Rural Reforms and Agricultural Growth in China

Article *in* American Economic Review · February 1992
Source: RePEc

1 author:

Justin Lin
National School of Development

Rural Reforms and Agricultural Growth in China

By JUSTIN YIFU LIN*

This paper employs province-level panel data to assess the contributions of decollectivization, price adjustments, and other reforms to China's agricultural growth in the reform period. Decollectivization is found to improve total factor productivity and to account for about half of the output growth during 1978–1984. The adjustment in state procurement prices also contributed positively to output growth. Its impact came mainly from the responses in input use. The effect of other market-related reforms on productivity and output growth was very small. Reasons for slowdown in agricultural growth after 1984 are also analyzed. (*JEL* O47, P27, Q11).

China's agricultural growth in the socialist period prior to the reforms starting in the late 1970's was sluggish. Despite stress on self-sufficiency, grain production and agricultural output barely kept pace with population growth. This picture changed in 1978, when China began a series of fundamental reforms in the rural sector. Growth rates in all major sectors of agriculture were accelerated to levels several times higher than the long-term averages over the preceding period (see Table 1).

The dramatic growth during 1978–1984 was a result of a package of market-oriented reforms. As the rural reforms were so successful, the government was encouraged to take a bolder approach to reforms in both rural and urban sectors in 1985. Although agriculture as a whole still grew at a respectable rate of 4.1 percent per year thereafter, rapid growth in the subsector of crops, especially grain and cotton, came to a sudden halt (see Table 1). Since most prominent leaders in China have an obsession with the idea of grain self-sufficiency, the disappointing performance of grain production has endangered the future of the market-oriented reforms.

Much has been written about China's economic reform.[1] There are disagreements among students of the Chinese economy about the main reasons behind the remarkable agricultural growth since 1979. The major changes are as follows. The state procurement prices for major crops, on the average, were raised 22.1 percent in 1979. The change from the collective system to the individual household-based farming system, now called the household-responsibility system (hereafter HRS), began in 1979 and was essentially completed by the end of 1983. The government has also introduced several other changes in its policies of grain procurement and marketing since 1979. Moreover, in addition to the aforementioned reforms, the availability of purchased inputs, particularly chemical fertilizers, increased substantially during this period.

Identifying the sources of the rapid agricultural growth during 1978–1984 is important for the future course of rural reforms in China. If the change from the collective

*Senior Fellow, Department of Rural Economy, Development Research Center, 9 Xihuangchenggen Nanjie, Beijing 100032, China, and Associate Professor, Economics Department, Peking University. I thank two anonymous referees for very helpful comments and suggestions on earlier drafts and Robert Ashmore for exposition improvement.

[1]For a survey of papers by Western economists, see Dwight H. Perkins (1988). In addition, there are several books and conference proceedings devoted exclusively to the economic reforms: see for example, Elizabeth J. Perry and Christine Wong (1985), *Journal of Comparative Economics* (1987), and *China Quarterly* (1988).

TABLE 1—AVERAGE ANNUAL GROWTH RATES OF AGRICULTURE, 1952–1987

Subsector	Annual growth rate (percentage) 1952–1978	1978–1984	1984–1987
Crops	2.5	5.9	1.4
Grain	2.4	4.8	−0.2
Cotton	2.0	17.7	−12.9
Animal husbandry	4.0	10.0	8.5
Fishery	19.9[a]	12.7	18.6
Forestry	9.4	14.9	0
Sidelines	11.2	19.4	18.5
Agriculture (overall)	2.9	7.7	4.1

Source: Ministry of Agriculture Planning Bureau (1989 pp. 112–5, 146–9, 189–92) and Ministry of Agriculture (1989 pp. 28, 34).
Notes: In 1952, the weights of the five agriculture subsectors were: crops, 83.1 percent; animal husbandry, 11.5 percent; fishery, 0.3 percent; forestry, 0.7 percent; sidelines, 4.4 percent. In 1987, the weights were: crops, 60.7 percent; animal husbandry, 22.8 percent; fishery, 4.7 percent; forestry, 4.8 percent; sidelines, 7.0 percent. For sidelines, outputs from village-run enterprises were excluded.
[a]The low base level in 1952 is the main reason for fishery's high average annual growth during 1952–1978.

system to HRS was the major factor underlying the sudden output growth, then future reforms should be oriented toward strengthening the position of household farms. On the other hand, recollectivization would be the logical course if the shift to HRS was detrimental to production, its harmful impact simply being compensated by rapid output growth arising from rises in price, increases in inputs, and other reforms. The main purpose of this paper is to disentangle the contribution to output growth of the HRS reform from those of other reforms, as well as from that of increased input availability.

Few attempts have been undertaken to assess the effects of particular components of the reforms. Exceptions include Lin (1989), James Guanzhong Wen (1989), and John McMillan et al. (1989). All three studies identify HRS as the main source of the dramatic output growth. However, there are serious drawbacks with each of these three studies.[2]

This paper applies the production-function approach proposed by Zvi Griliches (1963) to evaluate the effects of the various components of reforms on agricultural growth. The data used in this study are the province-level panel data from 1970 to 1987 for 28 of the 29 provinces in mainland China. The novelty of the present study, however, is the inclusion of separate proxies for changes in institution, prices, crop patterns, cropping intensity, and technology in the

[2]Lin (1989) employs a production-function approach. The results are suspect due to strong multicollinearity in the estimated production function. The multicollinearity problem arises from the fact that the panel data employed only cover the period from 1980 to 1983. Wen (1989) estimates a supply-response function. His estimate, based on only 35 observations, is not very credible. McMillan et al. (1989) use a Dennison-Solow-type growth-accounting technique to analyze the national aggregated time-series from 1978 to 1984. The customary criticisms against the Dennison-type growth accounting are applicable to their studies (see Zvi Griliches, 1963). In addition, their decomposition of the growth in total factor productivity into a price component and an incentive component requires strong assumptions about the form and parameters of the utility function, and their results are sensitive to these assumptions. Furthermore, the price used in their analysis should, theoretically, be marginal price, but they use instead the state above-quota procurement prices, which in general are lower than the prices prevailing in rural markets. Moreover, these two prices often move in opposite directions.

production function to assess the impacts of these changes.

The organization of the paper is as follows: Section I provides an overview of rural reforms in China. The data used in the empirical evaluation are briefly summarized in Section II. Section III discusses the estimation method and reports the empirical results. The growth accounting for 1978–1984 and 1984–1987 is reported in Section IV. Finally, some concluding remarks are presented in Section V.

I. Rural Reforms in China

Broad changes in rural policy began at the end of 1978. The government's original intention was to improve agricultural production through raising the long-depressed state procurement prices for major crops, modifying management methods within the collective system, and increasing budgetary expenditure on agricultural investments. The change from the collective system to the household-based farming system—the most far-reaching change to date in China's economic reforms—was explicitly prohibited in 1978.

A. *Price Reform*

Before the reforms, two distinct prices existed in the state commercial system: quota prices and above-quota prices. Quota prices applied to crops sold in fulfillment of procurement obligations; above-quota prices applied to crops sold in excess of the obligation. Effective in 1979, quota prices for grain, oil crops, cotton, sugar crops, and pork were raised an average of 17.1 percent. In addition, the premium paid for above-quota delivery of grain and oil crops was increased from 30 percent to 50 percent of the quota prices, and a 30-percent bonus was instituted for above-quota delivery of cotton.[3] The weighted average increase was 22.1 percent. If only the marginal prices, that is, the above-quota prices, are considered, the increase was 40.7 percent (see column 1 in Table 2).

