghai	8.406	10.343	8.140
Jiangxi	2.497	2.250	2.049	Ningxia	0.011	0.006	0.120
Shandong	0.058	0.020	0.022	Xinjiang	0.345	0.311	0.150
Henan	0.549	0.709	0.376				

4 Analysis of Rapeseed Spatial Agglomeration

4.1 Evolution Trend of Rapeseed Production Center in China

Based on the data of seeding area and yield of rapeseed in China from 1997 to 2020, the change distance and track of the center of gravity were obtained by using the regional center of gravity method. The change distance of seeding area and yield center of gravity was shown in Table 4. According to the obtained barycenter coordinates.

From the perspective of the sown area of rapeseed, the center of gravity of the sown area of rapeseed was between 109.21°–111.78° E and 30.54°–31.18° N during 1997–2020. The center of gravity of the sown area migrated to the southeast 260.03km. As a whole, and the latitude of the center of gravity of the sown area shifted to the south, with small changes in longitude and significant changes in longitude. It shows a shift to the south. From the perspective of rapeseed yield, the center of gravity of rapeseed sown area was between 108.92°–112.03° east longitude and 30.63°–31.44° north latitude during 1997–2020, and the center of gravity of sowing moved 321.37 km southeast. From Hubei to Chongqing. On the whole, the center of gravity of rapeseed in China has the characteristics of "expanding west" and "moving south". The distance of expanding west is greater than the distance of expanding south. The gravity center of the output of rapeseed in China is transferring in the same direction as the gravity center of the sowing area of rapeseed in general, but the moving distance and speed are smaller than the area.

Table 3. Location entropy of rapeseed in provinces and cities of China from 1990 to 2020

Province	1997	2010	2020	Province	1997	2010	2020
Beijing	0.000	0.000	0.004	Hubei	1.716	1.689	1.829
Tianjin	0.000	0.000	0.000	Hunan	1.994	1.838	2.109
Hebei	0.071	0.058	0.057	Guangdong	0.008	0.031	0.019
Shanxi	0.047	0.089	0.090	Guangxi	0.046	0.281	0.081
Inner Mongolia	0.147	0.608	0.519	Hainan	0.000	0.000	0.000
Liaoning	0.000	0.011	0.003	Chongqing	0.000	1.834	1.836
Jilin	0.000	0.000	0.000	Sichuan	1.906	1.767	1.876
Heilongjiang	0.944	0.016	0.007	Guizhou	2.139	2.179	2.173
Shanghai	2.318	2.284	2.082	Yunnan	1.691	1.885	2.032
Jiangsu	1.679	1.799	1.832	Tibet	2.318	2.457	2.417
Zhejiang	2.242	2.171	2.039	Shaanxi	1.340	1.611	1.621
Anhui	1.713	1.626	1.403	Gansu	0.805	1.209	1.157
Fujian	0.196	0.153	0.150	Qinghai	2.261	2.415	2.385
Jiangxi	1.567	1.182	1.436	Ningxia	0.000	0.033	0.026
Shandong	0.007	0.031	0.017	Xinjiang	0.725	0.757	0.453
Henan	0.486	0.554	0.371				

4.2 Spatial Autocorrelation Analysis

This paper uses stata16 to calculate the Moran's I index of China's rapeseed planting area from 1997 to 2020. As shown in Table 5, the Moran's I index of China's rapeseed planting area from 1997 to 2020 is significantly positive. This indicates that rapeseed planting in various provinces has significant positive spatial correlation and obvious spatial agglomeration characteristics. In other words, the rapeseed planting area of provinces adjacent to provinces with high planting area is higher, and the rapeseed planting area of provinces adjacent to provinces with low planting area is lower, which is not random distribution. The Moran's I index values were all between 0.18 and 0.32, and showed a downward trend year by year, from 0.321 in 1997 to 0.182 in 2020, indicating that although there was a positive spatial effect on the production layout of rapeseed, the spatial effect gradually weakened with the passing of time.

