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A Comparative Study on Factors Influencing Food Security in China and India

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Abstract This paper analyzes and compares the key factors influencing food security in two populous countries (China and India), and categorizes them into three types: agricultural production, economic development and income level, and income distribution. Using the prevalence of undernourishment as an indicator of food security, the paper empirically tests the degree of impact of various factors on food security in both countries using Tobit regression and Newey regression methods. The study finds that improving the level of economic development can significantly enhance food security in both countries; reducing the Gini coefficient has a significant impact on India, but not on China; increasing the agricultural production per capita has a much greater effect on China than on India. Therefore, both countries should take measures that are both similar and different according to their national conditions to improve their food security level.

Key words Food security, Influencing factors, Comparative study, Econometric model

1 Introduction

Food security is a complex and sensitive issue involving economic, social, and political factors, and is the most important livelihood issue. According to the 2023 *Report on the State of Food Security and Nutrition in the World*, the global agricultural system has the capacity to produce enough food to meet the needs of all people, but the number of hungry people in many parts of the world is increasing. The global food security situation is still very grim. As the world two most populous countries, China and India account for more than 35% of the world total population, and are also major food producing and consuming countries globally. Studying the food security of the two countries is of great significance for understanding the global food security situation and challenges.

In this study, we compared the influencing factors of food security in China and India, and attempted to sort out the main factors affecting food security in the two countries, and whether there are differences in these factors. Firstly, we constructed an econometric model, systematically examined the impact of factors such as economic level, agricultural production, and income distribution gap, and set the first and second terms of the Gini coefficient in the model, based on the existing literature finding the complex relationship between the Gini coefficient and food security. The research results show that the per capita GDP is a common factor affecting food security in both countries, and the Gini coefficient and per capita agricultural output have significant differences in their impact on China and India. The two countries should adopt different measures to solve the food security problem based on their own stage of economic development and national conditions.

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2 Literature review

There are many factors influencing food security. Without considering geopolitics, existing studies can be grouped into the following three categories.

The first category of influencing factors is mainly related to agricultural production, including agricultural technological progress, climate change, resource endowment, and agricultural inputs, *etc.* The amount of agricultural production determines the degree of food supply. Climate change directly affects food output, global warming, extreme weather events (such as droughts, floods, *etc.*) may lead to food reduction, and thus affect food security. To cope with the impact of climate change on food security, many countries have begun to take adaptive measures, such as cultivating drought-resistant, flood-resistant, and other stress-resistant varieties, improving agricultural production efficiency, and reducing the impact of climate change on food production[1]. Agricultural technological progress directly affects food output and quality[2-3], for example, the popularization and application of hybrid rice technology has significantly increased China's food output, effectively alleviating the pressure on food security[4]. In addition, agricultural mechanization, informatization, and other technologies also have a positive effect on increasing food output and ensuring food security[5]. Agricultural inputs, including resource endowments, also have an important impact on agricultural production[6]. India has abundant arable land resources, covering 1.53 million km^2, and sufficient water resources, ensuring India's food output in the world. In addition, agricultural support policies that are directly related to agricultural production also affect the quantity and structure of food production[7-8].

The second category of factors is related to economic development and income level. The level of economic development and

people's income level in China and India affect their food consumption and affordability[9-10]. India is in the early stage of industrialization, mainly exporting primary products such as grain, and due to its backward economy, it has weak competitiveness in the international market. It will try to reduce its domestic food consumption and use the foreign exchange earned from food exports to support its own industrialization. China is in the mid-late stage of industrialization, with a strong economy and abundant foreign exchange reserves. It has enough financial resources to support reasonable food trade policies, ensure domestic food supply, and maintain national food security by importing food to meet the needs of the people[11]. The level of economic development determines the income level of the people, and also affects the level and structure of food consumption. With the improvement in living standards in China, people's food consumption demands continue to move up the ladder, making it easier to achieve a nutritious and healthy balanced diet. India has a low per capita income level, and under the food consumption culture of vegetarianism, it has achieved highly self-sufficient food supplies with low-level nutrition.

The third category of influencing factors is related to distribution systems. Countries with higher Gini coefficients (more severe income inequality) often have higher incidence of food insecurity and undernourishment[12]. Severe income inequality limits the purchasing power of low-income families to obtain sufficient nutritious food. When income is concentrated in the hands of a few rich people, even if the national food supply is sufficient, the amount of food purchased by the rest of the families will also decline. The Gini coefficient, which reflects the income distribution gap, has a complex correlation or nonlinear relationship with food security. Some studies have found that in high-income countries such as Italy, there is a negative correlation between the Gini coefficient and food security, that is, the higher the degree of income inequality, the higher the degree of food satisfaction[13]. In low-income countries such as Rwanda, the two are positively correlated[14]. Although income disparity is relatively large, if the government has proper poverty assistance measures in place, it can eliminate the impact of income disparity on food insecurity, which is also related to the national food reserve policy. Sufficient and efficient food reserves help cope with emergencies such as food security[15].

