Chinese Agricultural Development in 30 Years: A Literature Review

Xiaohua YU
Courant Research Center "Poverty, Equity and Growth"
University of Göttingen
Platz der Göttinger Sieben3,
Göttingen 37073, Germany

xyu@uni-goettingen.de

Guo Qing ZHAO
School of Economics,
Renmin University of China，100872

zhaogq@ruc.edu.cn

Jul. 6, 2009

Please refer to:
Yu X. and G. Zhao: Chinese Agricultural Development in 30 Years: A Literature Review. *Frontiers of Economics in China*, Vol.4 (4):633-648.

Chinese Agricultural Development in 30 Years: A Literature Review

Abstract:

This paper reviews the current literature on Chinese agricultural growth in the past three decades, and finds that fertilizers, price reforms, human capital growth, and demographic changes are the main factors for the continuous growth of agricultural outputs and farmer income. The costs for the growth include severe environmental pollutions and the incoming population aging which should be cured in order to achieve a sustainable growth.

Key Words: Agricultural Development, Human Capital, Non-Point Pollution, China.
JEL: O4, Q1

1. Introduction

In the past three decades, Chinese agriculture has been keeping high growth rates, and successfully feeds the largest and continuously increasing population in the world. The outputs of grains increased from 305 megatons in 1978 to 501 megatons in 2007, and increased by 64%; while in the same period, the population increased from 963 million to1.32 billion, and increased by 37%.[1] The growth rate of grain outputs overtakes population growth. On the other hand, the grain acreage shrunk from 120.6 million hectares to 105.6 million hectares, and decreased by 12.4%, due to land degradation, desertification, urbanization and other reasons[2] (Rozelle, Veeck and Huang 1997, Brown 1995).

Obviously, the improvement of yields is the only means to break the constraints of land resources and achieve sustainable agricultural growth in China. Based on the FAO (Food and Agriculture Organization) statistics, (1) the yields of maize and wheat almost tripled, and the yields of rice almost doubled in China from 1965 through 2002; and (2) China is currently one of the countries with the highest yields in the world, more than double of those in African countries.

---

[1] Sources: China Statistical Yearbook (Various Edition),

[2] China changed its standard of the statistics for arable land acreage, which makes arable land acreage incomparable. This study uses the grain acreage to approximate the arable land acreage.

As Schultz (1953) pointed out, there are two stages in agricultural development: the Food Problem in developing countries and the Farm Problem in developed countries. Hayami and Godo (2002) added another problem between them--- the Poverty Problem in middle-income countries. In developing countries, food is always not enough to satisfy the demand due to low yields, which may cause high food prices and impede economic growth in non-agricultural sectors, as is happening in current Africa. Fortunately, so far, China has successfully solved the Food Problem by a continuous increase in yields, and currently is facing the Poverty Problems of farmers. As Hayami and Godo (2002) pointed out, the disparity between agricultural sector and non-agricultural sector will increase due to resource constraints in agriculture after economic take-off.

[Insert Table 1]

The income of farmers in China has been growing very fast so far. It has changed the livelihoods of a lot of poor farmers. The poverty rate in rural China has been substantively decreasing in the past three decades (Fan, Zhang and Zhang, 2004). Table 1 shows the changes in income and the poverty rate in rural China after 1978. The nominal net income for farmers increased from 133.57 yuan in 1978 to 2622.20 yuan in 2003, and increased to about 20 times in 25 years. When considering the inflation, the net income also increased by more than 4 times. The poverty population and the poverty rate, respectively, decreased from 250 million and 30.7% in 1978 to 23.6 million and 2.5% in 2005. The economic growth in rural China does not only change the poverty figure in China, but also changed the poverty map of the world (World Bank, 2008).

How could China sustainably improve agricultural yields and increase farmer income in the past three decades? What are the lessons and experiences in this period? Reviewing the current literature and turning around to have a look at what happened in the past three decades in China, this paper tries to give some answers to these questions. More importantly, and hopefully, it may give some policy implications for the ongoing agricultural development and poverty-fighting in China and other low-income countries such as the African countries as well.

2. Sources of Growth

Most economists attribute Chinese agriculture development to input increases, technical improvement and institutional changes (Fan 1991, 1999; Lin 1987, 1992a; Fan and Pardy 1997). In this section, we will briefly review the main findings from the current literature.

2.1 Physical inputs

Land, labor, capital and fertilizers, in general, are considered the main inputs for agriculture production (Brown 1995), and the agriculture in China is not an exception. So far, a large volume of literature has examined their roles in Chinese agriculture growth. Table 2 gives a brief summary of the output elasticities with respect to the different inputs in the current literature. The common finding is that the output elasticity with respect to land is general higher than other inputs. As one could expect, the land resource in China is relatively scarce, and the output would be very sensitive to the input.

