An assessment of the effects on China's food security

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Abstract: This paper investigates the relationship between food industry and food security. With data obtained from China Statistical Yearbook and Chinese Rural Statistical Yearbook, we use panel data covering over a decade to construct an index system for estimating the food security of China and demonstrate the food security of China has decreased year by year. Our results imply that food industrial competition and industrial development circumstance contribute to dynamic changes commonly associated with the food security. Results suggest that an increase in the agricultural investment would have much larger economic impacts on national food security. Furthermore, under some conditions, science and technology input should be taken into account.

Introduction

Global food security has been a topic around many international agencies, organizations, and governments in the last decade [1]. With the progress of science and technology, the high-speed improvement of China's economy- averaging 9.1% per year for 35 years since 1978 has many implications for China's domestic food and agriculture sector [2]. As for China, food security is not only an agricultural, economic, or public health issue, but also an important social problem regarding domestic and international implications [3].

The world Food Summit defined food security as, "Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." [4]This definition highlights the four important dimensions of food security: access, availability, utilization and stability. Sen estimated that food security has been broadened beyond notions of food supply[5]. Amrita argued that part of the complexity of measuring and achieving a state of global good security is due to its wide definition and scope [6]. Shida showed that emerging countries have played a significant role in increasing global good availability in the past decade [7]. They found that as they have increased their agricultural production in order to meet their growing demand, fast increases in food supplies in emerging countries have raised concerns regarding social and environmental impacts. Brown reported that from 2003 to 2012, the share of Brazil, Russia, India, China and South Africa in the world GDP grew from 9% to 21% [8]. China itself tripled its own contribution from 4% to 12%. Yet, some scholars such as Brown, Gale and Coleman state that China's food security issues are different from other large developing nations such as India in that the rest of the world seems to watch China more carefully and more critically, at the least because of the potential effect of China's imports on global prices, but also possibly because of China's meteoric rise to the world stage.

In this paper, we estimate the relationship between the food industry and food security using a panel dataset that spans over a decade. We compare determinants of national food security across three lead food industry: industrial competition, industrial development circumstance and industrial foreign interdependence. Our objective is to understand the factors that drive food insecure.

Conceptual framework

Food security is a complex and multi-dimensional concept and Food and Agriculture Organization(FAO) proposes a host of indicators to measure its four dimensions---availability, access, utilization and stability[9]. In order to measure the food industry security, we need to quantify the quantification index of industry operation which represents the security situation. Considering the complexity of food security, it is inaccuracy to measure the food industrial security only by one parameter[10]. So we try to synthetically take various factors into the measurement of the industry security.

In terms of systematization, relevance, measurability and controllability principle, this article constructs an index system for estimating the food industry security by synthetically referencing the research findings of the estimation index of food industry security we already have. (As shown in table 1)

Table 1 An index system and explanation for estimating the food industry security

Estimation subject	Name of index	Explanation or methods of calculating of the index	Meaning of the index
industrial development circumstance	Capital cost	＝The fund-raising real interest rates	Reflects collection and use capital price
	The proportion of the specialized middle school and above years of schooling population in rural family	Explanation: From “Rural residents level of education” in《Statistical Yearbook of China's rural areas》[11]	Reflects the quality of agricultural labor
	Average per person hourly pay of agricultural labor	＝The average pay of agricultural staff/12/160	Reflects the cost of agricultural labor
	Average per person cultivated area	＝Cultivated area/Quantity of population	reflects land element condition
	Effective irrigated area in the unit cultivated area	＝Effective irrigated area /Cultivated area	Reflects the level of farmland irrigation
	Food demand rate of increment	Explanation: forecast according to economic growth and the population[12]	Reflects the promoting effect to production owing to food demand
	Food commodity rate	＝Average per person food sell measures in rural inhabitant	Reflects the food marketability degree
	Food reserves rate	Explanation: this target data uses the concerned experts’ estimate, because our country does not have the food	Reflects the ability of resisting the food supply and demand

