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# Impact of eliminating government interventions on China's rice sector

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**Abstract**

China's economy has undergone fundamental changes since 1978. Agriculture, industry and services are being transformed into market economies. Marketing and domestic trade have also been reformed to take into account regional comparative advantages. The government, however, still controls input supply and output procurement to some extent. China is currently negotiating with the GATT in regard to gaining membership. Conditions for China's reentering the GATT are to eliminate the government interventions on domestic production and consumption, and international trade. This may affect China's comparative advantages in international markets, and therefore may result in changes in the structure of imports and exports. Will China continue to export rice or will it start to import rice under free trade, and if China continues to export, how much will China export? This paper attempts to model the potential effects of eliminating all government interventions on China's rice sector. We construct a rice industry model to facilitate our analysis. The model has three components, i.e., supply, demand, and price linkages. The estimated results are consistent with theory and are evaluated using several techniques. Results from model validation indicate that both static and dynamic models are reasonable and can be used to simulate effects of various government policies. Simulations are conducted to project China's rice economy to the year 2000. Two scenarios are compared: (1) continued current policy and (2) elimination of all government interventions. Eliminating all government interventions would increase production, stocks, and exports. Domestic consumption would decline due to the higher domestic prices from eliminating government subsidies on rice consumption. China would export more than 1.6 million metric tonnes of milled rice if there were no government interventions in the year 2000.

Prior to 1979, production, marketing and trade of all major agricultural commodities in China were rigidly controlled by the government. Compulsory quotas for major agricultural products were set at prices well below the world market. China also had a subsidized food policy under which centrally procured agricultural commodities were distributed to urban residents and international markets at very low prices. The net effect of this system was to support industrial development by taxing agriculture.

Under the pre-reform commune system, production incentives were low, restricting agricul-

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tural productivity. To stimulate productivity, the government has initiated a number of economic reforms since 1979 to decentralize production decisions from the collective system to the individual farm household. Important reforms were also introduced in the highly centralized and tightly controlled system of procurement, distribution, and marketing of agricultural production. However, all of these reforms were limited both in degree and scope. As China becomes increasingly integrated into the international market, further reforms must be made in order to take