[Insert Table 2 and Table 3]

Lin (1992), and Fan and Pardy (1997) decomposed the sources of agricultural growth in different periods, as shown in Table 3. We can find that fertilizer is the largest contributor in physical inputs to agricultural growth in China. Fan and Pardy (1997) find that 21.7% of the agricultural growth from 1965 to 1993 in China is contributed by fertilizer inputs; and 12.9% from power input. However, the contributions of land and labor are very little. Expansion of agricultural land in China is physically impossible, and rather, agricultural land is shrinking due to desertification and urbanization. Furthermore, 70% population lives in rural China, and the marginal output of labor is close to zero based on the dual-economy model (Watanabe 1996; Hayami and Godo 2005).

Watanabe (1996), Qiao et al. (2003), Hayami and Godo (2005), and Byerlee (1987) pointed out that fertilizer is crucial for the Green Revolution. Modern varieties of rice and wheat have semi-dwarf characteristics, with short and stout stems for sustaining heavier grain yields and with pointed leaves for better reception of solar radiation. Higher yields can be achieved by higher levels of fertilizer inputs. The statistics show the correlation between grain yields and chemical fertilizer utilization in China are very high after 1950. The statistics from FAO also show that China is the one of the most fertilizer-intensive agricultures in the world and the Nitrogen fertilizer use in China are significantly higher than other main developing countries. For instance, the fertilizers per hectare are more than ten times higher than those in African countries.

With further increase of fertilizer utilization, the Diminishing Law of Marginal Return comes to regulate Chinese agriculture. Fan (1991) finds that output elasticity with respect to fertilizer is 0.43 during the period from 1965 to 1985; while Chen, Huffman and Rozelle (2006) find that it decreases to 0.22 nationwide in the period from 1995 to 1999.

Fan and Pardy (1997) also find that the contribution of irrigation to agriculture growth before the Economic Reform in 1978 is about 9%, and the contribution after 1978 is almost nothing. Irrigational land usually has higher yields than dry land. In the era of the Planned Economy, China input a lot of manpower to develop a good irrigational system, which contributed a lot to Chinese agriculture growth, even after the 1978 Economic Reform. Fan, Zhang and Zhang (2004) calculate that the marginal return to the investment in irrigation is more than 1 yuan to1 yuan input nationwide in 2000. However, the expansion of irrigational land has been stopped by the scarcity of water resources in recent China (Brown 1995).

2.2 Technology

Xu (1999) finds that TFP (Total Factor Productivity) in Chinese agriculture increased by 47% from 1979 through 1996, and most technical innovations happened after 1987. There are mainly two innovations: the use of hybrid seeds and the changes in cropping system. Huang and Rozelle (1996) find that from 1975 to 1990, the technological change contributes 60% of the increase in rice productivity, in which the use of hybrid seeds is 49% and the changes in cropping system is about 11%. Consistent with Xu (1999), they also find that most technological changes happened after 1985. Similar results are shown by Mao and Koo (1997) in which technological innovations are the most important factor for agricultural growth in most provinces in China from 1984 to 1993; and in Jin et al. (2002) from 1980 through 1995 as well.

Apart from technological innovations, the technical and allocative efficiencies also changes. Using the data from Zhejiang Province between 1986 and 2000, Brummer, Glauben and Lu (2006) find that the increase in agricultural productivity mainly happened before 1990, and the technological efficiency increased very fast during that period and the allocative effects can be negligible; while after that both the technological and allocative efficiencies are stagnant.

Lin (1992b) points out that the technological innovation and diffusion, such as F1 hybrid rice in China, is induced by market demand.

Research and education is the engine for technical change (Mao and Koo 1997; Jin et al. 2002). As shown in Table 3, Fan and Pardy (1997) find that research contributed 19.5% of the agricultural growth from 1965 through 1993; and the fluctuation during this period is also very small. Fan, Zhang and Zhang (2004) calculated the marginal return of government R&D investment in agricultural is 6.75, significantly less than the study of Fan and Pardy (1997). This should be further scrutinized.

After the 1978 Economic Reform, particularly after 1990, China has invested a lot of money in plant biotechnologies to improve agricultural yields in order to feed the increasing large population. A survey of Chinese plant biologists shows that China is developing the largest biotechnology capacity outside of North American (Huang et al. 2002).

Lin (1992a) also studied the contributions of changes in cropping systems in China. He finds that the contribution of spread of multiple-cropping on Chinese agriculture growth is 1.94% from 1978 to 1984 and 20.9 % from 1984 to 1987. It indicates that the contribution of the changes in cropping system mainly happened after 1984.

2.3 Institutions

Institutions do matter for agricultural growth in China. In a series of studies, Lin (1987, 1992a, 1996, 1999, 2007) argues that the cooperative farming in the planned economy is not efficient because farmers tend to shirk, and the monitoring costs are very high. As shown in Table 3, Lin (1992a) finds that the Household Responsibility System contributed 46.89% of the agricultural growth from 1979 to 1984, compared with the benchmark period from 1984 through 1987.

