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This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the authors.

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ABSTRACT

This paper analyzes the relative importance of the major factors underlying the post-1978 increase in China's agricultural productivity. We present a method for assessing the role of price increases and strengthened individual incentives due to the introduction of the responsibility system. Data on pre- and post-1978 Chinese agricultural performance are used to calculate incentive indices, giving the fraction of their marginal product that peasants received under the pre-1978 regime.

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1. Introduction

Between 1978 and 1984 output in the Chinese agricultural sector increased by over 50 percent (Johnson 1985). These impressive output gains followed the adoption of a system stressing individual responsibility in place of a system of communal decision-making and rewards. The ongoing economic reform in China has attracted much attention in the West, in part because it represents a major social experiment in the design of institutions in which a system emphasizing ideology and social sanctions has been replaced by a system relying more heavily on economic incentives. However, not all the increase in Chinese agricultural output can be attributed to systemic changes, because at the same time, the prices of agricultural outputs and the use of inputs such as chemical fertilizers were increased.[1]

This paper presents a method for decomposing the productivity increase in Chinese agriculture in the post-1978 period into that part attributable to price increases and that part which reflects the effects of strengthened individual incentives under the new institutional structure. Our method combines standard growth-accounting techniques with a simple model of peasants' rational response to the institution within which they work. Subject to caveats both about the special functional forms assumed in our calculations and the shortcomings of the available data, we suggest that three-quarters of the 37 percent increase in agricultural productivity in China between 1978 and 1984 can be attributed to the incentive effects of the new responsibility system and one-quarter to higher prices. We also obtain a measure of the extent to which individual incentives operated under pre-1978 communal system: our calculations suggest that it was as if peasants were paid one-third of their marginal value product. As a result, we estimate that the effective quality of labor under the commune system was about 60 per cent of that under the responsibility system.

These findings have wider implications than simply providing an understanding of performance in Chinese agriculture. Much of modern microeconomic theory focuses on the design of institutions;[2] and Chinese policy is an experiment in institutional design on a huge scale. In the theorists' analyses, it is individuals' self-interested responses which constrain institutional design. In this paper, we use the results of the Chinese experiment to estimate empirically the force of incentive constraints. Our results suggest that rewarding individual effort yields large benefits. Hence, for other countries where communal methods have been tried and agricultural performance has been poor (such as Tanzania), these results suggest that prices and institutions need to be considered together as explanations of performance. The results also suggest that significant further gains could be achieved by comparable reforms in the Chinese industrial sector, allowing pice incentives to operate more freely than has hitherto been the case.

In Section 2 we briefly describe Chinese agricultural arrangements before and after 1978. Section 3 presents the theory underlying our decomposition method for estimating the relative importance of institutional changes and price changes for economic performance. Section 4 presents data on total factor productivity changes, our decomposition, and estimated incentive indices. Section 5 offers a conclusion.

2. Institutional Arrangements in Chinese Agriculture

A typical Chinese rural commune in 1978 consisted of three units: the commune, the production brigade, and the production team. The production team was the basic accounting and production-organizing unit. It owned virtually all the land, draft animals and farm machinery it used. Each team was given annual production targets (conveyed through the commune and brigade). It then drew up its annual production plan, deciding how to use its land, manpower, animals, and farm tools; when to plow and plant, and what types of fertilizer to use for which kinds of crops. All peasants, including women and children, were included in the team's labor plan.

There were two principal methods of allocating work among team members; assigning work on a daily basis, or assigning long-term fixed work. In grain production and other major farm tasks, work was assigned to work groups on a rotating basis. For other tasks, work was given to small groups of peasants who often retained a permanent responsibility for the job.

Each production team distributed income among team members largely according to an estimate of each member's labor contribution to production. Under the "labor-day-work-payment" system, the quantity of work done was measured in terms of labor days. For each day, those who presented themselves in the field would receive a labor day. The quality of work done was measured by work points received per labor day. Members of teams were classified into different grades according to their technical skills, capacity to work, and how well they met the labor norms set up by the team. Different numbers of work points were attached to each grade. Members periodically assessed each other's work and determined the grade each should be classified into, and thus the number of work points each should earn for labor days worked during the period of assessment. In this assessment process, team staff (team leaders and heads of work groups) played the main role.

