ECONOMIC GROWTH CENTER

YALE UNIVERSITY

Box 1987, Yale Station
New Haven, Connecticut 06520

CENTER DISCUSSION PAPER NO. 533

HOUSEHOLD FARM, COOPERATIVE FARM, AND EFFICIENCY:

EVIDENCE FROM RURAL DE-COLLECTIVIZATION IN CHINA

Justin Yifu Lin

Yale University

March 1987

Abstract

A model of household optimizing behavior in a household farm and a cooperative farm is presented in this paper. In the household farming system, the returns to scale are sacrificed, while, in the cooperative farming system, effort metering is required for the purpose of income distribution. Their relative efficiencies are compared with adoption of specific functional forms. It is found that, when monitoring is minimal in the cooperative farm due to the difficulty of monitoring in agricultural production, a household will supply more effort in the household farm than in the cooperative farm; and, as a consequence, the total output produced by the household farming system is larger than that produced by the cooperative farming system. In addition, a change from the cooperative system to the household system is very likely to be a Pareto-improvement. Empirical data collected from recent rural de-collectivization in China are applied to examine some implications of the above model. The results are consistent with the predictions of the theory. It is found that, due to the increase in effort supply by each household, a shift from the cooperative farming system to the household farming system resulted in a 19.7% productivity jump, and over 60% of the 26.4% output growth between 1980 and 1983 can be attributed to this institutional change.

This paper is motivated by an attempt to develop a consistent model that incorporates both the household farm and the cooperative farm under the same optimizing framework and to compare these two farming institutions' relative efficiencies. It also attempts to use the data collected from recent rural de-collectivization in China to examine some of the implications of the model and as a by-product to assess the impacts of recent rural institutional change on China's agricultural production.

An important issue that confronts most developing countries is how to develop their agriculture rapidly in order to support urban industrialization and to meet the ever-increasing food demand from explosive population growth. Small and fragmented holdings, which characterize the landscapes in most developing countries, are often regarded as a great obstacle for mechanization, irrigation, plant protection, efficient allocation of inputs, and so forth. Cooperative farming, consequently, is considered by many policymakers, in both socialist and nonsocialist countries, as an attractive way of land consolidation and productivity improvement. However, agricultural cooperatives in the developing countries often end up with failures, despite substantial government support.[1] Furthermore, the household farm seems to be the dominant form of farming institution in the developed countries. Nevertheless, the prevalence of household farms in the developed countries is not due to the lack of economies of scale in agriculture. Empirical evidences show that the returns to scale are not negligible.[2] Whereas opponents of the cooperative farm often argue that pooling of private land deprives peasants of a sense of independence and thus contains disincentive for production (Tai, p. 235), the formal models of cooperative farming developed by Sen, Israelsen, Putterman, and so forth, suggest that the incentives to work in a cooperative farm shall be higher than in a household farm. This paper hopes to contribute to the understanding of the prevalence of the household farm and the incentive issue in the cooperative farm.

The laborer is the most dynamic agent in production. He not only provides the "brute force," like machinery or draft animals, but also utilizes the other factors of production. It has been noticed that, given technology, the outputs which can be produced by certain amounts of physical inputs depend on how these inputs are utilized by laborers. It has also been noticed that different institutions may influence a laborer's willingness to contribute effort. Following Leibenstein's celebrated paper, the relative efficiency of different institutions is often referred to as "x-efficiency." There have only been a few econometric studies that tried to estimate the relative efficiencies of the cooperative farm versus the household farm in the economic literature; furthermore, their evidence is derived from an ad hoc inclusion of institutional dummies in the production function.[3] As Griliches (pp. 331-2) has commented, "it does not further our understanding of growth to label the unexplained residual changes in output as technical change. Nor does it help much to measure these changes accurately if we do not know what they are." The same comments should also be applicable to "x-efficiency," if we do not know what it is. To gain some insights about why peasants behaves differently in a cooperative farm than in a household farm and how productivity can be affected by a change from a cooperative farming system to a household farming system, a behavior model that consists of both these two institutions is needed.

The organization of this paper is as follows. Section I formulates a simple model of the household in which the optimum levels of effort contributions under the household farming system and the cooperative farming system are explored explicitly. Their relative efficiencies are compared under more specific functional forms. Predictions regarding how changes in the farming system will affect the level of effort supply are then derived. It is found that when monitoring of effort in agricultural production is difficult, a household will contribute less effort in a cooperative farm than in a household farm. Although the economies of scale are sacrificed in a household farm, the effort effect outweighs the scale effect. A change from the cooperative farming system will result in an increase in total output. In addition, this institutional change is a Pareto-improvement under very wide ranges of possible production technology. Section II describes the data sources. Two levels of data are used. The first data set consists of the township-level input-output data of grain production in three counties from a prefecture in Anhui Province. The data covers from 1979 to 1983. One of the counties had the majority of its cooperative teams changed to a household-based system in 1980, while the majority of cooperative teams in the other two counties changed in 1981. The other data set consists of the province-level agricultural input-output data from 1981 to 1983. As the rates of decollectivization in each province are available in this data set, the impacts on agricultural production of changing from a cooperative system to a household system can be directly assessed. Based on the theoretical model in Section I, Section III specifies the empirical framework to be applied to the above data sets. Results from both levels' analyses are reported in Section IV. The evidence indicates that the household system is a more efficient institution compared with the cooperative system, which is consistent with the implications of the model. Finally, some concluding remarks are presented in Section V.

