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China's Food Security and Challenges

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CHINA'S FOOD SECURITY AND CHALLENGES

By

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For years, hundreds of millions of people in the world are starving from the unbalanced distribution of foods. This food crisis is getting worse when more developing countries shifting farmlands and capitals for manufacturing and servicing industries as their economic growing. China, like other developing countries, also faces the same challenge. As the world's largest producer, consumer, and importer of agricultural products, China plays a major role in global food security. If China cannot increase its crop production significantly to satisfy its growing food demand, China will have to import more foods from the global market and thus raise the food price. When the food price increase and export more to China, the rest of the world will have less food supply and the higher price will also being not affordable for hundreds of millions of people. China must act to avoid the worst situation before it's too late.`

DEDICATION

To my mother, Xinfen Ko, a woman of courage and perseverance, and the world, which I cherish with all my heart.

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This paper is the result of a group of excellent people who have faith in me and support me, I cannot have done this research without them. It is with all the gratitude that I thank:

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INTRODUCTION

The world is starving. According to FAO(Food and Agriculture Organization of the United Nation), 815 million people are suffering from the lack of foods, the amount of hunger contains 11% of the global population in 2017. Among them, 520 million people are from Asia, 243 million people are from Africa. Another research of IFPRI(International Food Policy Research Insitute) shows that 52 countries out of 119 countries have significant high GHI(Global Hunger Index), which means these countries are facing serious famish problems. If the world doesn't take action, the situation is only going to be worse. According to the China Water Risk foundation, within the near future, the world has to increase one billion ton of cereal and 200 million tons of livestock every year from 2011 to feed two more billion people by 2050.[1]

In the time of globalization, China, as one of the most peopled countries, heavily influences the future of global food security. These days, every country is connected with each other, and if one country makes a wrong decision, the entire world will suffer. In the food crisis, the impact is direct- people's lives. Since 2004, China has

1PUBLIC POLICY, University of Pennsylvania, Feeding the Developing World: Six Major Challenges, Sep 17, 2015

become a large net food importer and has been increasingly depended on the import of foods from the world (according to the report of SIPRI in 2016). China is the largest agricultural importer of certain products, such as soybeans, which China imports 60% of the total amount from the global market. The recent projection shows that imports of feed, oilseeds, meat as well as high-value products will only increase soon. Figure 1 shows the rank of an amount of import in China. In 2015, China was the world's largest importer of vegetables (with 15% of the market share), the seventh largest importer of food products (with 5% of the market share) and the fourth largest importer of animals (with 7% of the market share).

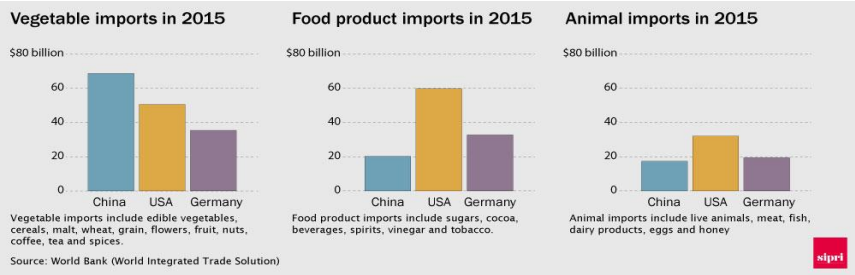

Figure 1. China’s global import rank in 2015(Source: world bank)

The impact of China on the global market will seriously influence the global food security, as the continue increasing income and the change in dietary, China continues increasing the amounts of importing agricultural commodities. In 2014, China’s grain import amount increased 34% to 90 million tons compare to the

previous years, which was the sum of grain production of France and Australia in 2012(National Bureau of Statistics of the People's Republic of China). If China does not act to raise the total food production, the entire world will be threatening of death from hunger. Since the price of food became higher, people in the third world become harder to afford those foods. China plays a serious part in saving the world from starving. China has a long self-sufficient policy going, and mainly focus on grains, whereas nowadays foreign dependence is increasing for animal commodities. This paper will focus on China's grain productivity , and other partial productivity to analysis the possibility of China reaching its goal.

1.1 Research Hypotheses

This current research will test the following hypotheses to evaluate the possibility of China to reach its 95% of self-food enough goal, and how China will reach it.

-Employment in China's agricultural industry has an impact on total grain production.

-Irrigated area has an impact on total grain production in China.

-Total usage power of machinery in agricultural industry has an impact on total grain production in China.

- Total usage of enzyme and fertilizer in agricultural industry has an impact on total grain production in China.

-Household Contract Responsibility System has an impact on total grain production in China.

-The analysis of impact of four agricultural inputs on agricultural labor productivity, and productivity, and total factor productivity.

CHAPTER 2

BACKGROUND

CHINA'S AGRICULTURAL INDUSTRY

Before the founding of New China in 1949 and before the reform and opening in 1978, it was the historical starting point of China's agricultural modernization and transformation. After the reformed and opened, the Central Committee of the Communist Party of China adopted a series of measures to develop agriculture, which greatly promoted China's transition from traditional agriculture to modern agriculture. The transition from a large rural-oriented country to an urbanized country, and a transition from rural to urban and agricultural to non-agricultural economy. There has been a trend of large-scale accelerated transformation. In the first half of the 21st century, China's agricultural development faced unprecedented opportunities and unprecedented challenges. The history of agricultural development in the past 60 years after the founding of New China has proved that it is necessary to embark on a path of characteristic agricultural modernization that suits China's national condition.

2.1 The challenge of China's agricultural industry

The population is large, the agricultural resources are relatively scarce; the food consumption is large, and the agricultural support population is insufficient. This is a prominent feature of China's national conditions. How to feed around 20% of the

world's population with about 10% of the world's cultivated land and 6.5% of water resources has long been the number one development problem facing modern China(source: FAO)

Agriculture is the foundation of the national economy. After the founding of New China, China's agricultural development and transformation is essentially agricultural modernization. The special national conditions determine that China must embark on a road of agricultural modernization with Chinese characteristics.[2] The path is not only one of the concrete roads of China's total road, but also an important part of China's five in one socialist modernization. This is an objective way that has been repeatedly proved by history in our developing country with a population of more than one billion.

2.2 China's agricultural growth within recent years

In 1978, China reformed and opened. Since then, people's income raised and the shift of the nation's population from the countryside to the city have resulted in significant changes in China's consumption patterns, and these changes will continue as income growth and urbanization continuing.[3] Specifically, rising incomes and

2 China's Agriculture: Drivers of Changes and Implications to China and the Rest of the World, paragraph 2, Jikun Huang, 27th International Association of Agricultural Economists Conference Beijing, China, August 2009,

3 China's Agriculture: Drivers of Changes and Implications to China and the Rest of the World, Jikun Huang, 27th International Association of Agricultural Economists Conference Beijing, paragraph 3, China, August 2009

urban expansion have boosted the demand for meats, fruits, and other non-staple foods and have had a defining effect on the agricultural economy as producers have shifted their production to meet demand. For example, the share of livestock output value rose 2.5 times from 14 percent to 35 percent between 1970 and 2005.[4] Aquatic products increased at an even more rapid rate. One of the most significant signs of structural changes in the agricultural sector is that the share of crops in total agricultural output fell from 82 percent in 1970 to 51 percent in 2005. In 2009, cropping accounts for less than half of agricultural GDP.[5]

Although agricultural growth speed has been lower than the growth speed in the rest of economy, its performance has been impressive since the late 1970s. After 1978, de-collectivization, price increases and the relaxation of domestic trade restrictions on most agricultural products accompanied the takeoff of China's food economy and allowed China's producers to meet the shifts in consumer demand (discussed in the section above).[6] Between 1978 and 1984, grain production increased by 4.7 percent per year; the output of fruit rose by 7.2 percent (Table 1). The highest annual growth

4 China's Agriculture: Drivers of Changes and Implications to China and the Rest of the World, Jikun Huang, 27th International Association of Agricultural Economists Conference Beijing, paragraph 3, China, August 2009

5 China's Agriculture: Drivers of Changes and Implications to China and the Rest of the World, Jikun Huang, 27th International Association of Agricultural Economists Conference Beijing, paragraph 3, China, August 2009

6 China's Agriculture: Drivers of Changes and Implications to China and the Rest of the World, Jikun Huang, 27th International Association of Agricultural Economists Conference Beijing, China, August 2009

rates (between 1978 and 1984) came in cotton, edible oils, livestock and aquatic commodity sectors, sectors that expanded in real value terms from 8 to 19 percent.[7]

Table 1. The annual growth rates (%) of agricultural economy, 1970-2005.

	Pre-reform	Reform period			
	1970-78	1979-84	1985-95	1996-00	2001-05
Agricultural GDP	2.7	7.1	4.0	3.4	3.9
Production:					
Grain	2.8	4.7	1.7	-0.7	1.1
Cotton	-0.4	19.3	-0.3	-1.9	5.3
Soybean	-2.3	5.2	2.8	2.6	1.4
Oil crops	2.1	14.9	4.4	5.6	0.8
Fruits	6.6	7.2	12.7	8.6	21.0
Meats	4.4	9.1	8.8	6.5	4.9
Fishery	5.0	7.9	13.7	10.2	3.6

7 China's Agriculture: Drivers of Changes and Implications to China and the Rest of the World, Jikun Huang, 27th International Association of Agricultural Economists Conference Beijing, China, August 2009

Planted area:					
Vegetables	2.4	5.4	6.8	6.8	3.1
Orchards (fruits)	8.1	4.5	10.4	1.5	2.4

Note: Growth rates are computed using regression method. Growth rates of individual and groups of commodities are based on production data. Sources: NSBC, 1985-2005 and MOA, 1985-2006.

Agricultural growth remained remarkable for all agricultural products except for grain and cotton during the period 1985-2005. Fishery production experienced the fastest growth between 1985 and 1995 (13.7 percent annual growth, Table 1). Although its annual growth rate fell in the following period, it still recorded 10.2 percent growth between 1996 and 2000. Over the same period, meat production, vegetable sown area, and fruit orchard output expanded at 7 to 9 percent annually. Other cash crops such as edible oil crops, also grew at rates much higher than population growth.

The overall growth of the agriculture sector kept at an average of nearly 4 percent annual growth rate in 2001-2005 (row 1, Table 1). Comparing the growth rates of individual commodities between the early and late reform periods, it appears that production growth of some individual commodities (measured in quantity terms)

fell. One explanation is that China's agricultural production system has been shifting from on that emphasizes total aggregate production to one that is more concerned with creating value-added and quality. During the three-year period, 2005-2007, China's agricultural GDP in real terms grew at an annual rate of more than 5 percent.

2.3 China's Agricultural Revolutions

China's stories have last over thousands of years, and there is always one main core of those stories: food security. Today, being the country with the largest population, the story of fighting food crisis continues. After WW2, China faced a critical problem that many lands have been ruined, and little people had the strength to farm.

2.3.1 China's Agricultural initial transformation and development period (1949-1978)

The time before the founding of New China and the reform and opening up, it was the historical starting point of China's agricultural modernization and transformation. During this period, China was not only one of the world's most populous country but the largest country with the largest rural population and the largest country with the largest poverty.[8] Mao Zedong's understanding of China's basic national conditions is quite profound. He pointed out in the report of the Second

8 Contemporary Chinese History Studies, Ann-Goun Hu, www.cpcnews.cn 2014

Plenary Session of the Seventh Central Committee of the Communist Party of China:

[9] “China still has about 90% of scattered individual agricultural and handicraft economies, which is backward. This is not much different from ancient times. We still have about 90% of our economic life staying in ancient times." "For a long period of time in the future, our agriculture and handicrafts, in terms of their basic form, will still be dispersed and individual, that is, like ancient times." This shows that China is a typical traditional agricultural society and less developed countries. The policy Mao Zedong launched in this time period is called Great Leap Forward, which later caused a great disaster in human history.