At the end of the agricultural year, the combined income of the team was divided by the sum of work points credited to all team members to determine the value of one work point. The disposable income of each member was determined by multiplying by the number of work points the individual peasant had accumulated over the agricultural year.[3]

At the end of 1978, the Chinese central government decided to introduce major reform in agriculture in large part because of poor agricultural growth performance over the preceding 20 year period. A "production responsibility system" was introduced to deal with the problems of shirking and mismanagement associated with the previous communal system. Under this, the individual peasant, rather than the production team, became the basic unit for decision-making in Chinese agriculture. Most aspects of collective management have since been abandoned, with only land ownership remaining within the collective (Lardy (1986a, 1986b), Watson (1984)). Introduction of this system began in 1979, and by the end of 1983 more than 90 percent of farm families operated under the responsibility system (Crook (1985)).

The responsibility system involves contracts signed between the production team and each household, which regulate the taxes and delivery quotas payable to the state and the welfare funds and investment funds payable to the team. Any production above the delivery quota is retained by the household who can sell it and receive the proceeds. Most restrictions on production activities on private plots have been removed and the size of private plots has increased.

The earlier grain self-sufficiency policy, which required each region to be self-sufficient in grain production, has also been abandoned. Peasants in each region are now allowed to specialize in planting these crops most suitable to their land, rainfall, temperature, and other environmental characteristics. The number of planned product categories and obligatory targets has been sharply reduced. In addition, control over collective production activities have been relaxed and production teams can organize any non-farm production as they see fit.

In addition to these changes, reforms in agricultural prices have occurred. Since 1979, state procurement prices have increased for most major farm products. Grain procurement prices have increased by 20 percent for compulsory delivery quotas, and the additional price premium for above-quota sales has been raised from 30 percent to 50 percent (Kueh, 1984). Furthermore, any extra grain produced can be sold at prices reflecting conditions in the open market, and substantial procurement price increases for other farm products have occurred. Comparable procurement and premium prices for cotton have been raised by 15 percent and 30 percent, respectively, and compulsory delivery prices for edible oil and pork have been increased by 25 percent (Kueh, 1984). Prices of tobacco, vegetables and soy beans have also been raised (Walker, 1984), and prices of some manufactured goods supplied to the agricultural sector have been reduced.

3. Decomposing the Effects of Price Increases and Changes in the Incentive System

The net effect of all these changes has been a sharp increase in output in Chinese agriculture.[4] However, assessing their importance of each is difficult because they have occurred largely simultaneously. While it has been the systemic changes involving the responsibility system which have attracted most attention, thus far it has not been clear what portion of the output gain to attribute to them, given the price increases.

Our procedure to make such a decomposition is based on growth-accounting techniques associated with Dennison (1967) and Solow (1957), but goes further in also incorporating behavioral responses of agricultural workers to changes in both the incentive system and prices. Since we seek an empirically-implementable model, we assume special functional forms in our analysis.

We assume that a peasant can choose the efficiency with which he works. If L represents the total number of peasants and ϵ is the effort of a typical worker, the contribution of labor to output measured in efficiency units is $L\epsilon$. This approach to representing the labor input in agricultural production is similar to that underlined Stiglitz's (1976) efficiency-wage hypothesis: but unlike Stiglitz, we model the individual's optimizing choice of effort. Although we describe ϵ as "effort", it should be interpreted broadly, to include everything that determines the effective quality of labor: ϵ might be increased not only by inducing the workers literally to exert more effort, but also by encouraging the use of entrepreneurial talent, or by removing restrictions on the kinds of tasks a worker may undertake and thereby allowing labor to flow to its most productive uses.

