
INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS
IGAE
29th | Milan Italy 2015
UNIVERSITÀ DEGLI STUDI DI MILANO AUGUST 8 - 14
AGRICULTURE IN AN INTERCONNECTED WORLD

Future Perspective of China's Feed Demand and Supply during Its Fast Transition Period of Food Consumption

Wanlu Dong[1], Xiaobing Wang[1], Jun Yang[2]

1. Center for Chinese Agricultural Policy of Chinese Academy of Sciences,Institute of Geographic Sciences and Natural Resources Research
2. School of International Trade and Economics, University of International Business and Economics

Abstract: China has experienced the dramatic change of food consumption pattern in the last 3 decades. However, there are different opinions toward the future change of this process. By adopting the well-developed Chinese agricultural partial equilibrium model- CAPSiM model, the demands on livestock products and main feed crops in 2011-2030 are predicted and analyzed. It is found that China's per capita consumption of livestock products will continue to rise in 2011-2030, even though its growth rate will slow down gradually. Meanwhile, the expansion of livestock production will pose great challenges on feed supply in China. More accurately, It is feed security instead of grain security confronted by China in the future. Based on the findings, the related policy implications are proposed.

Key words, feed demand, food consumption pattern, partial equilibrium model

`

1. Introduction

China keeps the high growth of agricultural production and succeeds in maintaining food security in the past three decades. Chinese is witnessed to experience a gradual transition in food consumption structure with the increased share of high value-added foods such as fruits, meat, fishery and dairy products. Such a trend is consistent with the process of urbanization and industrialization, summarized as "the livestock revolution" (Delgado 2003).The similar transition process can be observed popularly across all those countries after economic take-off, such as the period in England during 1800 to 1850 (Hartwell 1961), and in Japan and South Korea during 1961 to 2000 (Yang et al. 2013) as well as in many developing countries during 1970s to mid 1990s (Delgado 2003). Accompanying the rising food demand both in quantity and quality, China's agricultural production also grew quickly, with annual agricultural GDP rising by 4.6% in 1978-2011. Such a growth rate is about four times of the rate of population growth, which is the reason why China could maintain the high food self-sufficiency level and the status of net food exporter in the majority of years in 1978-2012. As a country of more 1.3 billion populations, China's tremendous achievements in food supply definitely contribute greatly to the global food security (CAAS 2012; China Daily 2014).

The debates and concern about the perspective of China's food security and its stand in global food security are always burning (Brown 1994). China's agricultural trade had converted from the surplus to the deficit in 2004 for the first time since 1990, and the deficit keeps rising afterward. In 2012, the agricultural trade deficits reached 49.2 billion US dollar (NBSC 2012). The situation of China's agricultural supply and demand has turned from the stage of "balance in total with slight surplus" to the new stage of "unbalance in total with remarkable shortage in structure" (Huang et al. 2012).

The change of consumption of livestock products and its induced feed demand is a vital issue to China's grain security and food security. The increase of consumption of livestock products is manifested in the highest growth among all agricultural products in China. Different to many other countries like Japan and Korea, China's enlarged demand on livestock products heavily depends on domestic production, which means that more feed required to raise animals. Whether China can make balance in supply and demand for feed crops turns to be the key component in its grain security and food security strategy in the future (Chen 2012; Huang et al., 2012).

However, researchers and policy makers do not reach consensus on whether and to what extent feed is and will be of security in China. In general, there are two contrary opinions. The first one could be defined as the pessimism. Researchers in this group believed that feed security would be exacerbated in the next two decades as the demand exceeded the domestic supply. From the perspective of consumption, Chinese diet will change dramatically in favor of more expensive food providing higher protein such as meat and dairy products rather than cheaper and less nutrient food like grain crops (Huang and Rozelle 1998; Yen et al. 2004; Yu and Abler 2009). According

`

to the procedure experienced by Japan and Korea, China's food consumption will continue the structure transition in the future (Yang et al. 2012). This, in turn, will lead to demand more grain crops as feed rather than direct consumption (Yu et al. 2012). However, the domestic supply of feed crops has been under the constraints of resource endowments in terms of land and water resources. Cultivated land per capita has declined because of population growth, urbanization, and industrialization (Zhao et al. 2006). The decline in arable area and water resource was exacerbated by a series of land and water degradation processes (Pingali et al. 1997). Moreover, rapid economic growth has attracted more rural labors immigrate into city and increased the opportunity cost of rural labor (Wang et al. 2011).

Therefore, many studies depicted the gap between feed demand and domestic supply would be enlarged in the future. Taking the maize, the most important feed crop, for example, Huang (2004) projected China's net import of maize would increase sharply to 57 million tons in 2020. While the import volume relatively is lower, Xu (2011) predicted China's maize import would rise to 17.4 million tons in 2020. Recently, Chen and Yang (2013) provided a range of estimation on China's net import of maize between 29.5 million tons and 53.6 million tons in 2020, and between 72.0 million tons and 160 million tons in 2030. Despite notable variation among studies, all indicated China's maize import would rise dramatically and gap between demand and supply enlarged in the future.

