

## FORECAST OF CHINA'S GRAIN PRODUCTION DEVELOPMENT AND ITS SELF-SUPPORT RATE ANALYSIS<sup>①</sup>

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**ABSTRACT:** This paper discusses four stern difficulties and challenges faced by the development of grain production in China. According to the basic national conditions of China and the amount of grain resources in the world market, China must meet the grain demands mainly by her own domestic production. Using the input-occupancy-output techniques and system science methods, this paper makes a forecast about China's grain output, grain import and self-support rate in the year 2030.

**KEY WORDS:** grain output forecast, self-support rate, input-occupancy-output techniques, system science methods

### I. STERN DIFFICULTIES AND CHALLENGES FACED BY THE DEVELOPMENT OF GRAIN PRODUCTION IN CHINA

Thanks to the opening and reform efforts, China's national economy has rapidly grown, with its average annual GNP(gross national product) growth rate reaching around 9.8% during the period 1978 – 1994 (State Statistical Bureau, 1995). The next 30 years are expected to witness fast economic growth in China. As shown by the results of our investigations, up to the middle of the next century when China's population basically cease to grow, agriculture, especially grain production, will become a vulnerable and weak link in its economic growth. China's grain production will remain in a strained or relatively strained situation for a long time. In this context, China should not be too optimistic about its grain production just because there have been a few years of good harvests. This conclusion was reached through an in-depth analysis and study of China's basic situation. In view of four major production factors (natural resources, labor, capital and science and technology), China's grain production will face the following stern difficulties and challenges:

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(1) Serious shortage of agricultural resources and their decreasing trend. Recent surveys of the nation's total existing farmland by the State Land Administration show that China's arable land is 125 million ha, and the arable land per capita is only 0.1 ha, which is only 40% of the world per capita average (0.25 ha). China has suffered from the continuous decrease of per capita arable land. On the one hand, the arable land was decreasing day by day with an annual average loss of 280 000 ha during the period 1978 – 1994, and on the other hand, China's population has reached an annual growth rate of about 13 million. It is predicted that by the middle of the 21st century, China's per capita arable land will be less than 0.07 ha.

Agricultural production needs not only arable land but also water. Unfortunately, China is a country with a serious shortage of water resources. The annual average precipitation is 630 mm. China's per capita water resources are only one quarter of the world average and most of its land is arid. Furthermore, the distribution of the water and land resources is unreasonable. For example, the northern part that accounts for 64% of the nation's total arable land only has 19% of its water resources (Sun *et al.*, 1994). Along with the economic development, the industrial sector and urban households have increased their demand for water. As a result, the proportion of irrigation water has declined. In 1952, agricultural irrigation water took 80% of the total used water resources while in 1989 the percentage was down to 68%. It is predicted that by the year 2000, only 60% of water can be used for agricultural irrigation (National Situation Analysis and Study Group, 1992). The shortage of water resources is the most important element restricting China's grain output.

(2) More rural surplus labor. In 1994, there were 333.86 million laborers in China engaged in agricultural production. Calculated on the actual labor force needed for per hectare of crops by using input-output techniques, China will, under the existing production organization and technical level, have at least 120 million rural surplus labors (in the narrow sense of agricultural surplus labor). If scale management is implemented and advanced technologies are adopted as in Japan and Thailand, China will have 230 million surplus rural labors (in the wide sense of the agricultural surplus labor), that is to say about 2/3 of the actual rural laborers is surplus labors (in the wide sense of the agricultural surplus labor) (Chen *et al.*, 1992).

(3) Serious shortage of fund, materials and facilities needed by agriculture. Only high input can lead to high output. Agricultural production is capital-consuming, obvious seasonal distribution and easy to suffer from natural disaster. In developed countries, the capital possessed by a farmer is much more than that possessed by an employee in industry. For example, in 1983 a farmer in the United States possessed US \$ 283 000 on an average but a worker in manufacturing sector only US \$ 82 000 (U. S. Department of Commerce, 1986). In 1994 a Chinese rural labor possessed 1218 yuan (RMB) on an average (calculated on the original value) for his or her fixed assets but an employee working for industrial enterprises possessed 40 148 yuan (RMB) for the production-oriented fixed assets (calculated on the original value), with an independent accounting system. It is obvious that Chinese farmers are much poorly equipped than their counterparts in the industrial sector. As a result of low comparative economic benefits, agricultural capital-profit rate is much lower than the produced in industry and the service sector. This has greatly hampered the flow of already tightened money into agriculture.

