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Potential Issues in Food Reform Process and Impacts of Policy Options:

The Case of China

LI Meng*

Abstract

During the last decade, increased use of inputs became a major source of growth in China's food sector. Especially, recent policies biased toward food production have stimulated input use rather than productivity growth in the food sector. If the cost of food production continues to rise, it will constrain growth in China's food production and weaken its competitiveness in world markets. If this occurs, farmers' income will further worsen. This paper attempts to analyze the impacts of alternative policy options, focusing on improving food production and farmers' income. For this purpose, we make use of GTAP database version 6.0 and construct a food-focused computable general equilibrium (CGE) model that can be used to analyze the economy-wide impacts of changes in a set of alternative options for the operation of China's food sectors. The simulations analysis shows that these alternative policies bring about higher food output, and that rural households also experience an increase in incomes. Meanwhile, these alternative policies have a major influence on the effectiveness of agricultural productivity growth in advancing economy-wide growth and equity.

Introduction

Following the introduction of economic reforms in 1978, China's agricultural output grew at an astonishing rate over the last two decades. Grain output more than doubled, rising to 500 million tons in 2001. In addition, following China's accession to the WTO, China's agricultural trade grew very rapidly and China's economic structure also changed dramatically. However, in the reform process, some potential issues are showing up. Firstly, we find that recent policies biased toward food production have stimulated input use rather than productivity growth in the food sector[1]. Given that increased input use, mainly for intermediates and production factors, drove growth in China's food sector in recent years, food production will become more costly as wages and prices for intermediate and capital inputs rise. This could curb growth in China's food production and weaken its competitiveness in world markets. Secondly, the rural income is widely recognized as a fundamental issue in China, due to at least three considerations. First, the current income level in most rural areas is still extremely low. The annual income per capita for rural areas as a whole was about US $ 500 at the official exchange rate in 2001. The second factor is the sheer size of the rural population. In 2000

* Doctoral Student, Graduate School of International Development, Nagoya University. E-mail: yixianli@yahoo. com

over 67% of China's 1.3 billion population lived in rural area. Thus, China simply can not achieve sustainable development without delivering substantial income growth in rural areas[2]. Third, a worrying problem in recent years is the income gap between the rural and urban sectors, which is widening as a result of the relatively slow income growth in the rural area. Therefore, farmer's income and food production have been identified by the Chinese Government as the most important two policy objectives for the rural economy[3]. Given this background, it is necessary and realistic to explore China's production structure and adoption of production technologies by an understanding of China's past production growth, output and input utilization choices. The objectives of this study are: firstly, to identify the potential issues by analyzing and measuring the sources of growth in China's food sector in the past; and secondly, to quantitatively evaluate the impacts of changes of a set of alternative policies focusing on improving food production and farmer's income.

In this paper, we construct a food-focused Computable General Equilibrium (CGE) model for China. This analytic framework allows us to evaluate the impacts of a set of alternative policies for the operation of China's food sectors. The alternative policy options cover production subsidies, TFP growth and the coming further trade liberalization. The economy-wide perspective of the analysis makes it possible to consider the broader economic repercussions of different food policy options.

Section 2 provides a brief background, focusing on reviewing the China's food policy reform. Section 3 analyzes and points out potential issues in the reform process. In Section 4, food CGE model and its database are presented. Section 5 is devoted to simulations, while Section 6 summarizes the results and extracts the policy implications. The appendix includes mathematical statement of the CGE model and SAM data.

2. Food reform in China: a brief review

2.1 The first phase (1978-85)

The rural reforms initiated in late 1978 occurred in three, reasonably distinct phases. The first phase of reforms focused primarily on decentralizing the system of agricultural production while emphasis during the second stage was given to liberalizing factor and output markets. Due to the poor performance of the agricultural sector for more than two decades, the central government decided to reform the rural areas in 1978. During the initial stage of the reforms, state procurement prices of agricultural products were raised, and rural markets were reopened for farmers to trade their products from their private plots. After 2 years of experiments, the government began to decentralize agricultural production from the commune system to individual farm households in 1981. By 1984, more than 99% of production units had adopted the household responsibility system (HRS).

In addition to decentralization of the production system, the government began to reform the agricultural procurement system. Prior to 1984, virtually all commodities were subject to various government procurement programs. Beginning in 1985, this procurement system was changed from a mandatory to a voluntary contract system, whereby procurement quantities for certain key commodities were determined by mutual agreement between individual farmers and the government. The procurement system for secondary commodities was abolished. The number of products under government procurement system was reduced from 113 to 38. It is expected that both technical efficiency[4] (from the decentralization of production system) and allocation efficiency[5] increased during this first stage of reforms. Production increased by more than 6.6% per annum, and productivity by 5.1% per annum[6].

2.2 The second phase (1986–1994)[7]

The second phase of reforms was designed primarily to liberalize the country's agricultural pricing and marketing systems. Based on the successful reform of the procurement system in 1984, the government reformed the markets for vegetables, fruits, and fishery products in 1987. The number of commodities subject to government procurement programs declined further from 38 in 1985 to only 9 in 1991. In 1993, the grain market was liberalized more and the grain rationing system that had been in existence for 40 years was abolished. In 1993, more than 90% of all agricultural products were sold at market-determined prices.

In the second phase, the reforms further expanded to the urban area on the base of the successful reform of the former. In the urban realm, there has been a progressive decline in the state control of the economy, with powers devolved from state agencies to enterprises, and a decrease in the use of mandatory planning mechanisms and a concomitant increase in the use of market forces to guide distribution and increasingly production choices. The role of the market has been gradually extended beyond goods and services to labor, now increasingly seen as a commodity. To take advantage of market opportunities, more power of decision-making was given to the localities, and in particular to the units of production themselves. Production units now have more autonomy to decide what to produce, how much and where to market the products. These reforms of the domestic economy have been accompanied by an unprecedented opening to the outside world in search for export markets and the necessary foreign investments, technology and higher quality consumer goods.

It is expected that agricultural allocation efficiency has improved during this period of reforms. As a result, agricultural production and productivity continue to rise with growth rates of 5.6% and 2.9% per annum respectively (although lower than those during the first phase of the reforms).

2.3 The third phase (1995-onwards)[8]

In 1995, a "governor's grain bag" policy was introduced. The policy means a transfer of administrative power over food production from central government to provincial governments. Each provincial government was required to ensure sufficient grain production. In addition, the grain policy announced in 1998 increased government intervention in grain production and marketing once again. Provincial governors were made fully responsible for production, marketing and inter-regional trade of grain.