We assume a Cobb-Douglas agricultural production function, given by

$$Q = \alpha_0 (\epsilon L)^{\alpha_1} K^{1-\alpha_1}, \qquad (1)$$

where Q and K represent total output and aggregate non-labor inputs (capital, land, pesticides, fertilizer, etc.) respectively, and α_1 defines the share parameters on factor inputs ($0 \le \alpha_1 \le 1$). The quantity produced by a representative peasant is thus

$$q = \alpha_0 \varepsilon^{\alpha_1} k^{1-\alpha_1}, \qquad (2)$$

where q and k represent output per peasant and capital per peasant respectively.

We suppose that each peasant receives an income which depends on his productivity and is given by

$$y = \beta pq + c, \qquad (3)$$

where p is the price at which additional output is sold; q is the quantity of output produced by the peasant; β is the fraction of the additional revenue generated that the peasant is allowed to keep; and c is a constant term.

Under the post-1979 responsibility system, c is negative (representing the output quota that the peasant must deliver to the government) and $\beta = 1$ (the peasant keeps the proceeds of sales of output beyond his quota).[5] Under the pre-1979 communal system, c is positive (the payment received by the peasant regardless of his own effort) and $0 \leq \beta \leq 1$, since peasants were typically not fully rewarded for effort at the margin, due to the reward structure in the commune. A commonly-made observation is that managerial difficulties in operating the communes gave rise to "the problem that individuals (in the commune) could see little connection between effort expended and what they received as income" (Macrae (1977, p. 371)). It was difficult to measure an individual's effort accurately; and to some extent the distribution of rewards within the commune was based on egalitarian criteria: Johnson (1985), Watson (1984). But priori, our analysis does not rule out the possibility that those problems were overcome by the commune managers, i.e. $\beta = 1$. While equation (3) does not fully model all the complexities of payment under the work-points system, it nonetheless captures its main features.[6] The parameter β is an index of the strength of the incentives offered to peasants: it measures the peasant's perception of what fraction of his marginal value product he would be paid.

We also assume that peasants receive utility from income but dislike effort. We capture this in the simple utility function

$$U(y,\varepsilon) = y - \frac{\varepsilon^z}{z\delta} \tag{4}$$

where $\delta > 0$ and $z > 1$ are constants. This function implies that the marginal disutility of effort, ε^{z-1}/δ, increases with effort. Without this property, there would be a corner solution for the optimal effort level from peasant optimizing behavior. The work-disutility coefficient z is such that

$$z-1 = \frac{\varepsilon \partial^2 u/\partial \varepsilon^2}{\partial u/\partial \varepsilon}. \tag{5}$$

Thus, analogous to the coefficient of relative risk aversion, z measures the curvature of the utility function. The utility function (4) also implies that the disutility of effort is independent of income level.

We now consider the peasant's optimizing choice of effort. Substitution of (2) and (3) into (4) and optimization with respect to ε implies that the optimal effort ε^* satisfies

$$\varepsilon^* = [\delta\alpha_1\alpha_0\beta p k^{1-\alpha_1}]^{1/(z-\alpha_1)} \tag{6}$$

Substitution of this into the per-worker production function (2) gives

$$q = \alpha_0[\delta\alpha_1\alpha_0\beta p]^{\alpha_1/(z-\alpha_1)} k^{z(1-\alpha_1)/(z-\alpha_1)}. \tag{7}$$

Finally, multiplication of both sides by L to revert to aggregate variables implies

$$Q = AL^{\gamma_1}K^{1-\gamma_1}, \qquad (8)$$

where $\gamma_1 = (z-1)\alpha_1/(z-\alpha_1)$ and

$$A = \alpha_0[\delta\alpha_1\alpha_0\beta p]^{\alpha_1/(z-\alpha_1)}. \qquad (9)$$

We label (8) the "institutional" production function to distinguish it from "technical" production function (1). The difference is that while (1) reflects technical (that is, biological and physical) relationships between inputs and outputs, (8) also incorporates the peasants' response to the institutional arrangements within which they work.[7]

We note that the institutional production function (8) is expressed in terms of the observable labor input L rather than the unobservable efficiency measure of labor εL, as in the technical production function. It is (8) rather than (1) that would be estimated by the conventional aggregate-production-function estimation; and the estimated factor shares would be γ_1 and γ_2, rather than those of the technical production relationship, α_1 and α_2. A would be the term estimated as total factor productivity.