For example, in 1993 China's rural credit cooperatives secured farmers' deposits amounting to 382.2 billion yuan. With the deduction of 114.3 billion yuan for farmer loans, about 163.9 billion yuan, a major part of the balance between the two (267.9 billion yuan) was invested to township enterprises, and the rest flowed into urban areas.

(4) Farmers' low education level. As showed by the national fourth population survey conducted on July 1, 1990, 22.27% of the nation's population above 15 years old is classified as illiterate or semi-illiterate, who are mostly (95%) in rural areas. About 12.12 million people among the employee in China have had higher education (1.87% of the total employee). However, there are only 234 300 people (0.05% of the rural labor forces) in the country who have been trained in agriculture, forestry, animal husbandry, fishery and water conservancy in institutions of higher learning.

The serious difficulties mentioned above, namely natural resources, labor, capital and science and technology will produce the following direct consequences:

(1) Small agricultural production scale. At present each farmer in China takes care of 0.41 ha of arable land on an average, which is the smallest production scale of farmers in the world. This will directly affect the modernization of the nation's agriculture. It will hamper the increase of grain production and affect economic benefits.

(2) Higher cost of grain production. The current Chinese market prices for major agricultural products such as wheat, rice and corn are higher than that on the world market. For example, in 1994 the dominant wheat price in China was 1470 yuan/t (about US \$ 179/t), while the world market only offered 1200 yuan/t (US \$ 146/t). The main reasons are the limited per capita arable land and great input of labor and resources for increasing per unit grain production. As shown by the investigations conducted by the State Price Bureau, the Ministry of Commerce and the Ministry of Agriculture, average labor used for per hectare of rice, wheat, corn, sorghum and millet in 1990 reached 228 work days in China, namely 52.3 work day per ton of cereals, while in the United States the same statistic was 0.23 work day per ton of cereals. This means that the labor input per ton of cereals in China is 227 times that in the United States. In addition, China's application of chemical fertilizer in 1991 was 2.9 times that in the United States. However, Chinese farmers' income is much lower than the American counterparts. If the above-mentioned situation does not change, along with the increase of farmers' income in the future, the cost of Chinese grain production will be much higher than that in the world market.

(3) Low comparative benefits of grain production. At present, the comparative benefits of grain production in China are lower not only than that of industrial and service sectors but also than that of growing vegetables, fruits, and most economic crops. The market economy mechanism will naturally direct farmers from commercial grain production and push the labor force and capital towards non-grain production sectors.

(4) Difficulties in increasing grain output. China has seen a remarkable fall in its grain output growth rate since 1984. During the period of 32 years from 1952 to 1984, the average annual increase in grain production was 7.61 million tons with an annual growth rate (2.9%) faster than the population growth rate in the same period. During the decade from 1984 to

1994, the increase was only 3.78 million tons with a rate (0.9%) lower than the population growth rate in the same period. During the decade, some economically developed provinces situated in coastal areas have witnessed a fall in their grain production. For example, grain production in Guangdong Province declined to 15.995 million tons in 1994 from 19.725 million tons in 1984. The decade is recorded with a drop for 3.73 million tons with a decrease rate of 18.9%. In the same period, grain production in Jiangsu Province dropped by 9.2% and in Zhejiang 22.7% (State Statistical Bureau, 1995). The government must pay much attention to them.

Mr. Lester R. Brown (1995), president of the World Watch Institute in the U. S. A., has published book on China's grain problem in which predictions are made for China's grain supply and demand during the period 1994 – 2030. He believed that as a result of limited water resources, the decrease of the area of arable land and the diminishing response of crop yields to additional fertilizer use, China's grain production may see a drop of one fifth by the year 2030. China will import grain about 354 million tons which are much more than the total grain in the world market. So he questioned: who will feed China by the year 2030? This is a serious question and a proper warning to China. We should pay much attention to what we have been warned against and prevent the possible shrinking of agricultural and grain production in the course of rapid economic growth. Our response and alternatives today will doubtlessly have impacts on the tomorrow of China's agriculture.