2.4 Summary

In summary, the institutional change from a centrally planned commune system to more market-oriented farm household production was achieved by the mid-1980s. Although the pricing and marketing reforms are incomplete and the government has retained its right to impose administrative controls on the market and has in fact increased its role since 1998, the reforms over the past two decades have obviously increased the role played by private sector participants and free markets. There has been considerable liberalisation in China's domestic food sector since the reforms initiated in late 1978. Thus, despite the cycles of removal and re-imposition of government controls, and the limited liberalisation with respect to international trade in food, there has been a steady movement toward liberalisation.

3. Potential issues in the reform process

China's agricultural output grew at an astonishing rate over the last two decades following the introduction of economic reforms in 1978. Grain output more than doubled, rising to 500 million tons in 2001. During the same period, following China's accession to the WTO, China's agricultural trade also grew very rapidly. China is changing its role in world trade. Thus, it is becoming necessary to evaluate its production potential.

The following sub-section explores China's food production structure and adoption of production technologies, by analyzing and measuring China's past production growth, output and input utilization choices.

3.1 Sources of output growth

In this study, we apply a growth accounting method to disaggregated national data for rice, wheat, corn, and other grain from 1978 to 2002, measuring the different sources of growth for the four grains to indicate China's potential growth in food production.

Our growth accounting analysis is divided into three phases that correspond to major shifts in China's agricultural policy. The first phase (1978–85) covers the transformation of the old commune system to the family-based HRS (household responsibility system). In the second phase (1986–94), the reforms shift from the rural to the urban economy. The provincial governor's grain responsibility system, which promotes grain production and self-sufficiency, marks the third phase (1995–2002). The growth rates of the four grains are observed to be quite different in these three periods, implying

Table 1: Growth rate and contribution of each grain (%, annual average)

	1978–85		1986–94		1995–02		1978–02	
	Growth Rate	Contribution	Growth Rate	Contribution	Growth Rate	Contribution	Growth Rate	Contribution
Total	3.6	100.0	1.9	100.0	4.3	100.0	2.9	100.0
Rice	2.9	33.8	0.6	10.9	4.5	37.6	1.9	29.5
Wheat	7.0	45.9	1.8	22.5	8.4	39.1	5.2	35.4
Corn	1.7	9.4	4.5	45.2	1.5	7.2	3.0	19.2
Other grain	3.8	10.9	3.7	21.4	5.0	16.1	3.9	15.9

Source: Calculated from *China Statistical Yearbook* (1978–2003)

strong institutional and policy impacts.

Over the last two decades, China's grain production increased obviously, led by rice, wheat, corn, and other grain. Among the four grains, wheat and other grain grew most rapidly, while wheat and rice had the largest contribution share (table 1). The contribution share of each grain is defined as the ratio of the output growth rate for each grain over/to the growth rate for the four grains in total, weighted by the share of each crop in the value of the four grains' output.

3.2 Contribution of TFP

On average, growth in TFP contributed more than 66% of the increase in total output of China's grains over the last two decades. The TFP contribution is defined as the ratio of the TFP growth rate over/to the growth rate of output (table 2).

Some studies, which use the same or similar methodology to compute TFP as a residual after input changes, examine China's agricultural productivity during the 1990's. For example, Li (1993) found that growth in TFP contributed about 50 % of growth in total grain output in the periods 1978–84 and 1985–87. Based on Fen's (2000) growth accounting analysis, TFP growth was found to contribute 75 and 70 % of the growth in aggregate agricultural output (including livestock and other commodities) over the periods 1979–84 and 1985–95, respectively. These results are comparable with our 1978–97 estimates (table 2). However, the study results show a much larger TFP contribution in the early period and a much smaller TFP contribution in more recent periods.

For the aggregate grain category, the contribution of TFP to the growth in output fell over time with each sub-period (table 2). In 1978–85, the growth rate of TFP exceeded the growth rate of output for aggregate grain, rice, and corn. TFP growth in the early period (1978–85) captures the efficiency gains from institutional changes. Before 1978, China's agricultural production was centrally planned and quite inefficient. In other words, China's production was well within its "production possibility frontier" — the set of efficient input combinations chosen by producers on the basis of profit maximization. This period (1978–85) saw a shift from the collective production system to the

Table 2: Growth rate and contribution of TFP to grain production (%, annual average)

Years	Total	Rice	Wheat	Corn	Other grain
TFP growth rate					
1978–02	2.1	2.4	3.1	1.4	1.8
1978–85	4.9	5.0	7.4	4.2	3.0
1986–94	0.4	−0.2	0.3	1.4	1.9
1995–02	0.7	2.9	2.9	−3.7	−1.8
TFP contribution					
1978–02	65.7	106.4	72.8	46.8	38.4
1978–85	122.4	164.4	107.5	216.9	63.2
1986–94	17.1	−55.1	20.2	27.0	50.4
1995–02	14.4	63.7	40.3	−230.4	−33.6

Notes 1: To capture the effects of change in production or input combinations, we applied an index number procedure: the Divisia index measure. In growth accounting analysis, TFP is obtained by subtracting an input index, which captures production factors or other physical inputs, from an output index. As a residual term, TFP captures all nonphysical input factors that affect output growth over time. The TFP growth rate can be expressed as the following equation:

$$G_{j,t} = In\left(\frac{Y_{j,t}}{Y_{j,t-1}}\right) - \sum \bar{S}_{j,f,t}\, In\left(\frac{X_{j,f,t}}{X_{j,f,t-1}}\right)$$

Where $G_{j,t}$=TFP growth, Y= output, X= input, $\bar{S}$ = input share(average for t and t−1), j= grains(rice, wheat, corn and other grain), f = input factors(labor, land, capital and intermediate input), and t = time.

2: Data for each crop's output and sown area, and price indices for the outputs and inputs were obtained from the *China Statistical Yearbook*, published by China's National Bureau of Statistics (NBS). The cost data, including person-day time of labor use, wages, and intermediate input costs by crop, were drawn from the annual household survey, "National Crop Production Cost and Labor Productivity Survey," published in the *China Rural Statistical Yearbook*. We aggregated inputs into categories: land, labor, intermediates input and capital. Because only aggregate data for variable expenses (costs of intermediate inputs) and fixed expenses (capital depreciation) were published, we defined intermediate and capital inputs as a single input. The implicit quantity associated with this input category is calculated by dividing its expenditure by the price index.

Source: Calculated from *China Statistical Yearbook* (1978–03), *China Rural Statistical Yearbook* (1985–03), and *China Commerce Yearbook* (1987–02)

household responsibility system (HRS); less administrative intervention in agricultural production and reduced mandatory quotas for grain purchased by the government; increases in government procurement prices; and the blossoming of free-market activities.