The parameters α_0, α_1, and α_2 are technologically determined, and δ and z are taste parameters: all are invariant to the institutional form. The two policy variables are the output price, p, and the share of the peasant's marginal output that he retains, β. The sole effect of a change in either or both of these policy variables is to change the coefficient A in the institutional production function (8). We can thus assess the effect of changes in β (as through the introduction of the responsibility system) on agricultural productivity for unchanged agricultural prices, and the effect of changes in prices for unchanged β, and in this way separate the two effects in which we are interested.

Using the subscripts i and j to denote parameter and policy variables for different years, (9) implies

$$\frac{\beta_i}{\beta_j} = \frac{p_j}{p_i}\frac{A_i}{A_j}^{(z-1)/\gamma_1} . \quad (10)$$

Given price indices p_i and p_j, total-factor-productivity estimates A_i and A_j, the labor-share exponent in production γ_1, and an estimate of the work-disutility parameter z, we can use (10) to compute the ratio of the incentive indices β_i/β_j. Since $\beta_i = 1$ for marginal production under the responsibility system, we can estimate β_j under the commune system. And having estimated β_i/β_j, we can compute

$$\frac{A'_i}{A'_j} = \frac{\beta_i}{\beta_j}^{\gamma_1/(z-1)} , \quad (11)$$

which is what the ratio of total factor productivities would have been if there had been no price changes; that is $p_j = p_i$. Thus (11) provides an estimate of the extent to which observed productivity increases were caused by the incentive effect of the institutional changes alone.

Finally, from (6) and the fact that $\alpha_1 = \gamma_1 z/(\gamma_1+z-1)$, we have, for a given capital-labor ratio k,

$$\frac{\varepsilon_i}{\varepsilon_j} = \frac{\beta_i p_i}{\beta_j p_j}^{(\gamma_1+z-1)/(z^2-z)} , \quad (12)$$

showing the effective quality of labor in year i relative to year j, as a function of the institutional arrangements (the β_i and β_j) and prices.

Our model ignores the possibility that the introduction of the responsibility system may have affected not only the quality of labor, but also the effective quality of land, especially to the extent that decentralized decision-making results in a better matching of crops to land. Also, the opening of new markets, by creating new gains from trade, may have caused productivity growth. And, if technical progress occurs, total factor productivity would increase (via a rise in the parameter α_o). Thus, to the extent that any of these effects is at work, our model will overestimate the relative efficiency of the responsibility system compared to the communal.

4. Measuring Incentive Effects

Equations (8) and (9) above imply that the effect of a change in the institutional incentive system is to change the measured total factor productivity, A. If we denote the responsibility system and the commune system by subscripts i and j, respectively, then the ratio A_i/A_j is equal to the ratio of outputs under the two institutional arrangements for any given input vector. It thus provides a measure of the productivity gain attributable to the strengthened incentives under the responsibility system and/or the increases in agricultural prices.

To provide some background to our computations of post-1978 productivity changes, Table 1 presents data on inputs and outputs for 1952 to 1977. In 1952 land redistribution had been accomplished and the peasants farmed their own land: a market system operated. From the time of the collectivization, 1953, to the end of the Cultural Revolution the annual change in total factor productivity was negative almost as often as it was positive. Productivity fell drastically during the Great Leap Forward (see the 1959 and 1960 estimates) and during the Cultural Revolution (in particular in 1968). Only in three years (1955, 1957, and 1958) was total factor productivity as high as it had been in 1952. By 1961, after the Great Leap Forward, total factor productivity was 74 percent of what it had been in 1952; and by 1977, it was 90 percent of the 1952 level.

