WEP Warwick Evans Publishing

Transactions on Economics, Business and Management Research
ISSN: 2960-1789, eISSN: 2960-2254 | Volume 11
EMFT 2024

Study on Supply-Demand Dynamics and Prospects of Grain in China

Shengwei Wang [1,2,3,4], Yu Wang [1,2,3,4,*], Ganqiong Li [1,2,3,4], Yongen Zhang [1], Wen Yu [1,2,3,4]

[1] Agricultural Information Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, P.R.China

[2] Research Center of Agricultural Monitoring and Early Warning Engineering Technologies of Beijing, Beijing 100081, P.R.China

[3] Key Open Laboratory of Intelligent Agricultural Early Warning Technologies and Systems, Chinese Academy of Agricultural Sciences, Beijing 100081, P.R.China

[4] Key Laboratory of Agricultural Monitoring and Early Warning Technology, Ministry of Agriculture and Rural Affairs, Beijing 100081, P.R.China

Corresponding author (WANG Yu) Email: wangyu06@caas.cn

Abstract. Food security is a major strategic issue of global significance related to economic development and social stability as well as an important foundation for national security. This paper mainly analyzed the changes in production, consumption, trade and price of grain in China, and applied the CAMES model to predict the trends in grain production, consumption, trade and price in the next decade (2024-2033) based on certain hypotheses of economic and social conditions and agricultural production conditions. According to the study, in the foreseeable future, grain production capacity will see a steady rise; consumption will continue a rigid growth (food consumption being basically flat, slower development of feed consumption, stable-to-declining oil extraction consumption, slight rise in industrial consumption and seed consumption and losses trending flat-to-down); imports will show a diversified development pattern and a downward trend; exports will witness a small increase; and price will be reasonable and fluctuate upwardy.

Keywords: I grain; production; consumption; trade; price.

1. Introduction

In 2023, the acreage sown in grain crops was 1.785 billion mu (mu, a traditional Chinese area unit) (equal to 119 million hectares), and the total grain output in China hit 695 million tons, having stabilized at 650 million tons above for 9 consecutive years. [16-17] Grain consumption in 2023 was 817 million tons, having risen by 1.7% compared to the previous year. Imports had surged by 11.0% to 163 million tons. Exports were 3.34 million tons and had plummeted by 20.3% year on year. Total grain (Grain in this paper includes cereals, tubers and beans. Total grain supply here refers to the sum of output and net imports, where the imports and exports of rice are calculated at a conversion rate of 70% of the quantity of unhusked rice.). supply reached 855 million tons. The CAMES grain price index was 108.32,(The CAMES grain price index is calculated based on the market price of rice, wheat, maize and soybean of the year, with 2011-2013 as the base period.) 1.41% down compared to the previous year.

2. Study on Current Supply and Demand of Grain in China

2.1 Steady Rise in Output

Having successfully overcome the influence of natural disasters including the rarely seen “grain-damaging rain” (continuous rain or rainstorm during the wheat harvest time, which will cause the granules to sprout or get mildewed) in Huang-Huai Area, the severe flooding in some parts of

North China and the Northeast and the drought in some parts of the Northwest, China hit a record high in grain output again in 2023. The acreage sown in grain crops was 1.785 billion mu (119 million hectares), showing a Y-O-Y increase of 0.5%. The per unit area yield of grain was 390 kg/mu (5,845 kg/hectare), having risen by 0.8% compared to the previous year. The grain output had improved by 1.3% to 695 million tons, having stabilized at 650 million tons or above for 9 consecutive years (Figure 1). Among them, the output of summer grain crops was 146 million tons, 0.8% lower compared to the previous year; the output of early grain crops was 28.34 million tons, 0.8% up year on year; and the output of autumn grain crops reached 521 million tons, having increased by 1.9%.