Table 1
Rice production, consumption, trade and stocks in China

| Year | Harvested area (1000 ha) | Production (1000 t) | Yield (t/ha) | Ending stocks (1000 t) | Export (1000 t) | Imports (1000 t) | Total consumption (1000 t) | Urban consumption (kg per person) | Rural consumption (kg per person) |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 31 500 | 41 811 | 1.33 | 3 000 | 428 | 0 | 46 383 | – | – |
| 1961 | 26 276 | 37 548 | 1.43 | 1 500 | 458 | 0 | 38 590 | – | – |
| 1962 | 26 935 | 44 090 | 1.64 | 5 500 | 684 | 0 | 39 406 | – | – |
| 1963 | 27 715 | 51 636 | 1.86 | 7 500 | 762 | 0 | 48 874 | – | – |
| 1964 | 29 607 | 58 100 | 1.96 | 5 500 | 985 | 0 | 59 115 | – | – |
| 1965 | 29 825 | 61 405 | 2.06 | 6 000 | 1487 | 0 | 59 418 | – | – |
| 1966 | 30 529 | 66 773 | 2.19 | 8 000 | 1577 | 0 | 63 196 | – | – |
| 1967 | 30 436 | 65 580 | 2.15 | 7 500 | 1299 | 0 | 64 781 | – | – |
| 1968 | 29 894 | 66 170 | 2.21 | 8 000 | 1179 | 0 | 64 491 | – | – |
| 1969 | 30 432 | 66 546 | 2.19 | 7 500 | 1280 | 5 | 65 771 | – | – |
| 1970 | 32 358 | 76 993 | 2.38 | 11 000 | 1292 | 8 | 72 209 | – | – |
| 1971 | 34 918 | 80 643 | 2.31 | 13 000 | 1426 | 19 | 77 236 | 27.99 | 130.31 |
| 1972 | 35 143 | 79 348 | 2.26 | 13 000 | 2631 | 0 | 76 717 | 28.96 | 119.77 |
| 1973 | 35 090 | 85 215 | 2.43 | 16 000 | 2060 | 102 | 80 257 | 29.63 | 139.38 |
| 1974 | 35 512 | 86 733 | 2.44 | 17 500 | 1630 | 30 | 83 633 | 29.66 | 139.38 |
| 1975 | 35 729 | 87 892 | 2.46 | 19 500 | 876 | 114 | 85 130 | 30.79 | 143.90 |
| 1976 | 36 217 | 88 063 | 2.43 | 20 000 | 1033 | 0 | 86 530 | 32.15 | 145.04 |
| 1977 | 35 526 | 89 996 | 2.53 | 21 000 | 1435 | 0 | 87 561 | 34.08 | 147.26 |
| 1978 | 34 421 | 95 850 | 2.78 | 26 000 | 1053 | 71 | 89 868 | 35.00 | 152.05 |
| 1979 | 33 344 | 100 625 | 3.02 | 29 000 | 1116 | 18 | 95 666 | 37.00 | 163.78 |
| 1980 | 33 878 | 97 934 | 2.89 | 25 000 | 580 | 110 | 101 464 | 38.65 | 171.32 |
| 1981 | 33 293 | 100 768 | 3.03 | 22 000 | 470 | 250 | 103 548 | 39.96 | 178.12 |
| 1982 | 33 056 | 113 117 | 3.42 | 26 000 | 580 | 75 | 108 612 | 41.29 | 132.82 |
| 1983 | 33 136 | 118 206 | 3.57 | 29 500 | 1160 | 100 | 113 646 | 43.01 | 130.19 |
| 1984 | 33 178 | 124 779 | 3.76 | 32 500 | 1010 | 100 | 120 869 | 47.02 | 135.30 |
| 1985 | 32 070 | 117 999 | 3.68 | 27 500 | 950 | 322 | 122 371 | 48.02 | 135.67 |
| 1986 | 32 266 | 120 557 | 3.74 | 24 500 | 1301 | 429 | 123 091 | 53.35 | 135.80 |
| 1987 | 32 139 | 121 716 | 3.79 | 22 500 | 698 | 421 | 123 329 | 58.90 | 135.00 |
| 1988 | 31 914 | 118 377 | 3.71 | 20 161 | 315 | 1042 | 121 596 | 60.44 | 134.19 |
| 1989 | 32 700 | 126 091 | 3.86 | 23 035 | 326 | 57 | 123 059 | 59.10 | 134.84 |
| 1990 | 33 064 | 132 532 | 4.01 | 28 220 | 689 | 67 | 126 752 | 56.70 | 134.99 |
| 1991 | 32 598 | 128 667 | 3.95 | 27 510 | 933 | 100 | 128 537 | | |
| 1992 | 32 753 | 130 354 | 3.98 | 28 064 | 900 | 100 | 128 595 | | |
| Annual Growth Rate (%) | | | | | | | | | |
| 1960–69 | −0.34 | 4.76 | 5.12 | 9.60 | 11.58 | – | 3.55 | – | – |
| 1970–79 | 0.30 | 2.71 | 2.41 | 10.18 | −1.45 | 8.45 | 2.85 | – | – |
| 1980–89 | −0.35 | 2.56 | 2.92 | −0.82 | −5.60 | −6.36 | 1.95 | 4.34 | −2.37 |
| 1960–92 | 0.12 | 3.62 | 3.49 | 7.24 | 2.35 | – | 3.24 | – | – |

Notes: Rice is measured in milled terms.
t, metric tonne = 1000 kg.

advantage of the international market. This paper focuses on the effects of eliminating all government interventions on the China's agricultural sector using the case of rice. China is negotiating its membership in the GATT (General Agreement on Tariffs and Trade). One condition for acceptance is to reduce and finally eliminate all government distortions on the economy. This paper may provide important policy implications for both China and other countries on the potential effects of China reentering the GATT on agricultural trade.

The paper is organized as follows. The first section presents a general overview of China's rice economy. Section 2 describes the conceptual trade model used in the study. The model is comprised of several components including production, consumption, stocks, and exports. Section 3 presents the empirical estimates of the model. The fourth section of the paper presents model simulation results to project the effects of lifting all government interventions on rice production, consumption, and international rice trade. The paper concludes by summarizing the paper's findings.

## 1. Overview of rice economy and policies governing the rice sector

Rice is the main staple food in China, contributing 40% of total calorie intake. Total rice production in China amounted to 130 million metric tonnes (in rough terms), and accounted for 38% of world total rice production in 1992. Therefore, the performance of the rice sector in China not only affects the well-being of 1.2 billion Chinese inside China, but also has a significant impact on the international rice market.

The performance of the China's rice sector has been very impressive in spite of government distortions. Production grew at 4.8% annually in the 1960's, and the growth slowed slightly during the 1970's and 1980's at 2.7% and 2.6%, respectively (Table 1). The longer-term growth from 1960 to 1992 was 3.6%, which exceeded population growth (1.8%). Yields increased rapidly during the 1960's and then increased steadily in the 1970's and 1980's.