The efficiency gains from institutional reforms can occur at any given level of technology. Therefore, the impact on growth lasts only for a limited time. A slowdown in TFP growth after the first period (1978–85) indicates that when China's grain production moved to its production possibility frontier at the given level of technology, efficiency gains from further reform became smaller. Hence, additional growth in TFP would have to come from technological change. The growth rate of aggregate output fell to 1.9 percent in the second period (1986–94), and the growth rate of TFP fell to 0.4 percent (table 2). Thus, the contribution of TFP to output growth fell to 17.1 percent for all grains. And when rapid growth in rice production came to a sudden halt during the second period, the TFP growth rate for rice turned negative (table 2).

The slowdown in grain output growth may have been due to changes in relative agricultural prices. Markets for vegetables, fruits, and fishery products were further liberalized after 1985, and prices for these commodities rose relative to grains. The slowdown in TFP growth may be related to the reduced public investment in agricultural research and development and in infrastructure (irrigation, flood control, etc.) after the early reform period[9].

The average growth rate of grain production rebounded dramatically during the third period (1995 –02), reaching 4.3 percent (higher even than during the first period). Other grain and wheat growth was especially rapid, while the growth rate for corn was just 1.5 percent (table 2). Total TFP growth was only 0.7 percent per year in the third period, so the contribution of TFP to grain growth fell to 14.4 percent from 17.1 percent in the previous period.

We deduced that the rise in grain prices relative to other agricultural products (except for rice) boosted production growth in the third phase. Higher grain prices were due not only to changes in market prices, but also to increases in government procurement prices. In addition, when the "governor's grain bag" policy was introduced in 1995, provincial governments were required by the central government to ensure sufficient grain production. The provincial governments subsequently introduced various production subsidies, especially subsidies on agricultural inputs such as pesticides and fertilizer. In some provinces, governments reinstated administrative measures to stabilize grain prices and maintain the area sown to grain crops. As the policy environment shifted toward supporting grain production, inputs into the grain sector grew while the contribution of TFP to growth actually fell.

In general, the high TFP growth rate and its large contribution to grain production growth in the period immediately following China's rural economic reforms was largely due to efficiency gains arising from institutional change. After 1985, the annual growth rate of TFP fell sharply. Increased grain output in recent years was due more to rising grain prices than to improvements in production technology. A fall in the contribution of TFP implies, on one hand, that the recent growth in the grain sector will be unsustainable since it is largely due to increased input use. On the other hand, lower TFP growth also implies that the gap in TFP growth between China's grain sector and other countries' agricultural sectors,[10] especially developed countries[11] is quite large. If China's economic environment and government policy can encourage more investment in agricultural research and development, water control systems, and land infrastructure, China can further increase productivity in its grain sector.

3.3 Contributions of intermediate inputs and production factors

In this sub-section, we analyze the contributions of labor, capital and intermediate inputs to grain production growth. The increase in production factors contributed 31 percent of growth in China's grain output during 1978–02. This contribution was primarily due to the increased use of intermediate

Table 3: Input contribution to production growth (%, annual average)

Years	Total input	Land use	Growth rate of Labor use	Capital and Intermediate use
1978–02	31.1	0.4	–4.1	5.0
1978–85	–41.4	–0.7	–10.5	4.7
1986–94	93.2	0.4	–1.7	5.1
1995–02	96.6	3.0	4.1	6.0

Notes 1: Aggregate data for variable expenses (costs of intermediate inputs) and fixed expenses (capital depreciation) were obtained from the *China Rural Statistical Yearbook*, and the quantity associated with this input category is calculated by dividing its expenditure by the price index.
2: A negative share implies input use fell and the growth rate of TFP was greater than the growth rate of output
Source: Calculated from *China Statistical Yearbook* (1978–03), *China Rural Statistical Yearbook* (1985–03), and *China Commerce Yearbook* (1987–02)

inputs and capital. Land use was nearly constant and the use of labor fell by more than 4 percent annually (table 3).

The use of intermediate inputs and capital in grain production increased in each sub-period over the last two decades. Moreover, the growth rate of intermediates/capital use rose over time, from 4.7 percent in 1978–85 to 6.0 percent in 195–02. This indicates that grain production is becoming more intermediate /capital - intensive, as does the decreased use of labor and relatively stable use of land over the 1978–02 period. Sown area (land) and labor days (time spent working) used in production of the four grains fell by 0.7 and 10.5 percent in the first period (1978–85). In this period, rice and corn acreage fell 1.1 and 1.9 percent, while wheat acreage rose slightly and other grain acreage rose 1.25 percent (table 4).

National sown area statistics indicate that the reductions in land use were due to changes in cropping intensity, as farmers moved from triple- and double-cropping to double- or even single-cropping (*Wang, L. and J. Davis*, *(2000)*. During 1978–85, total sown area for all crops fell by 0.7 percent, implying that grain area was not simply shifting to non-grain production (table 5).

Although labor-day statistics in the first period (1978–85) may be suspect, labor efficiency certainly rose due to the reforms. Before 1978, individual peasant income in China was calculated according to time spent in the collective field without reference to production outcome. This system strongly encouraged peasants to participate in collective work assignments but to put little effort into their actual work (or chu gong bu chu li in Chinese). The HRS encourages peasants to efficiently use labor time as incomes are determined solely by production output.

Labor's contribution to production growth differed significantly depending on whether it was based on labor day (or time spent) of peasants or the number of persons engaged in grain production. For example, in Fen (2000), with increasing numbersof laborers, the contribution of labor to production

Table 4: Growth in output and input use in grain production (%, annual average)

crop/year Rice	Output	Land use	Labor use	Capital and Intermediate use
1978–02	2.33	−0.47	−4.61	3.05
1978–85	3.46	−1.14	−9.76	1.86
1986–94	0.55	−0.77	−2.80	4.78
1995–02	5.16	1.95	2.58	0.67
Wheat				
1978–02	5.13	0.18	−4.89	6.45
1978–85	7.92	0.02	−10.55	8.06
1986–94	1.89	−0.10	−2.51	4.38
1995–02	8.60	1.38	1.80	8.97
Corn				
1978–02	3.83	1.04	−2.94	5.89
1978–85	2.19	−1.93	−11.82	3.79
1986–94	5.78	2.26	0.92	7.09
1995–02	1.91	4.49	7.76	7.25
Other grain				
1978–02	5.62	2.69	−1.41	7.18
1978–85	5.50	1.25	−8.91	10.47
1986–94	5.18	2.26	1.58	1.04
1995–02	7.28	7.44	8.20	18.93

Source: Data for each crop's output and sown area were obtained from the *China Statistical Yearbook*. Data for labor, capital and intermediate inputs were obtained from *China Rural Statistical Yearbook* and the China Commerce Yearbook.