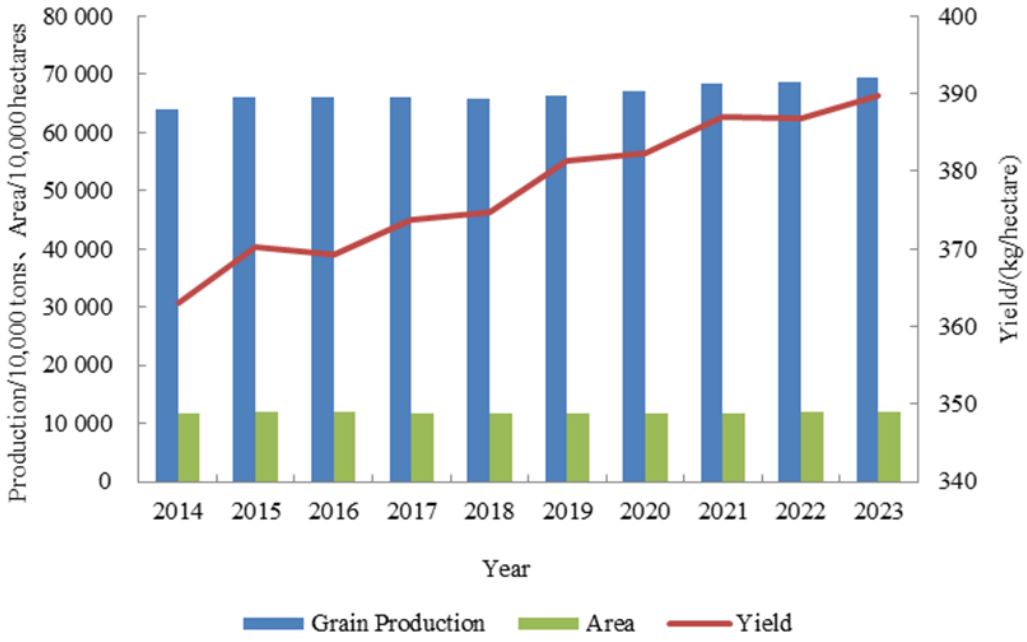

Figure 1 Grain planting area, yield and total output from 2012 to 2023 in China

(Data source: National Bureau of Statistics)

The output of cereals, beans and tubers all witnessed a rise. In 2023, the output of cereals (Cereals in this paper consist of rice, wheat, maize, millet, sorghum and other cereal crops.) had climbed by 1.3% to 641 million tons. To be specific, the maize output ushered in a growth, while the output of rice and wheat had declined. As affected by the shrinking planting area of rice, its output had slightly reduced by 0.9% year on year to 207 million tons. Despite the stable-to-increasing planting area of wheat, its output saw a dip by 0.8% to 137 million tons due to the declining per unit area yield under adverse weather such as the “grain-damaging rain” in Henan and continuous drought in winter and spring in Southwest China. In view of the improvement in both the planting area and per unit area yield of maize, its output reached 289 million tons, presenting a Y-O-Y growth rate of 4.2%. The output of beans was 23.84 million tons, 1.4% up compared to the previous year. With the output, planting area and per unit area yield of soybean hitting an all-time high, the soybean output had advanced by 2.8% to 20.84 million tons. The output of tubers (Tubers in this paper refer to sweet potatoes and potatoes, excluding taro and cassava. Every 5kg of fresh tubers are calculated as 1kg of grains. Tubers (such as potatoes) consumed as vegetables in suburban areas will be considered as fresh goods but not grains.) was 30.14 million tons, 1.2% higher than the previous year.

2.2 Increase in Consumption

Grain consumption in 2023 was 817 million tons, 1.7% up compared to the previous year. Among the total consumption, food consumption of grain (Food consumption of grain here refers to the food consumption of cereals, beans and tubers.) was 299 million tons, 0.3% higher year on year; feed consumption(Feed consumption of grain here refers to the quantity of cereals, beans (excluding soybean) and tubers consumed in feed production.) reached 244 million tons, having increased by

3.8%; oil extraction consumption (of soybean) was 93.8 million tons, showing a rise of 2.2%; industrial consumption climbed by 0.8% to 128 million tons; and other consumption(Other consumption here refers to the consumption of cereals, beans and tubers as seeds, post-production losses, etc.) was 52.18 million tons, showing a Y-O-Y increase of 1.9%. In China, food consumption of grain accounted for 36.6% of total grain consumption, compared to feed consumption of 29.9%, oil extraction consumption (soybean) of 11.5%, industrial consumption of 15.6% and other consumption of 6.4%. As to specific varieties, wheat consumption had surged by 7.7% to 148 million tons, presenting the fastest increase, which was mainly because the price gap between wheat and maize considerably boosted the increase in feed demand. Maize consumption was 296 million tons, 2.9% up compared to the previous year. Soybean consumption was 111 million tons, 2.0% higher than the last year. Rice consumption had declined by 5.5% year on year to 201 million tons, as mainly caused by the significant decrease in feed consumption of rice.

2.3 Continuous Growth in Trade

Grain imports continued to grow at highs, while exports remained a downward trend. In 2023, grain imports had soared by 11.0% year on year to 163 million tons, accounting for 20% of total grain consumption. In terms of the import structure, soybean took up 61.0% of total grain imports, compared to 16.6% for maize, 7.4% for wheat, 6.9% for barley, 3.2% for sorghum and 2.3% for rice. In the meantime, China's grain importers are highly concentrated, mainly the United States, Canada and Australia. China's grain exports in 2023 were 3.34 million tons, having plummeted by 20.3% year on year.