Contrast with Lin (1992a), a study by Fan and Pardy (1997) finds that the institutional changes from 1978 through 1984 contributed 38.6 % of agricultural growth; and furthermore institutional changes from 1985 through 1993 contributed 42.10% of the agricultural growth in China. The institutional changes from 1985 through 1993 have a larger contribution than those from 1978 through 1984. However, a later study by Fan, Zhang and Zhang (2004) finds that the institutional reforms contribute 60.08% of agricultural production growth during the period from 1978 through 1984, and -0.84 during the period from 1985 through 2000. It seems that there are some contradictions about the contributions of the institutional changes to Chinese agricultural growth.

It was a systematic work to reform the cooperative farming from the planned economy. In order to quickly achieve the goal of industrialization, China carried out a strategy of concentrating on development of heavy industries in the era of the planned economy (Lin, Cai and Li, 1999), and suppressed food price to extract from agriculture. In order to make the strategy work, China developed People's Commune System, which is a kind of cooperative farming (Lin 1996).

Reforming the cooperative farming in a planned economy to the Household Responsibility System is only one polar of the transition from a planned economy to a market economy, and the other important polar is the price reform (Wiens 1983).In a sense, the changes in price policies might be the center of the reforms. Ignoring the price reform, we may have some contradicting results in studying the institutional changes in China as we show above.

3. Price Reform and Agriculture

3.1 Price

Many developing countries have the Food Problem as Schultz (1953) suggested. Food shortage often causes increase in food prices, which may harm the strategy of industrialization. Before 1980s, many developing countries suppressed their food prices to extract from agriculture so that they can supply cheap food for non-agricultural sectors; and they imposed export taxes on agriculture commodities to collect the government revenues. In order to protect their industrial sectors and correct the imbalance among industries, they usually overvalued their currencies (Mamingi 1996, Hayami and Godo 2002, Tolley et al. 1996, Huang et al. 2006, World bank 2008).

Under such price polices, the food prices in developing countries were relatively lower than industrial products, such as chemical fertilizers, an important input for agricultural production. The basic microeconomic theory shows that farmers would input less than equilibrium input under the distorted price system.

The distorted price policy in China collapsed at end of 1970s, due to low agricultural yields and cumulated economic imbalances. After 1980s, a lot of developing countries changed their price policies, and started to deregulate food prices (Mamingi 1996, Tolley et al. 1996), as happened in China. Some countries even subsidized the inputs, such as chemical fertilizers, and made the input prices relatively lower than the equilibrium level. The reforms of price policies made food prices relatively higher than input prices, so that the marginal output might be lower than the optimal level, and the output would be higher than equilibrium quantity.

After the 1978 Economic Reform, China started to increase the purchasing prices for food, and subsidize agricultural inputs, such as fertilizers and machineries (Ye and Rozelle 1994, Qiao et al. 2003, Wiens 1983). Figure 1 shows the changes in the food purchasing price index and the agricultural inputs price index from 1977 to 2003. We can see that food prices increased very fast from 1978 to 1984, while the agricultural input prices did not change too much during the same period. As the result, the ratio of inputs prices index to food prices, known as the Price Scissors Difference, decreased very fast from 1978 to 1984.

[Insert Figure 1]

Agriculture is a continuous and dynamic process. The policies suppressing the prices of agricultural products kept farmers in a subsistent level, and farmers can not accumulate either physical or human capital to improve the outputs. In turn, the distorted price system impeded the economic growth in other sectors.

In such a sense, we can conclude that the miracle of the fast agricultural growth from 1978 to 1984 in China was driven by the reform of price policies, in particularly the correction of the Price Scissors Difference. As mentioned by Lin (1992a) and (Wiens 1983), the price reforms were very important for the growth of Chinese agriculture after 1978. Considering the changes in the price policies and dynamics of the production function, the contribution of the Household Responsibility System may be smaller than Lin (1992a) suggested.

3.2 Efficiency and Human Capital

Byerlee (1987), Watanabe (1996), and Hayami and Godo (2005) pointed out human capital is very important for the post-Green-Revolution agricultural development. The Green Revolution made modern agricultural production more complicated than the traditional system. Farmers need more knowledge to manage production, such as the utilization of fertilizer, the use of pesticides, and the management of irrigational systems.

Byerlee (1987) observed that inequality of production efficiency in South Asia increased after the Green Revolution. Xu and Jeffery (1998) found that the technical efficiency, allocative efficiency, and economic efficiency for conventional rice production in Jiangsu Province from 1985 to 1986 were 0.94, 0.88 and 0.83, respectively, while those for hybrid rice were 0.85, 0.72 and 0.61. The technical efficiency, allocative efficiency, and economic efficiency for conventional rice were all higher than those for hybrid rice.

Also, using the data for over 900 farmers in Jiangsu province in 1993, Fan (1999) found that technical efficiency, allocative efficiency and economic efficiency were 0.81, 0.71 and 0.57 respectively. However, compared with the historical data, he also finds that both technical and allocative efficiencies increased from 1980 to 1993. Similar results can be found in Zhejiang province by Brummer, Glauben and Lu (2006), the technical efficiencies before 1992 are lower than 0.4 and hereafter higher than 0.7.