Table 5: Growth in agricultural labor and Sown area (%, annual average)

Year	Toatl sown acreage	land in grains	Labor in agri.	Labor in grains
1978–02	0.16	0.39	0.99	−4.14
1978–85	−0.72	−0.74	1.63	−10.42
1986–94	0.40	0.41	0.95	-1.74
1995–02	1.45	3.01	−0.30	4.10

Source: Data was obtained from "National Crop Production Cost and Labor Productivity Survey," published in the *China Rural Statistical Yearbook* (1985–03)

growth was 5.6 percent in 1979–84. However, when the labor contribution to growth is based on the labor days of peasants, as in our study, time spent on grain production declined 10.4 percent annually and the contribution of labor to growth was negative. Given that most farmers in China allocate their time among many different crops and livestock, as well as to nonagricultural work, we believe that timespent on grain production is the most accurate measure of labor's contribution to growth in grain production.

In the second period (1986–94), area sown to grains was quite stable (with a 0.41% annual increase) and nearly identical to the change in total sown area (table 5). Land sown to rice and wheat fell slightly (table 4), while land sown to corn and other grain both rose by 2.26 percent. Labor used in production of the four grains fell 1.7 percent per year over this period (though rising slightly in production of corn and other grain). This is not consistent with national statistics that show the number of agricultural laborers rising by 0.95 percent during 1986–94. However, in the national statistics, agricultural laborers were classified by their main production activities. That is, those engaged primarily (more than 50 percent of labor time) in agriculture were counted as agricultural laborers. Our conclusion, based on household survey data, is that peasants working primarily in agriculture spent less time on grain production than before.

In the final period (1995–02), land and labor returned to grain production, rising by 3.0 and 4.1 percent annually (table 5). Compared with the increase of 1.5 percent in total area sown, grains successfully competed for additional land at the expense of other crops. Moreover, 1995–02 was the only period in which changes in land and labor use move in the same direction (rising) across the four grain crops. These observations all suggest that the market and policy environment during this period favored grain production.

While increased input use contributed more than 90 percent of the growth in grain output in the second and third periods (table 3), different inputs played different roles in that growth. In 1986–94, increased intermediate input and capital use was nearly the sole source of growth, while in 1995–02, increased labor and land use together contributed more than intermediate inputs and capital to grain output growth.

3.4 Summary

Our study finds that total factor productivity contributions to growth in food production diminished after 1986. Especially, in recent years (1995–2002), food policies biased toward food production have stimulated input use rather than productivity growth in the food sector. Thus, increased use of inputs, mainly intermediates and capital, became major sources of growth in China's food sector. Given that increased input use, including labor, drove growth in China's food sector in recent years, food production will become more costly as wages and prices for intermediate and capital inputs rise. This implies that farmer's income that will further decline. This is due to at least two considerations: from production side, on the premise that TFP contribution have decreased in recent years, increasing production cost will further extract the farmer's net income in future; and from demand side, Engel's rule and its resulting in a change in the terms of trade between agricultural products and non-agricultural products further enlarges income inequality between rural and urban sectors. This could constrain growth in China's food production and weaken its competitiveness in world markets.

However, the gap in productivity between China's food sectors and developed countries' food sector suggests that China can improve its food production technology if the economic and policy environment encourages investment in agricultural research and development, water control systems, and land infrastructure. In the following section, we construct a Food-focused Computable General Equilibrium (CGE) model that can be used to explore the impacts of a set of alternative policy options for the operation of China's food sectors.

4. Model specification

4.1 The major features of the food CGE model

This section will discuss the major characteristics of the food CGE Model used in this paper. Our model is generally based on the standard neoclassical CGE model (Dervis et al. 1982), but extends the standard model and implements the food CGE using GAMS[12]. Specifically, we initially introduce subsidy, an extra-variable, into government balance account in the analytical framework of CGE model[13]. Here, we assume that, in order to finance an exogenous increase on government expenditure, government will borrow funds from its capital account. In other words, production subsidy directly extracts a symmetric quantity from its saving account. A specific purpose of the analysis is to investigate how the change of production subsidy affects food cost, yield and farmers' income.

In addition, we further extend the model by allowing for the focuses of its analytical framework on both food sectors[14] and inter-linkage among agriculture and non-agriculture sectors. Our model specifies 12 industries including six agricultural sectors and six non-agricultural sectors. The aim is to clearly show the change of terms of trade, since domestic terms of trade (agriculture vs. non-agriculture) is one decisive factor in measuring changes in farmers' welfare. The agricultural sectors are disaggregated into five food sectors and one other-agricultural sector. The non-agricultural sectors are disaggregated into one food-processing sector and five other non-agricultural sectors.

The 12 sectors are shown as the following, which originate from the 57 sectors of the GATP database.[15]

1. Rice
2. Wheat
3. Other Grains
4. V-F Vegetables, fruit, nuts
5. Other Crops
6. Other Agriculture
7. Minerals and Energy

8. Food Processing
9. Light Manufacturing and Heavy Manufacturing
10. Construction
11. Trade and Transportation
12. Commerce and Other Services

One important reason for capturing the non-agricultural linkages is that some recent researches[16] strongly implied that analysis of the current agricultural policy excluding non-agricultural linkage is inaccurate. Another important reason for capturing the non-farm linkages is that with the diversification of farm households' earnings, they often have significant wage earning interests in other non-farm sectors, The food CGE model provides a better analytical framework as it captures these significant non-agricultural linkages.

In our food CGE model, economic institution specifies three parts, which are households, enterprises and government. The households and enterprises are classified into rural and urban categories. The specific purpose is to capture both the direct effects of exogenous shocks[17] on change of income between rural and urban households, and the indirect effects of different income accrued to rural-urban households on consumption of agricultural and non-agricultural products.

The model specifically allows labor factor mobility among sectors. In the simulations, labors are allowed to freely migrate from food sectors into non-food sectors, if the labor returns in food activities are lower than those in non-food activities. The degree of factor mobility is determined in the model by the different marginal opportunities for rural labor across sectors and the elasticity of the substitution between rural and urban labor.

Meanwhile, the labor factor is further classified into unskilled and skilled labor, to better capture the effects of exogenous shocks on unskilled-skilled labor migration intra-food sectors, and between food sector and non-food sectors. It is most important for us to capture the effects of unskilled-skilled labor migration on the ratio of capital to labor of inter-sectors, each sectoral output and the rural-urban income.

Our model makes use of the latest numerical SAM for 2001 as a database, representing a benchmark. If the initial conditions are perturbed by the postulated exogenous shocks, the economy-wide effects of these shocks should be captured and be interpreted in detail through the solution of the food CGE model.