## II. CHINA MUST FOLLOW THE PATH OF SELF SUFFICIENCY

Japan is much more limited than China in terms of per capita resources. In 1992, Japan's per capita arable land was only 0.033 ha. After the Second World War, Japan's rapid economic growth caused the shrinkage and decline of its agricultural and grain production. For example, Japan's grain production was 22.65 million tons in 1960, but only 19.2 million tons in 1970, 14.55 million tons in 1980 and 17.42 million tons in 1985. During those 25 years, Japan's grain production recorded a fall of 5.23 million tons with a 23% decline in 1985 compared to 1960. At present, Japan's grain supply comes from imports of wheat, corn and soybean, it is self-sufficient only in rice.

China is a country that has suffered from its scarcity of agricultural resources. Its production costs will be higher than the world average in the future. In view of the economics of development, in order to accelerate the economic growth and improve people's life, a nation should take full advantage of its existing production factors such as resources, labor and capital and give the priority to the development of the production sectors with international superiority and export value. Meanwhile, it should import the goods necessary for making up the insufficiency of its production factors. Economic development could gain a rapid speed if this policy is followed. China should, if possible, import grain and resource products such as high-grade iron ore, crude oil, ferrochrome ore and leopoldite from other countries for a long period of time. However, basic situation has determined that China can not follow the road that Japan and other Asian countries have taken, i.e. relying mainly on import of grain. The reasons are as fol-

lows:

(1) China is a densely populated country with 1.2 billion people. It is predicted that by the year 2030 China's population will reach 1.56 billion. Such a growth will constitute a remarkable increase in grain demand of about 725 million to 780 million tons by the year 2030. In comparison with 1994, the estimate implies an increase of 280 million to 335 million tons. The current total resource volume for the international grain export market is around 210 – 230 million tons. Under normal circumstances, China's grain import from the international market can only be limited to an amount below 30 million tons and it will be difficult to go over 50 million tons in the future. In the context, the imported grains can satisfy only 10% of China's grain demand.

The international grain market is able to meet the grain demand for Japan, with a population of 120 million. But it is unable to satisfy the grain demand of China with a population being ten times that Japan's and 21% of the world's. China has to meet its grain demand basically by self.

(2) Grain production is the means of making a living for most Chinese farmers. The development of grain production is directly related to the employment and income of most farmers. Over a long period of time from now on, China's urban economy and township enterprises will still be unable to absorb so large rural surplus labor. In this context, the vigorous development of agriculture and grain production will help to provide the employment and raise living conditions of the rural population. In the interests of Chinese farmers, China's economic development shall not be based on a shrunken and stagnant agriculture. Otherwise, it may lead to serious social problems and affect the nation's stability.

(3) China is a country with a vast territory. It is very costly to ship grain into China's inland areas and it is not economical. At present, Chinese harbors are only able to handle about 15 million tons of imported grain, and inland grain transport capacity can handle only about 30 million tons.

(4) So far as the current international situation is concerned, some developed countries are prone to use trade sanction as an important means in political conflicts. The security issue of grain should be a matter of attention. China must take the road of basic self-sufficiency in its grain supply.

In the condition that the international market can not provide enough cheap grain, the impacts of the following three factors on China's grain production and demand and supply shall be taken into account.

(1) The effect of the market economy mechanism on China's grain demand and supply. As a result of insufficient grain supply, grain prices may rise faster than resident consuming price index and the retail price index of commodities. The rise of grain price will improve the comparative advantages of farming and enhance farmers' input in grain production, and of restricting grain production. The rise of grain price will naturally restrict grain demand, including great consumption on meat production. It is a good example that in 1994, China's grain price went up, which enhanced farmers' enthusiasm for grain production and greatly increased input into agriculture in 1995, and made the year see a large scale increase in grain production.

(2) Government's macro-control functions. To ensure the grain supply and domestic stability, the Chinese Government will take full advantage of its macro-control functions in economic development. For example, the Chinese Government emphasize that agriculture is the foundation of the national economy and has adopted various policies and measures to support grain production. These efforts constitute an important input to grain production.