Wheat, maize and barley led the growth in grain imports, while the imports of rice and sorghum showed an evident decline. In 2023, the imports of wheat set a record high, mainly due to the wheat price lowered by the ample international supply, widening gap between domestic and international prices and damaged quality of new-season wheat. Wheat imports surged by 21.5% to 12.1 million tons. As influenced by the significant decline in international maize prices and the gap between the output and demand of maize in China, maize imports soared by 31.6% to 27.13 million tons, also hitting a secondary high. Barley imports had doubled to 11.32 million tons, mainly because the Chinese government stopped imposing anti-dumping duties and countervailing duties on barley imported from Australia. Soybean imports also grew from highs. As driven by increasing domestic demand for oil extraction and high price of soybean meal, soybean imports had grown by 11.4% to 99.41 million tons, a secondary high in all time. As affected by the high international rice prices and weakened demand for imports in China, rice imports had plunged by 57.5% year on year to 2.63 million tons. Sorghum imports were 5.21 million tons, showing a slump by 48.6%, mainly because sorghum procurement decreased in view of the sluggish liquor market and sorghum was less used to replace maize.

2.4 Flat-to-down Trend in Prices

In 2023, the CAMES grain price index was 108.32, 1.41% lower than the previous year (Figure 2). To be specific, soybean prices showed the largest decrease, with the average soybean price of the whole year in Heilongjiang producing area having dived by 14.6% to RMB 5.16/kg. Wheat prices witnessed the second largest decline, and the average purchasing price of common wheat was RMB 2.96/kg, 6.1% down compared to the previous year. Maize prices were basically flat to the previous year, and the average wholesale price in the producing area was RMB 2.71/kg. Rice prices saw a slight rise, with the average purchasing price increasing by 2.5% year on year to RMB 2.79/kg.

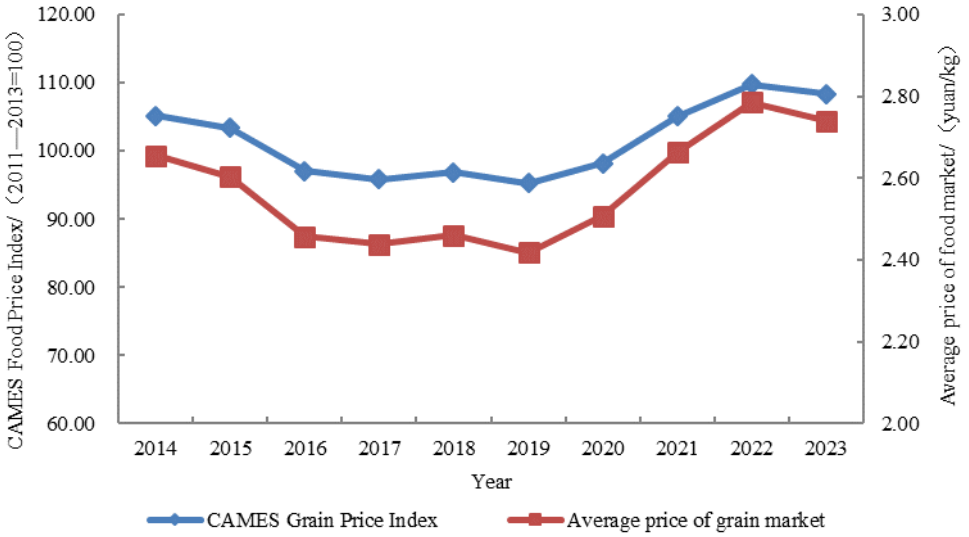

Figure 2 Grain price trends from 2014 to 2023

3. Study on Future Trends of Grain Production, Consumption and Imports in China in the Next Decade

3.1 Introduction to the Predictive Model

This study applies the China Agricultural Monitoring and Early-warning System (CAMES) developed by the Agricultural Information Institute of CAAS. [18] Combining technologies such as data mining, artificial intelligence, statistical analysis and neutral network and using knowledge of multiple disciplines including economics, agronomy, meteorology and computer science, CAMES achieves the integration of the biological mechanism and the economic mechanism based on the principles of correlation, unity and balance. With multiple functions such as monitoring, analysis, simulation, early warning and prospects, it is a large cluster system covering multi-variety and multi-market models.[19] Based on certain hypotheses of economic and social conditions (domestic and international economic development and population changes, urbanization level in China, urban and rural residents' income and consumption, the exchange rate of RMB, international crude oil price, etc.) and agricultural production conditions (employment in the primary industry, cultivated land resources, water resources, technological advancement, policy changes, etc.), CAMES presents prospects for production, consumption, trade and price of 20 kinds (varieties) of major agricultural products in China. The projections also consider the influence of the change in population structure and the enhanced health awareness on residents' dietary structure and consumption structure, the conversion between animal products and feed grains, the complementary or substitutive relations among agricultural products and the impacts of the agricultural policies of international organizations, regions, the world and other countries on China's agricultural product market through monetary policy, international trade, exchange rates, prices and other channels. These hypotheses are exogenous variables of the model, which are essential to the projections.