4.2 The Food SAM[18] and Equation System of Food CGE Model

The Food SAM, which provides a schematic portrayal of the circular flow of income in the Chinese economy from activities and commodities, to factors of production, to institutions, and back to activities and commodities again. The role of the food CGE model is to specify the market, behavioral, and system relationship embodied in each account of the SAM.

The following section introduces the equation system, which is a mathematical statement of the CGE model. First, equations defining the price system are presented. Second, the production and value-added equations are formed respectively. Next are equations that describe the mapping of value added into institutional income. A circular flow is then completed by equations showing the balance between supply and demand for goods by the various actors. Finally, there are a number of “system constraints” that the model economy must satisfy. These include both market clearing conditions and the choice of macro “closure” for the model.

In this equation system, cost minimization under a CES production function is to expresses the ratio of the composite intermediate input to value added in terms of the ratio of their prices. Domestic output is supplied to domestic or foreign markets, depending on the prices in these markets. Domestic producers, who seek to maximize profits, decide how much they sell in domestic and foreign markets. The treatment of export supply is based on the Constant Elasticity of Transformation (CET) function. The supply of domestic products and exports is derived from the revenue maximization condition.

The demand for each primary factor reflects the first order conditions for profit maximization based on value added and its price. Factor market distortions are allowed, differentiated by sector. The parameter is a constant of proportionality that indicates the degree to which the average return for a factor in a given sector differs from the marginal revenue product of that factor. The factor demand is derived from the profit maximization condition, and factor remuneration is equal to the value added price times the partial derivative of the production function with respect to each factor. Capital is inter-sectorally immobile,[21] and the capital stock in each sector is fixed, letting the first-order condition determine capital rents. The treatment of the labour market assumes full employment and allows for labour mobility, but takes into consideration distortions in the labour market. The model generally specifies two kinds of labour, that is, skilled labour and unskilled labour. Sectoral labour demand is a CES function of skilled and unskilled labour, and the demand for each type of labour is derived from the first-order condition. Sectoral wages are equal to the average wage level times fixed coefficients, which represent wage differentials between economic sectors and types of labour.

5. Simulation Analysis

5.1 Data, model calibration

For purposes of our analysis, we developed social accounting matrix (SAM) for China’s food sector based on necessary sources of data. To construct the Food SAM, we firstly make use of the GTAP (Global Trade Analysis Project, 2001) version 6.0 database to set up a related database which is a highly disaggregated input-output table, differentiating 57 industries. Then, these data are aggregated into 12 industries focusing on the food sector. The food sector is disaggregated into the following sectors: rice, wheat, other grain, vegetables, fruits, and other crops (see sectoral details in

Appendix A). These data mainly constitute one part of the SAM database that accounts for both production and consumption. Data for factors input, income and direct tax, etc. derives from 2002: China Statistical Yearbook, Agricultural Statistical Yearbook, China Labor Statistic Yearbook, China Development Report, and China Living Standards Survey 2001–2002.

Next, before solving the CGE model, a calibration procedure is undertaken so that the values of some key parameters are directly calculated from the model equilibrium conditions, such as saving rates, tax rates and wage rates. Relating to other parameters, mainly including shift and share parameters, such as the share and scale parameters in trade and production functions, we follow the common calibration procedure discussed in John Whalley (1984). Finally, the elasticities of substitution in trade and production function are taken from GTAP version 6.0, consisting of the elasticity of substitution between labour and capital, the elasticity of substitution between domestically produced goods and imports and the elasticity of substitution[20] between domestically produced goods and exports.

5.2 Simulation results

The model described in the above section is employed to analyze and explore the effects of a set of alternative options for the operation of China's food sectors. The options cover production subsidy, TFP growth and coming further trade liberalization. The economy-wide perspective of the analysis makes it possible to consider the broader economic repercussions of different policy options. Twelve

Table 6: Simulation Scenarios

	S0	Base run
Set1	S1	Increase production subsidy by 20% in food sectors
Set 2[21]	S2	Rice TFP growth 35%
	S3	Wheat TFP growth 25%
	S4	Other grain TFP growth 15%
	S5	V-F TFP growth 45%
	S6	Other crops TFP growth 15%
	S7	S2+S3+S4+S5+S6
Set 3	SS2	S2+Partial trade liberation
	SS3	S3+Partial trade liberation
	SS4	S4+Partial trade liberation
	SS5	S5+Partial trade liberation
	SS6	S6+Partial trade liberation
	SS7	S7+Partial trade liberation

Table 7: Government increase 20% production subsidy

GDP and National account	SIM1(%)	Household consumption	SIM1(%)
Private consuption	2.57	Rural	3.47
Fixed investment	−1.612	Urban	2.32
Government consumption	0		
Export	0.82	**Factor income**	
Import	−1.75	Unskilled labor	1.378
Direct tax	0.452	Skilled labor	1.782
Indirect tax	0.501	Capital	1.675
GDP	0.7		
foreign saving	0	**household and enterprise income**	
Government saving	−18.2	Rural	1.452
		Urban	1.635
Exchange rate(EXR)	−1.002	Enterprise	1.423
Price	**SIM1(%)**	**Quantity**	**SIM1(%)**
PX.PDR	−1.675	D.PDR	1.329
PX.WHT	−1.221	D.WHT	1.196
PX.ORGN	−0.650	D.ORGN	0.605
PX.VF	−2.086	D.VF	0.056
PX.ORCP	−0.067	D.ORCP	0.981
PX.OAGR	−1.118	D.OAGR	0.133
PX.ME	−0.112	D.ME	0.121
PX.PROF	−1.450	D.PROF	1.339
PX.LH	−1.267	D.LH	1.069
PX.CNS	−0.002	D.CNS	0.096
PX.TRA	−1.221	D.TRA	1.229
PX.COS	−0.882	D.COS	3.280
PM.PDR	−1.002	E.PDR	1.080
PM.WHT	−1.002	E.WHT	0.842
PM.ORGN	−1.002	E.ORGN	1.370
PM.VF	−1.002	E.VF	0.849
PM.ORCP	−1.002	E.ORCP	0.231
PM.OAGR	−1.002	E.OAGR	0.316
PM.ME	−1.002	E.ME	0.745
PM.PROF	−1.002	E.PROF	0.920
PM.LH	−1.002	E.LH	0.392
PM.CNS	−1.002	E.CNS	0.970
PM.TRA	−1.002	E.TRA	0.096
PM.COS	−1.002	E.COS	0.569

Source: CGE model simulation results.