On the contrary, the second group holds the optimists prospect to China's feed demand and domestic supply. There are three main reasons underpinning the optimism. First of all, some researchers got the results that China's per capita meat consumption became stable based on the statistical data from NSBC (Jiang et al. 2002). The food consumption would reach the summit quickly as China turned to be an aging society (Yu and Sun, 2012;Zhong and Xiang, 2012). Therefore, the demand of feed crops will keep stagnant or even decrease accordingly. Secondly, even though the consumption of livestock products will maintain steady increase, China could secure the feed crops through the promotion of efficiency of feed usage (Cui, 2012). Livestock production in China has changed from backyard production to the industrialized production, which is proved to use feed crops more efficiently (Ma et al. 2011; Ma et al. 2012). The last not the least, the further growth of yield of feed crops especially maize and soybeans could be achieved through the increase of total factor productivity (TFP) by adoption of advanced technologies (e.g., genetic modified technology) and improved infrastructure (Jin et al. 2002).

While the evolution of China's food consumption from different perspectives and its potential impacts on the feed crops (mainly focus on maize) have been analyzed by many studies, the results and related conclusion vary notably, or even contradictory. Moreover, few studies focus on the dynamic evolution and the distinguished characteristics of the consumption and production of livestock products in the future, as well as its impacts on feed demands. The target of this paper seeks to fill the gap to deeply analyze the change of demand and supply of livestock products and feed crops in next two decades (2011-2020). To meet the goal, the paper is organized as follows.

`

In the next section, we briefly provide an overview of China's historical change of production of livestock products and the feed demand. The third section describes our methodology and key assumptions. The projected results are summarized and analyzed in section 4. The final section provides the concluding remarks and policy implication.

2. The evolution of livestock production and the demand of feed crops

The production of livestock and fishery products in China increased dramatically in 1980-2012. As shown in Table 1, the production of poultry, beef and dairy products grew most significantly among all livestock products. Their production increased extraordinarily by 1847.6%, 2362.1% and 2735.0% respectively, from 936, 269 and 1367 thousand tons in 1980 to 18230, 6623 and 38754 thousand tons in 2012, with average annual growth rate of 9.7%, 10.5% and 11.0% for 32 years. While the growth rate of pork is lowest among all livestock products, it still rose notably by 346.6% from 11341 thousand tons in 1980 to 53427 thousand tons, with annual growth rate of 5.1%. The productions of mutton, eggs and fishery products increase quite similarly by 801.1%, 1213.7% and 1162.7% from 445, 2266 and 4497 thousand tons in 1980 to 4010, 28612 and 59077 thousand tons in 2012, with annual growth rates of 7.1%, 8.4% and 8.2%. In sum, China's total meat production (including the pork, poultry, beef and mutton) rose by 595.8% from 12054 thousand tons to 83872 thousand tons, with annual growth rate of 6.2%. Pork is the most important meat category dominated by Chinese meat consumption. Because the average annual growth rate of the production of pork is less than that of overall meat in 1980-2012, the share of pork in total meat production dropped remarkably from 94.1% in 1980 to 63.7% in 2012.

Except dairy products, the growth rates of other livestock products slow down since 2000, compared to those in the first two decades. As shown in table 1, the average annual growth rates of production of pork, poultry, beef and eggs decrease sharply from 5.7%, 14.0%, 15.1%, 9.5% and 10.6% in 1991-2000 to 2.5%, 3.1%, 2.1%, 3.5% and 2.3% in 2001-2012. While fishery products still kept the relatively high growth rate, its annual growth rate dropped notably from 8.1% in 1991-2000 to 6.7% in 2001-2012. Only the change of dairy products shows the different trend. Its average annual growth rate increased significantly from 6.8% in 1991-2000 to 12.7% in 2001-2012. The rapid growth of dairy production is mainly driven by the fast increase of demand (Fuller, 2006; Gale, 2007).

Up to now, there is no authoritative and reliable statistics about the supply and demand of feed in China, all existed analysis are implemented under certain assumptions. Currently, there are two kinds of quantitative approaches to estimate the feed demand. The first one is the implied demand approach, which calculates the feed demand by multiplying the outputs of animal products by the estimated feed-meat conversion ratios. The second one is the residual supply approach, which estimates the demand of feed grain by deducting the grain used for human consumption, seeds,

`

industry usage from total grain output. In this paper, we adopt the first approach. Actually, at least three key estimations are required before the calculation. They are the productions of different livestock products, shares of production by different feed-styles[1] and their corresponding feed-meat ratios[2]. All these three kinds of information are from the long-time historical database on agricultural demand and supply of China Agricultural Policy Simulation Model (CAPSiM), constructed by Center for Chinese Agricultural Policy (CCAP). The detail information of the model and database could see Huang and Li (2003) and Huang et al. (2007). The following is our estimation on China's feed consumption in 1980-2012.

China's feed consumption increased dramatically in the past three decades driven by the fast-growth production of livestock. As shown in Figure 1, the demand of commercial feed (excluding forage grass) increased by 385.8% in 1980-2012 from 44.9 million tons to 218.1 million tons, with annual growth rate of 5.1%. Similarly to the change of animal production, the growth rate of feed consumption also showed a decreasing trend. The annual growth rate of feed consumption dropped from 6.4% in 1981-1990, to 5.2% in 1991-2000 and further to 3.8% in 2001-2012. Such a dropping trend of feed consumption is not only consistent to the decreasing production, but also as a response to the rising feed efficiency (Ma et al. 2011). It is interesting to note that the feed consumption dropped in 2007 because of the outbreak of porcine reproductive and respiratory syndrome (PRRS) and Avian Influenza. The feed demand was reduced as lots of hogs and poultries were slaughtered. However, the increasing trend of feed demand recovered quickly and resumed its rapid growth shortly after the diseases.