The model's hypotheses for the next decade are as follows: The global economy will maintain a low or medium growth rate in the medium and long term, with an annual growth rate of 2.6%. The Chinese economy will continue to recover and develop steadily, with an annual GDP growth of 4.8%. While the growth of world population will slow down, China's population will maintain a long-term downward trend, decreasing by 1.3‰ each year on average. China's urbanization rate will continue to rise, and the urbanization rate of the Chinese population and the urbanization rate of registered residents will climb to 72.5% and 56.7% respectively. The income of Chinese residents will maintain a rapid growth, with the increase in rural residents' income faster than that in urban residents' income. The per capital disposable income of urban and rural residents will grow at an annual rate of 4.8% and

7.3% on average. The Chinese residents' consumption price will fluctuate slightly, up 2.0% to 2.4%. The international crude oil price will fluctuate at highs in the short term, but will stabilize and decline in the long run. The average exchange rate between USD and RMB (middle price) is 1: 6.4-7.0, and the appreciation of RMB can be predicted. The employed population in the primary industry in China will slip by around 4% per year on average, while the quality of labor force will continue to improve. In the meantime, China will adhere to the red line of cultivated land to guarantee the quantity and quality increase of cultivated land. The area of water-saving irrigation in China will constantly expand, and water use in agriculture will be more refined. The contribution rate of scientific and technological progress in China's agriculture will attain 69%, while the comprehensive mechanization rate in crop cultivation and harvest will exceed 80%. The agricultural policy in China will also continue to support the construction of China into an agricultural power. [20]

3.2 Prospects for Production

The grain planting area will be basically stable. The stable grain planting area makes the foundation for grain production. On one hand, to guarantee the cultivated land area for grain production, the Chinese government adheres to the red line of 1.8 billion mu cultivated land, implements the strictest farmland protection system and resolutely prevents the "non-agriculturalization" and "non-grain" use of arable land. On the other hand, the Chinese government also fully mobilizes the enthusiasm of farmers and local governments about grain production and establishes the grain safety guarantee system. It implements supporting policies on the minimum purchasing prices for wheat and rice, the subsidies for maize and soybean producers, subsidies for rice production, etc., and vigorously supports the major grain-producing counties and attempts to construct the horizontal inter-provincial benefit compensation system among the grain producing and sales regions. During the outlook period, the grain planting area will remain stable. It is projected that the grain planting area in 2024 will be 1.781 billion mu (119 million hectares), basically equal to the area in the previous year, be 1.783 billion mu (119 million hectares) in 2028, 0.5% up compared to the base period and be 1.784 billion mu (119 million hectares) in 2033, with an annual growth rate of 0.1% (Figure 3).

The per unit area yield of grain will usher in a steady rise. The potential for increasing grain output mainly rests in improving the per unit area yield. During the outlook period, the favorable conditions for increasing the per unit area unit include the follows. First, the improved variety constitutes an important foundation for yield improvement. With the implementation of the program of grain yield improvement and the advancement of seed industry revitalization action, a batch of groundbreaking grain crop varieties of independent intellectual property right will be cultivated. Hence, the new grain varieties of high yield, great quality, strong resistance and wide adaptability will be generalized, the industrialization of biological breeding will be promoted, and the contribution rate of high-quality seeds to yield improvement will exceed 45%. Second, the improvement of disaster resistance and stable production plays an essential role. As affected by global climate changes, China's extreme meteorological disasters will occur in a more frequent manner and be more likely to repeat. Yield will increase by preventing and reducing disasters. China will upgrade the quality of arable land and carry out the program of high-standard farmland construction. In addition, the Chinese government will strengthen infrastructure construction, promote efficient water-saving irrigation according to local circumstances, and strengthen the short-term warning of meteorological disasters and the medium- and long-term trend analysis, in order to achieve high and stable output regardless of drought and flood. The per unit area yield of grain is expected to be 396 kg/mu (5,933 kg/hectare) in 2024, up 1.5% year on year, be 414 kg/mu (6,213 kg/hectare) in 2028, having grown by 6.8% compared to the base period, and be 429 kg/mu (6,438 kg/hectare) in 2033, presenting a 10.7% increase compared to the base period and an annual growth rate of 1.0% (Figure 3).