Total rice consumption increased by 3.6% per annum during the 1960's, by 2.9% per annum during the 1970's, and by 2.0% per annum during the 1980's. These rates exceeded the population growth rates during the same periods, implying that per capita rice consumption has risen steadily over this time. However, per capita consumption has been stagnant since 1984.

These achievements were realized through a series of institutional changes and technological improvements. Since the formation of the new republic, China has experienced a number of policy and institutional reforms that in some cases have involved abrupt dislocations of the country's economic, social and political order. The mode of production has been the target of repeated government-sponsored change. Large-scale land reform was one of the first priorities of the newly formed Communist government. Soon after 1949, land was confiscated by the government, without compensation, and redistributed to peasant farmers. Beginning in 1952, some small-scale peasant farmers voluntarily pooled their land and other resources into a cooperative mode of operation. This was soon followed by government efforts to develop large collectivized operations, and by 1956 most agricultural production was done on a collective basis. Under this system landownership was vested in the collective, which usually consisted of approximately 200 families. Within the collective, an individual's income was tied to the number of work points accumulated throughout the year in line with the amount of time, effort, skill and 'political attitude' that was brought to one's collective work. [1] Home gardens on 'private plots', constituting about 5% of all arable land at this time, were also farmed by households, the produce from which could be sold on free markets.

This collective system of production remained more or less in place until the late 1970s, al-

[1] Lin (1988) gives an analysis of the economics of communal production systems as practiced throughout China at this time.

though the size of the basic collective unit did vary substantially over time. At the height of the commune movement in 1958–59 the average communal unit had grown to 5000 households covering 10 000 acres ($\approx$ 4047 ha) with food being allocated as much on the basis of need as on accumulated work points. Work on private plots was also prohibited at this time. But by 1962 the 'production unit', a subunit of the commune consisting of only 20 to 30 neighboring families, had become the basic unit of operation and accounting. Decisions regarding farm operations, including the adoption of new technologies, were primarily made by unit leaders. Market exchange of land between different production units in the collective system was outlawed.

The market-oriented rural reforms initiated in late 1978 were seen at the outset primarily as a means of freeing up rural trade fairs or 'free markets' whose main function was to provide an outlet for produce grown on the private plots of farm households working in their spare time. But events rather quickly overtook these quite modest aims and have subsequently led to, among other things, a radical overhaul of the collective system of farm production and management, a relaxation of regional self-sufficiency requirements, and moves to liberalize and decentralize many factor and product markets. This has included significant increases in the prices paid for state-purchased farm produce. These new policies sought to move away from a lopsided stress on grain production by encouraging diversification of the rural economy as well as product specialization and crop selection that were in greater accord with regional comparative advantage. Most importantly, they also sought to restore the primacy of the individual household as the basic unit of production and management in rural China. These institutional changes have demonstrably accelerated the rate of development of the Chinese agricultural sector.

Agricultural price policies have also had a substantial impact on agricultural production. In 1953 a system of production controls was introduced along with a series of demand management measures. These measures included a system of rationing and administered pricing coupled with a compulsory grain procurement program. Through this scheme, the government subsidizes the consumption of agricultural commodities (1) by paying the difference between official procurement prices and official urban, retail (or ration) prices; and (2) by subsidizing the importation, marketing, and processing of agricultural commodities. By 1987, the latest year for which relevant data are available, total price subsidies going to grain, cotton, oilseed, and meat products amounted to 9.7% of total government expenditures. The bill for these commodity subsidies alone was 1.2-fold higher than the total government expenditures on agriculture. [2]

Although the market has played an increasing role in both production and post-production agriculture, the sector continues to be influenced by a host of direct and indirect policy interventions. In addition to the administered pricing, rationing, and controlled distribution mechanisms that still apply to many agricultural inputs and outputs, there are a number of other measures – such as disaster relief payments, interest subsidies, and expenditures on infrastructure developments – that result in policy-induced transfers to and from producers and consumers alike.

## 2. Conceptual framework of China's rice sector model

Major components of the national rice model include a supply sector, a demand sector, and price linkage equations. Rice is measured in milled terms, and all prices are deflated by the consumer price index.

[2] The reported government expenditures on agriculture for 1987 were 19.6 billion yuan (*China's Statistical Yearbook*, 1991) and included agricultural production subsidies (separate from the consumer price subsidies discussed here, which are charged against the Ministry of Commerce budget); support for research, extension, and service agencies such as seed multiplication and veterinary stations; plus investments in agricultural infrastructure like irrigation, transport, and communications facilities.