		margin public statistical data	unbalanced risk
industrial competition	Industrial world market share	Domestic volume of food exports/World volume of food exports	Reflects the competition condition of the industry in the world market
	Industrial domestic market share	(Domestic consumption quantity—Volume of imports)/Domestic consumption quantity	Reflects the competition condition of the industry in the domestic market
	Competitive advantage index	=（Volume of food exports—Volume of food imports）/（Volume of food exports + Volume of food imports）	Reflects the competitive advantage of food industry
	Agricultural scientific research input	=The amount of agricultural special project funds for S&T/ Total agricultural output value	Reflects the agriculture science and technology input condition
	Labor productivity	=Total agricultural output value / Agricultural labor force population	Reflects the input-output benefits of the factors of labor force
	Land productivity	=Food yield / Food sown area	Reflects the input-output benefits of the factors of land
	Production concentration degree	=Average per household food sown area=Food sown area / Number of rural households	Reflects the formalization degree of food production
Industrial foreign interdependence	Industrial import foreign interdependence	= Food import volume / Food ultimate output	Reflects the influence size to the industry from transnational factors
	Industrial export foreign interdependence	=Food export volume/ Food ultimate output	Reflects the influence size to the industry from transnational factors
	Food degree of self-sufficiency	=Food ultimate output /Food total demand	Reflected the ability that food production satisfies the domestic demand

Methodology

For the empirical analysis of food industry security, we do research on methods of economics security and economics early warning system, and divide the whole index system into three parts: construction of the index, early warning system and synthesis estimation. There are four index security states: safe, almost safe, unsafe and crisis. The corresponding security ranking is A, B, C and D respectively. The bigger score becomes, the higher the risk is.

The statistical materials used in our warning system come from “China statistical yearbook” and “The Chinese rural statistical yearbook”. According to various index data, we calculate the

security status warning scope according to various index data, overseas index of correlation's data and world average included. Further based on broad survey and expert grading, the results are shown in table 2. (Because of the limitation of space, detail process is omitted).

Table 2 Estimation indexes' forecast data list

Year	Capital cost	The proportion of the specialized middle school and above years of schooling population in rural family	Average per person hourly pay of agricultural labor	Average per person cultivated area	Effective irrigated area in the unit cultivated area	Food demand rate of increment	Food commodity rate	Food reserves rate	Industrial world market share
2006	6.33	3.27	4.2	0.1	43.4	0.80	21.2	38.4	3.19
2007	6.33	3.45	4.5	0.1	43.9	0.80	21.8	37.3	3.30
2008	6.33	3.63	4.7	0.1	44.3	0.79	22.4	36.5	3.42
2009	6.33	3.81	4.9	0.1	44.8	0.78	23.0	35.4	3.55
2010	6.33	3.99	5.1	0.09	45.6	0.80	23.6	34.6	3.67
2011	7.3	4.17	5.4	0.09	46	0.79	24.2	33.7	3.81
2012	7.3	4.34	5.6	0.09	46.5	0.76	24.8	32.9	3.94
2013	7.3	4.52	5.8	0.09	46.9	0.68	25.4	32.1	4.08
2014	7.3	4.7	6	0.09	47.4	0.67	26.0	31.3	4.23
2015	7.3	4.88	6.3	0.09	47.8	0.66	26.6	30.2	4.38
Year	Industrial domestic market share	Competitive advantage index	Agricultural scientific research input	Labor productivity	Land productivity	Production concentration degree	Industrial import foreign interdependence	Industrial export foreign interdependence	Food degree of self-sufficiency
2006	94.7	-0.53	0.044	11874.9	4624.16	0.404	5.62	3.28	94.5
2007	94.4	-0.56	0.046	12479.4	4663.74	0.397	5.97	3.44	93.9
2008	94.1	-0.58	0.048	13083.8	4703.33	0.39	6.34	3.60	93.3
2009	93.8	-0.60	0.05	13688.3	4742.92	0.384	6.73	3.78	92.8
2010	93.4	-0.62	0.051	14292.8	4782.5	0.377	7.15	3.95	92.2
2011	93.0	-0.64	0.053	14897.3	4822.09	0.371	7.60	4.14	91.6
2012	92.6	-0.66	0.055	15501.7	4861.68	0.364	8.07	4.34	91.1
2013	92.2	-0.67	0.057	16106.2	4901.27	0.357	8.57	4.55	90.6
2014	91.8	-0.69	0.059	16710.7	4940.85	0.351	9.10	4.76	90.2
2015	91.3	-0.71	0.061	17315.2	4980.44	0.344	9.67	4.99	89.7

Our processing step is to calculate score value of qualitative index according to the index value's security state and its degree. Regarding the quantitative index, there are several kinds of situations:

1. If the index's security status decreased with its value, the following formula can be mapped on to the corresponding score in accordance with index security state:

$$F_{ij} = \text{score lower limit} + (\text{index value} - \text{upper warning limit}) \times \frac{\text{score upper limit} - \text{score lower limit}}{\text{upper warning limit} - \text{lower warning limit}} \quad (1)$$

In this formula, Fij is the score of index; the score upper limits and limits are of great importance to the security state of Sij , for example, defining score limits between 20 to 50 as "almost safe"; defining "crisis" as score vary from 80 to 100, then warning limits and index value can deter the security state of Sij .