3 Food security situation in China and India

China and India are the two largest developing countries, and their food security situation is of great concern. The rapid economic development, agricultural structural adjustment, and policy changes of the two countries have had a profound impact on food security[16]. Food security is a comprehensive concept, and its definition and connotation vary with time and region. Food security indicators are used to measure whether an individual or a group can obtain sufficient, safe, and nutritious food.

Table 1 Comparison of food self-sufficiency rates and prevalence of undernourishment between China and India in 2001 – 2021 %

Year	FSSR		POU		Year	FSSR		POU	
	India	China	India	China		India	China	India	China
2001	102.09	99.60	18.30	10.10	2012	107.18	96.50	14.80	<2.5
2002	104.44	101.22	19.90	9.50	2013	108.61	96.53	14.60	<2.5
2003	103.52	103.46	21.40	8.70	2014	106.96	95.71	14.40	<2.5
2004	103.54	97.16	22.00	7.90	2015	104.47	94.17	14.00	<2.5
2005	102.26	99.19	21.40	7.00	2016	102.96	95.74	13.50	<2.5
2006	99.76	98.96	19.40	6.10	2017	102.38	95.28	12.90	<2.5
2007	102.76	100.23	17.20	5.00	2018	104.13	96.24	13.10	<2.5
2008	102.48	98.84	16.20	3.90	2019	103.13	96.65	14.40	<2.5
2009	101.96	98.27	16.00	2.80	2020	105.22	94.03	15.90	<2.5
2010	101.76	97.72	15.70	<2.5	2021	109.47	90.22	16.60	<2.5
2011	103.47	97.98	15.40	<2.5	Average	103.93	97.32	16.53	<4.33

According to different dimensions and levels, food security indicators can be divided into different types. The indicators reflecting the national or regional level are mainly the food self-sufficiency rate (FSSR), which is calculated by the ratio of domestic food production divided by the sum of net imports and domestic food production. The indicators reflecting the individual level of food security are mainly the prevalence of undernourishment (POU), which measures the estimated percentage of undernourished individuals in the total population[17]. The macro supply level of food self-sufficiency rate and the micro demand level of malnutrition rate are not completely consistent. Taking China and India as examples (Table 1), India has a surplus of food self-sufficiency and is also a major country of food exports in the world, but the prevalence of undernourishment among its citizens is close to four times that of China, while China still cannot achieve 100% food self-sufficiency. The reason is that India achieved food self-sufficiency on the basis of most people being vegetarians, and India needs to use its comparative advantage of agricultural resources to export agricultural products and obtain foreign exchange[18]. Therefore, the prevalence of undernourishment is an actual occurrence indicator of food security, and the food self-sufficiency rate is an early warning and control indicator of food security.

4 Empirical study

4.1 Theoretical model Based on the previous study of the current situation of the factors affecting food security in China and

India, using the prevalence of undernourishment to measure the food security, and using the three categories of factors as explanatory variables, we constructed an econometric model as shown in equation (1).

$$POU_t = \beta_0 + \beta_1 GDPPC_t + \beta_2 GINI_{1t} + \beta_3 GINI_t^2 + \beta_4 APPC_t + \mu_t \quad (1)$$

where, POU (prevalence of undernourishment) is the explained variable, reflecting the food security situation. The estimates are reported as three-year moving averages, in order to reduce the impact of low reliability of basic parameters such as inter-annual fluctuations of food stocks. GDPPC (gross domestic product per capita) is an explanatory variable, representing the second category of influencing factors, indicating the purchasing power of the people. To eliminate the impact of inflation, FAO (Food and Agriculture Organization of the United Nations) uses the purchasing power parity (constant 2017, expressed in USD) as the measurement indicator. GINI (Gini Coefficient) is an explanatory variable, representing the third category of factors, reflecting the impact of income gap on food security. Due to the complex relationship between the Gini coefficient and food security, the linear term (GINI) and the quadratic term ($GINI^2$) of the Gini coefficient are set to represent various relationships as much as possible. APPC (agricultural production per capita) is an explanatory variable, representing the first category of factors, reflecting the degree of domestic food availability per capita. To eliminate the impact of inflation, this indicator is calculated using constant prices (constant 2015, expressed in USD). μ represents the disturbance term, β_0, β_1, β_2, and β_3 are the coefficients of the corresponding variables, and the subscript t represents the year.

4.2 Data sources and statistical description Gross domestic product per capita (constant 2017, expressed in USD), prevalence of undernourishment, agricultural production value (constant 2015, expressed in USD), and population are from the FAO database (https://www.fao.org/faostat/en/#data), and the Gini coefficient is from the World Bank database (https://data.worldbank.org/indicator/SI.POV.GINI). The agricultural production value is divided by the population to obtain the agricultural production per capita (constant prices). The missing Gini coefficients in some years are completed by linear interpolation.