Fan (1991) also uses the provincial data to compute the technical efficiency from 1965 to 1985, and finds that the technical efficiency increased from 0.646 in 1965 to 0.843 in 1985.

Liu and Zhuang (2000) use a survey data for more than 7000 farmers in 1990 from Sichuan Province and Jiangsu Province, and find that the technical efficiencies are 55% and 77% for Sichuan and Jiangsu Provinces, respectively. Also, education is statistically significant for explaining the differences in technical efficiencies in both provinces.

Wang, Cramer and Wails (1996) find that average profit efficiency of farmers in 1991 is only 0.62, and education, family size and per capita net income are positively correlated with and statistically significant for the profit efficiency.

Cheng, Huffman and Rozelle (2006) also use household data to compute the technical efficiency in different regions across China. They find that the technical efficiencies in North, Northeast, East and Southwest of China are 0.80, 0.85, 0.73 and 0.69, respectively. And ages are important for technical efficiency.

Concluding the above researches, we have (1) The technical efficiency for hybrid crops is usually lower than that for conventional crops due to the increasing complexity of managing production; (2) The technical efficiency and allocative efficiency in Chinese agriculture continuously increase before 1990, and hereafter are stagnant;(3) Regional disparity of the technical efficiency of agricultural production in China is very large; and the technical efficiency in Western China is usually lower than that in Eastern China;(4)Human capital is very important for explaining the differences in technical and allocative efficiencies in China.

3.3 Demographic Change and Human Capital Accumulation

During the era of the planned economy, China eliminated a lot of infectious disease, such as Malaria (Sachs 2005). It significantly decreased mortality rate and increased the life expectancy for Chinese people, and contributed a lot to the fast economic development after the Economic Reform in 1978 (Johnson 2000).

At the end of 1970s, accompanying with the Economic Reform, China also successfully carried out the "Birth Quota" policy. One couple is allowed to have only one child. The fertility rate significantly decreased after that.

Contemporary decreases in the mortality and fertility rates increase the rate of working forces in the society. Bloom and Williamson (1998) contribute the economic miracle of East Asia to such a demographic change. Cai (2004), and Wang, Cai and Zhang (2004) also find that the demographic change contributes a lot to economic growth in China, so does in agricultural sector.

Becker and Lewis (1973), and Becker, Murphy and Tamura (1990) suggested that there are interactions between quality and quantity of children. Reduction of fertility rates may induce parents to invest more in children's human capital so to increase the quality of children. Some empirical studies support that the "Birth Quota" does increase the investment on children's human capital in China (Schultz 2003, Rosenzweig and Zhang 2006).

Yu and Abler (2008) also finds that farmers in rural China even can lower their food quality in order to invest in the human capital, because human capital is related with higher economic efficiency of production and high future income as well.

The statistical data shows that the illiterate rate of farmers substantively dropped from 27.9% in 1985 to 7.4% in 2003, and average educational years increased from 5.6 years to 7.8 years during the same period. Byron and Manaloto (1990) find that the return to education is positive but the marginal return is decreasing. As we know, education is positively correlated with the productivity efficiency, so that it is consistent with the finding of Fan (1991, 1999) and Brummer, Glauben and Lu (2006) that the technical and allocative efficiencies has been substantively increasing in the past three decades and however the increasing speed slows down.

4. Poverty and Environment

4.1 Poverty and Farmer Income

China has successfully solved the Food Problem, and is facing the Poverty Problem as Hayami and Godo (2002) suggested. The increase in farmer income lags after that of non-farmers, and farmers are relatively poorer in middle-income countries, as is happening in China.

Though farmer income substantively increases after the 1978 Economic Reform , the grow rates are lower than that of urban residents. Hence, income disparity between farmers and urban residents has been substantively increasing since 1984 as shown in Figure 2. The net income of urban residents is as 3.2 times as that of farmers in 2006, while that number in 1984 is 2.57.

The income inequality between farmers has been increasing, as shown in Figure 2. Gini Coefficient substantively increased from 0.21 in 1978 to 0.37 in 2003.

[Insert Figure 2]

Taking the case of Japan as an example, Hayami and Godo (2002) found that off-farm employment is very effective to deal with the Poverty Problem---an increase in income disparity between farmers and urban residents. In 1955, 72% of the farmer income is from agriculture, and farmer income is only about 77% of the urban residents; while in 1998 the numbers were 14% and 105% respectively. The farmer income in Japan has overtaken that of urban residents, but most farmer income, about 86%, is from non-agricultural sector.

A similar trend can be watched in China. The share of agricultural income in net farmer income has been substantively reduced from 94.4% in 1978 to 79.7% in 2005.

Resource transferring between sectors, such as migration from rural areas to urban areas, is important for improving farmer income. Zeng (2002) finds that town-and-village firms are a good outlet for capital and labor transferring from agricultural sector to non-agricultural sectors, which significantly increased farmer income.