Corresponding to the increase in procurement prices, retail prices for pork, fish, and eggs were raised one-third, but no changes were made in grain and edible-oil prices. To compensate for this, each urban resident received a 5–8-yuan subsidy per month (State Statistical Bureau, 1988a p. 12). As a result, the government's price subsidies increased substantially. The financial burden became especially unbearable when an unexpected growth in output began to emerge in 1982. The price subsidies increased from 8.4 percent of the state budget to 24.6 percent of the state budget in 1984 (*China Statistical Yearbook*, 1988 pp. 747, 763). As a way to reduce the state's burden and to increase the role of markets, the mandatory quotas were abolished (for cotton in 1984 and for grain in 1985) and replaced by procurement contracts which were supposed to be negotiated between the government and the farmers. The contract price was a weighted average of the basic quota price and the above-quota price. This change resulted in a 9.2-percent drop in the price margin paid to farmers (see Table 2). Following the decline of grain and cotton production in 1985 and stagnation thereafter, however, the contracts were made mandatory again in 1986.

Alongside state commercial channels, market fairs have always existed and played an important role in rural China. Farmers, after fulfilling their quota obligations, could sell their produce in market fairs. With rare exceptions, the market prices are higher than the state procurement prices, even measured with the above-quota premiums. Moreover, as Table 2 shows, market prices and state procurement prices do not always move in the same direction. Table 2 also reports the time-series of state procurement prices and market prices relative to the prices of manufactured inputs in rural markets, which will be used in Section III to estimate the impact of price changes on agricultural growth.

[3]For a detailed chronology of the price changes in 1979 and thereafter, see Terry Sicular (1988).

TABLE 2—PRICE INDEX (1978 = 100)

Year	State above-quota price index (1)	Rural-market consumer price index (2)	Rural industrial-product price index (3)	Ratio of state above-quota price to industrial-product price index (4)	Ratio of market price to industrial-product price index (5)
1970	97.2	80.4	101.9	95.4	78.9
1971	98.4	87.4	100.4	98.0	87.1
1972	98.4	94.6	99.8	98.6	94.8
1973	98.1	99.6	99.8	98.3	99.8
1974	98.4	101.4	99.8	98.6	101.6
1975	98.7	105.5	99.8	98.9	105.7
1976	99.4	109.7	99.9	98.5	109.8
1977	100.0	107.0	100.0	100.0	107.0
1978	100.0	100.0	100.0	100.0	100.0
1979	140.7	95.5	100.1	140.4	95.4
1980	140.4	97.4	100.9	139.2	96.5
1981	145.1	103.0	101.9	142.3	101.1
1982	144.3	106.5	103.6	139.3	102.8
1983	144.9	110.9	104.6	138.6	106.1
1984	142.5	110.5	107.8	132.1	102.5
1985	129.4	129.5	111.3	116.2	116.3
1986	130.1	140.0	114.9	113.3	121.9
1987	130.2	162.8	120.4	108.1	135.2

Sources: See Appendix.

B. *Institutional Reform*

The change in farming institution from the collective system to HRS was not originally intended by the government. Before the reform, agricultural operations were organized in the production-team system. Each team consisted of about 20–30 neighboring households. Because of difficulties in monitoring agricultural work in a team, rewards to individual farmers were not tied directly to their efforts, and incentives to work were thus very low (Lin, 1988).

It was acknowledged in 1978 that the key to improving the farmer's incentives was to solve the managerial problems in the team system. However, the government at that time considered subdivision of collectively owned land into individual household tracts to be opposed to socialist principles, and thus it explicitly prohibited this practice. Nevertheless, toward the end of 1978, a small number of production teams, first secretly and later with the blessing of local authorities, began to try out the system of contracting land, other resources, and output quotas to individual households. A year later, these teams brought in yields far larger than those of other teams. The central authorities later conceded the existence of this new form of farming but required that it be restricted to poor regions. However, most teams ignored this restriction. Full official acceptance of HRS was eventually given in late 1981, when 45 percent of the production teams in China had already been dismantled. By the end of 1983, 98 percent of production teams had adopted HRS (see column 1 in Table 3). Thus, the shift in the institutional structure of Chinese agriculture by and large evolved spontaneously in response to underlying economic forces (Lin, 1987). Under HRS, collectively owned land was assigned to individual households with contracts of up to 15 years.[4]

[4]For a chronology of the policy evolution, see Robert F. Ash (1988). For a summary of the development from various types of responsibility systems to HRS, see Yak-Yeow Kueh (1984). For a discussion of some new issues related to HRS, see Reeitsu Kojima (1988).

TABLE 3—HRS, CROP PATTERN, AND CROPPING INTENSITY

Year	Household responsibility system (1)	Sown area (percentage) Grain crops (2)	Cash crops (3)	Other (4)	Multiple cropping index (percentage) (5)
1970	0	83.1	8.2	8.7	141.9
1971	0	83.1	8.2	8.7	144.7
1972	0	81.9	8.5	9.6	147.0
1973	0	81.6	8.6	9.8	148.2
1974	0	81.4	8.7	9.9	148.7
1975	0	81.0	9.0	10.0	150.0
1976	0	80.6	9.2	10.2	150.6
1977	0	80.6	9.1	10.3	150.5
1978	0	80.4	9.6	10.0	151.0
1979	0.01	80.3	10.0	9.7	149.2
1980	0.14	80.1	10.9	9.0	147.4
1981	0.45	79.2	12.1	8.7	146.6
1982	0.80	78.4	13.0	8.6	146.7
1983	0.98	79.2	12.3	8.5	146.4
1984	0.99	78.3	13.4	8.3	146.9
1985	0.99	75.8	15.6	8.6	148.4
1986	0.99	76.9	14.1	9.0	150.0
1987	0.99	76.8	14.3	8.9	151.3

Note: Column 1 indicates the proportion of production teams in China that had adopted the household-responsibility system.
Sources: The data for column 1, 1979–1981, are from *Economic Weekly News* [*Jingjixue Zhoubao*] (11 January 1982). Figures for 1982–1984 are taken from *China Agricultural Yearbook* (1984 p. 69, 1985 p. 120). Figures for 1985–1987 are inferred from the fact that no major change has occurred in the farming institution since 1984. Columns 2–5 are taken from Ministry of Agriculture Planning Bureau (1984 p. 132, 1989 pp. 130–1, 335–7) and *China Statistical Yearbook* (1988 pp. 224, 243, 276).

The government so far still stresses its intention of maintaining the stability of the newly instituted HRS. However, the doctrine of equating advanced technology with big tractors and efficiency with large farm size is still deeply rooted in the minds of many scholars and prominent leaders in China (Robert F. Ash, 1988). Due to increasing discontent with the stagnation of grain production after 1984, the call for recollectivization has emerged, under the guise of enlarging operational size to exploit returns to scale. In some localities, this call has resulted in disruption of contracts before expiration without the consent of farmers (Yaping Jiang, 1988). It is thus possible that farmers may be deprived of the economic independence and greater freedom they have been given in the past 10 years (D. Gale Johnson, 1990 Ch. 8).