Table 8: Effects of food TFP growth

	Change percent of Base level						
	Base	S2	S3	S4	S5	S6	S7
Production sectors							
Rice		24.74	3.91	0.78	1.69	0.24	26.87
Wheat		4.79	6.10	1.68	2.58	0.76	12.75
Other Grain		1.34	1.44	4.97	4.16	1.29	11.94
Vegetable and Fruit		1.32	1.35	3.65	37.24	0.99	39.92
Other Crops		1.42	1.25	1.61	3.33	5.24	10.80
Other Agriculture		2.98	2.10	4.08	8.23	1.79	16.03
Energy and Mineral		1.47	0.78	0.85	1.29	0.68	1.52
food processing		4.03	4.97	4.25	5.52	1.70	15.15
L-H Manufacturing		1.31	0.77	0.64	4.93	0.73	5.54
Construction		0.49	0.39	0.54	1.22	0.43	1.64
Trade and Transp		0.86	0.40	0.10	3.90	0.31	4.10
Service		0.54	0.27	0.41	0.72	0.27	1.61
Factor income							
Unskilled Labor		0.82	0.24	0.57	2.28	0.02	4.21
Skilled Labor		1.56	0.71	0.97	2.50	0.43	5.45
Capital		1.62	0.79	0.97	2.44	0.45	5.43
Household income							
Urban		2.62	1.28	1.65	4.17	0.78	8.78
Rural		1.56	0.62	0.82	3.17	0.29	6.25
Enterprise income		1.01	0.42	0.72	2.56	0.24	4.78
Government income		2.04	0.89	1.32	3.08	0.67	6.72
GDP		0.85	0.63	0.75	1.26	0.29	1.96

Source: CGE model simulation results.

simulations are performed and described briefly in the following table 6, and the simulation results are reported in tables7, 8 and 9.

5.2.1 Effects of increasing production subsidy (Simulation Set 1).

The government balance ensures that government revenue equals expenditure. Thus, we assume that, in order to finance an increase in government expenditure, government will borrow funds from the capital account. In other words, production subsidy extracts a symmetric quantity from the savings account. Since foreign savings are fixed in the model, the exchange rate will adjust to attain the current account balance. The exchange rate depreciates if imports increase more than exports and it appreciates otherwise.

Table 9: Effects of food productivity growth and sectoral tariff rate reduced by 50%

	Change percent of Base level						
	Base	SS2	SS3	SS4	SS5	SS6	SS7
Production sectors							
Rice		24.20	3.77	0.76	1.62	0.23	25.04
Wheat		4.80	6.10	1.68	2.58	0.77	12.77
Other Grain		2.04	2.19	7.54	6.31	1.96	18.12
Vegetable and Fruit		2.04	2.09	5.63	38.39	1.02	42.16
Other Crops		1.47	1.28	1.66	6.68	7.91	16.67
Other Agriculture		3.62	2.55	4.96	10.00	2.18	19.50
Energy and Mineral		1.96	1.05	0.64	1.64	0.90	5.13
food processing		4.88	6.01	5.14	6.68	2.05	18.33
L-H Manufacturing		1.76	1.04	0.85	6.61	0.97	7.42
Construction		0.52	0.42	0.58	1.30	0.46	1.75
Trade and Transp.		1.08	0.50	0.13	4.88	0.39	5.12
Service		0.83	0.42	0.63	1.10	0.42	2.24
Factor income							
Unskilled Labor		1.46	0.42	1.02	4.04	0.04	7.47
Skilled Labor		2.40	1.10	1.49	3.85	0.66	8.39
Capital		2.61	1.26	1.56	3.92	0.72	8.72
Household income.							
Urban		2.33	1.14	1.47	3.70	0.69	7.80
Rural		1.96	0.78	1.03	3.99	0.36	7.86
Enterprise income		1.24	0.52	0.88	3.14	0.29	5.86
Government income		−1.76	−0.77	−1.14	−2.66	−0.58	−5.80
GDP		1.11	0.82	0.98	1.64	0.38	2.55

Source: CGE model simulation results.

This simulation models a scenario in which the government increases production subsidy by 20%. The scenario brings about higher food output. Since the effective manner of cost-cutting lowers food production prices to strengthen its competitiveness in world market and expand the export, it also stimulates domestic consumption correspondingly. The economy-wide increase in GDP is equal to 0.7%. This increase is mainly driven by a 2.57% growth in domestic consumption demand. Otherwise, the significant food cost-cut effect of the production subsidy has a positive impact on farmer’s income. Rural households experience an increase in their incomes, mainly via the increase in wage level. The growth in consumption demand is mainly spurred by the increase in household income. Relatively speaking, rural households are able to increase consumption slightly more than urban households. Therefore, the increase in the income of rural households effectively favors consumption growth and, obviously, supports non-agricultural products output.

Due to lower production costs associated with the cost paid by the producer, production prices for most products decline. This affects the export/domestic price ratio and brings about a decline in the export/domestic price ratio, causing firms to shift production towards the export market. At the same time, consumers demand more domestically produced goods in response to a rise in the relative price of imports (PM: −1.002%; PD: −1.25%). The joint effect of increased exports and lower imports leads to a positive effect on the balance of payments. Since foreign savings are fixed, the exchange rate appreciates by 1.002% to correct the imbalance on the foreign account.

Correspondingly, the production subsidy also has various important indirect effects. Firstly, on the government account aspect, in order to finance the subsidy, government has to increase its borrowings. Although the various direct and indirect tax rates remain unchanged in this simulation, the increasing household income and consumption demand allows government to increase its revenue from direct taxes and indirect taxes. Secondly, on the investment aspect, investment is modeled as expenditure on goods and services in the economy. Thus, it implies that a decline in investment negatively affects the demand for goods and services. Typically industries that supply investment-type goods, such as the construction industry are hardest hit by sharp decreases in investment demand. The drop in demand has an adverse effect on output in all industries, especially those that specialize in investment goods (construction industry, machinery and equipment industry). However, the dominating effect remains the direct positive effect of the subsidy, as well as a positive indirect employment effect associated with the increase in private consumption. Since the model simulates a static scenario, the decline in investment does not affect the growth potential of the economy. GDP growth is measured at 0.7%. Thus, it is worth pointing out that poor investment growth resulting from the production subsidy will have a detrimental effect on the growth of capital stock and GDP growth in the long run.

5.2.2 Effects of Food TFP Growth (Simulation Set 2).

The technological change that we simulate in the CGE model is assumed to be neutral, We base the exogenous increase in the scale parameter of the CES value added function for each of the food categories to calculate the effects on both yield growth and income. The simulations of set 2 examine the effects of TFP growth.