### 2.1. Supply sector

We assume the supply of rice is determined by profit-maximizing producers. They maximize their net revenue received from their outputs subject to the technical and regulatory constraints imposed by their production function. Solving the producer's problem yields first-order conditions identifying the optimal level of inputs such that the value of the marginal product of the input will be equal to the price of the input. The relationships are expressed as functions of expected output prices and expected input prices. Their input demand relationships can be aggregated without specification bias, if and only if, each individual farmer faces the same price. Assuming all farmers face the same prices, the industry equation describing planted acreage is a function of the expected output price and expected price of inputs. Since there is little difference between planted acreage and harvested acreage, a function for harvested acreage is specified and estimated in this model. Hence, the relationship specifying harvested acreage is expressed as:

$$\mathrm{HA}_t = \mathrm{f}_1(\mathrm{HA}_{t-1}, P_t^{\mathrm{e}}, W_t^{\mathrm{e}}, e_{1t})$$

where $\mathrm{HA}_{t-1}$ is harvested acreage at $t-1$, $P_t^{\mathrm{e}}$ is expected price received by producers, $W_t^{\mathrm{e}}$ is expected input price, and $e_{1t}$ is the error term. One would anticipate positive coefficients for lagged acreage and expected price of rice and negative coefficients for input price.

Alternative approaches have been used to model price expectations. In China, a farmer's expectation of prices is based on both government policies and market information; where government policies played a dominant role before 1978. The recent grain market reform has made China's grain economy (including the rice sector) move further towards a market economy. More than 90% of the counties have opened their grain markets. Farmers have increasingly used market information in their decisions. Therefore, we specify harvested acreage as a function of both the expected free market price and government procurement price:

$$\mathrm{HA}_t = \mathrm{f}_1(\mathrm{HA}_{t-1}, P_{\mathrm{m},t-1}, P_{\mathrm{g}t}, W_t, e_{1t})$$

where $P_{\mathrm{m},t-1}$ is lagged market price for rice, and $P_{\mathrm{g}t}$ is government procurement price which is announced before each rice production season.

Yield is specified as a function of expected output, input prices, and agricultural research expenditures. One of the thornier problems to resolve when including a research variable in a yield equation concerns the choice of an appropriate lag structure. There is some evidence that substantially shorter lag lengths than normal may be appropriate for China. Stone, 1990) notes that some of the regional research systems in China move research on varietal improvement, at least for wheat and rice, through development, testing, and registration procedures, and on to seed production and extension in just 3–5 years. In these more advanced regions, major varieties may well turn over every 2–3 years, with a national average of just twice this rate. With this in mind, we include a research variable that was the deflated, weighted sum of past research expenditures $r_{t-i}$ given by:

$$R_t = \sum_{i=1}^{7} w_i r_{t-i}$$

where the weights are defined as $w_1 = w_7 = 0.05$, $w_2 = w_6 = 0.1$, $w_3 = w_5 = 0.2$, and $w_4 = 0.3$.

The yield equation is expressed as:

$$Y_t = \mathrm{f}_2(R_t, P_{\mathrm{m},t-1}, P_{\mathrm{g}t}, W_t, e_{2t})$$

where $Y_t$ indicates yield at year $t$.

### 2.2. Demand sector

We assume the demand for rice is determined by utility-maximizing consumers. They maximize their utility from their consumption of commodities they consume subject to the budget constraint. Solving the consumer's problem yields first-order conditions identifying the optimal level of commodities they buy. Therefore, the per capita rice demand is specified as:

$$D_t = \mathrm{f}_3(M_t, \mathrm{RP}_t, \mathrm{WP}_t, e_{t3})$$

where $D_t$ is total rice demand on a per capita base, $M_t$ is per capita income in real terms, $\mathrm{RP}_t$ is rice retail price (weighted average of free market price and government ration price), and $\text{WP}_t$ is wheat price.

The demand for exports from China is a function of the difference between domestic production and consumption and export price (FOB):

$$\text{EXP}_t = f_5(\text{RESD}_t, \text{FOB}_t, e_{t5})$$

where $\text{EXP}_t$ is exports, $\text{RESD}_t$ is residual of total production net of total consumption, and $\text{FOB}_t$ is free on board export price measured in local currency.