The maize and soybean meal, as the two dominated feed components, play a critical role in China's feed supply. Maize keeps the most important feed crops with the evidence that its share in total feed demand ranged between 50% and 65%. Different to the maize, the usage of soybean meals increased dramatically after 1996, when China liberalized the soybean market. Such a changing trend coincides with the rapid growth of import of soybean. China's soybean import rose sharply from almost zero in 1995 to 58.4 million tons in 2012. As shown in Figure 1, the soybean meals used as feed increased significantly by more than 10 times from 3.8 million tons in 1996 to 43.6 million tons in 2012. Correspondingly, its share in total feed consumption rose sharply from 3.2% to 20.0%.

The change of feed demand is critical to China's grain and food security. The quick expansion of livestock sector drives up the demand of feed, which is the main factor causing the imbalance of grain trade (Tuan et al. 2004). For example, the import of maize and soybean reached 1.7 and 34.9 billion US dollar respectively in 2012, accounting for 32.6% of China's agricultural import and 92.3% of grain import. The total trade deficit of the two commodities was 36.3 billion US dollar, almost three

[1] The feed-style in China is usually classified into backyard, specialized and industrial animal raisings.
[2] The feed-meat ratios are different by feed-styles as the variation of feeding conversion efficiency.

`

fourths (73.8%) of total agricultural trade deficit in 2012.

3. Methodology and scenario design

The China Agricultural Policy Simulation Model (CAPSiM) was adopted to analyze and simulate the China's demand for livestock and feed in the future. CAPSiM is a agricultural partial equilibrium model to analyze the impacts of policies and external forces on the production, consumption, price, market and trade of Chinese agricultural products and forecasting the future supply, demand, trade and price of agricultural products. The theoretical framework of CAPSiM is shown in Figure 1. Currently, CAPSiM has been used widely to assess the impact of various trade policies, technology innovation, urbanization, climate change on China's agriculture development (Huang et al., 2007; Yang et al., 2011; Huang et al., 2012).

There are another two important reasons for us to adopt CAPSiM for this study. First of all, comparing to many other quantitative studies based on the relatively simple linkage between livestock production and feed demand, CAPSiM develops a comprehensive model system to incorporate the complicated interaction among the income, meat consumption, animal raising styles, production of livestock and feed demand. Huang and Li (2003) provided the detailed description of these systematic relationship in CAPSiM model. Secondly, the credibility of official statistics is believed to be questionable by many researchers (Cheng, 1997; Zhong, 1997; Frank, 2000; Jiang, 2002). Therefore, the findings based on the official statistical data may lead to serious estimation bias and misleading conclusions. However, CAPSiM database is constructed by using the balance-sheet approach, which incorporates many survey data on agricultural production and consumption by CCAP. Moreover, the continuous efforts has been devoted to build up the long time serial balance-sheets from 1980 to 2012 of all agricultural commodities for more than 10 years, which makes the data in high-quality and reliable to carry out this study.

There are fourteen crops covered by the CAPSiM production model, including rice, wheat, corn, sweet potato, potato, other coarse grains, soybean, cotton, oil crops, sugar crops, vegetable, fruit, squash and other crops. Meanwhile, the production model also covers 9 categories of livestock products and fishery products, namely pork, beef, mutton, poultry, egg, milk, fish, shrimp and other fishery products. In the consumption model, there are 23 categories of products, namely rice, wheat, corn, sweet potato, potato, other coarse grains, soybean, edible oil, sugar, vegetable, fruit, squash, pork, beef, mutton, poultry, egg, milk, fish, shrimp, other fishery products, other foods and all the non-foods. In this study, we select the data of 2010 as the benchmark, and the forecasting period is the next two decades (i.e., 2011-2030).

`

Scenarios design

For the purpose of analyzing the supply and demand changes of different livestock products and feed crops during the 2011-2030, a series of assumptions are adopted based on various studies. Those assumptions include the economic growth, population growth rate, urbanization rate, wage growth rate, rural/urban income, and technology improvements. The values of different assumptions are mainly estimated according to the results from Huang (2004), Huang et al. (2010) and various forecasting data from World Bank, International Monetary Foundation (IMF), Asia Development Bank (ADB) and United Nations (UN). The detail assumptions on each key variables are shown as following.

- The growth rate of GDP: it is supposed that China's economy growth will slow down in the future but still maintain growth at fast speed. The annual average growth rate is assumed at 7.5% in 2011-2015, 7.0% in 2016-2020, 5.9% in 2021-2025 and 5.0% in 2026-2030.
- Population growth rate: the growth rate of China's population tends to descend. The annual average growth rate is 0.60% in 2011-2015, 0.44% in 2016-2020, 0.22% in 2021-2025, and 0.06% in 2026- 2030.
- The rural/urban income gap will gradually narrow. For the 2011-2030 period, rural income will have an average annual growth of 8.33% and urban income will grow slower at an average annual rate of 6.83%.
- Urbanization rate: the urbanization rate in China will continue to ascend. It is supposed that the urbanization rate will rise from 49.8% in 2010 to 56% in 2015, 60% in 2020, 64% in 2025 and 67% in 2030, respectively.
- Changes of rural labor wage and land rent. The average annual growth of the actual wage of rural labor from 2011 to 2030 is supposed to be 6.1% and that of the land rent will be 2.5%.
- Progress of agricultural technology. It is assumed that Chinese government will continue to increase the investment on agricultural technology and infrastructure. However, rising marginal cost for increasing unit production will mean lower contribution rate of technological progress. The future contribution rates of technological progress to the average annual unit production growths of different agricultural products are listed in Appendix 1.