C. *Market and Planning Reform*

The third most important element of the reforms is the greater role given to markets in guiding agricultural production. The prevalence of planning in agriculture before the reforms was a result of self-sufficiency in grain. Because grain procurement prices were depressed to levels lower than prevailing market prices, the more grain an area sold to the state, in effect, the more tax it paid. Areas with a comparative advantage in grain production were thus reluctant to raise their grain output levels. Consequently, grain-deficient areas had to increase grain production themselves if local grain demand increased due to growth in population or income. The national self-sufficiency policy thus degenerated into a policy of local self-sufficiency. To guarantee that each region would produce enough grain for its needs, planning in agricultural production was extensive. Mandatory targets often specified not only acreage for each crop, but also yields, levels of inputs, and so on. As planners gave priority to grain, insufficient consideration was given to profitability and regional comparative advantage. To increase grain output to meet state procurement quotas or local demand, local governments often expanded grain acreage at the expense of cash crops or raised cropping intensity to a level that brought net losses to farmers.

At the beginning of the reforms, the government recognized the losses in allocation efficiency caused by the self-sufficiency policy. The decision to increase grain imports, cut down grain procurement quotas, and reduce the number of products included in agricultural planning reflected an intention to increase the role of markets.[5] Moreover, the government loosened restrictions on private interregional trade in agricultural products. Special measures were also taken to encourage areas with traditional comparative advantage in cotton production to expand cotton acreage.[6]

All the aforementioned reforms reduced the role of state intervention and increased the function of markets in guiding agricultural production. As a result, cropping patterns and cropping intensity changed substantially between 1978 and 1984. The area devoted to cash crops increased from 9.6 percent of total sown acreage in 1978 to 13.4 percent in 1984, a 41.6-percent increase; meanwhile, the multiple cropping index declined from 151 to 146.9 (see Table 3).

The climax of the market and planning reform was the declaration at the beginning of 1985 that the state would no longer set any mandatory production plans in agriculture and that obligatory procurement quotas were to be replaced by purchasing contracts between the state and farmers. The restoration of household farming and the increase in market freedom prompted farmers to adjust their production activities in accordance with profit margins. The acreage devoted to cash crops further expanded, while grain acreage declined (see Table 3). The expansions in animal husbandry, fishery, and subsidiary production were even faster. As a result of these adjustments, agriculture still grew at a respectable rate of 4.1 percent annually during 1984–1987, although, the crop sector stagnated (see Table 1).

The market-oriented reforms had aroused anxiety in some sectors of the government from their very beginning. Concerns over "loss of control" were widely reported in the early 1980's (Sicular, 1988). In the wake of unprecedented success between 1978 and 1984, the pro-market group was able to push the reforms further in the market direction. However, when growth rates slowed down and grain output declined in 1985 and thereafter, the government retreated from its position. The voluntary procurement contract was made mandatory again. Throughout the period 1985–1991, administrative intervention in market and production has been increasing.

The above events are the major components of the rural reforms since 1978. As described, the reforms were highly successful up to 1984 but have encountered some problems since then. How much of the output growth during 1978–1984 can be attributed to various components of the reforms and what factors have been responsible for the slowdown since 1984 are the focuses of the following sections.

[5]For example, net grain imports increased from 6.9 million tons in 1978 to 14.9 million tons in 1982 (Ministry of Agriculture Planning Bureau, 1989 pp. 522, 535), grain purchase quotas were reduced 2.5 million tons in 1979 (Ash, 1988), and the categories of planned products were reduced from 21 in 1978 to 16 in 1981 and were reduced further to only 13 categories in 1982 (Kueh, 1984).

[6]In 1979, the government instituted a policy that awarded above-quota delivery of cotton with low-priced grain sale. This policy made a substantial expansion of cotton acreage possible in the traditional cotton-producing regions.

TABLE 4—INDEX OF CROP OUTPUT AND INPUTS (1978 = 100)

Year	Crop output (1)	Farm labor (2)	Labor in cropping sector (3)	Land (3)	Capital (4)	Chemical fertilizers (5)
1970	77.10	99.09	103.04	101.76	51.73	36.30
1971	82.82	101.16	104.00	101.29	58.60	41.55
1972	80.48	100.78	102.04	101.20	64.04	47.94
1973	88.25	102.91	103.76	100.80	69.02	58.52
1974	91.50	102.93	104.21	100.50	75.05	55.08
1975	94.22	100.81	103.35	100.11	79.97	60.87
1976	92.43	100.65	102.46	99.98	85.55	66.06
1977	91.47	100.05	100.41	99.82	93.09	73.09
1978	100.00	100.00	100.00	100.00	100.00	100.00
1979	107.10	102.17	103.66	100.10	104.22	120.15
1980	102.36	104.75	107.63	99.91	122.12	134.29
1981	108.52	107.81	111.58	99.44	131.74	141.44
1982	119.60	109.48	112.82	99.21	141.16	156.00
1983	129.42	111.22	115.34	98.89	153.40	169.06
1984	142.23	111.35	114.69	98.89	165.29	171.62
1985	139.52	106.65	104.56	97.46	176.65	167.38
1986	140.76	107.06	95.79	96.81	191.09	183.10
1987	148.21	108.48	88.70	96.47	209.71	192.10

Source: See Appendix.

II. Data

The data used in this study include observations for 28 of the 29 provinces in mainland China for 1970–1987.[7] A number of adjustments were required in order to make the data suitable for this study. Detailed information on sources and adjustments is given in the Appendix. Here, I only report a summary description of the data set.

In this study, agricultural output refers to crop outputs.[8] Values of crop output for each province are calculated from the physical outputs of seven grain crops and 12 cash crops, using official prices of 1980 as weights for aggregation. Nationally, these 19 crops accounted for 92 percent of total acreage and 72.5 percent of the cropping sector's output value in 1980.[9]

Inputs in the data set include four categories: land, labor, capital, and chemical fertilizer. Land refers to cultivated land; cultivated land is used rather than sown acreage because I also want to see how changes in cropping intensity affected outputs. Labor refers to the number of workers in the cropping sector. Capital includes tractors and draft animals, measured in horsepower. Chemical fertilizers refers to the gross weight of nitrogenous, phosphate, and potash fertilizers that each province consumed in each year. The output and input series are summarized in Table 4.

In addition to the four conventional inputs, five other factors are included to reflect various components of the reforms. These measures are the ratio of production teams converted to HRS, the index of

[7]Tibet is excluded because the lack of output data.

[8]In Chinese statistics, agriculture includes cropping, animal husbandry, forestry, fishery, and sideline production. Forestry, fishery, and sideline production are in general not included in agricultural productivity studies. Animal husbandry is not included, mainly for two reasons. First, data for the relevant output and input series of animal husbandry previous to 1979 are not available. Secondly, most activities of animal husbandry were carried out by individual households even before the HRS reform; therefore, the institutional reform should not have a direct impact, even though there might have been indirect effects.