Table 2 shows that the post-1978 situation has been strikingly different. (Tables 1 and 2 are presented separately because the input and output data series are noncomparable.[7]) In 1978 agricultural prices began to increase; and through the early 1980s the production responsibility system was introduced. These changes have resulted in successive increases in total factor productivity, except for a slight, transitional decline in 1979-1980.

From equation (9), changes in β affect the productivity parameter A in exactly the same way as changes in p: the incentive structure and prices are perfect substitutes. However, prices are available in the data, whereas β's are not. Using equation (10), we can estimate the ratio of incentive indices in different years, β_i/β_j. These incentive-index estimates use the total-factor-productivity estimates from Table 2, price indices, and the

Table 1: Chinese Agricultural Output, Inputs, Prices and Productivity Growth, 1952-77

Year	Index of Gross Agricultural Output Value[a]	Agricultural Labor Force (millions)	Sown Area Adjusted for Irrigation and Multiple Cropping (million hectares)	Value of Farm Capital (billion 1952 yaun)	Current Input Index	Total Factor-Productivity Growth $(\dot{A}/A)$[b]	Index of Agricultural Prices Relative to Industrial Prices[c] (1950 = 100)
1952	100	168.677	130.7	11.292	100		110.8
1953	101	169.940	132.6	12.024	107	-.0139	122.5
1954	103	171.575	135.5	12.166	118	-.0071	123.9
1955	110	174.134	137.9	11.885	128	.0457	120.7
1956	113	176.396	145.1	12.430	161	-.0355	125.6
1957	118	177.267	145.0	13.084	164	.0340	130.4
1958	131	178.193	142.7	15.532	204	.0563	134.1
1959	106	179.688	139.5	14.014	220	-.1967	135.3
1960	90	180.925	136.7	12.455	235	-.1484	136.3
1961	94	182.544	134.0	11.887	186	.0081	160.4
1962	105	185.017	136.0	12.604	198	.0908	152.8
1963	115	188.107	138.3	14.132	220	.0538	150.8
1964	125	192.005	139.9	15.308	244	.0491	151.2
1965	133	196.471	142.2	17.103	271	.0199	156.3
1966	141	201.265	142.7	18.106	290	.0307	168.3
1967	150	205.476	143.1	18.542	306	.0420	169.7
1968	140	210.076	143.5	18.399	321	-.0852	170.1
1969	143	214.946	144.0	18.519	341	-.0010	172.7
1970	158	220.702	144.7	19.893	367	.0714	173.0
1971	161	226.582	146.1	21.468	400	-.0181	177.8
1972	169	232.388	146.9	23.697	435	.0120	180.9
1973	178	238.274	148.4	23.280	464	.0298	182.0
1974	183	244.111	149.8	25.317	506	-.0088	183.1
1975	187	250.010	151.7	26.703	552	-.0125	183.7
1976	187	255.956	152.6	27.669	596	-.0290	183.7
1977	186	262.052	153.5	28.371	659	-.0372	183.7

Footnotes to Table 1:

[a]Source of output and input data: Tang 1980, pp. 27, 28).
[b]The growth in total factor productivity was computed by

$$\frac{\dot{A}}{A} = \frac{\dot{Q}}{Q} - \sum_{i=1}^{4} \gamma_i \frac{\dot{N}_i}{N_i},$$

where the N_i's are factor inputs and the factor shares are taken from Tang (1980, pp. 28): 0.50 for labor, 0.25 for land, 0.10 for farm capital, and 0.15 for current inputs (fertilizer, etc.).
[c]Source of price data: State Statistical Bureau (1984, pp. 357).