Around 45 million people died of starvation from famine from 1958 to 1962. Although China’s government continuing denying the huge amounts of death was not caused by policy but natural disaster, the truth is undeniable. In this period, China struggled to find the best developing way for each industry but failed. In the agricultural industry, China intended to be the exporter, and push harder to increase the crop productivity. To meet the amount of production given by the central government, local government in this period took every food produced by farmers and thus made farmers suffered.[10] In return, thousands of thousands of farmers rebilled.

9 Selected Works of Mao Tse-tung, chapter 4

10 Mao's Great Famine: The History of China's Most Devastating Catastrophe, 1958-1962, Frank Dikötter, 2011

Many men were killed, and the rest ran away from their hometown. The farmland then was left behind, no farmers were able to plant any crop in the era of riots. The cost was significant, people's lives. The agricultural condition did not increase eventually.

Then, China's government arranged another movement called "ten years of cultural revolution" started from May 1966 to October 1976. This revolution's purpose was to improve the manufacturing industry and to improve farmers' standard of lives. However, the result did not go as well as expected. The local government abused their power to clean their political rivals, also to steal wealth from the bourgeoisie. Quite: [11] "Over fiq`nd lives." [12]"Further, over twenty millions of people died in the revolution, over 100 million people were persecuted, and over 130 billion U.S. dollars were wasted."

2.3.2 China's Household Responsibility Policy (1981)

In 1981, the household responsibility policy released and gave a heavy boost to the agricultural production. The agricultural productivity has been found to increase by 20% since the agricultural system shifted from the production system to the household responsibility system.[13] Since 1982, the central government has issued five

11 Guanyin Yee. Dec. 1978 vice Chairman of the CPC Central Committee,

12 Guanyin Yee, vice Chairman of the CPC Central Committee, Dec. 1978

13 Rural Factors Markets in China after Household Responsibility System Reform

No. 1 documents for five consecutive years, affirming the rural reform based on the household contract responsibility system and the development of township enterprises and the construction of small towns.[14] In 1980, 14% of the production teams implemented the household contract system, which increased to 45% in 1981, further increased to 80% in 1982, and reached 90% in 1984. [15]" The improvement in incentive, nevertheless, may have simultaneously created allocative inefficiencies. When the household responsibility system was introduced, land and other resources in a team were in most cases allotted to each household in proportion to its size. Therefore, for the households in a team, their land-person ratio was equalized after the household responsibility reform. Households are at different stages in the life cycle. They thus have different endowments of family labor. In addition, households differ in abilities. An equal land-person ratio across households in a team thus does not fully equalize land-labor ratio across households. If each household faces the same production function, this egalitarian allocation of land will result in disparities in the marginal products of land and labor across households. These differences in marginal products represent an allocative inefficiency. Output can be increased if resources are

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Lin, Justin Yifu, EGC, Yale University

14 Contemporary Chinese History Studies, Ann-Goun Hu, www.cpcnews.cn 2014

15 Rural Factors Markets in China after Household Responsibility System Reform

Lin, Justin Yifu, EGC, Yale University

reallocated." Thus, China's government must adjust the policy for a further increase in crop production. [16]"One possible way to take advantage of these opportunities is through direct government intervention, like land-reallocation among households. Nevertheless, government intervention can be ruled out as an alternative for the near future. When the household responsibility system was first introduced, the land contracts, in general, ranged from 1 to 3 years. When an original contract expired, the land was reassigned and adjusted according to changes in household size and labor endowment. This practice was soon found to be impractical. As land might be assigned away in next contract, each household thus lacked 3 incentives to invest in land improvement and to maintain properly the soil fertility. To overcome this disincentive in land investment and land maintenance, the Chinese government has adopted a policy of lengthening the contract of land usage to each household for up to 15 years or longer." However, the problem is never that easy to deal with. There are many problematic issues China need to consider at the same time. The main problem is the policy of China that sacrificing agricultural industry to boost other industries. The trend of the economic growth in China continues to worsen its agricultural condition.

16 Rural Factors Markets in China after Household Responsibility System Reform

Lin, Justin Yifu, EGC, Yale University

2.3.3 China's Contemporary Agricultural Policies (1992-)

In 1992, Jiang Zemin first brought out the issue of China's "three rural issues." He pointed out: "Agriculture is the foundation of the national economy, and rural stability is the foundation of the stability of the whole society. The citizens' problem has always been the fundamental problem of China's revolution, construction, and reform."[17] The basics of solving the "Three Rural Issues" in the 1990s in addition to further developing agriculture, township enterprises, and small towns.[18] It has not fundamentally touched and broken urban and rural barriers and dual economic and social structures.

Since the second half of the 1990s, the GDP proportion of China's agriculture has continued to decline; agricultural labor productivity has been further widened compared with non-agricultural industries; and the income gap between urban and rural areas has continued to rise. The issue of "agriculture, rural areas, and farmers" has become increasingly prominent, reflecting the many contradictions in China's agricultural development. Agriculture is at a stage of rapid transformation.

The report of the 17th National Congress of the Communist Party of China officially proposed a major proposition of the road to agricultural modernization with Chinese

17 Selected Works of Jiang Zemin, Volume 1, People's Publishing House, 2006, p. 258

18 The Three Rural Issues were highlighted by Hu Jintao and Wen Jiabao as areas of rural development in China that need work, issued as agricultural, rural areas and farmers development

characteristics. China's agricultural transformation has entered a new historical stage, and the reform of the agricultural system with the theme of “liberating peasants, transferring peasants, and reducing peasants” has begun.[19] This is the seventh agricultural policy adjustment after the founding of New China. To liberate more people from agriculture and land, the CPC Central Committee and the State Council have taken a series of major measures to solve the problems of agriculture, rural areas, farmers and migrant workers in China: First, cancel agricultural taxes and adjust the distribution relationship between the state and farmers. After the pilot reform of agricultural taxes and fees, the agricultural tax was abolished nationwide in 2006, and the system of taxing farmers to land by 2,600 years has been withdrawn from the historical stage. The national farmers have reduced the burden of 22.3 billion dollars each year. Second, implement agricultural production subsidies and strengthen support and protection for agriculture. Agricultural production subsidies include direct subsidies for grain farmers, improved seed subsidies, agricultural machinery purchase subsidies, and comprehensive subsidies for agricultural materials. We will implement financial incentive subsidies to produce grain and oil, pigs and other large counties. Third, comprehensively liberalize grain purchases and sales, and take the decisive step of market-oriented reform of agricultural products. In 2004, it was decided to

19 Contemporary Chinese History Studies, Ann-Goun Hu, www.cpcnews.cn 2014

liberalize the purchase and sale of grain and implement the minimum purchase price policy. Fourth, implement the reform of the collective forest rights system and mobilize the enthusiasm of farmers for forestry and forest protection. In 2003, the pilot reform of the collective forest rights system was initiated, and the land contractual management rights and forest ownership were implemented to farmers. In 2008, this reform was pushed to the whole country. Fifth, reform the guarantee mechanism for rural compulsory education funds and realize free and compulsory education in the true sense. Sixth, establish and improve the rural social security system to eliminate the worries of farmers.

Implement a new rural cooperative medical care system and promote a new rural social endowment insurance system. Seventh, clean up unreasonable policies and restrictions and treat migrant workers fairly. These measures have greatly promoted China's transition from traditional agriculture to modern agriculture. The transition from rural-based countries to urbanized countries, rural-to-urban and agricultural-to-non-agricultural economies, and a large-scale accelerated transformation. From 1978 to 2012, the rural labor force fell from 70.5% to 33.6%; the proportion of agriculture in GDP fell from 28.2% to 10.1%; the proportion of rural population fell from 82.1% to 47.4%; meanwhile, the productivity of agriculture continued to increase, from 1978 to 2012. The per capita agricultural labor grain output increased from 1,076 kg to

2,129 kg. The living standards of farmers have improved. From 1978 to 2012, the Engel coefficient of rural families fell from 67.7% to 39.3%.

To summary periods of household responsibility policy to modern China's policy, table provides data of China's urbanization rate, real GDP grow, and top four animal commodities (pork, poultry, beef, and milk products), and four crops products (rice, wheat, corn, and soybeans). This was such a significant turning point of farmers in China that they not only increased their productivity, but also improve their standard of lives. People of China for the very first time in the over two thousand years history, tasted the feeling of freedom. It also impacted China's government profoundly that China became more opened to the entire world and the global marketing in the future. [20]Although China was still a developing country, and the per capita income remained below most developed countries, the high GPD growth rate each year boosted China to move into the "middle- income" country. The urbanization rate continued increasing from 0.25 in 1984 to 0.48 in 2002. As the increasing urbanization rate and real GDP per capita, per capita consumption of all commodities increased as excepted, except rice. Corn and soybean enjoy a huge increase in demand, and both were being used mainly for animal feeders (75% of soybeans were used in animal feeder in 2010, source: FAO).

20 Lopez, R. A. et al. 2017. What Drives China' s New Agricultural Subsidies?, World Development

Table 2. Statistics of China's agricultural economy

	Period 1: 1984–89 Mean	Period 2: 1990–94 Mean	Period 3: 1995–2001 Mean	Period 4: 2002–15 Mean
National-level variables				
Real GDP Per Capita (RMB)	1,089.67	2,678.59	6,859.29	27,309.46
Agriculture Share of GDP	0.27	0.22	0.17	0.11
Urbanization rate	0.25	0.28	0.33	0.48
Transfers from consumers (Billion RMB)	−38.81	12.76	−12.28	541.37
Budget transfers (Billion RMB)	11.13	12.76	40.99	103.25
Commodity-specific variables				
PSE	−2,188.51	−12,806.62	−401.09	22,351.37
Percent PSE	−13.58	−21.61	5.98	12.29
GEO × production value	2.30	4.44	8.00	18.11
Self-sufficiency	2.27	1.41	0.94	0.92
Production level (thousand tons)	28.23	31.11	33.64	42.19
Production value (billion RMB)	25.74	49.35	88.40	201.52
Consumption level (Thousand tons)	28.35	30.85	35.04	44.52
Consumption value (Billion RMB)	20.47	48.78	91.84	218.64
Demand elasticity w.r.t output price	−0.95	−0.93	−0.31	−0.36
Supply elasticity w.r.t output price	0.10	0.11	0.08	0.11
Supply elasticity w.r.t input price	−0.36	−0.38	−0.87	−0.64
Number of observations	72	66	105	195

Note: 1978 is the baseline year when real GDP per capita in China was 381 RMB. Note that the mean values for each period are the simple averages across commodities and years, not the weighted averages.

Source: Lopez, R. A. et al. (2017) What Drives China' s New Agricultural Subsidies? World Development

2.3.4 Other Challenges of China's agriculture

Urban population growth increases the challenge of feeding people. Chinese people demand more foods per capital than before. Also, the diet habit of Chinese people has transformed into more western style make it harder to suit people's appetite. To meet the increasing demand of meat market, more lands are used to grow foods for animals. This trend of production decreases areas once grows foods direct for humans.

Another critical situation China has been facing is the pollution problem. Land

and water have been polluted by the nearby factories which release poison water into rivers. This causes serious public health issues, in many areas where land and irrigation water are found to be highly polluted with toxic elements and pesticides, are being discarded for cultivation. Thus, millions of hectares of agricultural land may become unsuitable for agriculture in near future and this will have grave impacts on agricultural output and domestic food self-sufficiency. [21]"Aside from urbanization and pollution, land reform has been another heavily discussed topic in the context of agriculture and food security in China. Land administration is considered vital for food security (Georgina et al. 2013).