[9]Those crops excluded from the data set are mainly vegetables and fruits, which command higher value than grain and cash crops.

above-quota prices and market prices relative to manufactured input prices, the percentage of sown acreage for nongrain crops, and the multiple cropping index (the ratio of sown acreage to cultivated acreage). These measures are used to capture, respectively, the impacts of farming institutional change, state procurement price adjustments, and market reforms. The price indexes are the national indexes, and the other three measures are provincial-level observations.[10]

The total number of observations for each variable is 504. However, since information on the number of production teams converted to HRS in each province in 1980 is not available, that year's observations are deleted, and the actual number of observations that will be used in the analysis is 476. This data set presents an unusual opportunity for undertaking a careful analysis of the impacts of reforms on agricultural growth, as well as an opportunity for estimating the Chinese agricultural production function econometrically.[11]

III. Functional Form Specification and Results

If production were purely an engineering relationship between inputs and outputs, any variation in inputs, except for those due to random shocks, would be a result of changes in inputs. However, the observed production function in general is an economic relationship, as the intensity with which observed resources are utilized depends on economic decisions made by workers as well as managers in response to institutional arrangements, profitable opportunities, and so on (Harvey Leibenstein, 1966; Michael R. Carter, 1984; McMillan et al., 1989). Therefore, the technical efficiency of production can be altered by economic reforms.

Changes in relative prices are expected to affect not only the level of input use, but also the choice between work and leisure as in standard microeconomic analysis. Adjustments in crop patterns in response to soil, temperature, rainfall, and other region-specific characteristics are a major source of productivity growth in agriculture.[12] Changes in the multiple cropping index reflect, in a way, how intensively land and labor inputs are utilized. Finally, any change in farming institution alters the compensation scheme and is expected to affect the level of effort supplied by each farmer.

The agricultural-production function estimated is a Cobb-Douglas function with four conventional inputs: land, labor, capital, and chemical fertilizer (Fert). In addition, six other variables are included in the function: the proportion of teams that have changed to the household responsibility system (HRS), the index of market prices relative to manufactured input prices (MP), the index of above-quota prices relative to manufactured input prices (GP), the percentage of total sown area in nongrain crops (NGCA), the multiple cropping index (MCI), and a time trend (T) (see the Appendix for variable definitions). The nonconventional variables are incorporated to assess the impacts of farming institutional change, price adjustments, market reforms, and technological changes. Because the productivity of conventional inputs also depends on some omitted time-persistent region-specific variables (e.g., soil quality,

[10] Using the national index as a proxy for state procurement prices will not cause any trouble in the estimation, because the prices are set by the state and implemented uniformly in each province. However, market prices vary across provinces, although the general trends are the same. Using the national market-price index thus may reduce the sharpness with which the influence of market prices on output can be estimated.

[11] As pointed out by Dwight Perkins and Shahid Yusuf (1984 p. 46), attempts by other scholars to estimate the Chinese agricultural production function empirically have not yielded plausible estimates due to the lack of cross-sectional data. A floppy disk containing my data will be provided to researchers upon request.

[12] This factor is especially emphasized by Nicholas R. Lardy (1983). He attributes much of the stagnation in Chinese agriculture before the recent reform as well as the rapid growth after the reforms to the loss and gain of regional comparative advantages.

rainfall, irrigation, temperature, average education level, etc.), 27 provincial dummies are included in the production function in order to obtain consistent estimates. This specification gives rise to the estimation equation

$$\begin{aligned}(1)\quad \ln(Y_{it}) = {} & \alpha_1 + \alpha_2 \ln(\text{Land}_{it}) \\ & + \alpha_3 \ln(\text{Labor}_{it}) \\ & + \alpha_4 \ln(\text{Capital}_{it}) + \alpha_5 \ln(\text{Fert}_{it}) \\ & + \alpha_6 \text{HRS}_{it} + a_7 \text{MP}_{t-1} + a_8 \text{GP}_t \\ & + a_q \text{NGCA}_{it} + \alpha_{10} \text{MCI}_{it} + \alpha_{11} T_t \\ & + \sum_{j=12}^{39} \alpha_j D_j + \varepsilon_{it}\end{aligned}$$

where the α's are the parameters to be estimated, and ε is the error term. The output and the four conventional inputs are in natural-logarithm form. Because size of province varies greatly, to prevent the heteroscedastic problem, the output as well as the conventional input variables are normalized by the number of teams in each province in 1980. Theoretically, the relevant price variables should be the expected prices. For the government procurement price, the current prices at each year are the expected prices at that year, because changes in the state procurement prices are announced prior to the beginning of the production season. However, for the market prices, price expectation is a complicated function of past experience and other information on the economy (John Muth, 1961). Since no information about the structure of market-price expectation in China is available, the market prices are taken simply as the prices in the previous year.

The above specification is in the form of a one-way fixed-effects model. For comparative purposes, a two-way fixed-effects model, which includes both regional dummies and year dummies in the specification, will also be estimated. In the two-way fixed-effects model, the price variables have to be deleted because they are region-invariant national indexes. The coefficients of time dummies capture partly the impacts of year-to-year price changes on productivity. The resulting specification is as follows:

$$\begin{aligned}(1')\quad \ln(Y_{it}) = {} & \alpha'_1 + \alpha'_2 \ln(\text{Land}_{it}) \\ & + \alpha'_3 \ln(\text{Labor}_{it}) \\ & + \alpha'_4 \ln(\text{Capital}_{it}) \\ & + \alpha'_5 \ln(\text{Fert}_{it}) + \alpha'_6 \text{HRS}_{it} \\ & + \alpha'_7 \text{NGCA}_{it} + \alpha'_8 \text{MCI}_{it} \\ & + \sum_{j=9}^{36} \alpha'_j D_j + \sum_{k=37}^{52} \alpha'_k T_k + \varepsilon'_{it}.\end{aligned}$$

Expression (1) is designed with the intention of estimating the impacts of reforms in institution, price, and the role of markets on *productivity*. However, application levels of conventional inputs, the crop pattern (NGCA), and cropping intensity (MCI) may be endogenous to the shift to HRS and to price changes. If this is so, the impacts of HRS and price changes on *production* may be over- or underestimated in the specification of expression (1). Therefore, to assess their total impacts on agricultural production, I will also estimate a supply-response function in the form

$$\begin{aligned}(2)\quad \ln(Y_{it}) = {} & \beta_1 + \beta_2 \text{HRS}_{it} + b_3 \text{MP}_{t-1} \\ & + b_4 \text{GP}_t + \beta_5 T_t \\ & + \sum_{i=6}^{33} \beta_i D_i + \mu_{it}.\end{aligned}$$

T in this specification will capture not only the trend in technological change, but also the trend in the availability of inputs.

The appropriate method for obtaining consistent estimates of expressions (1) and (2) depends on the structure of disturbances ε_{it} and μ_{it}. If ε_{it} and μ_{it} are spherical disturbances, the covariance estimator of ordinary least squares (OLS) is the best linear unbiased estimator. If production is inside the efficiency frontier and the disturbance can be specified as the difference of two independent terms, one with a normal

TABLE 5—ESTIMATES OF PRODUCTION AND SUPPLY RESPONSE FUNCTION (DEPENDENT VARAIBLE = LN(VALUE OF CROP OUTPUT IN CONSTANT PRICES)