`

4. Analysis on the supply and demand of livestock products and feed

Change of the supply and demand of livestock and fishery products

With the rising income and fast urbanization, the consumption of livestock products will maintain a rapid growth in the next two decades, even though the growth rate varies remarkably by commodities. As shown table 2, while the growth rates will slow down generally in the future, the per capita consumption of beef, mutton and dairy products increases much faster than those of pork, poultry and eggs, which indicates the notable change of consumption pattern inside livestock products. For example, the per capita consumption of beef, mutton and dairy products will rise by 50.0%, 45.5% and 64.1% respectively in 2011-2020, much faster than the growth of 19.3%, 35.8% and 26.4% of pork, poultry and eggs. Moreover, such a trend will continue and get more obvious in 2021-2030. The growth rates of per capita consumption of beef, mutton and milk will drop to 25.0%, 21.9% and 26.5% in 2021-2030. Nevertheless, they are still much higher than those of pork, beef and eggs, of which the grow rates will decrease dramatically to 7.4%, 12.2% and 3.8% respectively in 2021-2030.

As the response to rising consumption, the production of the livestock products in China will also grow quickly. The changes of production by different commodities are consistent to their consumption. For example, the productions of beef, mutton and dairy will rise significantly by 48.6%, 43.3% and 62.0% respectively in 2011-2020, experiencing the highest growth among all livestock products. However, it is worthy to note that despite the fast growth, the increase of production still falls behind the consumption. As a result, the gap between demand and supply of those commodities expands and the self-sufficient level decreases to certain extent. As shown in table 2, the self-sufficient levels of beef, mutton and dairy products will drop from 100%, 99% and 89% respectively in 2010, to 98%, 93% and 84% in 2020. Such a circumstance will be further extended to the period of 2021-2030. The three commodities will still experience the highest growth among all livestock products. Their productions will rise by 22.3%, 14.3% and 18.7% respectively in 2021-2030. However, the gap between demand and supply is further enlarged. The self-sufficient levels of beef, mutton and milk will drop notably to 96%, 88% and 78% in 2030.

While the productions of pork, poultry and eggs grow much less than beef, mutton and milk, their self-sufficient levels will maintain in high level or even be improved in the future. As shown in table 2, the production of pork, poultry and eggs will rise by 23.1%, 42.4% and 30.9% respectively in 2011-2020, and 8.6%, 14.3% and 5.0% in 2021-2030. As the two most important meat categories dominated Chinese consumers' diet, the consumption of pork and poultry will increase moderately in the future. Their productions will grow closely with or even a little faster than the demands. Therefore, China will maintain the high self-sufficient levels of these three products, and even be the net exporter of poultry and eggs.

`

Similarly, the consumption of fishery products (including fish, shrimp, crabs and shellfish etc.) will also increase significantly in the next two decades. As shown in table 2, the per capita consumption of fishery products will increase from 18.9 kg/person in 2010, to 28.3 kg/person in 2020 and further to 33.5 kg/person in 2030. Its growth rate of 54.6% in 2011-2020, and 16.3% in 2021-2030 is ranked as the second highest only following milk among all livestock products.

Unlike milk, however, the demand of the fishery products will be mainly met domestically. The production of fishery products will grow from 27.78 million tons in 2010, to 42.96 million tons in 2020 and then to 49.97 million tons in 2030. The other distinguished characteristic of fishery products is both the import and export will increase quickly and in large volume. As shown table 2, the import of fishery products will increase from 2.31 million tons in 2010, to 2.77 million tons in 2020 and 3.25 million tons in 2030. Meanwhile, the exports will increase from 2.49 million tons in 2010, to 3.53 million tons in 2020, but decrease to 3.02 million tons in 2030. When the import was farther exploited, it will be found that a large proportion of China's aquatic imports is fishmeal, which is mainly used for high-protein feed. China will maintain the high self-sufficient level of fishery products.

Change of China’s feed demand in future

No doubt, China’s feed demand will keep growing driven by the rising animal production. As shown in Table 3, the total demand for commercial feed will increase by 30.0% in 2011-2020 from 202.6 million tons in 2010 to 259.3 million tons in 2020, and further rise by 7.9% in 2021-2030 to 279.7 million tons in 2030. The average annual growth of feed consumption will decrease from 2.5% in 2011-2020 to only 0.8% in 2021-2030. There are two main reasons for this slowdown. Firstly, as analyzed above, the growth of China’s livestock production drop significantly. For example, as the largest sector of feed demand, the growth of pork production will drop from 19.3% in 2011-2020 to only 7.4% in 2021-2030. Secondly, the production structure of livestock will experience remarkable change, which will shift gradually from pork and poultry toward beef, mutton, dairy and fishery products. It is well known that the swing and poultry are bred intensively by commercial feed, but the ruminant animals (e.g., cattle, cow, sheep and goat) could be fed by forage grass (e.g., grass, hay, straw). In term of feed-meat ratio, it is be much lower for those ruminant species and fishes comparing to the swine and poultry (Rae and Hertel, 2000; Zhou et al.,2008). The structure change will further dampen the demand on commercial feed.