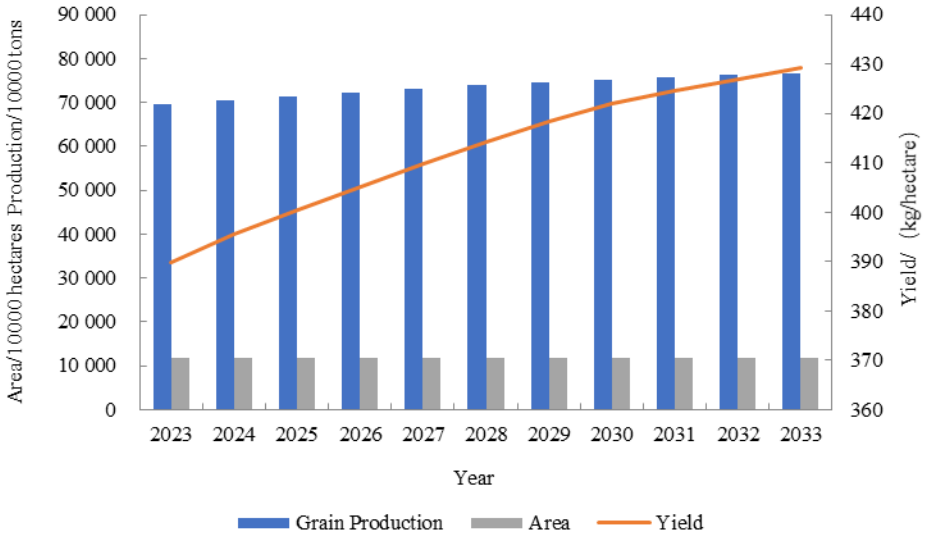

Figure 3 Food planting area, yield and total output from 2023 to 2033 in China

(Data source: 2024-2033 data from the prediction of the CAMES model developed by the Agricultural Information Institute of CAAS)

Grain output will show a steady increase. During the outlook period, China's grain output will ramp up steadily with the new-round action of 50-billion-kg grain production capacity improvement and the in-depth implementation of "increasing grain output through land area and technology". China's grain self-sufficiency(The grain self-sufficiency in this paper is calculated by dividing grain production by grain consumption.) will increase from 84.3% in the base period to 91.5% in 2033. The self-sufficiency of soybean will rise year by year and is expected to exceed 30% by the end of the outlook period. Grain output is anticipated to be 704 million tons in 2024, 1.3% up year on year, be 738 million tons in 2028, 7.3% higher than that in the base period, and be 766 million tons in 2033, showing a 11.3% increase compared to the base period and an annual growth rate of 1.1% (Figure 3). By the end of the outlook period, grain output will improve by 77.52 million tons compared to the base period, with maize as the most important driving factor. Maize output will grow by 43.01 million tons, accounting for 55.5% of the newly increased grain output, compared to 16.5 million tons and 21.3% for soybean output, 9.17 million tons and 11.8% for wheat output and 7.58 million tons and 9.8% for rice output. Per capita grain possession will grow from 488kg in the base period to 550kg in 2033.

3.3 Prospects for Consumption

Grain consumption will trend flat to up. With the advancement of the new urbanization strategy and the constant upgrading of the consumption structure, grain consumption will continue to rise despite no significant change in the total population during the outlook period. Industrial consumption will be the major driving force for the growth in grain consumption. Grain consumption is projected to be 803 million tons in 2024, 1.7% lower year on year, be 817 million tons in 2028, basically equal to that in the base period and be 840 million tons in 2033, 2.8% up compared to the base period and showing an annual growth rate of 0.3%. The grain supply and demand will stay in tight balance in the long term, as the production-demand gap will reduce year by year, decreasing from 128 million tons in the base year to 73.73 million tons in 2033.

Food consumption will be basically stable. In the context of the peak of population growth and population aging, the changes in the residents' food consumption structure are mainly driven by economic development and income growth. While generally maintaining the traditional consumption model, Chinese residents' food consumption will be transformed and upgraded in a diversified, nutritive and healthy manner. Consumption of starch-based staple food such as rice and wheat flour will gradually decrease and become relatively stable. During the outlook period, the food

consumption of grain will be stable on the whole. The food consumption is projected to be 297 million tons in 2024, 0.8% lower than the previous year, be 297 million tons in 2028 and be 299 million tons in 2033, basically equal to that in the base period (Figure 4). As a part of it, the food consumption of rice and wheat will trend flat to down, decreasing from 248 million tons in the base period to 241 million tons in 2033, with an annual decline rate of 0.3%. During the outlook period, the per capita food consumption of rice will drop from 111kg in the base period to 109kg in 2033, while the per capita food consumption of wheat will fall from 65kg in the base period to 64kg in 2033.