	One-way fixed-effects					
	OLS	Stochastic frontier	EGLS			Two-way fixed-effects
Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)
ln(Land)	0.65	0.59	0.67	0.67		0.58
	(0.07)	(0.05)	(0.04)	(0.04)		(0.09)
ln(Labor)	0.14	0.11	0.14	0.13		0.15
	(0.03)	(0.03)	(0.02)	(0.01)		(0.03)
ln(Capital)	0.037	0.057	0.050	0.070		0.10
	(0.040)	(0.034)	(0.027)	(0.015)		(0.04)
ln(Fert)	0.18	0.18	0.20	0.19		0.17
	(0.02)	(0.02)	(0.01)	(0.01)		(0.02)
Proportion in household farming (HRS)	0.19	0.22	0.19	0.20	0.18	0.15
	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.05)
(Market price)/(input price) at time $t-1$ (MP_{t-1})	0.00038	0.0010	0.00051		0.0034	
	(0.00123)	(0.0013)	(0.00061)		(0.0007)	
(Government price)/(input price) at time t (GP_t)	−0.00067	−0.00054	−0.00058		0.0021	
	(0.00055)	(0.00059)	(0.00035)		(0.0004)	
Multiple cropping index (MCI)	0.0020	0.0018	0.0015	0.0020		0.0020
	(0.0009)	(0.0011)	(0.0006)	(0.0006)		(0.0008)
Percentage of nongrain crops (NGCA)	0.0067	0.0093	0.0068	0.0078		0.0078
	(0.0023)	(0.0023)	(0.0015)	(0.0013)		(0.0022)
Time trend (T)	0.0065	0.0005	0.0028		0.021	
	(0.0065)	(0.0068)	(0.0042)		(0.003)	
Regional dummies	yes	yes				yes
Time dummies						yes
Adjusted R^2:	0.961					0.966
Log likelihood:		430.35				
$R_{it,it-1}$:	−0.15					

Notes: Numbers in parentheses are standard errors or estimated asymptotic standard errors. The estimated coefficients of 27 provincial dummies in columns 1, 2 and 6, and of 16 year dummies in column 6 are not reported.

distribution and the other one with a positive-half normal distribution, the stochastic-frontier regression developed by Dennis J. Aigner et al. (1977) will produce consistent estimates of parameters. If there exist intertemporal correlations and the covariance matrix is unknown, then the appropriate method for fitting expressions (1) and (2) is estimated generalized least squares (EGLS).

As a first step, I apply both OLS and the stochastic-production-frontier model to estimate expression (1). The results are reported in columns 1 and 2 of Table 5. For the sake of simplicity, the estimates for regional dummies are not presented. Except for the index of above-quota prices (GP), all other estimates have the expected positive sign in both models, and except for capital, the index of market prices (MP), the index of above-quota prices (GP), and the time trend (T), all other estimates are highly statistically significant. Moreover, the estimates resulting from the stochastic-production-frontier model differ little from the least-squares estimates.

The last row of columns (1) reports the estimated intertemporal correlation of the disturbance

$$r_{it,it-1}=\left(\sum_{i=1}^{28}\sum_{t=1}^{17}e_{it},e_{it-1}\right)\Big/\left(\sum_{i=1}^{28}\sum_{t=1}^{17}e_{it}\right)$$

where e_{it} represents the estimates for ε_{it}. The resulting $r_{it,it-1}$ is -0.15. Under the null hypothesis of no intertemporal or spatial correlation, $r_{it,it-1}$ has a standard error $N^{-1/2}$, where N is the number of observations (George G. Judge et al., 1985 p. 319). There are 476 observations in the sample, and the standard error under the null hypothesis is 0.046. Hence, the evidence suggests that intertemporal correlations exist in the disturbances. Although OLS still produces unbiased estimates for regression coefficients, the significance tests for the estimated coefficients are invalid.

In a one-way fixed-effects model with unknown intertemporal covariance, the individual effects cannot be consistently estimated when the time period is fixed. Nicholas M. Kiefer (1980) suggested that one could first eliminate individual effects by subtracting group means from both regressand and regressor and then estimate regression coefficients and the asymptotic variance-covariance matrix by EGLS. The estimates resulting from applying Kiefer's estimator to expression (1) are reported in column 3 of Table 5. As expected, the estimated coefficients differ little from those estimated using OLS, and their associated standard errors are uniformly smaller than those of OLS. While the estimates for market prices (MP), above-quota procurement prices (GP), and time record (T) are still not significantly different from zero, the estimate for capital is statistically significant at the 0.05 level (asymptotic $t=1.85$). Column 4 reports the estimates when the insignificant variables MP, GP, and T are dropped. The resulted estimates are basically the same as those in column 3. I shall adopt the estimates in column 4 for growth accounting in the next section.[13]

Column 5 of Table 5 reports the results of applying Kiefer's estimator to expression (2). The estimates for HRS are almost identical to those in columns 3 and 4. However, the estimated coefficients for the index of market prices (MP), the index of above-quota prices (GP), and time trend (T) are larger than those in column 3 and, in fact, are highly statistically significant.

The results of fitting the two-way fixed-effects model of expression (1′) are presented in column 6. All the estimated coefficients are in the same range as the estimates in column 4. These results support the use of the estimates in column 4 for growth accounting in the next section.

From the evidence presented in columns 3, 4, 5, and 6 of Table 5, one can conclude that the shift from the production-team system to HRS had a positive and significant effect on agricultural growth, which came primarily from the change in total factor productivity. The changes in both state procurement prices and market prices also had significant effects on agricultural growth. However, in contrast to the case of institutional reform, these effects derived from impacts on levels of input usage, cropping intensity (MCI), and crop composition (NGCA). The estimated coefficient of the time trend (T) is not statistically significant in column 3, but it is positive and highly significant in column 5. This implies that there was no increasing trend in technological change but that there was a positive trend in agricultural output growth during 1970–1987. The latter trend might stem from the increasing availability of inputs

[13] It would have been preferable to perform a test for the joint insignificance of MP, GP, and T before dropping them from the regression. However, this was not possible because the test statistic for Kiefer's EGLS estimator has not been developed.

TABLE 6—ACCOUNTING FOR CROP OUTPUT GROWTH: PRODUCTION FUNCTION

Explanatory variable	Estimated coefficient (1)	1978–1984 Change in explanatory variable (2)	1978–1984 Contribution to growth (percentage) (3) = (1) × (2)	1984–1987 Change in explanatory variable[b] (4)	1984–1987 Contribution to growth (percentage) (5) = (1) × (4)
Inputs			**19.34** **(45.79)**		**−0.42** **(−9.97)**
Land	0.67	−1.1	−0.74 (−1.75)	−2.4	−1.61 (−38.24)
Labor	0.13	14.7	1.91 (4.52)	−22.7	−2.95 (−70.07)
Capital	0.07	65.3	4.57 (10.82)	26.9	1.88 (44.73)
Fertilizer	0.19	71.6	13.60 (32.20)	11.9	2.26 (53.71)
Productivity			**20.54** **(48.64)**		**2.05** **(48.69)**
Household-farming reform (HRS)	20.00	0.99	19.80 (46.89)	0	0
Multiple cropping (MCI)	0.20	−4.1	−0.82 (1.94)	4.4	0.88 (20.90)
Ratio of nongrain crops (NGCA)	0.78	2.0	1.56 (3.69)	1.5	1.17 (27.79)
Residual			**2.35** **(5.57)**		**2.58** **(61.28)**
Total growth:			**42.23** **(100.00)**		**4.21** **(100.00)**

Notes: The estimated coefficients are taken from column 4 of Table 5. HRS, multiple cropping index (MCI), and percentage of nongrain crop area (NGCA) are in a semilog form in expression (1). To calculate the contributions of these variables to output growth in terms of percentage, the estimated coefficients of these variables are multiplied by 100. For land, labor, capital, and fertilizer, "change in explanatory variable" refers to the percentage growth of that variable. For HRS, multiple cropping index (MCI), and percentage of nongrain crop area (NGCA), the change refers to the difference in magnitude of that variable between t_1 and t_2. Changes in output and input are calculated from Table 4; changes in HRS, MCI, and NGCA are from Table 3. The numbers in parentheses are the percentage shares of contribution to total output growth, with total output growth set at 100.

such as chemical fertilizers. The positive and significant estimates of cropping intensity (MCI) and crop composition (NGCA) in columns 3, 4, and 6 suggest that, given the inputs and other variables, an increase in the cropping intensity or in the proportion of nongrain crops will also result in an increase in output.