### 2.3. Price linkages

Government procurement price depends on government agricultural expenditures, and institutional reforms, while the market price depends on the government procurement price and total rice supply:

$$P_{gt} = f_6(\text{AGEXPEND}_t, P_{g,t-1}, \text{D79}, e_{t6})$$

$$P_{mt} = f_7(P_{gt}, \text{SUPPLY}_t, P_{m,t-1}, \text{D79}, e_{t7})$$

where $\text{AGEXPEND}_t$ is government agricultural expenditures, and $\text{SUPPLY}_t$ is rice total supply defined as beginning stocks plus production.

Retail price is a function of deflated export price (FOB), total rice demand ($\text{TD}_t$) defined by per capita consumption multiplying by total population, and the lag of retail price:

$$\text{RP}_t = f_8(\text{FOB}_t, \text{TD}_t, \text{RP}_{t-1}, e_{t8})$$

Export price of Chinese rice is a function of the Thai rice price and the lag of the export price:

$$\text{FOB}_t = f_9(\text{THAI } P_t, \text{FOB}_{t-1}, e_{t9}$$

where $\text{THAI } P_t$ is deflated Thai rice price (5% broken).

### 2.4. Market clearance

We treat ending stocks as residual to close the model. The ending stocks variable is residual of total supply (production and beginning stocks) net of total demand (total domestic demand and exports):

$$S_t = \text{PROD}_t + S_{t-1} - \text{TD}_t - \text{EXP}_t$$

where $\text{PROD}_t$ is rice production.

## 3. Empirical results

The data used in this study cover the period from 1965 to 1989. The data on production, procurement price, market price, and agricultural expenditures are from various issues of *China's Statistical Yearbooks* (China State Statistical Bureau, 1981–1991). Agricultural research expenditures are published by Fan and Pardey (1992). Consumption, stocks, and exports are collected from USDA (1993). The export price and the Thai price are from IRRI's *World Rice Statistics* (1990).

All model equations were estimated using three-stage least squares. All have coefficients consistent with the hypothesized signs and are of reasonable magnitudes. Most estimated coefficients' $t$-statistics are significant. Durbin–Watson equation statistics indicate either no first-order autocorrelation or are inconclusive.

(1) Area and yield estimation

$$\begin{aligned}\text{HA}_t = {} & \underset{(1.91)}{8444.5} + \underset{(0.67)}{1409.1} * P_{gt} + \underset{(0.56)}{523.6} * P_{m,t-1} \\ & - \underset{(-0.77)}{3149.5} * W_t + \underset{(8.67)}{0.80983} * \text{HA}_{t-1} \\ & - \underset{(-1.55)}{1274.5} * \text{D79} \qquad R^2 = 0.854 \quad \text{D.W.} = 1.27\end{aligned}$$

$$\begin{aligned}Y_t = {} & \underset{(1.47)}{4.55} + \underset{(3.78)}{2.33} * P_{gt} + \underset{(2.55)}{0.11} * P_{m,t-1} \\ & + \underset{(1.99)}{0.00158} * R_t - \underset{(4.26)}{3.18} * W_t \\ & + \underset{(2.34)}{0.34} * \text{D79} \qquad R^2 = 0.939 \quad \text{D.W.} = 1.00\end{aligned}$$

(2) Consumption estimation

$$\begin{aligned}D_t = {} & \underset{(-1.41)}{-10.98} - \underset{(-1.51)}{21.33} * \text{RP}_t - \underset{(-1.81)}{8.16} * M_t \\ & + \underset{(1.64)}{38.20} * \text{WP}_t + \underset{(2.01)}{0.994} * D_{t-1} \\ & \qquad R^2 = 0.971 \quad \text{D.W.} = 1.96\end{aligned}$$

(3) Export estimation

$$\text{EXP}_t = \underset{(3.67)}{475.8} + \underset{(0.82)}{0.24 * \text{FOB}_t} + \underset{(1.53)}{0.061 * \text{RESD}_t}$$

$$R^2 = 0.680 \quad \text{D.W.} = 2.25$$

(4) Price equations

$$P_{gt} = \underset{(6.65)}{-0.018} + \underset{(2.41)}{0.0004 * \text{AGEXPEND}_t} + \underset{(3.45)}{0.735 * \text{RP}_t} + \underset{(4.08)}{0.0118 * P_{g,t-1}} + \underset{(2.68)}{0.086 * \text{D79}}$$

$$R^2 = 0.611 \quad \text{D.W.} = 2.06$$

$$P_{mt} = \underset{(-6.19)}{-1.326} + \underset{(7.71)}{0.445 * P_{gt}} + \underset{(2.31)}{0.43 * P_{m,t-1}} - \underset{(-1.65)}{0.000002 * \text{SUPPLY}_{t-1}} + \underset{(6.29)}{0.154 * \text{D79}}$$