As two dominated components of commercial feed, maize and soybean meal will play a rising important role in China's feed supply. The commercial feed could be classified into two categories: energy feed (various grains) and protein feed (bean pulps). As shown in table 3, the maize and soybean meal take the overwhelming share in energy feed and protein feed respectively. Moreover, their importance keeps rising in the future. For example, the share of soybean meal in protein feed will increase

`

from 70.6% in 2010, to 88.8% in 2020 and further to 89.2% in 2030. Meanwhile, the share of maize in energy feed will rise from 83.0% in 2010, to 84.9% in 2020 and further to 90.4% in 2030. In sum, the share of maize and soybean meal in China's total feed supply increases sharply from 79.3% in 2010, to 86.1% in 2020 and further to 90.0% in 2030.

The rising feed demand on maize and soybean meal has rich implications on the demand and supply of maize and soybean. As shown in table 3, the maize used for feed will increase from 118.1 million tons in 2010, to 153.4 million tons in 2020 and further to 173.8 million tons in 2030. Definitely, such a fast growth of feed demand will create great opportunity and severe challenge to the maize production. It is indeed that the maize production will increase quickly and fastest among all grains, from 177.2 million tons in 2010, to 223.0 million tons in 2020 and 241.8 million tons in 2030 (Column 8 of Table 2). However, the maize supply is still far behind the demand and the gap between demand and supply will be enlarged. As a result, China's import of maize will rise dramatically from 1.6 million tons in 2010, to 19.0 million tons in 2020 and 39.8 million tons in 2030. The self-sufficient level will drop remarkably from 99% in 2010, to 92% in 2020 and 86% in 2030.

The soybean is the best representative to show the vital role of import to ensure China's feed supply. With fast growth of production and remarkable change of production structure, the demand on protein feed and its proportion in total feed demand keep rising. For example, the proportion of protein feed in total feed demand will increase steadily from 29.8% in 2010, to 30.4% in 2020 and 31.3% in 2030 (Last row of Table 3). As the dominated composite of protein feed, the demand on soybean meal will grow dramatically from 42.6 million tons in 2010, to 69.9 million tons in 2020 and further to 78.1 million tons (Row 3 of Table 3), which will generate huge pressure on soybean supply. As shown in table 2, China's soybean supply heavily depends on global market to meet the fast growth of demand both on soybean oil and soybean meal. According to the simulation results, China's soybean import (including the equivalent soybean converted from imported soybean oil) will increase from 61.5 million tons in 2010, to 76.4 million tons in 2020 and 84.6 million tons in 2030. Such a huge import volume will create a great chance for soybean exporting countries (e.g., Brazil, Argentina and USA) to increase their production and export. As the import is much larger than domestic production, China's soybean self-sufficient level is quite low and also decreases steadily in the future from 20% in 2010, to 16% in 2020 and 15 % in 2030.

5. Main conclusions and policy implications

China's per capita consumption of livestock products will continue to rise in 2011-2030, even though its growth rate will slow down gradually. Accompanying the fast industrialization and urbanization in the past 3 decades, China's food

`

consumption pattern has changed dramatically toward consuming more high-valued agricultural products. Such a process is far from over. According to our findings, the evolution will continue in the next 2 decades, although the growth rate of consumption on high value-added foods will slow down. No doubt, the rising production of livestock products will pose great challenges on feed supply in China. One of the distinguished characteristics of the evolution of China's food consumption is that the consumption on products (e.g., beef, mutton and dairy products) from ruminate animals increase much faster than other livestock products, which means the promotion to increase forage grass will get more important and be an good strategy to ensure China's feed supply.

China will confront severe challenges of feed security instead of grain security in the future. The total commercial feed demand is estimated to rise dramatically from 202.6 million tons in 2010, to 259.3 million tons in 2020 and 280 million tons in 2030, which means the feed demand will increase about 6 million tons annually in 2011-2020, and 2 million annually in 2021-2030. It will lead to great pressures on China's agricultural production and its limited resources. China has to utilize the global resources to ensure its feed supply. As the two most important feed crops, the gaps between demand and supply of maize and soybean will be remarkably enlarged in the future. It is estimated that China’s import of maize and soybean will reach 19.0 million and 76.4 million tons in 2020, 39.8 million tons and 84.6 million tons in 2030. Correspondingly, the self-sufficient levels of maize and soybean will drop notably to 92% and 16% in 2020, and further to 86% and 15% in 2030.

China should set up the feasible policies to improve feed supply domestically and ensure the availability from oversee markets. First of all, our results reveal that the demand on products from ruminate animals will increase significantly. Meanwhile, China owns the great potential to promote the production of forage grass (Xu and Zhang, 2004). Therefore, more policy and technological supports should be provided enhance the capability, production and utilization of forage grass. Secondly, as a country with limited agricultural resources and confronting severe ecological problems, China should pay more attention on the rising important role of technology in promotion of production and ensurance of food security. Therefore, It is vital for China to increase the investments on agricultural R&D, enhance the adoption of new technologies abroad and strengthen the utilization of new technologies to improve the productivity. The last but not the least, after WTO accession, China has become one of the world most liberalized agricultural markets, and its agricultural import rose dramatically afterward. China is the world largest importer of soybean and will be the case of maize as we predicted. Therefore, China should actively take part in the

`

negotiation of global and regional policy portfolios of agricultural trade liberalization, aiming at securing the sustainable increase of global agriculture trade and reducing trade risks under the framework of a fair global trade.

Brown L R. 1995. Who will feed China?: wake-up call for a small planet. *WW Norton & Company*.