IV. Sources of Agricultural Growth during 1978–1984 and 1984–1987

This section attempts to assess the relative contributions of the various components of reforms and changes in inputs to agricultural growth in 1978–1984 and 1984–1987. Table 6 reports the growth ac-

Table 7—Accounting for Crop Output Growth: Supply-Response Function

Explanatory variable	Estimated coefficient (1)	1978–1984 Change in explanatory variable (2)	1978–1984 Contribution to growth (percentage) (3) = (1) × (2)	1984–1987 Change in explanatory variable (4)	1984–1987 Contribution to growth (percentage) (5) = (1) × (4)
Household-farming reform (HRS)	18.00	0.99	17.82 (42.20)[c]	0.00	0.00
[Market price]/[input price] (MP)	0.34	−0.93	−0.32 (−0.76)	15.71	5.36 (127.32)
[State procurement price]/ [input price] (GP)	0.21	32.14	6.75 (15.98)	−24.03	−5.04 (−119.72)
Trend (T)	2.10	6.00	12.60 (29.74)	3.00	6.30 (149.64)
Residual			5.38 (12.74)		−2.41 (57.24)
Total growth:			42.23 (100.00)		4.21 (100.00)

Notes: The estimated coefficients are taken from column 5 of Table 5. HRS, index of market price (MP), index of state procurement price (GP), and time trend (T) are in a semilog form in expression (2). To calculate the contributions of these variables to output growth in terms of percentage, the estimated coefficients of these variables are multiplied by 100. The change in explanatory variable refers to the difference in magnitude of that variable between t_1 and t_2. Changes in output and input are calculated from Table 4; change in HRS is from Table 3; and changes in MP and GP are from Table 2. The numbers in parentheses are the percentage shares of contribution to total output growth, with total output growth set at 100.

counting based on the estimate of the agricultural production function in column 4 of Table 5, and Table 7 reports that based on the supply-response function estimated in column 5. In Table 6, the sources of output growth are divided into three categories: change in conventional inputs, productivity change due to reforms, and unexplained residual. The first two categories are in turn subdivided into several items. In Table 7, the sources of output growth are divided into the shift to HRS, the changes in market prices and state procurement prices, the time trend, and the residual.

The total output growth during 1978–1984 was 42.23 percent. From the accounting in Table 6, it appears that 45.79 percent of this output growth came from increases in inputs. The most important source of growth from inputs was the increase in the application of fertilizer, which alone contributed to about one-third (32.2 percent) of the output growth during 1978–1984. The growth derived from increases in labor and capital and the adverse impact on growth resulting from reduction in cultivated land were minor. Rural reforms also contributed significantly to output growth during 1978–1984. The productivity change resulting from various reforms made up 48.64 percent of the output growth. Among the various components of reform, the shift from the production-team system to HRS is clearly the most important one. This institutional reform alone produced 48.69 percent of the output growth, as much as the combined effects of input increases. The changes in cropping intensity (MCI) and crop pattern (NGCA), which might partially reflect the effect of reforms in the role of planning and markets, had small impacts on growth (one negative and one positive). In this growth accounting, 5.57 percent of the output growth was unexplained residual.

Although the changes in market prices and state procurement prices during 1978–1984 did not affect the total factor productivity, the growth accounting in Table 7 indicates that the substantial increase in the state procurement price had a significant impact (probably through input use, cropping intensity, and/or crop mix) on output growth, contributing 15.98 percent of the growth. However, compared to the estimated 42.20 percent that could be attributed to HRS in the supply-response function, the impact of price changes on output growth was not spectacular.[14]

Tables 6 and 7 also attempt to account for the slowdown in output growth after 1984. Several causes might be responsible for such a change. As Table 6 shows, the dominant reasons for the spectacular growth during 1978–1984 were HRS reform and the sharp increase in the use of chemical fertilizers. The HRS reform was completed in 1983–1984. Therefore, even without any other cause, the rate of output growth would have fallen to about half of the previous level. The growth rate of chemical-fertilizer input dropped from 8.9 percent per year during 1978–1984 to 3.7 percent during 1984–1987. If fertilizer use had continued to increase at the previous rate, its contribution to output growth would have been 5.54 percent of the 1984 level, instead of the 2.26 percent that actually occurred. Moreover, there was a swift outflow of the labor force from the cropping sector to other sectors. The growth rate of the labor force dropped from 2.3 percent per year during 1978–1984 to −8.6 percent per year during 1984–1987. This outflow of labor force alone caused output to fall 2.95 percent compared to the 1984 level. Table 7 shows that the sharp drop in the state procurement prices relative to input prices was probably the determining factor behind the decrease in the growth rate of chemical-fertilizer usage and the exodus of labor. The change in state procurement prices resulted in a 5.04-percent drop in output in 1987 compared to the 1984 level. The adverse effect of the drop in state procurement prices on output growth, however, was compensated for by the rise in market prices, which lifted the 1987 output level 5.36 percent over that of 1984.

V. Concluding Remarks

This paper attempts to evaluate the impacts of various components of reform on agricultural growth in China. The findings indicate that the dominant source of output growth during 1978–1984 was the change from the production-team system to HRS. It is also found that the change in crop pattern away from grain to nongrain crops had a positive impact and that the decline in cropping intensity had a negative impact on growth during 1978–1984. However, both effects were very small in magnitude. The results also suggest that the changes in state procurement prices and market prices had a significant impact on output growth, probably through their influences on application levels of inputs, cropping intensity, and/or crop pattern. However, not all the increases in input use during 1978–1984 could be attributed to the rise in state procurement prices; part of them come from improvements in availability, as revealed by the positive time trend in the supply-response function.

It is worth noting that this paper measures only the one-time discrete impact of the HRS reform on productivity and output

[14] If one follows the convention of growth accounting and treats residuals as productivity change, then, based on Table 6, the increase in total factor productivity during 1978–1984 was 22.89 percent, and 89.73 percent of this increase was attributable to HRS. McMillan, et al. (1989) estimated the increase in total factor productivity as 41 percent and attributed 78 percent of the increase to HRS. McMillan et al.'s larger estimate for improvement in total factor productivity is mainly due to the fact that output in their study includes not only crops, but also animal husbandry, fishery, and forestry. According to their definition, the output growth during 1978–1984 was 61.76 percent. However, with the exception of livestock feed, they employed only those inputs used for crops to construct the index of current inputs and capital. Animal husbandry, fishery, and forestry all had higher rates of growth than crops. Moreover, animal husbandry and fishery are in general more intensive in current inputs and capital than crops. Therefore, McMillan et al.'s estimate of growth in total factor productivity had an upward bias.

growth. The shift from the production-team system to HRS, however, also improves farmers' incentives to adopt new technology and may thus be expected to speed the diffusion of new technology (Lin, 1991). Therefore, HRS would also have a long-term, dynamic impact on the growth of agricultural productivity, which is not measured in this paper.