Human capital is once again plays very important roles in off-farm employment. Yang (2004) finds that those having higher education are more efficiently allocate their time between off-farm and farm activities and hence have higher income. Similar results are also observed by Zhao (1997, 1999) and Schultz (2003).

4.2 Non-point pollution and Environment

Water pollution is very severe in China, and about 75% lakes have been polluted. Non-point pollution from agriculture is one of the most important reasons. In particular, Nitrogen and Phosphorus eutrophication of major Chinese lakes and water systems has been worse and worse since 1970s as China started to intensively use fertilizer to improve the agricultural yields (Zhang et al. 2004, Yin et al. 2001 , Liu et al. 2005).

Another negative effect of overly intensive use of fertilizer is that it may harm the fertility of soil and may salinize land.

Since the marginal return of land is very large in China, farmers usually can not resist the temptation of deforestation or destroying grassland in order to exploit new cropping land. It causes floods and droughts in many mountainous areas. In return, land salinization and deforestation may cause more loss of land (Rozelle et al. 1997), and may harm agriculture itself.

In order to remedy such a negative trend, China initiated a big program- Returning Cropping Land to Forest and Grassland in 1999. However, how to trade off food production and environmental protection is still a big challenge for Chinese governments in a long run.

5. Policy Implications and the Future of Agriculture in China

Reviewing the current literature, the lessons and experiences of the development of agriculture in China in the past three decades include:

(1) Chemical fertilizers are very important for modern agriculture. China subsidizes fertilizers to stimulate farmers to use more fertilizers to improve yields after the economic reform in 1978. However, the marginal effect for agricultural production is diminishing while the pollution from them is increasing. The government should think about how to reduce non-point pollution and land salinization while maintaining a high productivity.

(2) Human capital is very important for improving technical and allocative efficiencies of agricultural production. In order to well adapt the newly-developed technologies, it is important to increase the educational level of farmers in China.

(3) Given the limited land resource, agriculture can not solve the Poverty Problem in China. Rural-urban migration and off-farm employment are important to enhance farmer income and reduce farmer poverty. Human capital is once again playing an important role here.

(4) Demographic bonuses have contributed a lot to Chinese economic growth including the agricultural sector. However, the effect is diminishing as the population is aging. It is a time to rethink the "Birth Quota" policy in order to have a sustainable agriculture and a vital rural community.

Acknowledgements: We are deeply grateful to Professor David Abler at the Penn State University for his advice on writing this paper.

References:

Becker G. S. and H. G. Lewis (1973) "On the Interaction between the Quantity and Quality of Children." *The Journal of Political Economy*, Vol. 81(2) Part 2: New Economic Approaches to Fertility. pp. S279-S288.

Becker G. S., K. M. Murphy and R. Tamura (1990) "Human Capital, Fertility, and Economic Growth." *The Journal of Political Economy*, Vol. 98, No. 5, Part 2: The Problem of Development: A Conference of the Institute for the Study of Free Enterprise Systems. (Oct., 1990), pp. S12-S37.

Beck G. S., T. J. Philipson and R. R. Soares (2005) "The Quantity and Quality of Life and the Evolution of World Inequality." *The American Economic Review,* Vol.95(1):277-291.

Bloom D. and J. Williamson (1998) "Demographic Transition and Economic Miracles in Emerging Asia." *World Bank Economic Review*, Vol. 12(3):419-455.

Brummer B, T. Glauben and W. Lu (2006) "Policy Reform and Productivity Change in Chinese Agriculture: A Distance Function Approach." *Journal of Development Economics*, Vol.(81):61-79.

Brown L. R. (1995) *Who Will Feed China?: Wake-Up Call for a Small Planet.* W.W. North Company.

Byerlee D.(1987) "Maintaining the Momentum in Post-Green Revolution Agriculture: A Micro-Level Perspective From Asia ", Discussion Paper, Department of Agricultural Economics, Michigan State University, 1987.

Byron, R. P., and E. Q. Manaloto,1990."Returns to Education in China." *Economic Development and Cultural Change*,Vol.38:783—796.

Cai F. (2004) "Demographic Transition, Population Dividend, and Sustainability of Economic Growth: Minimum Employment As A Source of Economic Growth." *." Population Research* (in Chinese). Vol.28(2):2-9.

Chen Z., Huffman W. and S. Rozelle (2006) "Farm Technology and Technical Efficiency: Evidence from Four Regions in China." Working paper No.06022, Department of Economics, Iowa State University.

Fan S. and P. G. Pardy (1997) " Research, productivity, and output growth in Chinese agriculture." *Journal of Development Economics*, Vol. 53(1):115-137.

Fan S. (1991) "Effects of Technological Change and Institutional Reform on Production Growth in Chinese Agriculture." *American Journal of Agricultural Economics*, Vol. 73(2):266-275.

Fan S. (1999) "Technological Change, Technical and Allocate Efficiency in Chinese Agriculture: the Case of Rice Production in Jiangsu." EPTD, Discussion Paper No.39, IFPRI.