$$R^2 = 0.370 \quad \text{D.W.} = 2.06$$

$$\text{RP}_t = \underset{(16.83)}{0.703} + \underset{(1.65)}{2.48 * \text{FOB}_t} + \underset{(0.91)}{0.314 * \text{RP}_{t-1}} - \underset{(-1.76)}{0.000103 * \text{TD}_t}$$

$$R^2 = 0.768 \quad \text{D.W.} = 2.31$$

$$\text{FOB}_t = \underset{(0.99)}{39.42} + \underset{(3.51)}{0.95 * \text{THAI } P_t} + \underset{(8.04)}{0.876 * \text{FOB}_{t-1}}$$

$$R^2 = 0.564 \quad \text{D.W.} = 2.23$$

## 4. Model validation and simulation

Model validation provides confidence to the user that the model reflects results similar to actual experience even though any model is a simplification of reality. There are several ways to validate a model. Model coefficients can be evaluated and compared with hypothesized signs and magnitudes. Equation summary statistics, such as the *R*-square, and the Durbin–Watson statistic can be analyzed as in the previous section. In this section, the elasticities calculated from the model are reviewed. Model statistics calculated from static and dynamic deterministic simulation results are presented.

Table 2
Elasticities for China's rice model

| Variables | Short run | Long run |
|---|---|---|
| Harvested area | | |
| with respect to procurement price | 0.044 | 0.227 |
| with respect to market price | 0.017 | 0.087 |
| with respect to input price | −0.115 | −0.594 |
| Yield | | |
| with respect to input price | −0.333 | |
| with respect to research | | 0.190 |
| Per capita consumption | | |
| with respect to rice retail price | −0.518 | −2.380 |
| with respect to income | −0.099 | −0.456 |
| with respect to wheat price | 0.366 | 1.680 |
| Net exports | | |
| with respect to FOB | 0.318 | |

### *4.1. Elasticities*

Demand and supply elasticities evaluated at the mean of the data set are presented in Table 2. Even though the elasticities are derived from a rather simplified model, they do shed light on the response of China's rice sector to price changes. The elasticities indicate that the response of rice acreage to the changes in both government procurement prices and market prices is inelastic in both the short run and in the long run. The response of rice acreage to input price changes is more elastic than that to output price changes although it can also be classified as inelastic. The responses of yield to input price changes and research investment are also inelastic.

The response of per capita consumption to rice retail price changes is inelastic in the short run, but is elastic in the long run. The income elasticity calculated from the model indicated that rice in China has become an inferior good. The response of rice consumption to wheat retail price changes is inelastic in the short run, while it is very elastic in the long run. The response of exports to export price (FOB) is inelastic in the short run.

Table 3
Validation statistics for China rice model

| | Mean | MARE | *U*-Theil | PTPE |
|---|---|---|---|---|
| Static | | | | |
| HA | 33 080 | 0.016 | 0.011 | 0.580 |
| Y | 4.07 | 0.052 | 0.032 | 0.400 |
| D | 97.4 | 0.016 | 0.100 | 0.280 |
| ES | 19 024 | 0.143 | 0.083 | 0.360 |
| EXP | 1 138 | 0.308 | 0.170 | 0.320 |
| Dynamic | | | | |
| HA | 33 080 | 0.024 | 0.016 | 0.416 |
| Y | 4.07 | 0.052 | 0.032 | 0.400 |
| D | 97.4 | 0.017 | 0.110 | 0.240 |
| ES | 19 024 | 0.212 | 0.169 | 0.319 |
| EXP | 1 138 | 0.657 | 0.319 | 0.280 |

Notes: Mean absolute relative error is defined as:

$$\text{MARE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{y-\hat{y}_t}{y_t}\right|$$

Theil's inequality is defined as:

$$U = \frac{\sqrt{\sum_{t=1}^{n}(y_t-\hat{y}_t)^2}}{\sqrt{\sum_{t=1}^{n}y_t^2}+\sqrt{\sum_{t=1}^{n}\hat{y}_t^2}}$$