This study also attempts to account for the slowdown in output growth after 1984. In addition to the fact that the one-time discrete effect of the HRS reform had ended in 1984, the evidence suggests that the rapid exodus of the labor force from the cropping sector and the sharp decline in the growth rate of fertilizer usage were responsible for the stagnation. The sharp reduction in state procurement prices is probably the reason for both trends.

The above findings have wider implications than simply improving the understanding of rural reforms in China. An important issue that confronts most developing countries is how to develop agriculture rapidly in order to support industrialization and to meet the ever-increasing food demand brought on by explosive population growth. Small and fragmented holdings, which characterize the landscapes in most densely populated developing countries, are often regarded as a great obstacle for mechanization, irrigation, plant protection, efficient allocation of inputs, and so forth. Consequently, many policymakers and scholars, not only in China but also in many other developing countries, consider collective farming an attractive method for land consolidation and productivity improvement. However, my findings suggest that the household farm has advantages of its own. Since the household farm leads to a more productive use of inputs, it may be a more appropriate institution for the growth of agriculture in developing countries, including China.

Appendix: Data Sources and Adjustments

This appendix documents the data sources and describes the various calculations and adjustments that have been made to make the panel data suitable for econometric analysis.[15]

Gross Value of Crops.—The gross value of each province's crops is calculated from the gross physical outputs of seven grain crops (rice, wheat, corn, potatoes, sorghum, millet, and soybeans) and 12 cash crops (cotton, peanuts, rapeseed, sesame, jute, ramie, sugar cane, sugar beets, tobacco, tussah silk cocoons, mulberry silk cocoons, and tea), using the official 1980 prices as weights for aggregation. The output data for 1970–1978 were taken from State Statistical Bureau (1980a), data for 1979–1987 were from the annual *China Agricultural Yearbook*, and the data on 1980 prices were from State Statistical Bureau (1980b). The indexes are reported in Table 4.

Land.—The data on cultivated land for 1970–1979 were taken from State Statistical Bureau (1980a), data for 1980–1983 were from State Statistical Bureau (1984a), and data for 1984–1987 were provided by the Agricultural Division of the State Statistical Bureau. The data for 1987 can also be found on page 224 of the 1988 *China Statistical Yearbook*. The summary indexes of national aggregation of land and other input series are reported in Table 4.

Labor Force in the Cropping Sector.—The data on the labor force in the cropping sector were estimated from the data on the farm labor force. The data on farm labor prior to 1980 were provided by the Agricultural Division of the State Statistical Bureau, and data for 1980–1987 were taken from the 1981–1988 volumes of the *China Agricultural Yearbook*. The farm labor force includes those working in cropping, animal husbandry, forestry, fishery, and sideline production. To obtain an estimate of the labor force in the cropping sector, the farm labor forces were weighted by the value share of crop output in total agricultural output. The gross values of crops are calculated as described above. The gross value of agriculture for each province prior to 1986

[15] Since the page numbers are too numerous to list, detailed information will be provided by the author upon request.

was obtained from State Statistical Bureau (1987), while the values for 1986 and 1987 are from the 1987 and 1988 *China Statistical Yearbook*. The reported values were measured at current prices in each year. They are converted to the values at 1980 prices by deflating with the state-procurement price index on page 401 of State Statistical Bureau (1984b), with the index in 1980 being set to 100.[16] Other weighting methods were also tried, and the regression estimations were similar; however, the fits were not as good. Because crop and agricultural output may fluctuate from year to year, the values of three-year averages are used in computing the weights.

Capital.—Capital is measured by the horsepower of tractors and draft animals. Data on the numbers of tractors for 1970 and 1975–1978 were taken from State Statistical Bureau (1980a). Data on the number of tractors for 1971–1974 and on draft animals prior to 1979 were provided by the Division of Agriculture of the State Statistical Bureau. Data on the numbers of tractors and draft animals after 1978 were taken from the *China Agricultural Yearbook* (1980–1988). To convert these numbers into horsepower, the following weights are used: 18 hp for big tractors, 12 hp for walking tractors, and 0.7 hp for draft animals. These weights are recommended by the State Statistical Bureau.

Chemical Fertilizer.—This refers to the gross weight of fertilizer consumed. Data for 1970, 1975, and 1979 were taken from State Statistical Bureau (1980a); data for the rest of years prior to 1980 were provided by the Agricultural Division of the State Statistical Bureau; data for years after 1979 were taken from the *China Agricultural Yearbook* (1981–1988).

Changes in Farming Institution.—These changes were measured by the ratio of teams in each province that had converted to HRS by the end of each year. All households were in the production-team system before 1979; after 1984, over 99 percent of teams had adopted HRS. The ratios for 1981 and 1982 were provided by the Research Center for Rural Development of the State Council, and those for 1983 and 1984 were available in the 1984 and 1985 *China Agricultural Yearbook*. However, detailed information about the change in the farming institution for each province is not available for 1979 and 1980. Since, nationally, only 1.02 percent of all teams converted to HRS in 1979, it should be acceptable to generalize that the farming institution in each province was still the production-team system in 1979. However, in 1980, 14.4 percent of teams had converted. Therefore, I eliminated the 1980 observations from the data. As a result, the data set contains 476 cross-section and time-series observations. Information on the ratio of teams converted to HRS nationally is reported in Table 3.

Index of State Above-Quota Prices Relative to Input Prices.—The relevant data should be the above-quota prices relative to input prices. However, the price indexes given in State Statistical Bureau (1984b) and State Statistical Bureau (1988b) were quota prices. Quota price indexes were converted to above-quota price indexes by the following adjustments. (i) The above-quota price series for grain was calculated. (ii) The above-quota prices for cash crops were inferred. (iii) The above-quota price index for crop output was calculated as the weighted average of the above two series, using each year's percentage shares of grain and cash crops in the total output as weights. (iv) Finally, the resulting above-quota price indexes were divided by the indexes of manufactured input prices in rural areas to obtain relative price indexes. The original series set the index in 1950 equal to 100. For ease of interpretation, the series is converted by setting the 1978 index to 100, as reported in Table 2.

[16]Technologically, the labor intensity in the cropping sector is lower than that in animal husbandry, fishery, and sideline production. Therefore, in perfect competitive markets, using the value share of crop output in total agricultural output as a weight may lead to an exaggeration of the labor force in the cropping sector. However, the prices of crop outputs in China in general are suppressed, compared to output prices in other sectors. Therefore, using the value share as a weight may understate the labor force in the cropping sector. These two considerations may cancel each other out, to a certain extent.

Index of Market Prices Relative to Input Prices.—Table 2 also reports the index of market prices and the index of market prices relative to input prices. The market-price index, available in State Statistical Bureau (1988b), was a weighted average of prices for crops, livestock, and other products sold in rural market fairs. Therefore, this series contains some errors in measurement if it is to be used as a proxy for the market prices of crops. This error may reduce the estimated effect of changes in market price on growth in terms of crops.

Percentage of Area Devoted to Nongrain Crops.—This percentage was obtained by dividing the sown acreage of nongrain crops by total agricultural sown acreage. The data on total sown acreage for 1970, 1975, and 1979 were taken from State Statistical Bureau (1980a); for the rest of years prior to 1979, data were provided by the Agricultural Division of the State Statistical Bureau; and for years after 1979, data were from *China Statistical Yearbook* (1981–1988). Data on nonagricultural sown acreage were obtained from the difference between total agricultural sown acreage and total grain sown acreage. Data on total grain sown acreage prior to 1980 were available in State Statistical Bureau (1980a), and data after 1979 were from *China Agricultural Yearbook* (1981–1988). Table 3 reports the percentages of sown area in grain, cash crops, and other crops on the national level, which were taken from Ministry of Agriculture Planning Bureau (1989 pp. 130–1), and *China Statistical Yearbook* (1988 p. 243).