Misappropriation of farmland in the rural areas is not a news in China. A nationwide campaign conducted in 2006 to regulate farmland allocation for commercial purposes detected 22395 illegal land appropriation cases (Jiang 2007). Since the 1980s, prioritizing the need for land for nonagricultural purposes over the need for ones under agriculture has been serving as an implicit way to cater labor force for industrialization and urban development. And with the surge of more remunerative nonfarm market sectors, farmers are also becoming more unlikely to stick to the land to which their right is not firm." Rainfall is also a problem for China

21 Mingsheng Fan, Jianbo Shen, Lixing Yuan, Rongfeng Jiang, Xinping Chen, William J. Davies, Fusuo Zhang; Improving crop productivity and resource use efficiency to ensure food security and environmental quality in China, *Journal of Experimental Botany*, Volume 63, Issue 1, 1 January 2012, Pages 13–24

in increasing the crop production. [22]North-West China suffers from a very limited rainfall (less than 400 mm per year). In these regions, desert and grassland are the major landscape features and only patches of oasis agriculture exist.

The vast area of South and South-West China are very mountainous, and agriculture is only good in their valleys. Most of the arable land in China is concentrated in the North China Plain, the North-East China Plain, and some river deltas. In total, China's arable land is about 120 million hectares, less than 0.1 hectares per capita and far below the world average (National Bureau of Statistics of China, 2009). China has "many fundamental policy issues with China's agriculture today." [23] The lack of land ownership and limited utilization rights, low productivity due to a small size and low input, and the low profitability of farming are just a few of the problems that cannot be tackled easily. All that can be hoped is that the Chinese Government will take all the necessary measures to maintain farmers' initiatives and help them to stay in business with a decent livelihood. This will avoid unnecessary fluctuation in China's food production. However, the policy issue is always difficult to deal with, since no one knows what China's government will do next. Table 3

22 China's success in increasing per capita food production, Jianhua Zhang, Journal of Experimental Botany, Volume 62, Issue 11, 1 July 2011, Pages 3707–3711, https://doi.org/10.1093/jxb/err132 Published:06 May 2011

23 China's success in increasing per capita food production, Jianhua Zhang, Journal of Experimental Botany, Volume 62, Issue 11, 1 July 2011, Pages 3707–3711, https://doi.org/10.1093/jxb/err132 Published:06 May 2011

summary the three periods of Chinese policies' influences mention above on crop yields.

Table 3. Level of agricultural and economic indicators at the beginning and end of the period and before the policy reforms

	1961–1965	1974–1978	2002–2006
Yield crops ($/hectare)	526	846	1566
Yield livestock ($/head)	120	131	605
Output/land ($/hectare)	179	245	658
Output/worker ($/EAPa)	210	261	717
Inputs			
Workers/1,000 ha	855	939	918
Fertilizer/worker (kg)	5	20	81
Fertilizer/hectare (kg)	14	77	266
Tractors/1,000 workers	0.2	1.1	2.1
Tractors/1,000 ha	0.6	4.1	6.9
Feed/stock (kg of maize equivalent)	358	543	788
Feed/worker (kg of maize equivalent)	74	160	312
Stock/1,000 workers	206	294	395
Stock/1,000 ha	176	276	363

GDP			
GDP (billions 2000 US$)	72	147	1736
Agriculture (billions 2000 US$)	37	63	206
Manufactures (billions 2000 US$)	8	31	590
Services (billions 2000 US$)	28	39	634
Trade			
Total imports (billions 2000 US$)	–	4	526
Total exports (billions 2000 US$)	–	7	667
Openness (trade as % of GDP)	5	10	62

Source: Authors using FAO (2008) and World Bank (2008) a EAP is economically active population, in this particular case in agriculture J Prod Anal (2010) 33:209–223 217.

CHAPTER 3

LITERATURE REVIEW

The objective of this literature review is to discuss research that has already been conducted on the topic of improving the total factor productivity or change the sever situation of China's agriculture has faced (i.e. climate change, nature lack of agricultural lands).

3.1 China's Food Condition

The food crisis in China has long been an issue of interest for many researchers, but the problem remains unsolved. Researchers have provided evidence of how China is facing an ever-challenging agricultural issue than ever. Quote: " In recent years, agricultural growth in China has accelerated remarkably, but most of this growth has been driven by increased yield per unit area rather than by expansion of the cultivated area. [24] China's agricultural problem becomes more important not only for feeding the people but to be independent of importing from other countries. Recently, U.S. declares a trade war against China, and one important item China imports from the U.S. is soybeans. If China intends to raise the tariff on soybeans to hurt the U.S, it might turn out to be China hurts more, since China import 48% of soybeans from

24 Mingsheng Fan, Jianbo Shen, Lixing Yuan, Rongfeng Jiang, Xinping Chen, William J. Davies, Fusuo Zhang; Improving crop productivity and resource use efficiency to ensure food security and environmental quality in China, *Journal of Experimental Botany*, Volume 63, Issue 1, 1 January 2012, Pages 13–24

U.S.[25]

Researchers also focus on how China has done throughout the history to address the increasing demand for foods. It seems China has steadily increased its production Quote: [26]"Chinese cereal production has increased steadily from 83.4 Mt in 1961 to 474.2 Mt in 2009 (Fig. 1A), accounting for 9.5% of total global cereal production in 1961 and 21.8% in 2009. The net increase over this period is 390.8 Mt with an annual growth rate of 3.7%, which is substantially higher than the world means growth rate in cereal production of 2% during the same period. In 2009, China was responsible for approximately 29.1% of global rice production, 20% of maize, and 16.9% of wheat production (National Bureau of Statistics of China, 1950–2010; FAO, 2010). The success of crop production in China has impacted on both global food supply and on natural resource use and availability and both changes have received global recognition." [27] Also, this production improvement is mainly attributed by the progress in agricultural technology. Quote: "To pursue the fastest and most practical route to improved yield, the near-term strategy is application and extension of existing agricultural technologies. This would lead to substantial improvement in crop and soil

25 New York times, STEVEN LEE MYERS, 04/09/2018

26 Mingsheng Fan, Jianbo Shen, Lixing Yuan, Rongfeng Jiang, Xinping Chen, William J. Davies, Fusuo Zhang; Improving crop productivity and resource use efficiency to ensure food security and environmental quality in China, Journal of Experimental Botany, Volume 63, Issue 1, 1 January 2012, Pages 13–24

27 National Bureau of Statistics of China, 2009

management."[28] Modern researchers believe China's crop production can be enhanced by the improvement in technology. However, the lack of natural recourses and the limited farm land will make increasing the food production profoundly hard. "In total, China's arable land is about 120 million hectares, less than 0.1 hectare per capita and far below the world average." As for the climate difficulty, China still do not have a good day to relax." [29] China's water resources are very unevenly distributed in location and in time of year. The areas near the south-east coastlines receive the most rain, more than 1500 mm per year, while inner areas like Xingjiang have less than 200 mm per year. A 380 mm (15 inches) isohyet starting from the north-east to the south-west divides the map of China into two almost equal halves." It seems China should not only address the food crisis problem by focus on agricultural technology improvement which can directly influence the crop production, but should also try to solve the climate problem. Furthermore, compare to the rest of the world, it takes more afford for China to feed its people.30" China has to feed 20% of the global population with only about 5% of the planet's water resources and 7% of its arable land. Food security will always be an issue with such limited

28 China's success in increasing per capita food production, Jianhua ZhangJournal of Experimental Botany, Volume 62, Issue 11, 1 July 2011, Pages 3707–3711, published: 06 May 2011

29 China's success in increasing per capita food production, Jianhua ZhangJournal of Experimental Botany, Volume 62, Issue 11, 1 July 2011, Pages 3707–3711, published: 06 May 2011

30 China's success in increasing per capita food production, Jianhua ZhangJournal of Experimental Botany, Volume 62, Issue 11, 1 July 2011, Pages 3707–3711, published: 06 May 2011

conditions." This is the reason China must act now. Throughout all possible solutions, this paper will run models to test four types of productivities (grain productivity, land productivity, labor productivity, and total factor productivity growth index) to find out the proper and realistic solution.

3.2 Green Revolution (1960)

While enjoying the increasing wealth gained from the growth of the economy, the food security issue has long been a bothersome problem for China. There are many researchers trying to find the possible solution to address the problem. Some researchers brought out the cases of China's success in increasing per capita food production in the past. An analysis of China's grain production over the years shows that there was a trend of increasing yields over time, although some significant fluctuations occurred periodically (see table in the data page). It is concluded that this increasing trend has largely been maintained by technical progress in China's agriculture. Several major breakthroughs can be counted. For example, the First Green Revolution and the adoption of the semi-dwarf trait in rice and wheat breeding greatly increased their yield potential starting from the late 1960s (Gaud, 1968; Wang et al., 2010).[31] China's progress in this synchronized with the significant

31 China's success in increasing per capita food production, Jianhua Zhang, Journal of Experimental Botany, Volume 62, Issue 11, 1 July 2011, Pages 3707–3711, https://doi.org/10.1093/jxb/err132 Published:06 May 2011

achievements at the International Maize and Wheat Improvement Centre (CIMMYT) and the International Rice Research Institute (IRRI), respectively, on wheat and rice. After siting the policy in the past which successfully increase the crop production, this researcher then provides another solution.32 Another major technical progress has been the use of heterotic in maize and rice. The use of heterotic in maize started in the USA as early as the 1940s but China's maize yield only started showing a significant yield increase in the 1970s with the development of useful inbred lines. In recent years, maize production in China has again shown a significant increase. This is largely due to the increased market demand for animal feed. Growing maize has become more profitable now than ever.

The same increase in grain production gained from the policy or technology improvement in the past cannot guarantee to have the same impact in the future. The researcher did not further bring out a further suggestion for China's government to act in the future. This paper, on the other hand, will provide a possible solution for China to consider doing it in the nearby future. China did not sit and wait to see the world ends, for years after the world war, agricultural growth in China has accelerated significantly, most of this growth has been driven by increased yield per unit area

32 China's success in increasing per capita food production, Jianhua Zhang, Journal of Experimental Botany, Volume 62, Issue 11, 1 July 2011, Pages 3707–3711, https://doi.org/10.1093/jxb/err132 Published:06 May 2011

rather than by expansion of the cultivated area. Looking towards 2033, as a lot of researches suggest, to meet the demand for grain and to feed the growing population, the annual crop production should be increased to about 580 million tons and yield should be increased at least 2% annually since now.

The increase in total factor productivity of crop will become more difficult with climate change, resource scarcity (e.g. land, water, energy, and nutrients), environmental degradation (e.g. declining soil quality, increased greenhouse gas emissions, and surface water eutrophication), policy changes (e.g. Household Responsibility System), and education trend (e.g. teachers encourage students to do IT industry rather than farming to make more money). Under these difficulties, China's government sets a goal of increasing the food self-sufficiency from 90% to at least 95% to feed its population. This article will set a regression model of total factor production function regards four controllable factors as employment, machinery, irrigated land, and fertilizers to see if China can reach its goal and not drag the whole world into the food shortage crisis in 2033.[33]

If China cannot address its food problem in time, the entire global food market will be influenced. This article will provide a history of how China attempted to solve

33 China's success in increasing per capita food production, Jianhua Zhang, Journal of Experimental Botany, Volume 62, Issue 11, 1 July 2011, Pages 3707–3711, https://doi.org/10.1093/jxb/err132 Published:06 May 2011

food crisis problems in the past, and then look at the present agricultural condition. This article then will provide some possible solutions for China's food security. The economists of whom are interested in how China will react to the food problem, and China's policymakers will find this article useful and benefit from it. Although China has a lot of political issues that may not be changeable, this article will not focus too much on the policy-making part, but on the variables, which can be utilized. The results will found be useful by farmers or local government in China if the policy and big environment of China remain the same soon.