Percent turning point error is defined as:

$$\text{PTPE} = \frac{1}{n}\sum_{t=1}^{n}\text{TPE}_t$$

$$\text{if } \frac{[y_t - y_{t-1}]}{[\hat{y}_t - \hat{y}_{t-1}]} > 0 \quad \text{then} \quad \text{TPE}_t = 0$$

$$\text{else} \quad \text{TPE}_t = 1 \quad \text{for all } t$$

## 4.2. Static and dynamic simulation

The dynamic simulation differs from the static simulation in that after the initial period, the model's predicted values of lagged endogenous variables are used to generate future values of the endogenous variables. The model's goodness-of-fit measures are presented in Table 3. In general, more errors appear in the dynamic simulation than static simulation since the predicted values of lagged endogenous variables rather than the actual values of lagged endogenous variables are used in the simulation. The mean absolute relative error (MARE) and Theil's inequality statistic are low except for exports. The percent turning point error (PTPE) provides a measure of how well the modeling system predicts turning points over the simulation period. The PTPEs for harvested area and yield are high: 0.580 and 0.400 in static simulation, and 0.416 and 0.400 in dynamic simulation.

## 4.3. Effects of eliminating government interventions on China's rice sector

This section of the paper reports on simulations to capture the effects of eliminating all government interventions in the rice industry. Government interventions in China include trade restrictions and measures, state procurement pricing, state consumer subsidies, disaster relief, interest subsidies, advance payments, input pricing, research and development, transfers through the tax system, infrastructure development, transfers from enterprise profits, and other state outlays on agriculture.

There are several ways of measuring the effects of government intervention on producers and consumers. The most commonly used measures are the producer subsidy equivalent (PSE) and consumer subsidy equivalent (CSE).

The particular advantage of these measures is that they can capture the effects of a comprehensive set of policy measures. Several economists have reported PSEs and CSEs in Chinese Agriculture. Recently, Webb (1989) estimated PSEs and CSEs for major agricultural commodities in China, but took into account only procurement pricing and border measures. Gunasekera et al. (1991) has attempted to estimate the PSEs and CSEs for Chinese agricultural commodities due not only to these interventions but also to various other key government measures such as: direct income support (disaster relief); indirect income support, including advance payments to farmers, interest subsidies, and administered input pricing; and other support measures including research and development and transfers through the tax system, expenditure on infrastructure development, and transfers from profits of other rural enterprises. From their estimation, the PSE for rice is −46.1%, indicating that rice producers are implicitly taxed by the government, while the CSE for rice is 53.6% and the CSE for wheat is

Table 4
Projection of China's rice economy

| Year | Harvested area (1000 ha) | | Production (1000 t) | | Yield (t/ha) | | Consumption (1000 t) | | Per capita consumption (kg) | | Ending stocks (1000 t) | | Net exports (1000 t) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Actual | | | | | | | | | | | | | | |
| 1985 | 32 070 | | 117 999 | | 3.68 | | 122 371 | | 115.61 | | 27 500 | | 628 | |
| 1986 | 32 266 | | 120 557 | | 3.74 | | 123 091 | | 114.49 | | 24 500 | | 872 | |
| 1987 | 32 139 | | 121 716 | | 3.79 | | 123 329 | | 112.84 | | 22 500 | | 277 | |
| 1988 | 31 914 | | 118 377 | | 3.71 | | 121 596 | | 109.55 | | 20 161 | | −727 | |
| 1989 | 32 700 | | 126 091 | | 3.86 | | 123 059 | | 109.19 | | 23 035 | | 269 | |
| 1990 | 33 064 | | 132 532 | | 4.01 | | 126 752 | | 110.84 | | 28 220 | | 622 | |
| 1991 | 32 598 | | 128 667 | | 3.95 | | 128 537 | | 110.98 | | 27 510 | | 833 | |
| 1992 | 32 753 | | 130 354 | | 3.98 | | 128 595 | | 109.51 | | 23 588 | | 800 | |
| 1993 | 32 942 | | 127 400 | | 3.87 | | 128 228 | | 107.68 | | 23 756 | | 1 000 | |
| Projections | | | | | | | | | | | | | | |
| 1994 | 32 982 | 33 204 | 129 639 | 132 034 | 3.76 | 3.81 | 128 085 | 126 658 | 106.07 | 104.89 | 24 280 | 31 592 | 1 030 | 1 264 |
| 1995 | 33 077 | 33 220 | 130 596 | 132 701 | 3.78 | 3.82 | 128 291 | 125 728 | 104.78 | 102.68 | 25 602 | 37 298 | 982 | 1 267 |
| 1996 | 33 116 | 33 299 | 132 534 | 134 821 | 3.83 | 3.88 | 128 944 | 125 317 | 103.85 | 100.93 | 28 099 | 45 348 | 1 093 | 1 454 |
| 1997 | 33 145 | 33 427 | 133 231 | 135 944 | 3.85 | 3.89 | 130 135 | 125 518 | 103.37 | 99.69 | 30 131 | 54 263 | 1 064 | 1 511 |
| 1998 | 33 165 | 33 595 | 133 888 | 137 231 | 3.86 | 3.91 | 131 949 | 126 414 | 103.26 | 98.93 | 31 070 | 63 537 | 1 001 | 1 547 |
| 1999 | 33 210 | 33 795 | 134 648 | 138 651 | 3.88 | 3.93 | 133 711 | 127 897 | 103.19 | 98.71 | 31 063 | 72 749 | 943 | 1 542 |
| 2000 | 33 277 | 34 020 | 135 491 | 140 179 | 3.91 | 3.94 | 135 255 | 129 270 | 102.94 | 98.39 | 30 394 | 82 103 | 905 | 1 558 |