Multiple Cropping Index.—This index was obtained by dividing the total agricultural sown area by the cultivated land in each province. Table 3 reports the series for multiple cropping index on the national level. The data for 1970–1986 was from the Ministry of Agriculture Planning Bureau (1984 p. 132). For 1984–1987, figures are calculated from the total sown acreage and total cultivated land in China in the corresponding years.

REFERENCES

Aigner, Dennis J., Lovell, C. A. Knox and Schmidt, Peter, "Formulation and Estimation of Stochastic Frontier Production Function Models," *Journal of Econometrics*, July 1977, *6*, 21–38.

Ash, Robert F., "The Evolution of Agricultural Policy," *China Quarterly*, December 1988, (116), 529–55.

Carter, Michael R., "Resource Allocation and Use Under Collective Rights and Labour Management in Peruvian Coastal Agriculture," *Economic Journal*, December 1984, *94*, 826–46.

Griliches, Zvi, "The Source of Measured Productivity Growth: United States Agriculture, 1940–60," *Journal of Political Economy*, July 1963, *71*, 331–46.

Jiang, Yaping, "All We Want Is To Cultivate Land: An On-The-Spot Report of a Dispute of Land Contract in Shunyi County, Beijing" [in Chinese: "Wo men bu gou yao zhong di: beijing shunyixian yiqi chengbao tudi hetong jiufeng jishi"], *People's Daily* [*Renmin Ribao*], 26 October 1988.

Johnson, D. Gale, *The People's Republic of China: 1978–1990*, San Francisco: ICS Press, 1990.

Judge, George G., Griffiths, W. E., Hill, R. Carter, Lutkepohl, Helmut and Lee, Tsoung-Chao, *The Theory and Practice of Econometrics*, 2nd Ed., New York: Wiley, 1985.

Kiefer, Nicholas M., "Estimation of Fixed Effect Models for Time Series of Cross-Sections with Arbitrary Intertemporal Covariance," *Journal of Econometrics*, October 1980, *14*, 195–202.

Kojima, Reeitsu, "Agricultural Organization: New Forms, New Contradictions," *China Quarterly*, December 1988, (116), 706–35.

Kueh, Yak-Yeow, "China's New Agricultural-Policy Program: Major Economic Consequences, 1979–1983," *Journal of Comparative Economics*, December 1984, *8*, 353–75.

Lardy, Nicholas R., *Agriculture in China's Modern Economic Development*, Cambridge: Cambridge University Press, 1983.

Leibenstein, Harvey, "Allocative Efficiency vs. 'X-Efficiency'," *American Economic Review*, June 1966, *56*, 392–415.

Lin, Justin Yifu, "The Household Responsibility System Reform in China: A Peasant's Institutional Choice," *American Journal of Agricultural Economics*, May

1987, *69*, 410–5.

______, "The Household Responsibility System in China's Agricultural Reform: A Theoretical and Empirical Study," *Economic Development and Cultural Change*, April 1988, *36* (supplement), S199–S224.

______, "The Household Responsibility System in China's Rural Reform," in Allen Mauder and Alberto Valdes, eds., *Agriculture and Governments in an Interdependent World: Proceedings of the XX International Conference of Agricultural Economists*, Aldershot, U.K.: Dartmout, 1989, pp. 453–62.

______, "The Household Responsibility System Reform and the Adoption of Hybrid Rice in China," *Journal of Development Economics*, October 1991, *36*, 353–72.

McMillan, John, Whalley, John and Zhu, Lijing, "The Impact of China's Economic Reforms on Agricultural Productivity Growth," *Journal of Political Economy*, August 1989, *97*, 781–807.

Muth, John, "Rational Expectations and the Theory of Price Movement," *Econometrica*, July 1961, *29*, 315–35.

Perkins, Dwight H., "Reforming China's Economic System," *Journal of Economic Literature*, June 1988, *26*, 601–45.

______ **and Yusuf, Shahid,** *Rural Development in China*, Baltimore: Johns Hopkins University Press, 1984.

Perry, Elizabeth J. and Wong, Christine, eds., *The Political Economy of Reform in Post-Mao China*, Cambridge, MA: Harvard University Press, 1985.

Sicular, Terry, "Agricultural Planning and Pricing in the Post-Mao Period," *China Quarterly*, December 1988, (116), 671–705.

Wen, Guanzhong James, "The Current Land Tenure and Its Impact on Long Term Performance of the Farming Sector: The Case of Modern China," Ph.D. dissertation, University of Chicago, 1989.

***China Agriculture Yearbook* [*Zhongguo Nongye Nianjian*]**, Beijing: Agriculture Press, 1981–1988 (annual).

China Quarterly, December 1988, (116).

***China Statistical Yearbook* [*Zhongguo Tongji Nianjian*]**, Beijing: China Statistical Press, 1981–1989 (annual).

***Economic Weekly News* [*Jingjixue Zhoubao*]**, 11 January 1982.

Journal of Comparative Economics, September 1987, *11* (3).

Ministry of Agriculture, *China Agriculture Statistical Material, 1987* [in Chinese: *Zhongguo Nongye Tongji Ziliao, 1987*], Beijing: Agriculture Press, 1989.

Ministry of Agriculture Planning Bureau, *A Comprehensive Book of China Rural Economic Statistics, 1949–1986* [in Chinese: *Zhongguo Nongcun Jingji Tongji Ziliao Daquan, 1949–1986*], Beijing: Agriculture Press, 1989.

______, *Agricultural Economic Data, 1949–1983* [in Chinese: *Nongye Jingji Ziliao, 1949–1983*], Beijing: Ministry of Agriculture, 1984.

State Statistical Bureau, (1980a) *National Agricultural Statistics for the 30 Years Since the Founding of the People's Republic of China, 1949–1979* [in Chinese: *Jianquo 30 Nian Quanguo Nongye Tongji Ziliao, 1949–1979*], Beijing: State Statistical Bureau, 1980.

______, (1980b) *Scheme for Computing Gross Agricultural Value* [in Chinese: *Nongye Zongchanzhi Jisuan Fangan*], Beijing: State Statistical Bureau, 1980.

______, (1984a) *National Agricultural Statistics (Continuation), 1978–1983* [in Chinese: *Quanguo Nongye Tongji Ziliao (Xubain), 1978–1983*], Beijing: Statistical Bureau, 1984.

______, (1984b) *China Trade and Price Statistics, 1952–1983* [in Chinese: *Zhongguo Maoyi Wujia Tongji Ziliao, 1952–1983*], Beijing: China Statistical Press, 1984.

______, *A Compilation of National Income Statistics, 1949–1985* [in Chinese: *Guominshouru Tongji Ziliao Huibain, 1949–1985*], Beijing: China Statistical Press, 1987.

______, (1988a) *A Compilation of Price Statistics Documents* [in Chinese: *Wujia Tongji Wenjian Huibian*], Beijing: China Statistical Press, 1988.

______, (1988b) *China Price Statistical Yearbook, 1988* [in Chinese: *Zhongguo Wujia Tongji Nianjian, 1988*], Beijing: China Statistical Press, 1988.