Fan, S.,L. Zhang, and X. Zhang, (2004), "Reforms, Investment, and Poverty in Rural China," *Economic Development & Cultural Change*, Vol.52:395-420.

Hayami Y. and Y. Godo (2002) *Agriculture Economics (nogyo keizai ron*), in Japanese, New Edition, Iwanami Shoten, Publishers, Tokyo.

Hayami Y. and Y. Godo (2005) *Development Economics*, Third Edition, Oxford University Press, New York

Huang, J. and S. Rozelle.(1995). Environmental Stress and Grain Yields in China. *American Journal of Agricultural Economics* 77: 853-864.

Huang J. and S. Rozelle (1996) "Technological Change: Rediscovering the Engine of Productivity Growth in China' s Rural Economy." *Journal of Development Economics,* Vol. (49):337-369.

Huang J., S. Rozelle, C. Pray and Q. Wang (2002) "Plant Biotechnology in China." *Science*, Jan. 25, 2002, Vol.295:674-677.

Huang J.,S. Rozelle, and W. Martin (2006) "Distortions to Agricultural Incentives in China", Agricultural Distortion Research Working Paper XX, 2006. http://iis-db.stanford.edu/pubs/21628/china_agricultural_trade_distortions_feb_2007.pdf.

Jayne T. S., D. Mather and E. Mghenyi (2006) "Smallholer Farming Under Increasingly Difficult Circumstances: policy and Public Investment Priorities for Africa." MSU International Development Working Paper No.86, 2006, Department of Agricultural Economics, Michigan State University.

Jin S., J. Huang, R. Hu and S. Rozzelle (2002) "The Creation and Spread of Technology and Total Factor Productivity in China's Agriculture." *American Journal of Agricultural Economics,* Vol.84(4):916-930.

Johnson D. G.(2000) "Population, Food and Knowledge" , *The American Economic Review,* Vol.90(1):1-14.

Liu G.D., W.L. Wu and J. Zhang (2005) "Regional Differentiation of Non-Point Source Pollution of Agriculture-Derived Nitrate Nitrogen in Groundwater in Northern China." *Agriculture, Ecosystems and Environment*, Vol.107(2-3):211-220.

Liu, Z., Zhuang, J.,(2000). "Determinants of Technical Efficiency in Post-Collective Chinese Agriculture: Evidence from Farm-level Data*." J. Comparative Economics* 28, 545-564.

Lin J. Y. (1987) "The Household Responsibility System Reform in China: A Peasant's Institutional Choice." *American Journal of Agricultural Economics*, Vol. 69(2):410-415.

Lin J. Y. (1992a) "Rural Reforms and Agricultural Growth in China." *The American Economic Review,* Vol. 82(1):34-51.

Lin J. Y. (1992b) "Hybrid Rice Innovation in China: A Study of Market-Demand Induced Technological Innovation in a Centrally-Planned Economy." *The Review of Economics and Statistics,* Vol. 74(1):14-20.

Lin J. Y. (1996) “Household Farm, Cooperative Farm, and Efficiency: Theory and Evidence from Chinese Experience.” *The Economics of Agriculture: Papers in Honor of D. Gale Johnson*, Edited by J. Antle and D. A. Sumner, pp.321-341. The University of Chicago Press, Chicago.

Lin J. Y., F. Cai and Z. Li (1999) *The China Miracle: Development Strategy and Economic Reform*, revised and expanded. Shanghai People's Publishing House and Shanghai Sanlian Sudian, 1999.

Lin J. Y. (2007) “Development and Transition: Idea, Strategy, and Viability.” Marshall Lectures, October 31-November 1, 2007, Cambridge University.

Mamingi N. (1996) “How Prices and Macroeconomic Policies Affect Agricultural Supply and the Environment.” Policy Research Working Paper No.1645, World Bank. Washing D.C.

Mao W. and W. W. Koo (1997) “Productivity Growth, technological Progress, and Efficiency Change in Chinese Agriculture after Rural Economic Reforms, A DEA Approach.” *China Economics Review*, Vol.8 (2):157-174.

Qiao F., B. Lohmar, J. Huang, S. Rozelle and L. Zhang (2003) “Producer Benefits from Input market and Trade Liberalization: The Case of Fertilizer in China.” *American Journal of Agricultural Economics*, Vol.85:1223-1227.

Rosenzweig M. R., and J. Zhang (2006) “Do population Control Policies Induce More human Capital Investment? Twins, Birthweight, and China’s ‘One Child’ Policy.” IZA Discussion Paper No.2082, IZA, German.

Rozelle S., G. Veeck and J. Huang (1997) “The Impact of Environmental Degradation on Grain Production in China, 1975-1990.” *Economic Geography*, Vol. 73, No. 1. (Jan., 1997), pp. 44-66.

Sachs J. (2005) *The End of Poverty*, Penguin Books Ltd, New York.

Schultz T. P. (2003) “Human Resources in China: The Birth Quota, Returns to Schooling, and Migration.” Discussion Paper No.855, Economic Growth Center, Yale University.