3.3 China's Successes in Increasing Food Production and Agricultural Labors

A sign of the transition from traditional agriculture to modern agriculture is the rapid increase in grain yields. [34]" In the past 2000 years, China's grain yield has increased by 70%; while between 1949 and 1978, the yield per unit of planted area has increased by 145%; between 1978 and 2010, the yield per unit of planted area has increased by 96.7%, and China's land productivity has reached the average level of high-income countries is much higher than the average level of upper-middle-income countries. [35] China's grain yields are not only far higher than those of Russia, Brazil, India, etc., and the level of the United States is also close. In 2011, US grain yields

34 Contemporary Chinese History Studies, Ann-Goun Hu, www.cpcnews.cn 2014

35 Contemporary Chinese History Studies, Ann-Goun Hu, www.cpcnews.cn 2014

were only China's. 1.19 times. The continuous improvement of grain yields has enabled China to solve the problem of eating more than one billion people with limited cultivated land resources.

The transformation of China's agriculture is also reflected in the continued decline in the proportion of agricultural labor. In 1952, the proportion of China's agricultural labor force was 83.5%, which was higher than that of the United Kingdom and the United States in 1820, and it was much higher than that of Japan in 1870. In 1973, the proportion of China's agricultural labor force fell to 78.7%. It was higher than Japan's 1870 level; in 1992, it fell to 58.5%, still higher than the US 1870 level; in 2012 it fell to 33.6%, still higher than Japan's 1950 level. This reflects that China's agricultural transformation is both a latecomer and a "long-term" of industrialization. It takes hundreds of years to complete the transition from a big agricultural country to a modern power. The process of agricultural transformation is a process of increasing the relative labor productivity of agriculture and non-agriculture. This is the fundamental reason for the widening income gap between rural and urban residents. Until the relative labor productivity of agriculture and non-agriculture shrinks, the income gap between rural and urban residents is likely to shrink.

China's agricultural labor is abundant and its cultivated land resources are scarce.

Therefore, compared with other big countries in the world, China's agricultural labor productivity is low, which has been lower than the world average labor productivity. In 1970, it was only equivalent to 1/4 of the world average, but it grew. The rate is quite fast, much higher than the world average growth rate, and by 2011 is equivalent to 3/4 of the world average. However, China's agricultural labor productivity (calculated in terms of agricultural value added, the US dollar price in 2000) is still much lower than that of the United States, Russia, Brazil, etc. China's agricultural labor productivity gap with these countries is much larger than the non-agricultural labor productivity gap.[36] This aspect has the reasons for resource constraints. On the other hand, it also shows that China also has a large potential for agricultural labor transfer to realize the replacement of labor by modern factors such as capital and technology.

3.4 Modern agricultural elements

In fact, agricultural modernization is the continuous strengthening of the input of modern agricultural elements, so that the basic production function combination method is constantly changing and occupying a dominant position and is universally applied to the entire agricultural production department. Increase grain yields and increase total agricultural output without increasing agricultural resources, especially

[36]Contemporary Chinese History Studies, Ann-Goun Hu, www.cpcnews.cn 2014

cultivated land resources. This is the process by which modern factors of production replace natural elements. Since the 1990s, modern agricultural elements have been applied on a large scale in China. The outstanding performance is that the white (plastic) revolution has taken place with the goal of saving land, saving time and water saving. By 2008, the use of agricultural plastics reached 2.007 million tons. In 2011, it reached 2.295 million tons. From 1978 to 2008, China's agricultural mechanization increased by a factor of seven. In 2012, the number of large and medium-sized agricultural tractors, rice harvesters and corn combine harvesters was 4.9 million units, 5.1 million units, and 2.3 million units respectively. Mechanized sowing and harvesting rates for wheat, rice, and maize increased by 55%. The proportion of machine-farming, machine-casting, and machine-receiving continued to increase.[37] By 2009, the proportion of machine-farming area to planting area reached 66.0%. Technological advances have become a major factor in the increase in agricultural output. In 2012, the contribution rate of agricultural science and technology progress reached 54.5%, which doubled compared with 27% in the early stage of agricultural reform. At the same time, excessive investment in modern factors such as fertilizers and pesticides has also brought about the question of whether agriculture can be sustainable. China's chemical fertilizer application has reached 1.93

[37] Contemporary Chinese History Studies, Ann-Goun Hu, www.cpcnews.cn 2014

times the internationally recognized safety limit for chemical fertilizer application (internationally recognized as 225 kg per hectare). At the same time, about 500,000 tons of agricultural film remains in the soil every year in China, and the residual film rate reaches 40%. In addition, 60% to 70% of pesticides remain in the soil."

3.5 Sea rice (2017)

China's recent endeavor to increase the amount of farming area and lay its eye on the nearby sea has been paid off. Recently, the science and technology have brought a breakthrough in planting in the sea.

[38]"The sea rice of Qingdao Sea Rice R&D Center ushered in a special examination on the 28th - Dajiao.com, a salt-tolerant rice material evaluation conference, reported that after more than ten experts evaluated, the theoretical output of the highest yield was 620.95 kg, far exceeding expectations. At present, China has nearly 300 million mu of saline-alkali land for transformation and utilization. Yuan Longping's team plans to promote 100 million mu of salt-tolerant rice planting in the country within 5 to 8 years. If calculated according to 400 kg per mu, the output is equivalent to 19% of the total national rice production in 2016. The Qingdao Sea Rice R&D Center is located on the west side of Baididi Park on the bank of Jiaozhou Bay in Qingdao. It is the director and chief scientist of Academician Yuan Longping, the

38 World journal, Xinhua News, Sep. 29, 2017

father of the world's hybrid rice. The Baididi Park and the Jinkou Zhenhai Rice Field in Jimo District began harvesting on the 28th. The Jinkou Zhenhai Rice Experimental Field is also a large-scale planting base for the trial of “sea rice”. According to the base staff, the development of salt-tolerant rice has lasted for four years. After 1,162 field experiments, more than 30,000 intermediate test and matching materials were obtained. This year, a total of more than 300 salt-tolerant rice materials were tested. Only a few materials performed well, and the heading was strong, and the elimination rate was as high as 95%. On the same day, more than 10 experts from the Chinese Academy of Sciences, Jiangsu Academy of Agricultural Sciences, Hunan Academy of Agricultural Sciences, Qingdao Academy of Agricultural Sciences, National Hybrid Rice Engineering Technology Center, Shandong Rice Research Institute, Hunan Agricultural University, Yangzhou University and other scientific research institutions witnessed more than 300 seas. The performance of rice materials, and the evaluation of "good seedlings" with high salt and alkali resistance and excellent performance.[39] This small area harvested, threshed, removed, measured moisture, weighed, and finally passed a fixed formula, the expert group gave the result of the per mu. Among the four materials, the maximum output measured by small area is 620.95 kg/mu. According to the 8-fold of field planting yield, the yield per mu can reach 500 kg.

[39] World journal, Xinhua News, Sep. 29, 2017

Even the lowest yield of salt-tolerant rice material, small area. The yield per mu also reached 438.14 kg.[40] In this period, China's yield had been found profoundly in the increase of the amount.

Qingdao Sea Rice Research and Development Center was established in 2016. It was jointly established by Qingdao Municipal Government and Academician Yuan Longping and National Hybrid Rice Engineering Technology Research Center. Yuan Longping is the director of R&D Center and Hai Rice R&D Base is in Baidi Park of Lisong District. Within, it covers an area of 40 acres. The center currently carries out research on salt-tolerant rice and saline-alkali rice improvement techniques, super-high-yield hybrid rice and third-generation hybrid rice technology, rice quality, and taste. The goal is to build a national-level research and development platform such as the National Key Laboratory of Salt-tolerant Rice and the National Sea Rice Engineering Technology Research Center within three years, to build a global leading team of hybrid rice, and to provide technical support and international promotion platform for the "Belt and Road". To solve the global food security problem, we will feed 500 million people in the world.

3.6 Agricultural Machinery

Agricultural robot technology can reflect agricultural machinery level and reduce

[40]World journal, Xinhua News, Sep. 29, 2017

agricultural labors. For many developed countries like the U.S, Japan, South Korea, and German, the agricultural robot has been already introduced into this industry for many years. In those countries, the robot is well developed, but for China, the journey is just beginning. This sector will talk about how China can introduce robots into the agricultural system and what type of robot is useful in which area.

In Aug. 2018, [41]"China launched a pilot project to replace farmers with "robots". The seven-year pilot project has been launched, including unmanned tractors, pesticide spray drones, and unmanned rice trans planters. These technologies are not yet widely available in China. China's mass production is inefficient, and contaminated farmland will be modernized through the project."

As in other developed countries, the agricultural machinery is already well developed, this includes their environment and people's habits. China must learn and utilize other countries advantage in agricultural robots, below will show America, Japan, South Korea, German, those developed countries' current agricultural robot condition.

American agriculture has achieved highly mechanized, large-scale and specialized production. In 2007, the single farm tractor in the United States was 85.06

41 Xio-cion Wrong, Robots reshape China's agricultural production model, www.huanqiu.com, Aug. 2018

hm2, the planting area was 37.45 hm2, and the harvested area was 28.6 hm2. Dr. Hou Fangan summarized the agricultural mechanization business model in the United States and summarized it into three main types, namely, self-purchasing (battalion), company hire (machine hire), custom service or contract services (custom work services or contract services).[42] From the perspective of social output, among the various types of agricultural mechanization management models in the United States, the proportion of white-purchasing self-use type is the highest, which is the dominant mode, followed by customized service, and then the company leasing type, farm self-operated agricultural mechanized operation output. The amount of China's total power usage will be more and more important for China, if it want to continue increase its productivity of agriculture. In order to make a proper improvement of China's machine condition, China has to be carefully select the right type of tools when importing from other countries. The socialized operation mechanism of various agricultural mechanized business models has matured.

Japan's agricultural mechanization business model can be divided into self-purchasing self-use type, joint use type, entrusted and entrusted business type and compound business type. Japan's agricultural machinery cooperation organization

42 Wang Peipei,Li Guanfeng,Liu Xiaowen,Yu Enzhong.Classification of Agricultural Mechanization Management Models in China[J].Journal of Agricultural Mechanization Research,2013,(4).

mainly establishes agricultural machinery banks, that is, several farmers join, one buys harvesters, the other buys trans planters, and the other several buy tractors and irrigation and irrigation machinery, operate independently, and coordinate and use them in a unified manner. The user pays the rent to the owner of the implement. This practice has the characteristics of a low investment, high efficiency, low operating costs, and significant social benefits. It was promoted in Tokyo in 1978 and there are currently more than 1,000 such organizations in Japan.

South Korea's agricultural mechanization business model can be divided into cooperative utilization and individual joint utilization mode. The cooperative utilization model is divided into three types: joint farmer, agricultural association, and experimental farm management operated by agricultural associations. Due to the joint use of agricultural machinery, the management of inefficient and conservative operators will cause the utilization rate of agricultural machinery to decrease, so the proportion of private management and utilization of farmers is gradually increasing. The operation of the joint utilization business model is also becoming more and more difficult.

Germany develops the agricultural machinery chain, which is a kind of agricultural machinery mutual aid cooperative. It is a form of voluntary joint farming and agricultural self-service cooperative services. The participating farmers all have

their own agricultural machinery and exchange and use each other through the liaison and coordination of the agricultural machinery chain. Realize interoperability and help each other. It has greatly reduced farmers' investment, improved the efficiency of agricultural machinery use, and promoted agricultural production. Through this form of professional cooperation in agricultural machinery services, the level of comprehensive agricultural mechanization has been further improved, the investment of farmers has been saved, and the productivity of agricultural labor has been greatly improved." From above, China must know each countries' condition is different to adjust their experiences to fit China itself the best.