Through processing the original data, sample sets that meet the requirements are obtained. The descriptive statistics of the main variables are detailed in Table 2.

Table 2 Descriptive statistics of major variables

Variable	China				India			
	POU//%	GDPPC//USD/capita	GINI//%	APPC//USD/capita	POU//%	GDPPC//USD/capita	GINI//%	APPC//USD/capita
Obs	21	21	21	21	21	21	21	21
Mean	4.33	10 145	40.52	570.76	16.53	4 535	34.81	279.32
Std. Dev.	2.70	4 460	2.09	68.00	2.82	1 355	0.75	39.24
Min	2.50	3 902	36.72	449.35	12.90	2 647	32.90	213.91
Max	10.10	17 847	43.70	665.73	22.00	6 609	35.90	343.16

4.3 Regression analysis results The Equation (1) is estimated using Stata software. Since China's prevalence of undernourishment has been less than 2.5% since 2010, the Tobit regression command is used to estimate China's equation. The P value of the likelihood ratio test is $0.000 < 0.05$, indicating that the inclusion of four explanatory variables is helpful for the model, that is, the model construction is meaningful. The Newey regression command is used to estimate India's equation, and the P value of the F-test is $0.000 < 0.05$, indicating that there is no problem with the model construction.

By conducting regression analysis on the indicators affecting food security in China and India, the results of Table 3 show that:

Table 3 Regression analysis results

Variable	India		China	
	Coefficient	P	Coefficient	P
GDPPC	−0.001 6	0.055 0	−0.001 3	0.000 0
GINI	89.333 7	0.070 0	−0.906 9	0.840 0
$GINI^2$	−1.310 9	0.067 0	0.011 6	0.829 0
APPC	0.001 8	0.959 0	−0.015 5	0.012 0

(i) GDPPC (Gross domestic product per capita). The coefficients of both China and India are negative, significant at the 1% level for China and at the 10% level for India, indicating that the increase in per capita income has an important impact on food security in both countries. The marginal effect of India is 0.001 6, slightly larger than that of China, which is 0.001 3.

(ii) GINI (Gini coefficient). The P values of the linear and quadratic terms of the Gini coefficient in China are both above 0.8, not significant, indicating that the income gap in China does not have a significant impact on food security. On the one hand, China has relatively high per capita income and is rapidly moving towards a high-income country; on the other hand, China's characteristic poverty alleviation policies guarantee the minimum survival needs. The linear and quadratic terms of the Gini coefficient in India are both significant at the 10% level, the linear term coefficient is positive, indicating that as the income distribution gap widens, the ability of low-income people to obtain food that meets their nutritional needs decreases, and the prevalence of undernourishment increases. The quadratic term is negative, indicating that there is a peak effect of the Gini coefficient on food security. Using the utest command, the peak is 34.07. Beyond the peak, as the per capita income increases, the impact of income inequality decreases. In terms of the impact of the Gini coefficient on food security, India and China are completely different. The main reason is that the two countries have different per capita incomes. India is

less than half of China and is still a poor country where income inequality has a great impact on low-income families.

(iii) APPC (Agricultural production per capita). The coefficient of APPC in China is negative and significant at the 5% level. APPC reflects the amount of food available per capita domestically, indicating that an increase in food supply helps reduce the prevalence of undernourishment. The P value of APPC in India is 0.959, showing no significance, indicating that India's food supply has no significant impact on food security. Regarding APPC, China and India perform completely differently. The reason is that in terms of food self-sufficiency rate, China is basically below 100%, so the increase in food production can be used for domestic consumption. While India has been over 100% for a long time, although India's extremely high food self-sufficiency rate is based on the vegetarianism of most people, it also reflects the increase in food production, but only increases export earnings, and does not increase food intake, so it has no significant impact on reducing the prevalence of undernourishment. In addition, India still shows as an agriculture-dominated country, with agriculture accounting for a large proportion of GDP, and the impact of APPC is partly reflected in the gross domestic product per capita.

5 Conclusions and recommendations

The analysis results of the factors influencing the food security in China and India show that the influencing factors are not exactly the same for both countries, but the gross domestic product per capita is a common factor. Due to the different stages of economic development in the two countries, the income inequality has a significant impact on food security in India, but not much in China. The two countries have different food consumption patterns and natural resource endowments, resulting in no significant impact of the agricultural production per capita on food security in India, but significant in China.

According to the different effects of various factors on food security, we came up with the following recommendations.

(i) Both countries need to vigorously develop the economy, increase people's income, and ensure sufficient financial resources to purchase food that meets nutritional needs.

(ii) China should improve food production efficiency to ensure a high level of domestic food supply capacity. India should develop industry to relatively reduce the proportion of agriculture in GDP.

(iii) Both countries need to solve the problem of income inequality, but it is relatively more urgent for India, which will also help improve food security. China's income inequality has no significant impact on food security, but it cannot be ignored, because it will cause other social adverse consequences.

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