Schultz T. W. (1953) *The Economic Organization of Agriculture*, McGraw-Hill, 1953.

Tolley G., V. Thomas, J. Nash, and J. Snyder (1996) “What We Know about Agricultural Prices: Policies, Politics and Supply.” *The Economics of Agriculture: Papers in Honor of D. Gale Johnson,* Edited by J. Antle and D. A. Sumner, pp.121-155. The University of Chicago Press, Chicago.

Wang D., F. Cai and X. Zhang (2004) “Saving and Growth Effects of Demographic Transition: the Population Factor in the Sustainability of China' s Economic Growth.” *Population Research* (in Chinese). Vol.28(5):2-11.

Wang J., G. l. Cramer, and E. J. Wailes (1996) “Production Efficiency of Chinese Agriculture: Evidence From Rural Household Survey Data.” *Agricultural Economics,* Vol.15(1):17-28.

Watanabe T.(1996) *Development Economics: Economics and Contemporary Asia*. Second Edition(in Japanese) Nihon Hyoron Shya, 1996.

Wiens, Thomas B., (1983), "Price Adjustment, the Responsibility System, and Agricultural Productivity," *American Economic Review*, Vol.73, p319-325.

World Bank (2008) *Agriculture For Development*, 2008 World Bank Development Report.

Wu S., D. J. Walker and S. Devadoss (1998) "Productivity Growth and Its Components in Chinese Agriculture after Reforms", Presented at 1998 American Agricultural Economic Association Annual Meeting, Salt Lake City, Utah.

Xu, X., Jeffrey, S.R., (1998). Efficiency and Technical Progress in Traditional and Modern Agriculture: Evidence from Rice Production in China. *Agric. Econ*. 18, 157-165.

Xu, Y., (1999). Agricultural Productivity in China. *China Econ. Rev*. 10(2), 108-21.

Yang D. T. (2004) "Education and Allocative Efficiency: Household Income Growth During Rural Reforms in China." *Journal of Development Economics.* Vol.74:137– 162.

Ye Q. and S. Rozelle (1994) "Fertilizer Demand in China's Reforming Economy" *Canadian Journal of Agricultural Economics*, Vol.42(2):191-207.

Yin C.Q., C.F. Yang, B.Q. Shan, G.B. Li and D.L. Wang (2001) "Non-Point pollution from China's Rural Areas and Its Countermeasures." *Water Science and Technology*, Vol.44(7):123-128.

Yu X. and D. Abler (2008) " The Demand for Food Quality in Rural China." *American Journal of Agricultural Economics,* Forthcoming.

Zeng Y. (2002) *Reform and Economic Growth in Rural China (choukoku noson Keizai no kaikaku to kei zai sei cho)* (in Japanese), Japan Agricultural and Forest Statistical Associatial (norin toukei kei kai), Tokyo, 2002.

Zhang B., and C. A. Carter "Reforms, the Weather, and Productivity Growth in China's Grain Sector." *American Journal of Agricultural Economics*, Vol. 79, No. 4. (Nov., 1997), pp. 1266-1277.

Zhang W., S. Wu, H. Ji and H. Kolbe (2004) "Estimation of Agricultural Non-Point Source Pollution in China and the Alleviating Strategies." *Scientia Agricultura Sinica.* Vol.37(7):1009-1013.

Zhang X. and S. Fan (1999) "Estimating Crop-Specific Production Technologies in Chinese Agriculture: A generalized Maximum Entropy Approach." EPTD Discussion Paper No.50, IFPRI.

Zhao Y. (1997) "Labor Migration and Returns to Rural Education in China," *American Journal of Agricultural Economics*, Vol.79: 1278-1287.

Zhao Y.(1999) "Labor migration and earnings differences: the case of China," *Economic Development and Cultural Change,* Vol. 47(4):767-782.