Table 2: Chinese Agricultural Output, Inputs, Prices, and Productivity Growth, 1978–84

Year	Index of Gross Agricultural Output Value[a]	Agricultural Labor Force (millions)	Total Sown Area of Farm Crops (10,000 mu)	Total Horsepower of Agricultural Machinery (10,000hp)	Usage of Chemical Fertilizers (10,000 tons)	Total-Factor-Productivity Growth ($\dot{A}/A$)[b]	Index of Agricultural Prices Relative to Industrial Prices[c]
1978	229.6	294.26	225,156	15,975	884.0		198.0
1979	249.4	294.25	222,715	18,191	1,086.3	0.041	241.6
1980	259.1	302.11	219,569	20,049	1,269.4	-0.007	256.7
1981	276.2	311.71	217,736	21,319	1,344.9	0.038	269.2
1982	306.8	320.13	217,132	22,589	1,513.4	0.072	270.7
1983	336.2	325.10	215,990	24,503	1,659.8	0.066	279.9
1984	393.7	325.38	216,332	26,509	1,739.8	0.155	282.5[d]

Footnotes to Table 2:

[a]Source of output and input data: State Statistical Bureau (1985, pp. 213, 243, 252, 275, 281). Inputs and outputs measure total activity, including rural manufacturing; data on solely farm inputs and output were not available.

[b]The growth in total factor productivity was computed by

$$\frac{\dot{A}}{A} = \frac{\dot{Q}}{Q} - \sum_{i=1}^{4} \gamma_i \frac{\dot{N}_i}{N_i},$$

where N_i's are the factor inputs and the factor shares γ_i are taken from Tang (1980. pp. 28): 0.50 for labor, 0.25 for land, 0.10 for farm capital, and 0.15 for current inputs (fertilizer, etc.).

[c]Source of price data: State Statistical Bureau (1984, pp. 357).

[d]Source of price data: State Statistical Bureau (1985, pp. 530).

labor-share and utility-function parameters. Agricultural price indices are reported in the last column of Table 2. The labor-share parameter we take to be 0.50, following Tang (1980).[8] We need also the unobservable parameter z, which measures the curvature of the utility function. The only theoretical restriction is that it must exceed one. Although not directly observable, z can be calculated indirectly. Between 1978 and 1979, there were substantial agricultural price increases (of 22 percent), but little change in the commune system (Watson, 1984, p. 90). Assuming that from 1978 to 1979 β was unchanged, we can from (10) infer the value of z. This we compute to be 3.448, and we use this value for z in our other computations.

Table 3 reports estimates of the incentive-index ratio β_i/β_j in the first row. If we presume that $\beta = 1$ in 1984 (peasants receive their full marginal value product under the responsibility system), then the 1984 estimate in Table 3 implies that in 1978 β was 0.30. In the commune system as it was organized at the end of the Cultural Revolution, it was as if an individual worker was paid just under one-third of his marginal value product.

Using equation (11) and the β_i/β_j estimates, we can also deduce the incentive effects of the introduction of the responsibility system alone. The results are also reported in Table 3. We calculate that if there had been no price increase between 1978 and 1984, total factor productivity would have increased by 27.55 percent, compared with the 37.00 percent that it actually increased. This implies that 75 percent of the productivity gain in Chinese agriculture between 1978 and 1984 can be attributed to the strengthened individual incentives generated by the new institutions, and the remaining 25 percent to the price increases.[9]

Table 3:
Incentive Indices and Total Factor Productivity Change in Chinese Agriculture, 1979-84

	1979[d]	1980	1981	1982	1983	1984
Ratio of Incentive Indices β_t/β_{1978} [a]	1.000	0.910	1.044	1.244	1.655	3.387
Actual Total Factor Productivity A (1978 = 100).[b]	104.10	103.37	107.30	111.27	118.62	137.00
Hypothetical Total Factor Productivity A', Assuming No Price Changes (1978 = 100).[c]	104.10	98.11	100.88	104.49	110.65	127.55

Footnotes to Table 3

[a]Computed using equation (10).
[b]Computed from Table 2.
[c]Computed using equation (11).
[d]By our choice of z β_{1979} equals β_{1978}, and so by assumption all of the increase in productivity in 1979-1978 is due to the price increase.

Finally, using equation (12) to compute $\epsilon_{1978}/\epsilon_{1984}$, we find that the effective quality of labor in 1978 was about 60 per cent of what it became in 1984.