(3) The whole nation will implement the strategic policy of establishing a national grain-saving economic system including a grain-saving living consumption system and grain-saving production system, for example, establishing a grain-saving animal husbandry production system, increasing the proportion of aquatic products, soybean by-products and vegetables in people's diets and controlling the excessive demand for meat. This will help to slow down the fast growth of grain demand and ensure the balance between grain demand and supply.

### III. MODERATE DEGREE OF IMPORT GRAIN

In grain issue, China must take the policy of basic self-support and moderate import. The meanings of moderate import are: consider domestic need of import; consider domestic farmers' benefits and practice moderate protection; consider the ability to repay in foreign exchange and the need of industrialization; consider the grain resource in world market and the international relationship.

There are some reasons about the policy of moderate import:

(1) It can alleviate the domestic grain pressure and dispose the domestic resources optimally. It is beneficial to make the comparative superiority. According to our investigation and China's national conditions, using China's resource potentialities and technological potentialities, China has the ability to meet grain self-support. It is very costly to do so.

(2) It is beneficial to take China's agricultural characteristics and superiority. Along with moderate import grain, according to the national conditions China can be able to develop comparative superior agricultural production in world market more quickly.

(3) It is beneficial to increase farmers' income. At present, the comparative benefit of grain production in China was very low. It is predicted that this situation will be more serious in the early years of the 21st century. Along with moderate import grain, farmers can use more agricultural resources to produce more comparative superior agricultural products and increase their income.

(4) It is beneficial to control the growth rate of market prices for major agricultural products and decrease the inflation rate. Instead of using high costs to exploit and make use of barren land to produce very costly grain, it can control the domestic grain prices to import grain moderately.

### IV. FORECAST OF CHINA'S GRAIN OUTPUT AND SELF-SUPPORT RATE IN THE YEAR 2030

By using input-occupancy-output techniques to make a prediction for China's grain production, a research team of the Institute of Systems Science of the Chinese Academy of Sciences

has developed 10 constant and variable forecasting equations with high precision since 1980. These equations takes the following 18 factors into account; arable land, multiple cropping index, grain sown area, disaster stricken area, intensity of damage, scenarios for policy variables, inflation, comparative benefits for grain production, chemical fertilizer application, manure application, proportion of irrigated area, proportion of machine sown area, total power of farm machinery, number of farm stock, application of plastic film, popularization of high-quality seed, power supply in agriculture and labor forces. The team completes its report on the national grain output prediction at the end of each April and submits it to the national leaders and government agencies concerned in early May. The average error rate for the predictions made from 1980 to 1994 is 1.4%, with an advance period of prediction of six months. The meteorological prediction method and remote sensing method currently used worldwide usually have an average error rate of 5% – 10% with the prediction being made two months in advance. The predictions made by the team have attracted closed attention from the government agencies concerned.

Long-term grain output prediction involves very complicated factors with many uncertainties. In addition, it is prone to more errors than annual predictions. By using input-occupancy-output techniques and forecasting equations, the team has made a prediction for China grain production to the year 2030. Here we will introduce one of the equations<sup>①</sup> (Chen *et al.*, 1996).

$$\begin{aligned} \hat{Y} = & 138.436 - 3.580(T) + 32.768(D) - 62.985X_4 + 0.908(6.58e^{0.0063988X_6} \\ & \quad (2.29) \quad (-2.51) \quad (3.56) \quad (-1.78) \quad (6.26) \\ & + 1.08)X_6 + 4.140X_7 + 26.070X_9 + 0.401(4.8624424e^{0.000999363X_{11}})X_{11} \\ & \quad (3.64) \quad (3.19) \quad (4.48) \\ & + 0.308X_{12} + CA \\ & \quad (3.10) \\ R^2 = & 0.9949, F = 809, N = 42, D.W. = 1.70 \end{aligned}$$

where  $Y$ ——yield per unit area

$T$ ——time trend

$D$ ——variable for policy (in a year seeing full promotion of people's initiatives, the value is 1, otherwise is zero)

$X_4$ ——disaster stricken area

$X_6$ ——net chemical fertilizer application per unit area

$X_7$ ——proportion of irrigated area

$X_9$ ——average draught animals for per unit area

$X_{11}$ ——manure application

$X_{12}$ ——compared price

$CA$ ——constant readjustment (for prediction)

Respective predictions have been made on the national grain output in the year 2000, 2020

① Numbers in brackets are test values.

and 2030 as follows:

Alternative A (low prediction): 485 million tons for the year 2000, 625 million tons for the year 2020 and 685 million tons for the year 2030.