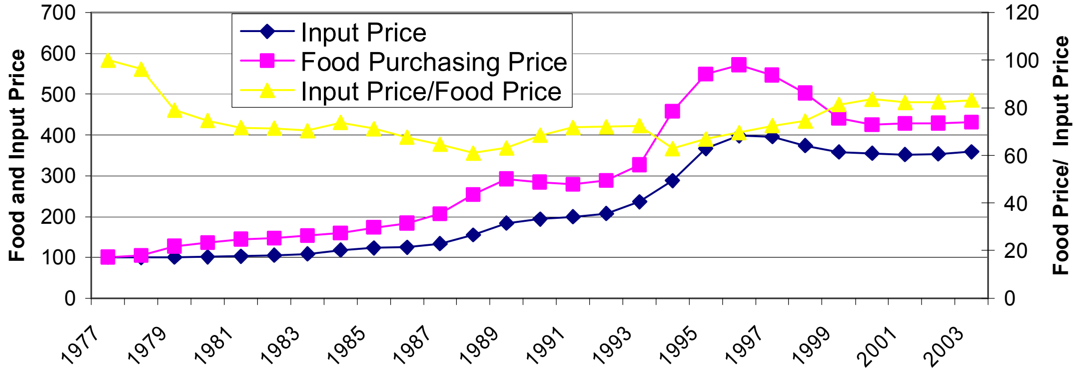

Figure 1 Changes in Food Price and Input Price

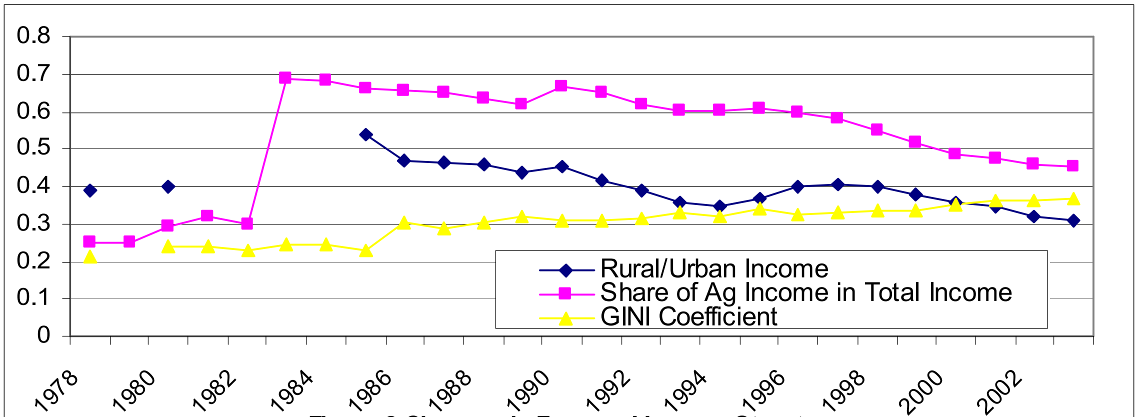

Figure 2 Changes in Farmers' Income Structures

Table 1, Rural Income and Poverty in China (1978-2003)

Year	Poverty Line (yuan) Current Price	Poverty Rate (%)	Population Below Poverty Line (Million)	Net Income (yuan) Current price	Net Income (yuan) 1978 Price
1978	100	30.7	250.0	133.57	133.57
1980	130	26.8	220.0	191.33	186.46
1990	300	9.4	85.0	686.31	324.45
2000	625	3.4	32.1	2253.42	517.42
2005	683	2.5	23.6	3254.90	708.71

Source: China Rural Household Survey Yearbook (2006).

Table 2, Output Elasticity with Respect to Main Inputs in The Current Literature .

Authors	Data	Products	Region	land	Labor	Fertilizer	Irrigation	Capital	Machinery
Chen, Huffman and Rozelle(2006)	1995-99	Total value of Outputs	North	0.35	0.48	0.23		-0.06	
			Northeast	0.60	-0.06	0.16		0.22	
			East	0.43	0.12	0.14		0.19	
			Southwest	0.38	0.05	0.35		0.01	
Lin(1992)	1979-87	Total value of Outputs	Nationwide	0.65	0.14	0.18	0.00		0.04
Fan(1991)	1965-85	Gross value of Agriculture Outputs	Nationwide	0.36	0.28	0.43	0.06		0.06
Fan and Pardy (1997)	1965-93	Aggregate Outputs	Nationwide	0.15	0.11	0.21			0.15
Zhang and Carter (1997)	1980-90	Grain Output	Nationwide	0.36	0.23	0.24	0.17		0.04
Xu and jeffery(1998)	1985-86	Conventional Rice	Jiangsu Province		0.09	0.31			0.09
		Hybrid Rice			0.11	0.08			0.04
Zhang&Fan(1999)	1975-96	Total value of Grains	Nationwide	0.40	0.17	0.11			0.16
	1975-97	Total value of Cash Crops	Nationwide	0.13	0.24	0.18			0.21
	1975-98	Total value of Other Activity	Nationwide	0.34	0.23				0.22

Table 3 Sources of Agriculture Growth in China

Authors	Data	land	Labor	Fertilizer	Capital	Power	Irrigation	Multiple Cropping	Nongrain Crops	Institution	Research	Public Investment	Residual
Lin(1992)	1979-1984	-1.75	4.52	32.20	10.82			1.94	3.69	46.89			5.57
	1984-1987	-38.24	-70.07	53.71	44.73			20.90	27.79	0.00			61.28
Fan and Pardy(1997)	1965-1978	-1.80	12.50	38.00		24.70	9.00			0.00	25.20		-7.60
	1979-1984	-0.80	5.60	12.00		7.80	-0.40			38.60	19.10		18.10
	1985-1993	0.10	6.20	9.10		5.50	-0.90			42.10	14.10		23.70
	1965-1993	0.10	7.50	21.70		12.90	3.70			17.60	19.50		17.10
Fan, Zhang and Zhang (2004)	1978-1984									60.08		12.43	27.49
	1985-2000									-0.84		63.45	37.59