CAAS. 2012. Agriculture in China. Available at : http://www.caas.cn/en/agriculture/agriculture_in_china/index.shtml

Chen G J. 2012. Changes in supply and demand of Chinese feed grain and its effects on future grain self-sufficiency. *Chinese Journal of Animal Science*, 48(4), 23-26. (In Chinese)

Chen Y F, Yang L. 2013. China's grain supply and demand forecasts. Report of the Conference "China's food security strategy and policy research towards high-income countries". The State Council Development Research Center. (In Chinese)

Cheng G Q, Zhou YH. 1997. Estimates of supply and demand of China Feed. *Problems of Agricultural Economy*, 18(5), 25-29. (In Chinese)

China Daily. 2014. Positive policy for food security. Available at : http://usa.chinadaily.com.cn/epaper/2014-03/21/content_17369156.htm

Cui X L. 2012. Substantial growth in Chinese imports of corn will not repeat the mistakes of soybeans fall, *China's Foreign Trade,* 4, 64-65. (In Chinese)

Delgado C L. 2003. Rising consumption of meat and milk in developing countries has created a new food revolution. *The Journal of Nutrition*, 133(11): 3907S-3910S.

Food and Agriculture Organization. 2009. Livestock in the balance.

Fuller F, Hayes D, Smith D. 2000. Reconciling Chinese Meat Production and Consumption Data. *Economic Development and Cultural Change*, 49(1), 23-43.

Fuller F, Huang J, Ma H, et al. 2006. Got milk? The rapid rise of China's dairy sector and its future prospects. *Food Policy*, 31(3), 201-215.

Fuller F, Tuan F, Wailes E. 2002. Rising Demand for Meat: Who Will Feed China's Hogs?. *China's Food and Agricultural: Issues for the 21st Century*, 17-19.

Gale F, Huang K S. 2007. Demand for food quantity and quality in China.

Hartwell, R M. 1961. THE RISING STANDARD OF LIVING IN ENGLAND, 1800-18501. *The Economic History Review*, 13(3), 397-416.

Hu X P, Guo X H. 2010. Analysis and prediction on Chinese food demand structure in 2020--Perspective based nutrition standards[J]. *Chinese Rural Economy*, 6, 4-15. (In Chinese)

Huang J K, Li N H. 2003. Chinese Agricultural Policy Analysis and Prediction Model-CAPSiM. *Journal of Nanjing Agricultural University*, 3(2), 30-41. (In Chinese)

Huang J K, Yang J. 2012. Qiu Huanguang. Thoughts on national food security strategies and policies in the new era. *Issues in Agricultural Economy*, 3, 4-8. (In Chinese)

Huang J K. 2004. Past and future of Chinese agriculture, 3, 95-104. (In Chinese)

Huang J, Rozelle S, Rosegrant M W. 1999. China's Food Economy to the Twenty-first Century: Supply, Demand, and Trade. *Economic Development and Cultural Change*, 47(4), 737-766.

`

Huang J, Rozelle S. 1998. Market development and food demand in rural China. *China Economic Review*, 9(1), 25-45.

Huang J, Yang J, Rozelle S. 2010. China's agriculture: drivers of change and implications for China and the rest of world[J]. Agricultural Economics, 41(s1), 47-55.

Jiang N H, Xin X, Yin Jian. 2002. Analysis on factors affecting Chinese urban and rural livestock consumption. *Chinese Rural Economy*, 12, 48-54. (In Chinese)

Jiang N H. 2002. Theories and methods of national and provincial meat products statistics adjustment. *Journal of Agrotechnical Economics*, 6, 12-20. (In Chinese)

Jin S, Huang J, Hu R et al. 2002. The creation and spread of technology and total factor productivity in China's agriculture. *American Journal of Agricultural Economics*, 84(4), 916-930.

Ma H Y, Hu Q L, Li W, et al. 2011. Hog Production in China: Technological Bias and Factor Demand. *Agricultural Sciences in China*, 10, 468-479.

Ma H Y, Huang J K, Rozelle S. 2004. Reassessing China's Livestock Statistics: An Analysis of Discrepancies and the Creation of New Data Series. *Economic Development and Cultural Change*, 52(2), 445-73.

Speedy A W. 2003. Global production and consumption of animal source foods. *The Journal of Nutrition*, 133(11), 4048S-4053S.

Tuan F C, Fang C, Cao Z. 2004. China's soybean imports expected to grow despite short-term disruptions. *USDA Economic Research Service*.

Xiao H B, Wang J M, Oxley L et al. 2012. The evolution of hog production and potential sources for future growth in China. *Food Policy*, 37(4), 366-377.

Xu X, Zhang W. 2004. Consideration on Mechanization Condition of Forage Grass Production and its Development Opportunities in China. *Chinese Agriculture Mechanization*, 3, 003. (In Chinese)

Xu Z G. 2012. On a number of hot issues of industrial development of China's corn. *Agriculture Engineering Technology(Agricultural Product Processing Industry)*, 11, 22-25. (In Chinese)

Yen S T, Fang C, Su S J. 2004. Household food demand in urban China: a censored system approach. *Journal of Comparative Economics*, 32(3), 564-585.

Yu X H, Bernhard B, Zhong F N. 2012. How to protect China's food security. *Journal of Agrotechnical Economics*, 02, 4-8. (In Chinese)

Yu X, Abler D. 2009. The Demand for Food Quality in Rural China. *American Journal of Agricultural Economics* , 91(1), 57-69.