CHAPTER 4

DATA AND EMPIRICAL MODELS

This paper examines the development process, characteristics and direction of the agricultural modernization road with Chinese characteristics, with a view to prospecting China's agricultural development tomorrow. This research paper will provide possible solutions of how to increase the crop productivity based on the result of models. To increase the crop production, this article will utilize four independent variables: agricultural employment, irrigated area, the total power of agricultural machinery, and total fertilizer consumptions, and four dependent variables as follow: grain, land, worker productivity, and total factor productivity growth index to find out appropriate way to increase productivity. After calculating regression functions, this article will also provide how much percent of each variable must increase to reach the 95 percent of food-self-sufficiency in the next twenty years.

4.1 China’s Agricultural Inputs

Data collected below are the trend of four variables of agricultural change in China after the world war. China’s agriculture employment started to increase after the Great Chinese Famine(1957-1962). As the figure 2 shows below, there was a rapid drop of ag employment in 1957, due to the decrease of the population from the thirty million people died from the dry weather and miss leading policies. However,

China quickly recovered from the great famine after the population dropped and foods became enough again for the remains. In 1992, the amount of China's farmers reached its peak at 390 million people. China's members of farming teams started to increase in 1960s. In 1970s, the member of farming team had increased to five million people. From this historic event, it is obvious that policies played an important role in China's agriculture industry. During the 1990s, the aftermath of the Tiananmen Square protests(1989) has slowly recovered and led China into an international and growing country. As the figure 2 showed, the amount of ag employment boosted after China's economic condition became clearer for the world outside and promising. In 2004, people began to seek new job opportunity in urban areas. This phenome is not a random happening, it was contributed by the long- last education that young man is not expected to stay in the farming county and be a farmer. However, compared to other developed countries' experiences, the drops in ag employment is quite normal as one country becoming more developed.

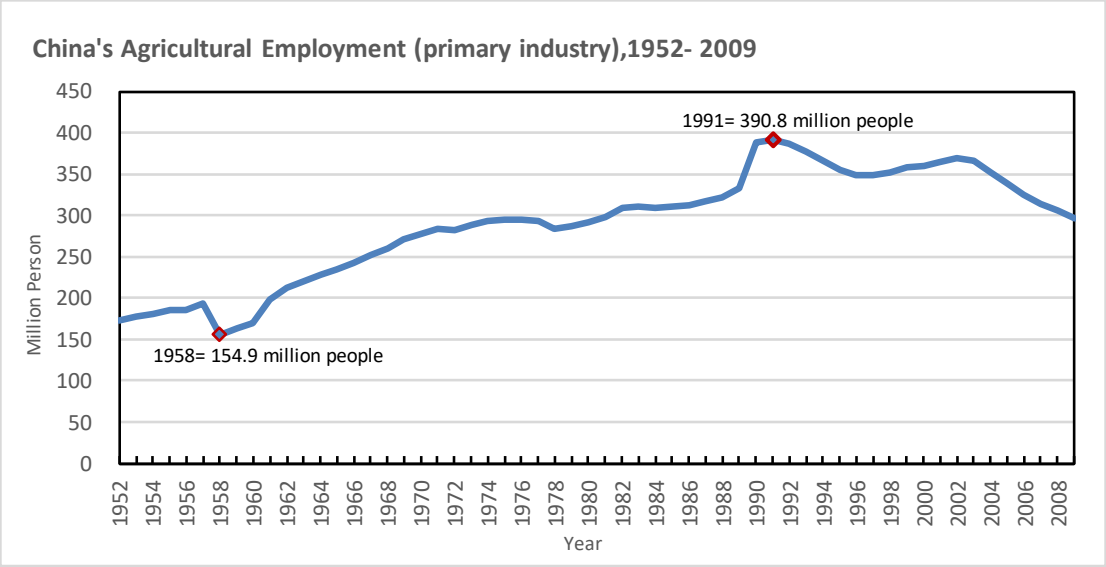


Figure 2. The trend of China's ag employment from 1952 to 2008, source: USDA

The irrigated area has a smoothing growing trend from 1949 to 2010(view figure 3). There's an interesting boost happened from 1957 to 1962. Just like the reason why agricultural employment dropped during the same period, the great increase amount of irrigated area at this time was caused by the policy to increase food production. The policy of "Mao's grand strategy for Cold War competition Mao's grand strategy for Cold War competition inflicted a catastrophic agricultural failure in China and victimized tens of millions of Chinese peasants. It argues that Khrushchev's 1957 boast about the Soviet Union surpassing the United States in key economic areas inspired Mao to launch an industrialization program that would push the People's Republic past Great Britain in some product categories within fifteen years. Beginning in 1958 Mao imposed unrealistic targets on Chinese grain production to

extract funds from agriculture for rapid industrial growth. Maoists placed relentless pressure on communist cadres for ruthless implementation of the Great Leap Forward. In the beginning, China enjoy the increase amount of irrigated lands. The increases were attributed by the new method of controlling river flooding. However, contrary to Maoist plans, China's grain output in 1959-1960 declined sharply from 1957 levels and rural per capita grain retention decreased dramatically. Throughout China, party cadres' mismanagement of agricultural production was responsible for the decline in grain output, and the communist state's excessive requisition of grain caused food shortages for the peasants. But the key factor determining the famine's uneven impact on the peasantry in the provinces was the degree to which provincial leaders genuinely and energetically embraced Maoist programs. This is illustrated by a close examination of the Great Leap famine in Anhui Province."[43]

43 Yixin Chen Cold War Competition and Food Production in China, 1957-1962, Article in Agricultural History 83(1):51-78 · February 2009

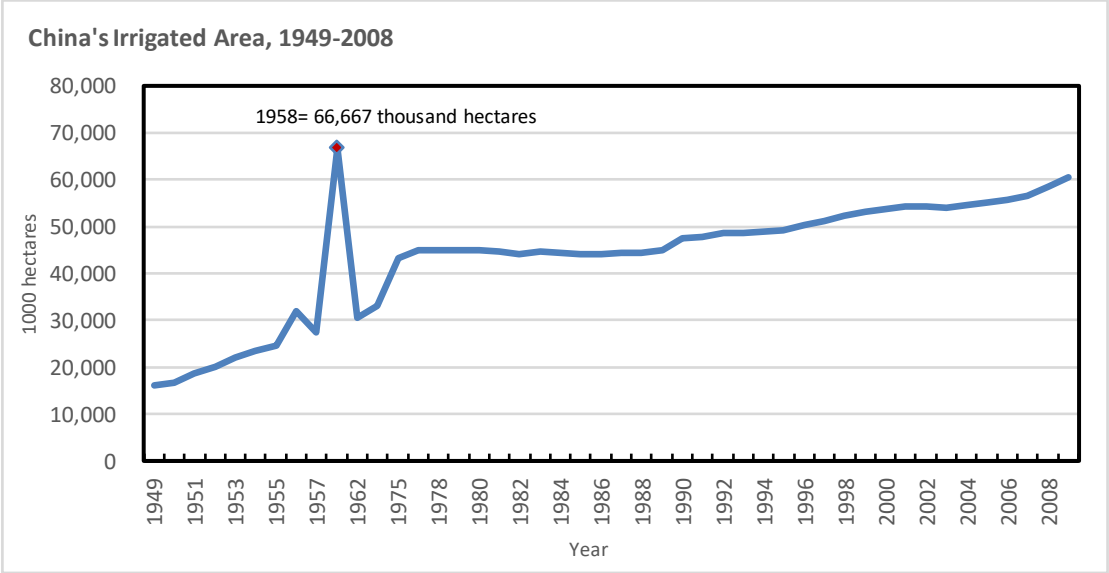


Figure 3. The trend of China's ag Irrigated area from 1949 to 2010, source: USDA

The total power of agricultural machinery started in 1978(view figure 4) since that is the year for China to introduce machines into the agricultural industry. One thing interesting to pay more attention is the year 1981. This was the year when China practiced the household duty policy of agricultural industry. Household duty policy allowed farmers to have freedom of managing their own farms, and thus created a boost in agricultural production. However, the expansion did not last long. After local government's farming teams slowly losing their authorities, farming teams can no longer teach farmers how to do and what to do. What's worse, farmers do not know the principle of markets. Often, farmers grow the same crop altogether, and the price of that type of plants decrease, and at the same time, other necessary food cannot meet the demand. The final table shows the water crisis in China. The map shows that

almost every farmland is in areas with polluted water recourse.

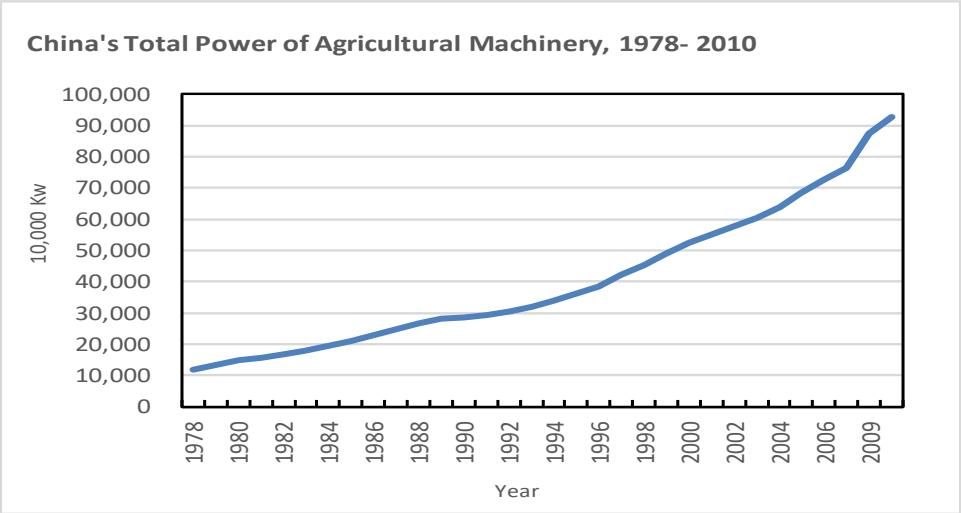


Figure 4. The trend of China's total power of agricultural machinery from 1978 to 2010, source: USDA

The use of fertilizer in China's agricultural industry was not as important as other sectors(e.g. employment, irrigated area) fifty years ago (see figure 5). It was not until the 1970's did China started to lay an eye on using fertilizer. Chemical fertilizer has been one of the most successful industries in China for the past two decades. The production and consumption of fertilizer continue to grow rapidly each year. The huge amount of fertilizer used for agricultural purpose contributed greatly to increase grain production(see regression model in the next chapter). In the future, China has to find a balance between using fertilizer to increase crop productivity and water pollutions.