Table 8 presents the yield and income effects of productivity growth for each of the crops and for all crops combined, calculated as the deviations from the latest data base (2001) solution of the CGE model. The scenarios of TFP growth indicate obviously positive output in all food sectors and in almost all non-agricultural sectors, bearing out the favorable effect of agricultural growth linkages. The sole exception is in construction and mining, to which the linkages of rural household consumption and of agricultural production are particularly weak. Relatively smaller proportionate growth benefits accrue to farmer's income. This result is explained by the declining agricultural terms of trade which serve to partly offset the positive direct effect of food productivity growth on farm-household incomes.

Note that the income gains are higher for urban relative to rural households. This finding appears because the incremental consumption demand arising from the increased agricultural incomes was biased toward products of urban industry and imported goods, reinforcing the bias in the induced income growth against rural households. All this would have contributed to the persistence of a highly inequitable income distribution.

Otherwise, exogenous TFP growth in the food sector brings about a more efficient allocation of factor endowments. Migration is based on the wage (marginal product of labor) differential between sectors. As the labor returns in the nonagricultural activities are higher than those in agriculture, more labor move from agricultural to non-agricultural sectors. The additional labor leads to downward pressure on the wage-rental ratio, which increases the relative profitability of the labor-intensive sectors. As a result, the output of the labor-intensive sectors increases. Since the labor-intensive sectors demand relatively more labor than the capital-intensive sectors, the labor-intensive sectors mainly absorb the migrant labor. In non-agricultural sectors, because of output expanding effects, the overall increased demand for labor in the non-agricultural activity eliminates any tendencies for wage-rental ratio to decline. The downward demand for labor in the agricultural activity cushions the rise of wage-rental ratio in agricultural sectors. The joint effects result in an increase in aggregate wages level, favor overall non-agricultural income and increase per capita farm income.

A final point concerning Table 8 is that the positive impact of crop productivity growth on GDP is borne out. The combined effect from the five crops is 1.9 percent of the base GDP. The corresponding results of I-O multiplier analysis show much larger income effects of crop productivity growth-in terms of GDP (4.7 percent). These comparative findings reflect the economy-wide supply constraints built into the CGE model, which lead to price responses that dampen the quantity adjustments relative to those generated by the fixed-price I-O model.

Moreover, it is also worth pointing out that public investment in agricultural research, irrigation, education and other rural infrastructures has been a major driving force to the growth of agricultural production in China. The policy could stimulate China's TFP growth and increase the efficiency of farmers' private inputs. Being a cost-effective, green box policy measure, public investment in agricultural research, etc., deserves focused attention.

5.2.3 Effects of Food TFP growth and partial trade liberalization (Simulation Set 3).

In this section, we make use of the food CGE model to investigate the likely effects of crop productivity growth on the assumption that a more liberal trade regime will exist in future.

We simulate a partial trade liberalization scenario in which all sectoral tariff rates are reduced by

50 percent. The scenario can be considered realistic in the context of present conditions. The economy-wide effects arising from the CGE model simulation of trade regime in combination with the simultaneous productivity growth in the five crop categories are shown in Table 9. There are some notable differences with the corresponding entries in the last column of Table 8, which contain the changes induced by crop productivity growth alone. Among the production sectors, it would appear that the major beneficiaries of trade liberalization are the traditional export sectors and such highly import-dependent sectors as energy and heavy manufacturing. Food output obviously increases.

Otherwise, this simulated result shows how the incomes differ from those resulting from crop productivity growth without trade liberalization: Factor incomes increase with trade liberalization. The distribution of labor income benefits differs in the trade regime scenarios represented in Table 9, because the tariff removal helps to significantly benefit agricultural and labor-intensive industries according to current economic structure, and results in a positive effects on income distribution. That unskilled labor income increases by a greater proportion than skilled labor income under partial free trade suggests a more favorable income distribution than that resulting from no trade liberalization.

The income changes induced on the different household groups show an even stronger pro-equity impact of trade liberalization. Farm households receive the largest income gains, which is in sharp contrast with the earlier simulation result under the existing trade regime. Also, the rural households are made better off to a greater extent than urban households. The extent to which a liberalized trade regime changes the income effects of crop productivity growth for the two household groups. It shows that, while rural households increase their income benefits from crop productivity growth with partial tariff cut, urban households are better off under the existing trade regime. In general, these results are qualitatively consistent with the conclusion from an earlier study that trade liberalization in the China during the current period would on average have favored rural over urban households.[22]

However, the government income declines by 5.8 percent under the tariff cut. This implies that the revenue loss from the removal of tariffs appreciably exceeds the revenue gains from the larger trade tax base and from the larger incomes of households and enterprises.

The impact of trade liberalization on GDP appears relatively substantial. In combination with crop productivity growth, partial trade liberalization generates a GDP expansion of 2.55 percent, while the increases in crop productivity alone are found above to resulte in a 1.96 percent GDP growth.

The above simulation results would seem to indicate that the extent to which the trade regime is liberalized matters a great deal in the China context. It has a major influence on the effectiveness of agricultural productivity growth in advancing the two objectives of growth and equity in the current period. However, it is worth pointing out that the conclusion is derived from the current economical structure. Thus, it is essential for China to how to construct a feasible industrial and economic structure supporting its sustainable growth in the context of WTO membership.

6. Summary and Conclusions

Using a growth accounting methodology, the paper finds that total factor productivity contributions to growth in food production diminished after 1986. Especially, in recent years (1995–2002), increased use of inputs, mainly intermediates and capital, became major sources of growth in China's food sector. Given that increased input use, including labor, drove growth in China's food sector in recent years, food production will become more costly as wages and prices for intermediate and capital inputs rise. On one hand, this implies farmer's income will thereby further worsen. This is due to at least two considerations: from production side, increasing production cost further extracts the farmer's net income; and from demand side, Engel's rule and its resulting in a change in the terms of trade between agricultural products and non-agricultural products further enlarge income inequality between rural and urban sectors. On the other hand, this could constrain growth in China's food production and weaken its competitiveness in world markets.

However, the gap between productivity growth in China's food sector and productivity growth in developed countries suggests that China can improve its food production technology if the economic and policy environment encourages investment in agricultural research and development, water control systems, and land infrastructure. Moreover, it is also worth pointing out that public investment in agricultural research, irrigation, education and other rural infrastructures has been a major driving force to the growth of agricultural production in China. The policy could stimulate China's TFP growth and increase the efficiency of farmer's private inputs. Being a cost-effective policy measure, public investment in agricultural research and other farm improvements deserves focused attention.

This paper makes use of GTAP database version 6.0 to construct a food-focused computable general equilibrium model that can be used to analyze the economy-wide impacts of changes in a set of alternative options for the operation of China's food sectors. The options covered production subsidy, TFP growth and coming further trade liberalization.