The growth of feed consumption will considerably slow down. Since the expected decline in the amount of pigs on hand in 2024 will result in the slight dip in pig feed consumption, the feed consumption of maize will be basically flat compared to the previous year. The wheat and rice feed used as substitution will also reduce. Therefore, the feed consumption of grain in 2024 will witness of a small decrease. In the medium-long run, the increase in residents' consumption of animal-derived food such as meat, eggs, milk and aquatic products will boost the growth in the demand for energy feed and protein feed ingredients. Hence, the feed consumption of grain will continue to rise, but at a lower rate. It is estimated that the feed consumption will be 232 million tons in 2024, 5.0% lower year on year, be 234 million tons in 2028 and 239 million tons in 2033, being basically flat to the base period. The growth will significantly slow down compared to the growth rate of 4% in the past decade (Figure 4).

Oil extraction consumption (soybean) will be stable-to-decreasing. During the outlook period, the demand for soybean oil and soybean meal will continue to increase along with the rising residents' income and the expanding scale of livestock breeding and aquaculture. The increase in oil extraction consumption will considerably slow down due to negative population growth, the concept of healthy diet, the reduction and replacement of soybean meal as feed and the limited growth space for soybean supply in the international market. The oil extraction consumption (soybean) is projected to be 93.19 million tons in 2024, showing a 0.7% decrease compared to the previous year, be 92.17 million tons in 2028, 1.2% lower than the base period and be 91.3 million tons in 2033, with a 2.1% decrease compared to the base period and an annual decline rate of 1.2% (Figure 4).

Industrial consumption(Industrial consumption of grain mainly includes liquor making, flavorings making and agent and medicine preparation.) will present a small increase. With the accelerated upgrading of the grain industry, the proportion of the output value of the traditional finished grain product processing industry will decline, while the output value of grain deep processing and food processing industry will grow more quickly. The production capacity of grain will become the advantage for processing. Industrial demand for grain will show a stable rise. The industrial consumption is expected to be 130 million tons in 2024, 2.0% up year on year, 143 million tons in 2028, 12.6% higher than that in the base period and 161 million tons in 2033, showing a 26.9% increase compared to the base period and an annual growth rate of 2.4% (Figure 4).

Other consumption(Other consumption of grain mainly includes seed consumption and post-production losses.) will trend flat to down. During the outlook, the per unit area seed consumption of grain will be stable-to-decreasing given the new improved varieties, the popularization of precision seeding technology and the upgrade of mechanical equipment. The seed consumption of rice, wheat and maize will all stabilize around 10 million tons. The post-production losses of grain will see an annual decline by 0.9% on average, mainly because the ability to save and reduce losses throughout the whole chain including grain production, transportation, storage, processing and sale will be improved, the mechanical operation for grain production will be more precise and the upgrade of high-standard storage facilities will be accelerated. Other consumption of grain is anticipated to be 50.65 million tons in 2024, 2.9% decrease compared to the previous year, 49.4 million tons in 2028, 6.0% lower than the base period and 49.08 million tons in 2033, with a 6.6% decrease compared to the base period and an annual decline rate of 0.7% (Figure 4).

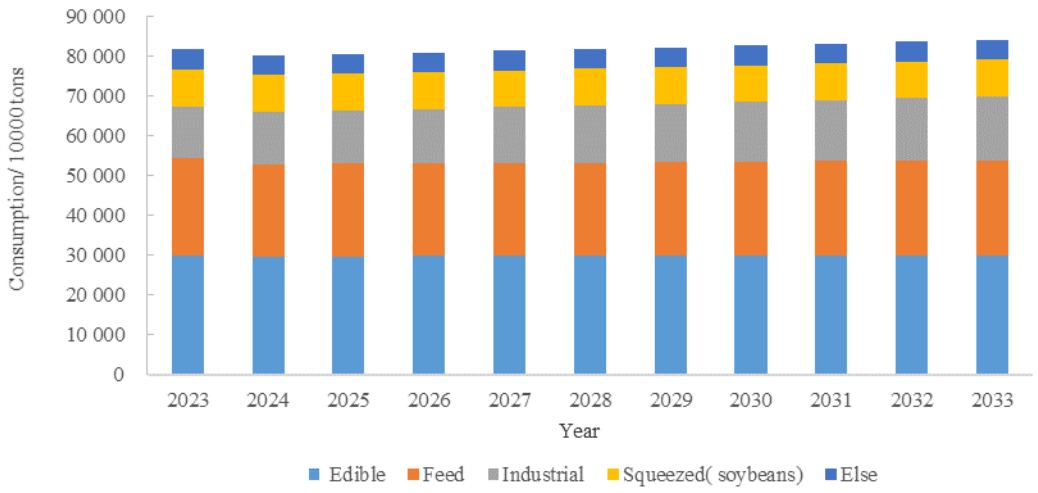

Figure 4 Trend of grain consumption from 2023 to 2033 in China

(Data source: 2024-2033 data from the prediction of the CAMES model developed by the Agricultural Information Institute of CAAS)