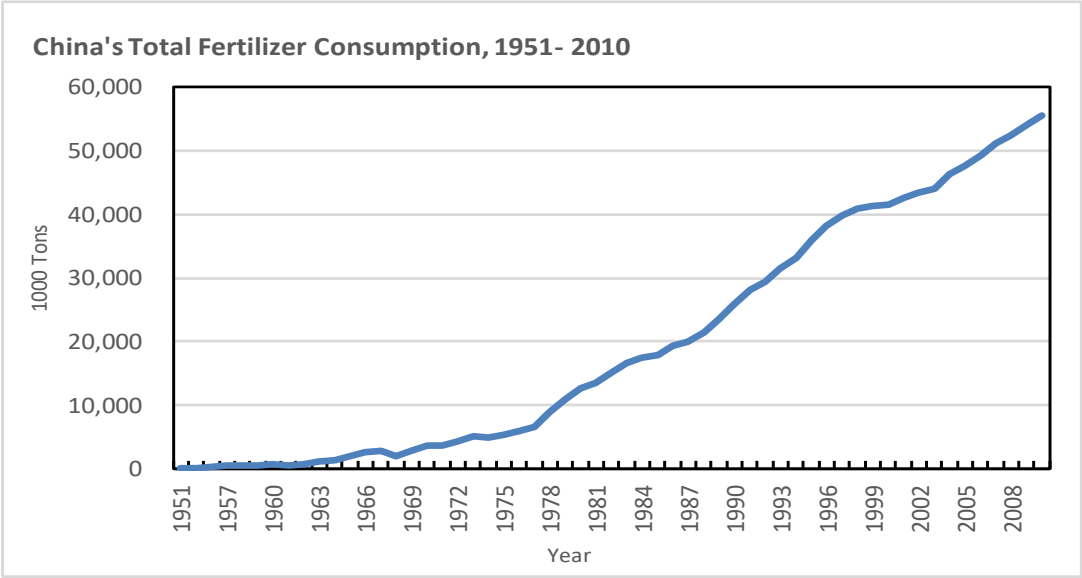


Figure 5. The trend of China's total fertilizer consumption from 1951 to 2010, source: USDA

4.2 China's Agricultural Production and Productivities

China's grain production steadily increases from 1949 to 2009(figure 6). In the graph, the sudden drop of production occurred during Chinese Great Famish(1957-1962). After the great famish, China recovered quickly and with many efforts, grain production increased each year. China's high price promotion encouraged farmers to increase their grain production. A drop occurred since 1998, when China's government suggested farmers to adjust their production. After grain production remained constant between 2002 to 2004, China's policymakers to deploy various

measures in early 2004 to promote grain production.[44]

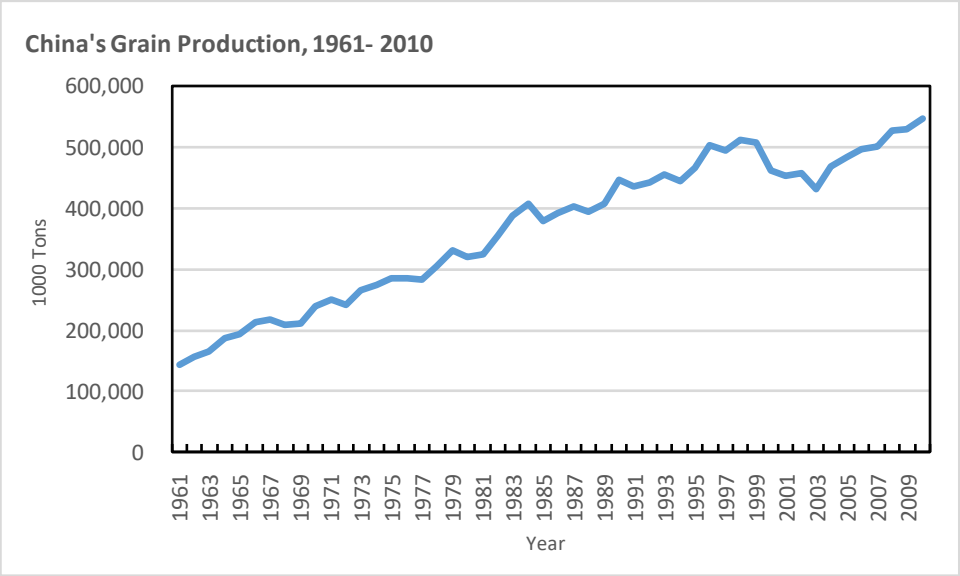


Figure 6. The trend of China's total grain production from 1949 to 2009, sources: USDA

China's historical land yield has been increasing steadily over fifty years. Although China has faced many policy failures in the past, the cereal yield of irrigated land did not have significant changes. It still managed to produce more kilograms of cereal each year(figure 7). After a remarkable 86% increase in cereal production from 1980 to 2005, recent crop yield growth in China has been slow. This was due to many constraints including lodging, heat during grain fill, mid-season' drought (crop water

44 Wei-Ming Tian. 2017. Grains in China: Foodgrain, Feedgrain and World Trade

deficit), terminal (grain filling) drought, irrigation problems and poor management of N fertilizer. [45] In the future, China's cereal yield irrigated land is likely to grow over time. However, we should not assume this trend will remain unchanged. China's farmers and government must keep searching new method to improve its productivity to secure its food supply. Also, land production has its limitation, it will not continue to be productive if people stop improving lands' condition.

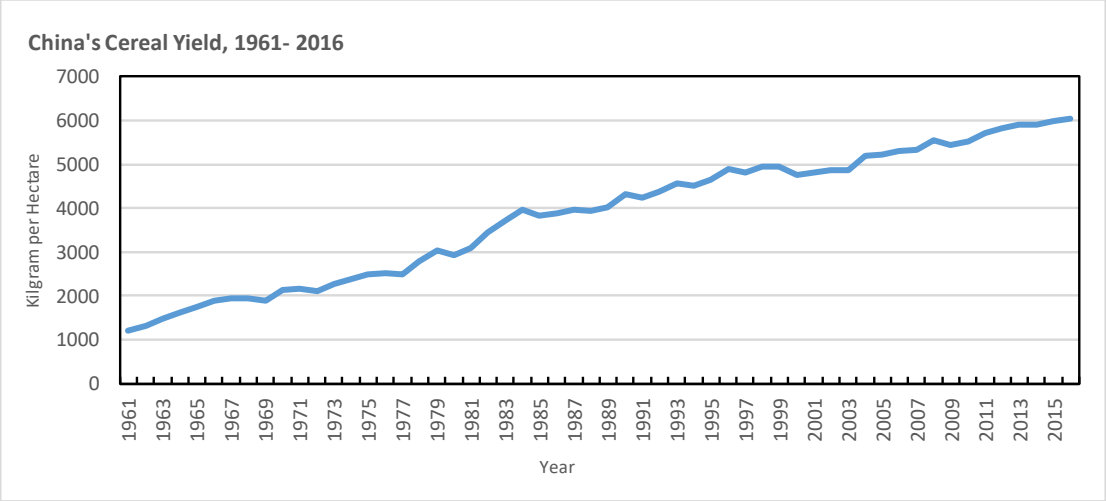


Figure 7. China's Cereal yield (kg per hectare). Source: world bank

China's agricultural productivity per labor has been slowly increasing over time. Between the year 1991 to 2004, the increase was not significant. However, after 2004,

45 Xiaoyun Li. 2016. Patterns of Cereal Yield Growth across China from 1980 to 2010 and Their Implications for Food Production and Food Security.

China’s agricultural labor productivity has been increased rapidly. To the year 2017, China’s agricultural productivity per labor has reach 6,000 U.S. dollar per worker(figure 8). It has always been a problem that China’s agricultural productivity remain much lower than developed country(0.8% of the U.S.)[46] China must find a way to increase its agricultural productivity in the future to free more labor from this industry if it wants a further economic growth. Plus, the increase in agricultural productivity can also help improve its crop production.

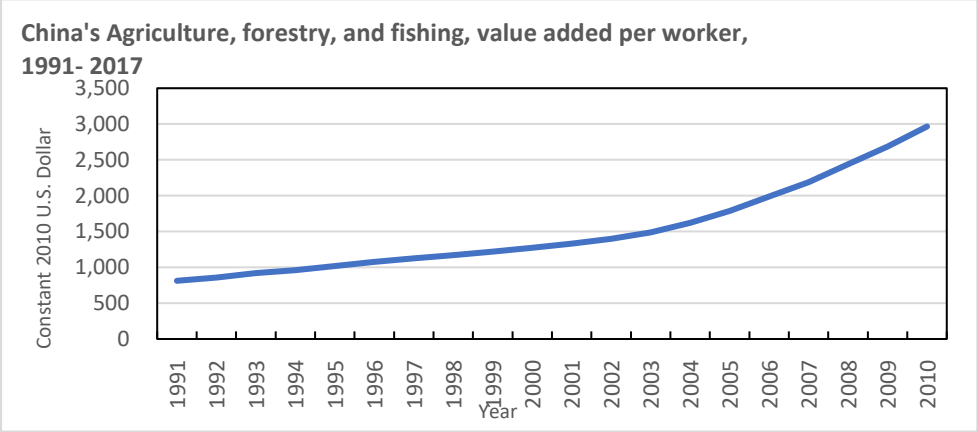
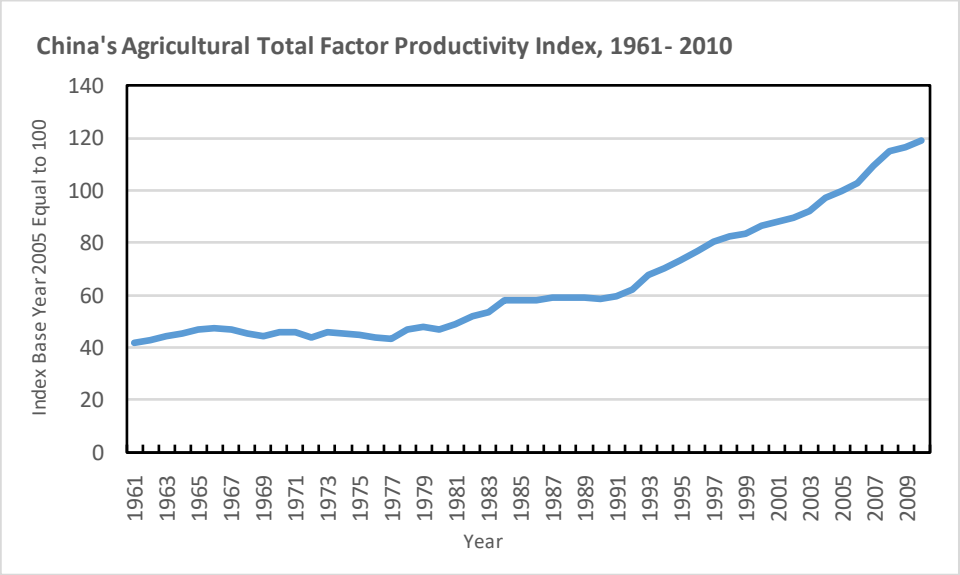


Figure 8. China's Agriculture, forestry, and fishing, value added per worker (constant 2010 US$). Source: world bank

Total factor productivity index provides the information of China’s TFP trend

46 Douglas Zhihua Zeng. 2005. China's Employment Challenges and Strategies After the WTO Accession.

over times. Between years 1961 to 1981, China's TFP indexes remained almost constant (figure 10.). After the household responsibility policy launched in year 1981, China's TFP index started to climb. From the observation, we can see the household responsibility policy played an important role in increasing China's agricultural production. Since the 1990s, modern agricultural elements have been applied on a large scale in China. The outstanding performance is that the white (plastic) revolution has taken place with the goal of saving land, saving time and water saving. The TFP index responded to the success of white revolution in China. With the help of plastic film mulch technology, grain and cash crop yields have increased by 20–35% and 20–60%, respectively. [47]



47 E K Liu. 2014. 'White revolution' to 'white pollution'—agricultural plastic film mulch in China.

Figure 9. The trend of China's total factor productivity growth index agriculture between 1961 to 2015. Source: USDA.

4.3 Economic Model

China's Grain, Agriculture, Land, Labor Productivity, and Total Factor Productivity Growth Index

This develop section discusses the impact of four independent variables(irrigated land, agricultural employment, total fertilizer consumption, and total power of agricultural machinery) on four depend variables. The four dependent variables are Chia's grain, land, labor productivity and total factor productivity. All dependent and independent variables use in regression are collected from the year 1961 to the year 2010. The reason of select these four independent variables is to see how each of the important variables will influence on China's crop productivity. Irrigated lands, agricultural labors, fertilizer, and machinery are important sectors that shift China's agricultural industry.