The simulation (set 1) shows the positive effects of production subsidy, which brings about higher food output in an effective cost-cutting manner. Further, it prompts domestic consumption correspondingly, resulting from a decline in the import/domestic price ratio. The joint effect of increased exports and lower imports leads to a positive effect on the balance of payments. Meanwhile, rural households also experience an increase in their incomes, mainly via the increase in wages level. Rural households are able to increase consumption slightly more in relative terms than urban households. Therefore, the increase in the income of rural households effectively favors consumption growth and, obviously, supports non-agricultural products output. However, it is worth pointing out that, as production subsidy extracts a symmetric quantity from the saving account, poor investment growth will have a detrimental effect on the growth of capital stock and GDP growth in the long run. Thus, the option has to become a countermeasure for the short-term. Starting from a long-term viewpoint, simulations (set 2) examine the effects of TFP growth. The simulation results indicate obviously positive output in all food sectors and in almost all non-agricultural sectors, bearing out the favorable effect of agricultural growth linkages. On the other hand, relatively smaller proportionate growth benefits accrue to farmer's income. This result is explained by the declining agricultural terms of trade which serve to partly offset the positive direct effect of food productivity growth on farm-household incomes. Among the primary factors, skilled labor and capital consistently show the largest proportionate income benefit. Relatively smaller income increases accrue to unskilled labor. Also, income gains are higher for urban relative to rural households. This finding is proved by the quantitative analysis that the incremental consumption demand arising from the increased agricultural incomes was biased toward products of urban industry and imported goods, reinforcing the bias in the induced income growth against rural households. Meanwhile, more labor move from agricultural to non-agricultural sectors. The additional labor leads to downward pressure on the wage-rental ratio, which increases the relative profitability of the labor-intensive sectors. As a result, the output of the labor-intensive sectors increases in non-agricultural sectors. Since the labor-intensive sectors demand relatively more labor than the capital-intensive sectors, the labor-intensive sectors mainly absorb the migrant labor. In non-agricultural sectors, because of output expanding effects, the overall increased demand for labor in the non-agricultural activity eliminates any tendencies for wage-rental ratio to decline, While the downward demand for labor in agricultural activity cushions the rise of wage-rental ratio in agricultural sector. The joint effects result in an increase in aggregate wage level, favor non-agricultural sectors and increase per capita farm income.

The last set of simulations aims to investigate the effects of crop productivity growth on the assumption that a more liberal trade regime will appear in future. There are some notable differences with the corresponding simulations postulating changes induced by crop productivity growth alone. Among the production sectors, it would appear that the major beneficiaries of trade liberalization are the traditional export sectors and such highly import-dependent sectors as energy and heavy manufacturing. Food output clearly increases as a result. Further, this simulated result shows how the incomes differ from those resulting from crop productivity growth without trade liberalization: Factor incomes increase with trade liberalization, as the tariff removal helps to expand agricultural and labor-intensive industries, and generally have positive effects on income distribution. That unskilled labor income increases by a greater proportion than skilled labor income under partial free trade suggests a more favorable income distribution than that resulting from no trade liberalization. However, it is worth pointing out that the conclusion is derived from the current economical structure. Thus, it will be essential for China to construct a feasible industrial and economic structure supporting sustainable growth in the context of WTO participation.

In this study, we have found a few contradictions and problems in the current crucial period of chinese agricultural development, namely, a drop in grain productivity, high cost of grain production and slow growth of farmer's income. Those problems have a close relation with the top priority of all tasks in current China: to tackle the three problems of agriculture, farmers and rural economy. Thus, it is key for China to take more direct and effective policies and measures to strengthen, support and protect agriculture and increase rural incomes in line with the need to balance urban and rural development. The present study on food policy and modeling must be extended in two respects: firstly, disaggregate of the national level into regional or provincial level; and secondly, further disaggregate of household groups, farm enterprises and farm products.

Notes

1 A detailed analysis is provided in sub-section 3.1 to 3.3.

2 Given that the increased resources allocated to agricultural sectors and the rural sector would lead to rising agricultural productivity and rural income, which in turn would create a strong demand for increased nonagricultural production in the overall economy. The expanding domestic demand will generally act as the main engine for economic growth to substitute possible declining exports and investment demand in future.

3 See *Ministry of Agriculture in China* (2004).

4 Technical efficiency is the ability to achieve maximum output given a set of input and technology.

5 Allocation efficiency is a measure of the degree of selecting both the optimal combination of input quantities regarding the inputs' price, and the optimal combination of output quantities regarding to the outputs' price.

6 See *Ministry of Agriculture in China (1999)* and Watson and Findlay (1999).

7 See *Ministry of Agriculture in China (2001)* and Findlay and Watson (1999).

8 See Wang et al. (2000) and *Ministry of Agriculture in China*(1999).

9 See Huang (1999b).

10 See Avanson et al. (1999).

11 See Gopinath and Roe (1997).

12 A software, called General Algebraic Modeling System for solving complex mathematical and statistical problems. See Brooke and Kendric (1998).

13 Our model system mainly originates from Ezaki and Sun (2000).

14 Upon request, we use necessary data now available.

15 Upon request, we will provide necessary relationships among database.

16 See Lin and Demor (2004), whose study assess the degree of interdependence between agriculture and non-agriculture industries in China using techniques from input-output analysis. They find that when backward linkages from agriculture to non-agriculture are ignored, the agricultural multipliers are understated by about 20%. When backward linkages from non-agriculture to agriculture are omitted, the non-farm multipliers are understated by about 8%.

17 These refer to three sets of different simulations concerning production subsidy, TFP growth and coming further trade liberalization.

18 To construct the latest Food SAM, we firstly make use of *GTAP database version 6.0* to set up a related database which is a highly disaggregated input-output table, differentiating 57 industries. These data are then aggregated into a new I-O table including 12 industries we need. These data mainly constitute a database on production and consumption aspects. Data for factors input, income and direct tax, etc. are derived from 2002 *China Statistical Yearbook, Agricultural Statistical Yearbook, China Labor Statistic Yearbook, China Development Report and China Living Standards Survey (2001–200)*.

19 In the capital market, capital stocks are fixed in each sector and capital rents serve as equilibrating variables. Capital market distortions are allowed, differentiated by sector. A constant of proportionality indicates the degree

to which the average return for a factor in a given sector differs from the marginal revenue product of that factor.

20 These necessary elasticity values are presented

21 In set 2 simulations, for the values we initially set at 1.0 in the base-model solution, the new values of the scale parameter are as follows: 1.35 for rice, 1.25 for wheat, 1.15 for other grain, 1.45 for vegetable and fruit, and 1.15 for other crops. The assumption proportion refers to the consumption-share ratio for each food category in recent years.

22 See Ministry of Agriculture in China (2004).

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