2. If the index's security status increased with value, the following formula can be mapped the corresponding score on to security state:

$$F_{ij} = \text{score upper limit} + (\text{index value} - \text{lower warning limit}) \times \frac{\text{score upper limit} - \text{score lower limit}}{\text{upper warning limits} - \text{lower warning limit}} \quad (2)$$

3. If a satiety point existed. The farther from the point, the less security it is. For this situation, the following formula can be mapped the corresponding score on to security state:

When the index is at the safe state, the formula is:

$$F_{ij} = 2 \times \left| \text{index value} - \frac{\text{upper warning limit} + \text{lower warning limit}}{2} \right| \times \frac{\text{score upper limit} - \text{score lower limit}}{\text{upper warning limit} - \text{lower warning limit}} \quad (3)$$

When the index is at the unsafe status, there are two situations:

when the index security status increased with value, the formula is:

$$F_{ij} = \text{score upper limit} - (\text{index value} - \text{lower warning limit}) \times \frac{\text{score upper limit} - \text{score lower limit}}{\text{upper warning limit} - \text{lower warning limit}} \quad (4)$$

when the index security status decreased with value, the formula is:

$$F_{ij} = \text{lower score limit} - (\text{index value} - \text{lower warning limit}) \times \frac{\text{score upper limit} - \text{score lower limit}}{\text{upper warning limit} - \text{lower warning limit}} \quad (5)$$

What needs to explain is, when we use the formula above to calculate the score, we must identify the maximum and the minimum of the warning limits. However, some of indexes don't have warning limits at "safe" or "crisis". For this situation, we adopt the following processing method:

1) If the index doesn't have an upper warning limit, we take two times lower warning limit as the upper warning limit. When the index value is bigger than two times lower limit, we take the index value as upper limit.

2) If the index doesn't have a lower warning limit, there are two situations: if the lower warning limit is bigger than zero, we take zero as the lower limit; if the lower warning limit is

smaller than zero, we take two times the limits superior as the lower limit.

We set four weights of first-level index by experts grading: The weight of industrial development circumstance and industrial foreign interdependence accounts for 0.4 and 0.2 respectively. The industrial competition weight is 0.4. We assume that the weights of second-level index are same, so we can obtain the detail weights.

By using the formula below, there is a weighted summation with the score which mapped on to index. As the result, we can obtain the overall degree of security index for the first-level index Si :

$$S_i = \sum \frac{W_{ij} F_{ij}}{\sum W_{ij}} \quad i = \text{1,2,3} \qquad (6)$$

In the formula, Wij is the weight of Sij, Fij is the score of index calculated above, thus the value of Si is between 0 and 100.

By using the formula below, we can obtain the overall degree of security index S for whole food industry.

$$S = \sum \frac{W_i S_i}{\sum W_i} \quad i = 1,2,3 \qquad (7)$$

In the formula, Wi is the weight of Si and the value of S is between 0 and 100.

Estimate results

Using the estimation model which already has been established, we estimate and evaluate China's food industry security condition between 2006 and 2015. Some models and methods, such as linear regression and gray forecast, are applied to forecast eighteen index data of food industry from 2006 to 2015 (Concrete process is omitted). As shown in table 2.

Two conclusions mark the indicates from the estimation results. The first is there are two ingredients driving China's food industry security from security to insecurity status. One is the industrial competition, and the other is industrial development circumstance. This indicates there exists a disparity in food industry between China and western developed countries in these aspects, and also contains potential risk. Moreover, with these index score increasing year by year, it means Chinese food industry security state has the possibility to get much worse. So the government must pay more attention to it. Secondly, some index scores are under the security limit, such as industrial import foreign interdependence, industrial export foreign interdependence and food degree of self-sufficiency. From above we conclude that Chinese food industry foreign interdependence is not high, and trade influence on food industry security is not so much.

Conclusion

Proceeded from the conception of food industry security, this article constructs an index system for estimating the food industry security and evaluates it of China during the period of 2006-2015. The empirical result indicates that during that time the condition of Chinese food industry develops from basic security to insecurity. After 2009, the security degree gradually exacerbated year by year. The industrial competition and industrial development circumstance are

the key elements affecting food industry security. On the contrary, Chinese food industry foreign interdependence is not high, and international trade influence on food industry security is not much.

In the contrast with some developed countries, Chinese agricultural labor force quality is rather lower than developed countries. Therefore, it is necessary to strengthen rural labor force vocational skill training and encourage each kind of education training organization and employers to develop farmer vocational skill training.

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