3.4 Prospects for Trade

Grain imports will present a downward trend in general. In the next decade, using international grain sources to fill the gap between production and demand of scarce grain and improving the variety structure will still play an important role in guaranteeing the supply and stabilizing the price of grain. China's grain trade will remain at highs, while imports will witness a decline. It is anticipated that grain imports will be 141 million tons in 2024, having plummeted by 13.6% compared to the previous year, 116 million tons in 2028, 26.8% down compared to the base period and 110 million tons in 2033, with a 30.2% decrease compared to the base period and an annual decrease rate of 3.5%. Import demand for rice, wheat, maize and soybean will all see a decrease. By the end of the outlook period, grain imports will lose by 47.83 million tons. Among the imports, maize imports present the fastest decline, 18.57 million ton or an annual decline rate of 12.3%, followed by wheat, the imports of which decrease by 5.76 million tons, showing an annual decline rate of 7.5%. Soybean imports will reduce by 16.96 million tons, with an annual decrease rate of 1.9%. During the outlook period, the imports of rice will occupy 4.2% of total grain imports, showing little change; the proportion of wheat imports in total grain imports will drop from 6.7% in the base period to 4.4%; the proportion of maize imports will plunge from 16.0% in the base period to 6.2%; and the proportion of soybean imports will head up from 60.5% in the base period to 71.3%.

Grain exports will grow steadily. Presenting a growth trend, grain exports are expected to be 4.06 million tons in 2024, surging by 21.6% compared to 2023, 4.85 million tons in 2028, with an annual growth rate of 4.1% and 5.88 million tons in 2033, presenting an annual growth rate of 4.0%. Among them, rice exports make the largest contributor. In 2033, rice exports will soar by 33.3% compared to the base period to 3.99 million tons, accounting for more than 80% of the newly increased grain exports. The main reasons lie in that China's rice will be supplied to African and Asian countries, as China will constantly deepen the opening of its grain market, strengthen international cooperation, and, in particular, promote the grain trade cooperation with the countries on the "Belt and Road".

Grain imports will develop in a diversified pattern. During the outlook period, seeing the complex and changing international political and economic conditions, increasing uncertainties in international grain import and export and high risk of supply chain disruption, import diversification will be an important approach to reduce the impact of fluctuations in the international grain market. In the future, China will not only stabilize the traditional international grain market, but also actively explore import channels. China will build the new platform of international grain cooperation on the Belt and Road and gradually cultivate a grain import pattern characterized by diversified import seasons, multiple transportation routes, a multi-level import structure and diverse trade partners, in

order to guarantee the match between grain demand and supply in time and space, practically improve the utilization of the international grain market and enhance the stability and flexibility of grain trade.

3.5 Prospects for Price

Grain prices will fluctuate upward. According to the research on the pattern of grain supply-demand in the next decade (Table 1) and the judgment on the macroeconomic and social conditions at home and abroad, we predict that grain prices in 2024 will be stable-to-rising, and CAMES grain price index will hover around 110. In the long run, grain prices will fluctuate upward, mainly driven by the rising costs of grain production such as the agricultural means of production, labor and land. In the meantime, uncertainties will increase in the global economic prospects, influence of extreme weather, rising energy prices and policies on trade and biofuel, which will exert long-term impacts on the global grain market, and therefore raise the costs of China's grain imports and increase the possibility of price rise in China's market. With the deepening reform of the grain purchasing and storage system and the pricing mechanism, market will play a decisive role in the distribution of grain resources. Grain prices will be reasonable and better reflect market supply and demand.