Since β is calculated as a residual, it is sensitive to changes in parameters. The least reliable of our parameter estimates is the utility-function curvature parameter z. The z estimate we use is 3.448. If instead z were 2.0, we would have estimated $\beta_{1978}/\beta_{1984}$ to be 0.76; this would have attributed 40 percent of the productivity gain to the changed incentive scheme. If z were 3.0, these estimates would have been 0.41 and 69 percent respectively. If z were 4.0, they would have been 0.22 and 79 percent. Thus our estimates are sensitive to changes in the estimate of z; but over a wide range of z values our model attributes most of the productivity increase to the changed incentive structure.

5. Conclusion

This paper presents a method for assessing the relative importance of price increases and strengthened individual incentives for increased agricultural performance in China following the economic reforms introduced in 1978. We employ a production-function approach in which optimizing effort of peasants is captured: peasant supply of effort increases as either the prices of agricultural products or the fraction of their value marginal product they receive increase. Subject to caveats about the structure of our theoretical model and the shortcomings of the data, our results suggest that one-quarter of the increase in productivity in Chinese agriculture between 1978 and 1984 was due to higher prices, and three-quarters to changes in the incentive scheme. We estimate that the incentive effect of the change from the pre-1978 communal system to the post-1978 responsibility system resulted in a 28 per cent increase in total factor productivity in agriculture.

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Footnotes

[1]Lardy (1986b) remarks that "The simultaneous implementation of so many reforms makes it difficult, if not impossible, to measure the relative importance of each of these changes. If the individual elements of the reform had been implemented separately, their individual contribution to the acceleration of agricultural growth might have been measured."

[2]The literature on mechanism design can be so characterized: for surveys of various mechanism-design issues, see Groves and Ledyard (1985), Hart and Holmstrom (1986), and McAfee and McMillan (1987).

[3]The foregoing description of the commune system closely follows Cheng (1982). Commune members were also allowed to farm small plots of land for personal use. (In pastoral areas, they were also allowed to keep a limited number of livestock.) In most areas, 5 percent of the arable land was allocated for private plots. Peasants used private plots for fruits, vegetables, tobacco and produce for feeding chickens and pigs. Peasants were permitted, under some restrictions, to engage in sideline production such as weaving, knitting, gathering medical herbs, and handicrafts. Peasants could trade their produce from private plots and sideline occupations through a farm market, but this was subject to strict government regulation. Transactions were conducted mainly between commune members, and public agencies and enterprises were not permitted to trade in this market. Peasants were not allowed to go to urban areas and sell their products to urban residents.

[4]The average output of a rural worker rose 54.2 percent between 1980 and 1984. In that period, per-worker production of grain rose 24 percent; of cotton, 124 percent; of oilseeds, 50 percent; and of meat, 24 percent (Xinhua, 22 Sept. 1985).

[5]However, if next year's quota (c in equation (3)) depends upon this year's output, then the peasant's incentive to produce this year is reduced, effectively making β less than 1 under the responsibility system. See Freixas, Guesnerie, and Tirole (1985).

[6]For a more detailed model of the operation of the work-points system, see Lin (1986a).

[7]The input data used in the total-factor-productivity computations of Table 2 are subject to problems not easily overcome except by detailed analysis of the type Tang performed on the pre-1977 data. Only chemical-fertilizer inputs are measured, not natural-fertilizer inputs; and capital should include draft animals, whereas here it is only machinery. Since the omitted inputs are the more traditional inputs, the data probably overstate the growth rate of inputs and so underestimate the growth rate of total factor productivity.

[8]Tang based his factor-share estimates on income share in 1952, when incomes were determined by competitive market forces.

[9]In a complementary analysis, Lin (1986b) used the fact that the responsibility system was introduced gradually between 1980 and 1983, at different rates in different provinces, to estimate the incentive effects. Lin found that about 50 percent of the output growth between 1980 and 1983 was attributable to the responsibility system. (Our estimate that the responsibility system accounted for 75 percent of the growth in total factor productivity implies that it accounted for about 40 percent of the growth in output.)

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