Table 4. 1997–2020 China rapeseed sowing area and yield gravity center change distance

Rapeseed planting area center of gravity coordinates				Rapeseed yield center of gravity coordinates			
Year	East longitude	North latitude	Travel distance (km)	Year	East longitude	North latitude	Travel distance (km)
1997	111.78	30.65	——	1997	112.03	30.93	——
1998	111.72	30.86	24.34	1998	110.81	31.04	135.50
1999	111.62	31.09	28.12	1999	111.84	31.29	117.07
2000	111.75	31.35	32.42	2000	111.85	31.35	6.41
2001	111.66	31.07	33.24	2001	111.98	31.11	30.75
2002	111.68	31.18	12.78	2002	111.46	31.41	66.87
2003	111.53	31.37	26.79	2003	111.30	31.44	18.13
2004	111.43	31.36	11.13	2004	111.60	31.44	33.30
2005	111.33	31.24	17.45	2005	111.45	31.36	18.67
2006	111.16	31.09	24.89	2006	111.30	31.24	21.89
2007	110.86	31.30	40.50	2007	111.08	31.37	28.18
2008	110.63	31.18	28.78	2008	110.76	31.34	35.76
2009	110.58	30.96	25.12	2009	110.64	31.16	23.79
2010	110.52	30.89	10.18	2010	110.58	31.21	8.43
2011	110.44	30.81	12.73	2011	110.17	30.95	53.51
2012	110.42	30.84	3.62	2012	110.28	31.00	13.57
2013	110.42	30.80	4.29	2013	110.37	30.99	10.40
2014	110.32	30.80	10.81	2014	110.26	30.97	13.30
2015	111.77	31.11	164.81	2015	110.19	30.95	7.31
2016	110.18	30.70	182.63	2016	110.01	30.90	21.77
2017	109.34	30.77	93.12	2017	108.95	30.84	117.16
2018	109.21	30.61	23.71	2018	108.92	30.80	5.85
2019	110.13	31.21	122.24	2019	109.07	30.80	17.16
2020	109.44	30.54	106.64	2020	109.15	30.63	21.42

Table 5. Results of Moran's I index of rapeseed planting area during 1997–2020

Year	Moran's I	Z-value	P-value	Year	Moran's I	Z-value	P-value
1997	0.321	3.026	0.001	2009	0.233	2.317	0.010
1998	0.305	2.894	0.002	2010	0.237	2.349	0.009
1999	0.292	2.791	0.003	2011	0.232	2.318	0.010
2000	0.255	2.491	0.006	2012	0.224	2.255	0.012
2001	0.265	2.580	0.005	2013	0.219	2.235	0.013
2002	0.261	2.554	0.005	2014	0.219	2.237	0.013
2003	0.233	2.317	0.010	2015	0.221	2.256	0.012
2004	0.223	2.231	0.013	2016	0.224	2.288	0.011
2005	0.239	2.362	0.009	2017	0.194	2.047	0.020
2006	0.247	2.416	0.008	2018	0.202	2.131	0.017
2007	0.220	2.192	0.014	2019	0.191	2.041	0.021
2008	0.218	2.187	0.014	2020	0.182	1.971	0.024

5 Conclusion

In this paper, the temporal and spatial changes of Chinese rapeseed production and comparative advantages of production were studied. On the basis of analyzing the location advantage of rapeseed in China, this paper summarized the change rule of rapeseed production agglomeration in China. The results are as follows:

(1) From the perspective of comparative advantages, Overall comparative advantage of rapeseed in Chinese provinces and cities remained stable from 1997 to 2020, and the dominant provinces and cities have always maintained the advantage. The Yangtze River Basin region has outstanding advantages and competitiveness levels in rapeseed production, and Qinghai, Sichuan and Hubei have significant resource endowments in rapeseed production.
(2) From the perspective of spatial distribution of rapeseed, the production location of Chinese rapeseed is characterized by agglomeration from dispersion to agglomeration. The center of gravity of planting area and yield is located in the producing area of Yangtze River Basin, from Hubei provinces to Chongqing. The center of gravity of rapeseed production in China presents the characteristics of "westward expansion" and "southward migration".
(3) A global spatial autocorrelation analysis of Chinese rapeseed production shows that there is a positive spatial effect on the production layout of rapeseed in China, with obvious spatial agglomeration characteristics, but this spatial effect gradually weakens with the passage of time.

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