Alternative B (high prediction): 510 million tons for the year 2000, 675 million tons for the year 2020 and 725 million tons for the year 2030.

The common preconditions for alternatives A and B are: continuous implementation of joint contracting responsibility system, a stable country, protection of arable land (it is estimated that by the year 2030 China's arable land will see a reduction of 61 million ha from the current statistics, and the grain sown area will be 106 million ha) and continuous implementation of family planning policy (China's population in the year 2000, 2020 and 2030 are predicted to be 1.29 billion, 1.5 billion and 1.56 billion respectively). The differences between the two alternatives are: alternative B takes the possible government policies favorable for grain production into full account and its definition on comparative benefits for grain production, agricultural input, agricultural science and technology and scale management and operation are greatly different from the definitions of alternative A.

The elasticity coefficient method, thermal method and grain demand method are also used to make the predictions for China's grain demand in 2000, 2020 and 2030.

Alternative 1 (low): 500 million tons for the year 2000, 675 million tons for the year 2020 and 735 million tons for the year 2030.

Alternative 2 (high): 520 million tons for the year 2000, 700 million tons for the year 2020 and 778 million tons for the year 2030.

The main differences between the two alternatives are: alternative 1 presumes a more effective implementation of strategic policy for the establishment of a resource-saving national economic system including the establishment of grain-saving production system and grain-saving living consumption system, restricting grain consumption in production activities and daily life, controlling the excessive growth in meat consumption and applying the diet system with Chinese characteristics.

It is apparent, in accordance with the above predictions, that China will see a fast growth in its per capita grain demand with 388 – 403 kg for the year 2000, 450 – 467 kg for the year 2020 and 470 – 500 for the year 2030.

The above predictions for grain production and demand tell us that China will basically meet its grain demand in the year 2000, 2020 and 2030, though the possible shortage is big and increasing. In these three years, China's grain shortage will be 15 million tons, 37 million tons and 52 million tons respectively, and it is expected that China will import 15 million tons, 35 million tons and 50 million tons of grain from abroad for the year 2000, 2020 and 2030 respectively. At present, the total grain export volume of international market is about 210 – 230 million tons. Around 2030 the exportable grain resources may reach 300 million tons. China's cereal import will take up 7%, 13% and 17% of the grain resources in world market in the year 2000, 2020 and 2030 respectively. In this case, it will not have a serious impact on the world food market.

It can be seen from the above analysis of China's grain production and demand and its as-



sociated imports, that China's self-sufficiency for grain will be 97% for the year 2000, 95% for the year 2020 and 92% for the year 2030. China will be able to basically solve the problem of feeding its large population through the vigorous development of agriculture. It is expected that around the year 2040, China's population will cease to grow and per capita grain consumption will be basically stabilized as a result. The development of agricultural science and technology will open vast perspectives for the enhancement of grain production. This will also help to narrow the discrepancy between grain demand and supply in China.

## REFERENCES

- Brown Lester R, 1995. *Who will Feed China—Wake-up Call for a Small Planet*. W. W. Norton & company, New York, London.
- Chen Xikang *et al.*, 1992. *Input-occupancy-output Analysis in China Urban and Rural Economics*. Beijing: Science Press. (in Chinese)
- Chen Xikang *et al.*, 1996. China's grain supply and demand in the 21st century. *Bulletin of the Chinese Academy of Sciences*, 10(2). (in Chinese)
- National Situation Analysis and Study Group, the Chinese Academy of Sciences, 1992. *Opening up of New Channels and Practicing of Thrift: China's Potential in Natural Resources and Manpower and Its Response Strategy*. Beijing: Science Press. (in Chinese)
- State Statistical Bureau, 1995. *China Statistical Year Book*. Beijing: China Statistical Press. (in Chinese)
- Sun Ye *et al.*, 1994. *China's Agricultural Natural Resources and Regional Development*. Nanjing: Jiangsu Science and Technology Press. (in Chinese)
- U. S. Department of Commerce, Bureau of the Census, 1986. *Statistical Abstract of the United States*. 106th Edition, Washington, D.C. 1985.