This paper chooses grain productivity as one of the important variables since the goal is to feed China's people. Grain is the primary crop for Chinese people. China must increase this type of production to feed its people, while other types of crop will be more efficient by imports. Total factor productivity growth index is the dependent variable that shows the total output of the agricultural industry. It allows us to see the

whole picture of China's agricultural productivity, and how these four major independent variables will influence it in the future. Land productivity is an important topic for researchers to observe the output of agricultural products based on each hectare. From land productivity, it is easy to observe whether each independent variable has effect on land production, and how much they influence it. The worker productivity in agriculture is to see each worker will generate how much output on agricultural productivity. It is important to test if there's a connection of it with four independent variables, because after all, all output of agriculture need somebody to make it.

Table 4. China's Dependent Variables

Dep. Var.	**definition**	**units**	**Mean**
Grain Production	The production of crop that human consumed, include corn, rice(milled), wheat, oats, rye.	1000 tons	326,323.06 (1961-2010)

Total Factor Productivity Index	The index calculates the growth of total factor productivity.	based year 2005= 100	71 (1961-2010)
Cereal Yield	The production of cereal includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains per hectare.	Kg/hectare	3832.55 (1961-2016)
Labor Productivity	Agriculture(crops and livestock), forestry, and fishing, value added per worker.	U.S. dollar	2282.64 (1991-2017)

Source: USDA, 2015

Table 4 shows each dependent variable's definition, unit it uses, and the mean. The grain production is calculated by 1000 tons, total factor productivity growth index is calculated with the base year 2005 equal to 100, cereal yield is calculated by each year's total cereal production divided by total hectares, labor productivity is calculated by total output in agricultural industry divided by amount of agricultural labors. The mean of grain production is 326,323.06 thousand tons. The mean of cereal yield is 3832.55 kilograms, compare of U.S's average 2136.53(source: USDA 2016) is slightly higher.

Table 5. China's Agricultural Independent Variables

Indep. Var.	**definition**	**units**	**Mean**
Agricultural employment	Number of economically active adults in agriculture	million person	288.99 (1952- 2009)
Irrigated Lands	Area equipped for irrigation	1000 hectares	36,807.56 (1949- 2008)
Total Fertilizer Consumption	total sum of nitrogen(N),	1000 tons	18,473.89

	phosphate (P2O5) and potash (K2O) used in agriculture		(1951- 2010)
Total Power of Ag Machinery	Aggregating the number of power used by agricultural machinery (include2-wheel tractors, 4-wheel tractors, and combine-harvesters)	10000 kw	38,603.48 (1978- 2010)

Source: USDA, 2016

Table 5 shows the independent variables' definitions, units, and means. The agricultural employment is calculated by head. China has a hugest number of farmers or job relate to agricultural industry workers in the world. The irrigated lands are calculated by area equipped for irrigation. The mean of irrigated lands is 36,807 thousand hectares. Total fertilizer consumption is calculated by the total sum of three types of fertilizer use in agriculture, the mean for it is 18,473 thousand tons. The total

power of agricultural machinery is calculated by the aggregated amount of power used in agriculture, the mean of it is 386 million kw.

China's grain/TFP/land/labor production use Q as the output, the equation is Q= f (X1, X2, X3, X4), where X1 is agricultural employment, X2 is irrigated area, X3 is total power of agricultural machinery, X4 is total fertilizer consumption. The paper will run the simple linear model to find out each variable's parameter and run double-log model to find out variables' elasticity. Finally, the test will show the result of t-test and give a prediction of production in the future based on test results.

4.3.1 China's Grain Productivity

The result of the simple linear regression model is showen in table 6. The result from the simple linear regression model can still be useful. This paper also distinguishes periods before and after household duty policy took place in the year 1981, mainly to see if any production improvement occurred due to this policy. Variables irrigated area(X2) and enzyme/fertilizer(X3) do not have significant t-test scores. The coefficient of the dummy variable shows that the household reasonability policy does have a significant impact on China's grain production. Also, the model has a significant F-test value, so it is safe to say that all the Bi are not equal to zero. From the R-square result: 0.965433, it is safe to say that about 96.54% of the grain production is contributed by our four independent variables(ag employment, irrigated

area,)

This paper uses the model to address the problem of increasing the grain production by 2% for each year. If using 2011 as an example, increase the 2% of grain production in 2010, which is 546,480 thousand tons, divided by three will equal to 10,929.6 thousand tons for each independent variable. Tus, for agricultural employment, China must invest 1,337,197 million dollars to increase the grain production by 10,929.6 thousand tons. For irrigated lands, China must increase 1,018 thousand hectares to reach the goal. For total fertilizer, China must increase 22,737.9 thousand tons to meet the goal.

From the result above, we develop a table of each independent variables telling each variables' parameter estimate, elasticity, and t-test varies(table 6). For agricultural employment, the parameter estimate is 367.0329, is the highest of all variables. It indicates agricultural employment varies with higher range between each year, each year's change in employment was significant. The agricultural employment is the third inelastic variable within four variables(0.325), it influences the grain production not much like others do. The t-test result of the agricultural employment and total fertilizer usage are significant, it means both has significant impact on grain production. On the other hand, irrigated lands and total power of agricultural machinery does not have significant t-test results. For the irrigated lands, the

parameter estimate is the smallest one(0.279437), which means each year's irrigated land increase will increase grain production the lest. The irrigated lands variable is an inelastic variable(0.03707428), which means it has little influence on grain production. The total fertilizer consumption has 6.241197 parameter estimate, which indicates it influence the grain production little. Increase the amount of irrigated lands may solve the crop production in the future, however, many China's potential lands for food production doesn't acquire enough water resources(figure 9), this topic will be disguises in the next paragraph. It has a most high elasticity among four variables(0.377738185), it means it has the significant impact on the grain production. It can be one solution to solve the problem to increase China's future grain production, by increasing fertilizer usage in crop production. However, the increase amount of fertilizer may further make the water pollution worse. Total power of agricultural machinery has a -1.452724 in parameter estimate, it indicates it has negative influence in grain production. It has a negative inelasticity and has a significant t-test. Researchers brought out the same result with it, the possible explanation is machines used in China are not efficient. The more inappropriate machines were introduced in China, the less grains were produced.

Table 6. Grain Production Model

Dep. Var.	Parameter Estimates	T-Test
Constant	109372	7.958362
Ag employment	367.0392	5.796146
Irrigated Lands	0.279437	1.256803
Total Fertilizer consumption	6.241197	4.594023
Total Power of Ag machinery	-1.452724	-1.783364

Table 7 interprets each variable's elasticity. With elasticity the research paper can further give some interpretation for the result. From this table, it is safe to say, every 1% increase in agricultural employment will increase 0.325% of grain production. Every 1% increase in irrigated area will increase the grain production by 0.038%. Every 1% increase in total fertilizer consumption will increase the grain production by 0.378%. Every 1% increase in total power of agricultural machinery will decrease the grain production by 0.185%. For the dummy variable, the result shows the grain production after household responsibility policy practiced in 1981 has 49733.47 thousand tons more grain production than the period before the policy during years from 1949 to 1980.

Table 7. Elasticity of independent variables

	Grain production	Agricultural employment	Irrigated area	Total fertilizer consumption	Total power of ag machiner-y
avg.	326313.0609	288.9918966	43293.55704	19749.5614	41454.812
coefficient		367.0392	0.279437	6.241197	-1.452724
elasticity		0.325060095	0.03707428	0.377738185	-.1845540

China's grain production has all four inelastic independent variables(agricultural employment, irrigated area, and total fertilizer consumption, and total power of agricultural machinery). This observation indicates that these three variables influence little with grain production. China may have a huge boost in grain production by increasing the amount of irrigated lands. However, many lands had long been lacked water, even for the current exit farm lands(figure 10). From the figure, the heavy farming lands were running out of water, it limited the potential of further increasing the crop production. The most lacking water areas were in the north east part of China, where China depend on the most for crop production. If China want to increase its crop production, it must solve the water problem first. China must bring back water resource from other industries. If China can gain and save more water and put it into agricultural sector, China may have a better chance to improve its crop production in nearby future.

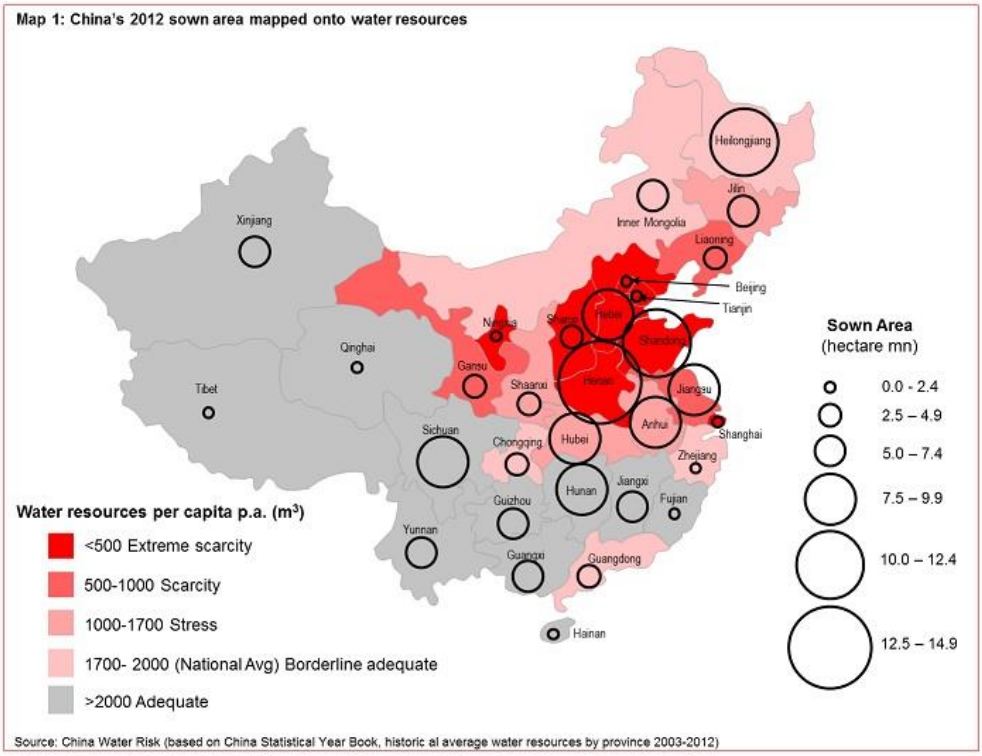


Figure 10. China's sown area mapped onto water resources. Source: Claudio Delang, Hong Kong Baptist University.

4.3.2 China's Total Factor Productivity Growth Index Agriculture

China's rate of growth in agricultural productivity has been increasing significantly through history. During the first ten years between 1961 to 1970, however, it grew rather slow. It was not until 1970's did China's productivity started to increase fast. Rate of growth in agricultural productivity is calculated using the output collected from FAO gross agricultural output (GAO). We include China's agricultural total factor productivity(TFP) indexes to see the overall productivity trend from year 1961 to year 2015.

Figure 10 presents agricultural TFP indexes (base year 2005=100) over 1961-2015 using primarily FAO data, supplemented in some cases by national statistics. Output is FAO gross agricultural output (GAO). Input growth is the weighted-average growth in quality-adjusted land, labor, machinery power, livestock capital, synthetic NPK fertilizers, and animal feed, where weights are input (factor) cost shares. Agricultural TFP indexes are estimates by country and for groups of countries aggregated by geographic region and income class. Input growth is the weighted-average growth in quality-adjusted land, labor, machinery power, livestock capital, synthetic NPK fertilizers, and animal feed, where weights are input (factor) cost shares(Source: world bank). Presents agricultural TFP growth indexes (based year 2015=100) over 1961-2015 using for primarily FAO data, supplemented in some cases by national statistics. To calculate total factor productivity, we use the rate of growth in an economic series X between years t and t+1 is defined by Ln(Xt/Xt+1). The average rate of growth in series X over years t to t+n is the coefficient β from the regression Ln(Xt) = α+ βt. This is determined in Excel using the formula Ln(logest(Xt:Xt+n)), where (Xt:Xt+n) corresponds to the addresses of the cell range containing the series (formula source: USDA, 2018).