Yu X, Abler D. Where Have All the Pigs Gone? Inconsistencies in Pork Statistics in China. *China Economic Review*, Forthcoming.

Yu X, Sun M. 2012. A study of the impact of the aging of population in China on Consumption. *Jilin University Journal Social Sciences Edition*, 52(1), 141-160. (In Chinese)

Zhang M. 2007. A research into the international competitiveness of China’s aquatic product. Ph D thesis, Huazhong Agricultural University. (In Chinese)

Zhao Q G, Zhou S L, Wu S H et al. 2006. Cultivated land resources and strategies for its sustainable utilization and pritection in China. *Acta Pedologica Sinica*, 43(4), 662-672. (In Chinese)

Zhong F N, Xiang J. 2012. Impacts of demographic dynamics and professional structure on food demand. *Issues in Agricultural Economy*, 9, 12-16. (In Chinese)

`

Zhong F N. 1997. Bias on meat production Statistical data and their causes. *Chinese Rural Economy* , 10,63-66. (In Chinese)

Zhou Z Y, Tian W M, Malcolm B. 2008, Supply and demand estimates for feed grains in China. *Agricultural Economics*, 39,111-122.

`

Table 1: Change of production (thousand tons) and annual growth rates (%) of different livestock products during 1980-2012 in China.

	Meat					Fishery products	Dairy products	Eggs
	Total	Pork	Poultry	Beef	Mutton			
1980	12054	11341	936	269	445	4497	1367	2266
1990	28570	22811	3435	1256	1068	12370	4751	7946
2000	60139	39660	12707	5131	2641	27062	9191	21820
2012	83872	53427	18230	6623	4010	59077	38754	28612
1980-1990	9.0	7.2	13.9	16.7	9.1	10.6	13.3	13.4
1991-2000	7.7	5.7	14.0	15.1	9.5	8.1	6.8	10.6
2006-2012	2.8	2.5	3.1	2.1	3.5	6.7	12.7	2.3
Total growth	595.8	371.1	1847.6	2362.1	801.1	1213.7	2735.0	1162.7
Average	6.2	5.0	9.7	10.5	7.1	8.4	11.0	8.2

Source: NSBC

`

Table 2: China's supply and demand of livestock products and main feed crops in 2010, 2020 and 2030 (thousand tons)

	Livestock products							Main feed crops	
	Pork	Beef	Mutton	Poultry	Eggs	Dairy products	Fishery	Soybean	Maize
2010									
Output	43877	4742	3097	15374	17658	34006	27781	15083	177245
Import	201	24	57	542	0	4408	2308	61450	1570
Export	110	22	13	435	78	73	2486	509	130
Net import	91	2	43	107	-78	4335	-177	60941	1440
Total demand	43968	4744	3140	15481	17580	38341	27604	66114	197430
Food consumption	42327	4330	2907	14588	16778	37593	25232	63887	17991
Per capita demand (Kg/person)	31.6	3.2	2.2	10.9	12.5	28.1	18.9	47.8	13.5
Self-sufficient (%)	100	100	99	99	100	89	101	20	99
2020									
Output	54947	7048	4436	21889	23120	55076	42960	14816	223050
Import	667	126	350	62	0	10593	2770	76428	18992
Export	71	5	0	197	49	57	3528	340	143
Net import	597	121	350	-135	-49	10536	-758	76089	18849
Total demand	55544	7170	4786	21754	23071	65612	42202	90905	241899
Food consumption	52975	6756	4553	20861	22269	64864	39830	88541	11517
Per capita demand (Kg/person)	37.7	4.8	3.2	14.8	15.8	46.1	28.3	63.0	8.2
Self-sufficient (%)	99	98	93	101	100	84	102	16	92
2030									
Output	59603	8617	5069	24611	24282	65362	49976	14722	241572
Import	782	344	667	76	0	18492	3246	84577	39847
Export	60	2	0	159	41	30	3021	307	100
Net import	722	342	667	-83	-41	18462	224	84270	39748
Total demand	60325	8959	5736	24529	24241	83824	50201	98992	281319
Food consumption	57757	8545	5503	23636	23440	83076	47829	96472	7620
Per capita demand (Kg/person)	40.5	6.0	3.9	16.6	16.4	58.3	33.5	67.6	5.3
Self-sufficient (%)	99	96	88	100	100	78	100	15	86

Source: CAPSiM simulation results

`

Table 3: China's feed demand in 2010, 2020 and 2030 (thousand tons)

	2010	2020	2030
Total commercial feed	202630	259323	279740
Protein feed [a]	60346	78722	87544
-Soybean meal	42580	69906	78104
Energy Feed	142326	180600	192197
-Maize	118100	153412	173800
Ratio of protein feed in feed demand (%)	29.8	30.4	31.3