Table 1 2023-2033 China's Grain Supply-Demand Balance Sheet Unit: 10,000 tons

Category	Year										
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Production	69541	70809	71463	72409	73259	74073	74804	75469	75939	76365	76801
Import	16309	14086	12847	12193	11929	11577	11374	11286	11149	11045	10918
Consumption	81707	80579	80873	81232	81663	82092	82561	83075	83505	84067	84527
Edible	29930	29828	29832	29837	29847	29850	29895	29937	29954	29981	29986
Feed	24407	23189	23275	23355	23485	23598	23705	23840	23963	24099	24190
Squeezed(soybeans)	9380	9319	9291	9265	9240	9217	9196	9177	9159	9144	9130
Industrial	12759	13095	13408	13730	14065	14411	14759	15120	15451	15851	16229
Else	5231	5149	5069	5045	5026	5017	5008	5002	4977	4991	4993
Output	334	406	424	441	461	485	511	529	548	569	588
Balance changes	3809	3910	3012	2930	3063	3073	3106	3151	3036	2775	2604

4. Uncertainties

4.1 Climate Factors

Climate change is the biggest uncertainty for food security. In 2023, equatorial central and eastern Pacific had experienced the abrupt transition from the "triple" La Nina to the moderate-intensity El Nino event, which caused numerous extreme weather events worldwide such as high temperature and heatwave, drought, rainstorm and flood and exerted serious influence on the security of global food supply. China also suffered from natural disasters including the rarely seen "grain-damaging rain" in Huang-Huai Area and the severe flooding in some parts of North China and the Northeast, adversely influencing grain production. According to the predictions of the WMO (World Meteorological Organization), the El Nino event will continue until at least April 2024, and extreme weather events will continue to threaten the security of grain production and supply worldwide. As projected by the meteorological departments in China, the meteorological conditions for agriculture in China will be poor in 2024, indicating great uncertainties facing grain production. In the medium- and long-term, global warming will increase the frequency and intensity of extreme weather incidents in China and in the world, which will bring uncertainties in China's grain production security and market stability.

4.2 International Factors

Global grain production, transportation, supply and market prices have been deeply affected by geopolitical conflicts and protectionism in recent years. Since 2023, rice production in major rice exporters was reduced due to the El Nino event. India, the biggest rice exporter of the world, released a series of measures to restrict its rice exports, causing tight supply of rice in the world and fluctuations of international rice prices at highs. China's rice market has also been impacted. In the foreseeable future, global economic growth will slow down. As predicted by the IMF (International Monetary Fund), the world economy will develop at a low speed in the next five years, and the growth is expected to be 3.1% in 2024, which is 0.7% lower than the average growth rate from 2000 to 2019, 3.8%. Regional security issues still existed, such as the Ukraine crisis, the Israeli-Palestinian conflict and the Red Sea crisis, and geopolitical conflicts and protectionism are still the main factors affecting international grain supply and demand and the market. The changes in major rice exporters' policies on rice production, supply and exports will affect the international rice price, and further impact China's market. Moreover, due to the large import volume and high concentration of importers, China's soybean, maize and wheat will be vulnerable to the impacts from the international market. Therefore, when the prices of soybean, maize and wheat in China are affected by the international market, the domestic unhusked rice and husked rice market will fluctuate under the influence of product substitution and the linkage between the international and the domestic market. As the conflicting forces in the balanced region of major powers will be weakened, the global grain price, industry chain and supply chain are still encountered with significant impact and uncertainties.

4.3 Other Risks

The core essence of guaranteeing the steady development of grain crop production is to stabilize the planting area, improve the per unit area yield and enhance efficiency. The current policies such as the minimum purchasing price of rice and wheat, the support to maize and soybean production and the rewards for major grain-producing counties are playing a weakening role in motivating the local governments and farmers' enthusiasm about grain planting. However, the new supporting policies still need to be further explored and validated. Hence, great uncertainties can be foreseen in stabilizing production and increasing output. The focus lies in improving the per unit area yield, where the seeds and the arable land are emphasized. Currently, considering the lack of breakthrough varieties of high yield, great quality, strong resistance and wide adaptability as well as the low proportion of the medium- and low-yield land, it will be difficult to achieve the goal of improving the per unit area yield in a large area. The government's policies and regulatory measures such as policies on import and export, particularly the number and pace of import quotas released, will result in the changes in domestic supply and demand of maize and wheat, and further affect the price of maize and wheat, especially the high-quality wheat. In addition, with the accelerated commercialization of genetically modified maize and soybean, maize and soybean planting will embrace greater comparative advantages. In this context, the Northeast China will see a bigger risk of "changing paddy to vegetable field" and "changing rice planting to soybean planting", adversely influencing the stability of rice planting area. The changes in agriculture support policies, particularly the subsidy and insurance policies, will exert direct influence on grain farmers' enthusiasm about production and the structure of grain production.

Author Contributions

Conceptualization, Y.W.; methodology, software and validation, W.Y.; formal analysis, Y.W.; writing—original draft preparation, T.W., Y.Z.; writing—review and editing, S.W.; supervision, G.L., Y.W.; funding acquisition, S.W. All authors have read and agreed to the published version of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding

This research was funded by National key research and development program (2023YFD2000105).

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