The regression model uses agricultural employment, irrigated land, total consumption of fertilizer, total usage of machinery as independent variables. Uses

gross output as dependent variables. The regression model ran by double-log method; thus, the result of coefficients is representing elasticity of each variables. Form the model, we develop China's TFP growth index table. The t-test result of all variables are significant, it means all independent variables have significant impact on total factor productivity index.

Table 8. China's Total Factor Productivity Index in Agriculture

	Parameter Estimates	**T-Test**	**Elasticity**
Constant	58.952800	2.556069	4.205348
Ag employment	0.0004840	3.557959	0.24026
Irrigated Lands	-0.0895310	-5.878759	-0.572315
Total Fertilizer consumption	0.0000139	3.938148	0.668294
Total Power of Ag machinery	0.0008290	2.818921	0.201446

Table 8 shows each independent variables' result from a double-log model. All four independent variables are inelasticity to the TFP index, which indicated the little influence on the change of TFP index. For agricultural employment, the parameter is 0.000484, is the second smallest one within three positive parameter estimates. The irrigated lands have the negative parameter and elasticity among all. It means each

year; the irrigated lands have large negative influence on TFP index. The reason behind it is that each land increase may not necessary brings out enough production with the land. Many irrigated lands in China are not appropriate for any crops, the increase amount of them will only pull down the agricultural production. Total power of machinery has the largest elasticity(0.0008290). It means it plays the most significant role of influencing TFP growth index that every 1 % increase in fertilizer usage will increase the TFP by around 0.97% of TFP. The interesting thing is that irrigated lands has the negative elasticity which means each 1% increase in irrigated area will decrease the TFP by -0.16%. Only the irrigated area does not have the significant t-test result.

4.3.3 China's Land Productivity

China's land productivity has been increasing slowly and constantly through the 1961 to 2010. Based on the graph, all the human deserters ever happened in China seems unable to impact the land's productivity.

This land productivity model runs China's land yield based on the same independent variables as grain productivity models, from 1978 to 2008. The regression model is run with the method of double-log approach. The result is showed in table 9.

The regression model uses agricultural employment, irrigated land, total consumption of fertilizer, total usage of machinery as independent variables. Uses

yield per hectare as dependent variables. The regression model ran by double-log method; thus, the result of coefficients is representing elasticity of each variables. Form the model, we develop China's land productivity table.

Table 9. China's Land Productivity

Dep. Var.	Parameter Estimates	T-Test	Elasticity
Constant	6822.641	5.209850	10.21234
Ag employment	0.006526	0.442136	0.035573
Irrigated Lands	-1.007413	-1.169685	-0.135672
Total Fertilizer consumption	-0.112954	-2.647408	-0.535263
Total Power of Ag machinery	0.080950	4.994640	0.425256

Table 9 shows each independent variables' result from a double-log model. For all t-test results, agricultural employment and irrigated lands do not have significant impact on land productivity. On the other hand, total fertilizer consumption and total power of agricultural machinery have significant impact on land production. If China intend to increase the land productivity in the future, it can focus on promoting the usage of fertilizers or agricultural machines. For agricultural employment, the parameter is 0.06526, is the smallest one within three positive parameter estimates.

Agriculture employment influence the lest in land production, very one worker increase in agriculture will increase 0.006526 kilograms in land productivity. For irrigated lands, its parameter estimate is -1.007413, and elasticity is -0.1355672, not like the one in TFP growth index, this time the irrigated land has large influence on land productivity. Every 1000 hectare increases in irrigated lands will decrease the land productivity by around 1 kilogram. Total power of agricultural machinery's parameter estimate is like agricultural employment that influence not much to the labor productivity. Total fertilizer has negative parameter estimate(-0.112954). It means every 1000 tons increases in the consumption of fertilizer will decrease the land productivity by 0.112954 kilograms. Total power of agricultural machinery has the largest elasticity(0.425256). It means it plays a rather significant role of influencing the land's productivity that every 1 % increase in machinery usage will increase the yield per hectare by around 0.43%. The interesting thing is that irrigated lands and total fertilizer consumption have negative elasticity which means each 1% increase in irrigated area will decrease the yield per hectare. Only the irrigated area does not have the significant t-test result.

4.3.4 China's Labor Productivity

China's labor productivity has been increasing steadily over the period. Compared to the land productivity, labor productivity grew slower, especially between

1991 to 2002. After the year 2002, China's Agriculture, forestry, and fishing, value added per worker started to increase significant.

This Agriculture, forestry, and fishing, value added per worker (constant 2010 US$) productivity model runs China's labor productivity based on the same independent variables as grain productivity models, from 1978 to 2008. The regression model is run with the method of double-log approach.

The regression model uses agricultural employment, irrigated land, total consumption of fertilizer, total power of machinery as independent variables. Uses China's Agriculture, forestry, and fishing, value added per worker as dependent variables. The regression model ran by double-log method; thus, the result of coefficients is representing elasticity of each variables. Form the model, we develop China's worker productivity table.

Table 10. China's Worker Productivity Agriculture

Dep. Var.	**Parameter Estimates**	**T-Test**	**Elasticity**
Constant	70.066530	1.001599	6.004334
Irrigated Lands	-0.169874	-2.284971	-0.877436
Total Fertilizer consumption	0.002780	2.230415	1.246375
Total Power of Ag machinery	0.014900	1.850919	0.185839

Table 10 shows each independent variables' result from a double-log model. From the t-test result, only total power of agricultural machinery does not have significant impact on labor productivity. For total power of agricultural machinery, their parameter estimates, and elasticity are all negative. It is obvious that the amount of irrigated lands has negative influence on the agricultural value add per worker. Total power of agricultural machinery has a rather large parameter estimate among negative ones. Every 1000 tons increase in consumption of fertilizer will increase the labor productivity by 0.002780 dollars. The reason of irrigated lands has such high influence in labor productivity is because each land increase in agricultural usage will dilute each labor's productivity. The total power of agricultural machinery has an 0.185839, it's an inelastic variable. This indicates that although the increase in the total power of agricultural machinery will increase the worker productivity, the influence is not significant. Total fertilizer consumption has the largest elasticity(0.0149). It means it plays the most significant role of influencing the worker's productivity that every 1 % increase in total fertilizer consumption will increase the worker productivity by around 1.24%. The interesting thing is that total fertilizer consumption, and total power of agricultural machinery have positive elasticity which means very percent increase in these independent variables will

increase the worker productivity.

Base on the result above, China has several methods to improve its agricultural productivity per worker. There exist different conditions of elasticities between each dependent variable. Many of them are contradict to each other. To draw this question, many suggest using the total factor productivity growth index as the main productivity to increase, but it will be hard for China.

With three positive elasticities calculated from agricultural employment, total fertilizer consumption, and total power of agricultural machinery, it may be valid to increase these variables to increase the growth rate. However, combined with all other land productivity, and labor productivity, it may seem over simplified the situation of China's agricultural condition. We need to narrow down and focus on increasing grain production as like China did to itself. Although China utilizes its four agricultural inputs to increase the grain productivity will inevitably decrease some partial agricultural productivities, it must do so to ensure the grain productivity. If China can put enough attention in improving its grain production, it will have better chance to reach its goal of reaching the 95 percent self-sufficient food supply policy.

CHAPTER 5

CONCULUSION

China, as one of the world's largest consumer, and importer of agricultural commodities, every step it takes will shake the global food market. China has tired many policies in the past to meet its continuing increasing demand of foods, but in vain. Many ended in disasters. In the modern period after 2002, China has replaced its long existing tax policy with the producer subsidies. This temporarily solved the aim of 95% self-sufficiency policy. However, the government intervention will not be the long-term solution if producers become too rely on the subsidies. The market mechanism will have to be introduced to fix the problem of producing efficiency. In fact, China's self-sufficiency police mainly focus on the grain productivity, and the animal products are relay on imports. This paper discusses the problem of China's food security and solutions China's government had tried in the past. This paper also analyzes possible solutions and shows why it is difficult for China to increase its crop production in the long run. In the end, the paper brings out the statistical data of grain productivity, total factor productivity growth index, worker productivity, and land productivity with four independent variables(agricultural employment, irrigated lands, total fertilizer consumption, and total power of agricultural machinery). The paper then further run the regression model to see how much percentage of each variable

should increase for China to reach the 95% self-food sufficiency in 2033. As China's population continue growing after it canceled its One- Child policy and the diet habit changing, it needs more foods to feed its people. The urbanization also caused China harder to achieve it 95% self-sufficient in feeding people. The more urbanized China gets, the more foods it needs to feed its people's western diets. Also, the lack of water resource pulls China's leg from moving forward to improve its crop production.

There are many experts and researchers try hard to find out ways to achieve China's food policy. In the past, we see many policies directed by the Chinese government. Many ended in deserters that caused millions of deaths. China has spent billions of budgets trying to improve its crop production but in vain. There's a one successful moment in history that China's Household Responsibility policy did make the crop production increased. The success did not last long however, it ended very soon when local policymakers no longer able to communicate with farmers. The policy ended up booking the trust between government and farmers. China's agricultural industry has been highly independent on government's policies. China has to be extremely careful in making agricultural policies in the future if it wants to improve its agricultural condition.

From the result of the models and data, China's land productivity, worker's productivity, and total factor productivity index shows different elasticity conditions

with independent variables. There thus generates many contradict solution of increasing China's grain production. If China wishes to increase its grain productivity, it may think of increasing its agricultural workers' amounts. However, China's labor force has been directed or motivated by the tech industry, and it will be very difficult to increase the number of farmers. China must focus on a broad scope of the production function, which is total factor productivity. To increase its TFP growth index, China needs to increase the total fertilizer consumption and total power of machinery usage. If we narrow down the plan to focusing on increasing grain production, from the model result, we can make a conclusion of how China should do to reach the goal. To achieve feeding the growing population, China must increase the grain production significantly. The goal for China to be able to sustain the increasing grain consumption, it should increase the grain production by 2% annually. If China can increase the agricultural employment, irrigated lands, and total fertilizer consumption altogether, every 1% of these three independent variables will increase the grain production by 0.7398%. To meet the goal of 2% increases of grain production, China must increase agricultural employment, irrigated lands, and total fertilizer consumption each by 2.703168234% annually. It will be unrealistic for China to increase its agricultural employment. If we only utilize total fertilizer consumption, then China has to increase It is a challenge for Chinese farmers, and its

government. However, if China does not act, very soon it will run out of time to make any difference.

There are many other ways to increase crop production to achieve the 95% of self-sufficient of feeding people(e.g. sea rice, agricultural machines). China recently has invested a great deal amount of time and efforts to try to increase the amount of crop it produces. The technology imported from German and other developed countries were promising to solve the problem. The agricultural machinery will help farmers to harvest, however, the price currently is still too high for farmers to afford. If China can lower the machinery cost, farmers may able to improve their producing cost, and thus able to increase their food production. Also, the sea rice maybe another way out for China to solve its lack of water resources. If the technology of sea rice can be spread around the coastal area, there will be a great and bright future of crop production in the future.

Critics have said that China can import more from large agricultural export countries such as U.S or Brisiel to solve the food crisis problem. This argument did not take the limitation of those countries' crop productivity into account. If China's population continue growing, soon, there will be no country can feed this huge population. Based on empirical results, in the future, China will be able to sustain and increase its grain production and other partial agricultural outputs. With the global

mechanism and China's endeavors, China will be a secured place where no one will have a empty stomach ever again.

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