Note: Scenario 1 represents current policy regime, and Scenario 2 represents lifting all government interventions in the rice sector. Rice is measured in milled terms.

19.5%, indicating that consumption of both rice and wheat is subsidized in China.

To simulate the rice production, consumption, stocks and exports under no-government interventions, we recalculate the producer, consumer, and export prices using Gunasekera et al.'s findings. The rice producer prices under free market would be 46.1% higher, the rice consumer price 53.6% higher, and the wheat consumer price 19.5% higher, compared to current policy regime prices.

Macro-level data also have to be projected. The population is projected using a 1.5% growth rate from 1993 to 2000, which is slightly lower than the growth rate from 1981 to 1990. National income and exchange rates are projected using 7.8% and 5.1% annual growth rates, respectively, which are the average growth rates from 1960 to 1992. Other exogenous variables including wheat consumer prices, agricultural research investment, and agricultural expenditures are also projected using the growth rates from 1960 to 1991. International rice price (Thai FOB, 5% broken) is taken from an international rice trade model developed at the University of Arkansas (Wailes, Fan and Cramer, 1994). Producer, consumer, and export prices are endogenous, and therefore are generated from the simulation.

Two different scenarios are compared: (1) current policy regime (or base scenario), and (2) eliminating all government interventions (free market scenario). Dynamic simulation is performed. The results are presented in Table 4. If the government keeps current policies from 1994 through 2000, producers would increase the rice harvested area from 33.0 to 33.3 million ha, a 0.15% average annual increase. If the government eliminates all interventions, producers would plant 33.2 million ha in 1994 and 34.0 million ha in 2000, an 0.4% increase per annum. The elimination of all government distortions would not increase the rice planted area substantially. The marginal increase of the area would mainly come from northern China if water supply conditions allow. Under the current policy, average yields would increase from 3.76 metric tonnes (t) per ha to 3.91 t per ha (annual growth rate 0.65%) from 1994 to 2000, while under the free market scenario, average yields would increase from 3.81 to 3.94 t per ha (0.56% per year). Consequently, the total production would increase from 129.6 million t in 1994 to 135.5 million t under the current policy (0.74% per annum), and increase from 132.0 to 140.2 million t under the free market situation (0.99% per annum).

Under both scenarios, per capita consumption would decline slowly as rice has become an inferior good. Due to the elimination of the government subsidies on rice consumption, per capita rice consumption would be smaller under the free market situation than under the current policy regime. Under the current policy regime, China will reduce rice exports slightly from 1.03 million t in 1994 to 0.905 million t in the year 2000, while exports would increase substantially under the free market situation from 1.26 to 1.56 million t. Due to improved production capacity and sluggish domestic and international demand, China will start to build large rice stocks including both privately-owned and government-owned inventories.

## 5. Conclusions

China's agricultural economy is heavily distorted by the government. As China is negotiating with the GATT to regain its membership, the government is slowly opening up its agricultural economy. This paper attempts to model the potential effects of eliminating all government interventions on China's rice industry. We constructed a rice industry model which can facilitate our analysis. The results from model validation indicate that both static and dynamic models are reasonable and can be used to simulate effects of various government policies. The simulations are conducted to project China's rice economy from 1993 to the year 2000. Two scenarios are compared: (1) continued current policy, and (2) elimination of all government interventions. Eliminating all government interventions would increase production, stocks, and export. Domestic consumption would decline, due to the higher domestic prices from eliminating government subsidies on rice consumption. China's rice exports would increase from 1.26 million t in 1994 to 1.56 million t in 2000 under no-government interventions, comparing to a reduction from 1.03 to 0.905 million t under the current policy regime.

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