Source: Authors' calculation based on CAPSiM simulation results

`

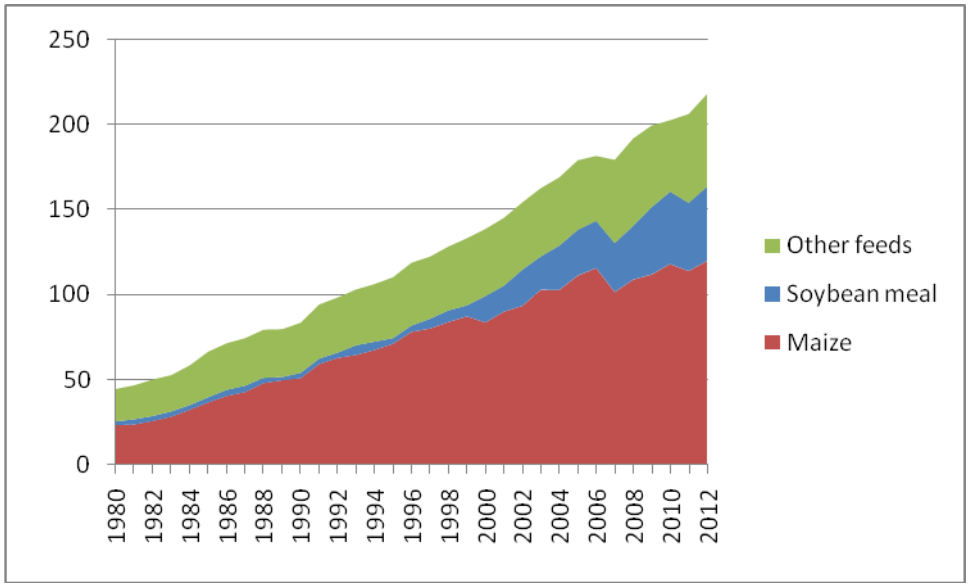

Figure 1: Change of China's feed demand by categories (thousand tons) in 1980-2012
Source: Estimated by authors based on NSBC database

`

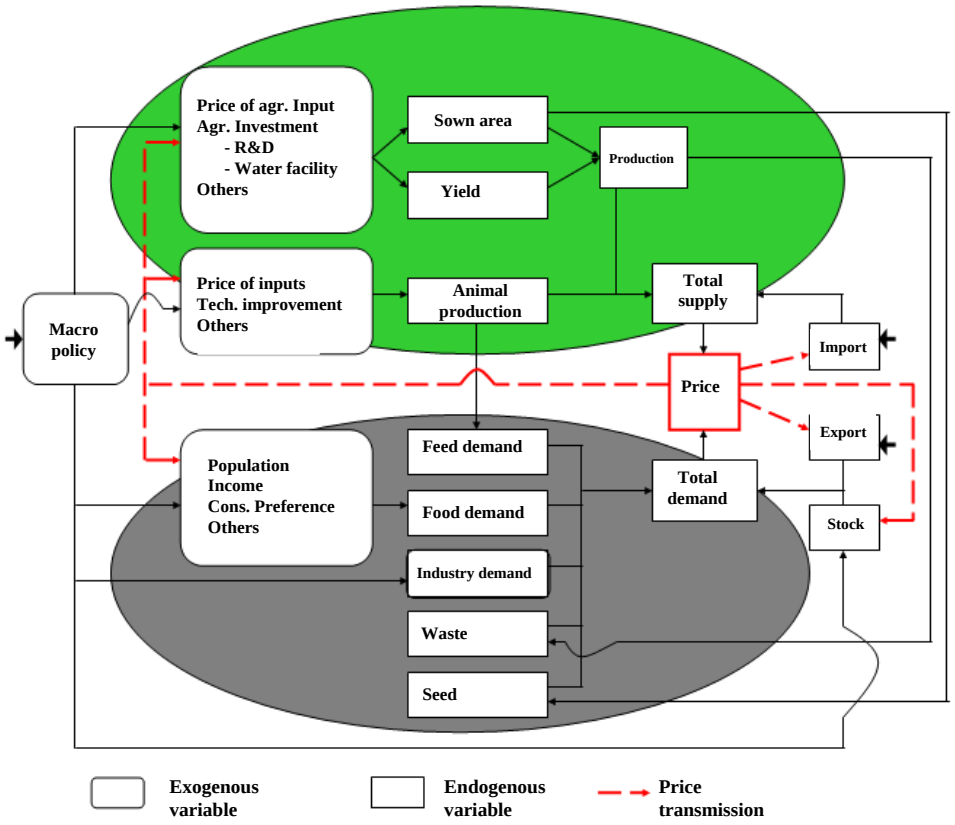

Figure 2：Theoretical framework of CAPSiM model

Appendix table 1：Contribution of technology improvement to the annual growth of yield in different periods by agricultural products (%)

	2011-2015	2016-2020	2021-2025	2026-2030
Rice	1.13	0.84	0.63	0.47
Wheat	1.13	0.84	0.63	0.47
Maize	1.13	0.90	0.70	0.51
Sweet Potato	1.13	0.84	0.68	0.54
Potato	1.13	0.90	0.72	0.58
Other grains	1.20	0.96	0.77	0.61
Soybean	1.20	0.96	0.77	0.61
Cotton	1.40	1.12	0.90	0.72
Vegetable oils	1.40	1.12	0.90	0.72
Sugar	1.23	0.86	0.60	0.42
Vegetables	1.60	1.28	1.02	0.82
Fruits	2.25	2.03	1.82	1.64
Pork	2.98	2.59	2.25	1.96
Beef	4.28	3.00	2.55	2.17
Mutton	3.47	2.43	2.06	1.75
Poultry	4.13	3.30	2.64	2.12
Eggs	2.82	2.25	1.80	1.44
Milk	4.62	2.77	1.66	1.00
Fishery products	4.31	3.88	3.49	3.14

Source: estimated by authors based on the studies by Huang (2004) and Huang et al., (2010)

`