I. THEORETICAL FRAMEWORK

In order to examine the relative efficiencies of the cooperative farming system compared with the household farming system and derive testable hypotheses about households' behaviors in responding to changes in institutions, a one-period household model is constructed. It is assumed that N identical households exist. Each household is bestowed with the same given amounts of labor force, L, and land, K. Effort consists of quantity of work and quality of work. Production of a single commodity with an exogenously determined price is hypothesized to be a function of effective labor expended and land employed. For a given unit of labor force, the effective labor depends on the quantity of work and the quality of work that are provided by this unit of labor. The quantity of work is the conventionally measured labor hours. The quality of work is the way that a laborer utilizes the conventional inputs in the process of production. The quantity of work and the quality of work that are provided by a laborer will be called "effort." Effort is assumed to be a variable ranging from zero to one. One means that the maximum technologically possible amount of quantity of work and quality of work are provided, while zero means no effort is contributed. These N households can either work separately as N independent household farms or they can pool their resources together as a cooperative farm in order to exploit the economies of scale. Identical production functions are assumed for both types of farms.

$$(1) \qquad Q^t = Q(E^t, K^t), \qquad t = h, c,$$

where t denotes a household farm (h) or the cooperative farm (c), and E^t is the effective labor. In the cooperative farm, $E^c = e_1L + \ldots + e_nL$, and $K^c = nK$. In a household farm, $E^h = e_iL$, and $K^h = K$, for $i = 1, \ldots, n$. (In this paper, superscription denotes types of farm and subscription denotes each household. Superscriptions and subscriptions will be suppressed when there is no confusion).

Land and labor force are assumed given; each household, nevertheless, can choose its level of effort contribution to maximize its utility whether it works independently or belongs to the cooperative. More concretely, it is assumed that

$$(2) \qquad \max_{e_i} U_i = U(e_i, I_i), \qquad \text{for } i = 1, \ldots, N$$

where I_i is the ith household's income received from its own household farm or from the cooperative. If a household works independently, its income is just the value of its output, that is,

$$(3) \qquad I_i = PQ_i,$$

where P is the relative price of the agricultural product to the industrial product, or the terms of trade between rural goods and urban goods.

The distribution of income in the cooperative is based on the principle "to each according to his work." Each household will be awarded work points for its contribution of effective labor. Net income of the cooperative will be divided according to each household's share of work point in the total work points of the cooperative. As the endowed labor force is the same for each household, a household's work points will only depend on its level of effort contribution and the degree of accuracy with which effort is measured in the cooperative. The more accurate effort metering is, the higher are the costs. The income of a household in the cooperative is thus

$$(4) \qquad I_i = s_i \cdot [PQ^c - C(\pi)],$$

where s_i is the ith household's work point share, C is the cost of effort metering, and π is the degree of accuracy of metering. C(.) is assumed to be a convex function. Implicitly in this model is that effort metering is required in the cooperative farm for the purpose of determining each household's income share; however, no metering is necessary in the household farm due to the fact that income need not to be subdivided.

In the remaining part of this section, we will first consider each household's optimum effort contribution in the household farm and in the cooperative farm, and then the relative efficiencies of these two farming institutions will be compared, with adoption of more specific functional forms.

<u>Household Farms</u>

The first-order condition for the ith household's utility maximization subject to (1) and (3) is the following:

$$(5) \qquad -\frac{\partial U_i/\partial e_i}{\partial U_i/\partial I_i} = P \, . \, \partial Q_i/\partial e_i .$$

The left-hand side can be interpreted as the marginal rate of substitution between income and leisure. The right-hand side is the marginal income of effort. An optimum level of effort contribution is reached at the point where the marginal rate of substitution between income and leisure equals the marginal income of effort. Condition (5) may be solved to provide a supply of effort to household farm function:

$$(6) \qquad \tilde{e}_i^h = \tilde{e}_i^h(L, K, P).$$

Since each household is assumed to be identical, in equilibrium they will all have the same work intensity and produce the same amount of output.

The Cooperative Farm[4]

Determination of the effort supply in the cooperative farm is a more complicated matter. As income in the cooperative farm is distributed according to each household's work point share, we need to know how work point and work point share are determined before we can investigate each household's optimum effort contribution. The ith household's work point share, s_i, is a ratio between the work points accumulated by the ith household, h_i, and the total work points in the cooperative, H:

$$(7) \qquad H = \sum_{i=1}^{N} h_i .$$

The work point represents the ith household's contribution of effective labor that is perceived and credited by the management of the cooperative. Since the endowed labor force, L, is identical in each household, the work point is, therefore, only a function of e_i, the effort contribution by a household, and π, the degree of accuracy with which the effort is measured.

(8) $$h_i = h(\pi, e_i), \quad \text{with} \quad e_i, \pi \in [0,1].$$[5]

When the measurement is perfect, $\pi = 1$. In this case, $h_i = h(1, e_i) = e_iL$. The work points received by each household just equals its contribution of effective labor. When monitoring does not exist, $\pi = 0$. Under this condition, $h_i = h(0, e_i) = 1$ for all i; that is, every household is assumed to have worked equally at the maximum intensity, no matter how hard it actually works.[6] The work point function also has the following properties:

(9)
$$\frac{\partial h_i}{\partial e_i} \geq 0, \qquad \text{equality holds when } \pi = 0;$$
$$\frac{\partial h_i}{\partial \pi} \leq 0, \qquad \text{equality holds when } e_i = 1;$$
$$\frac{\partial^2 h_i}{\partial \pi \partial e_i} > 0 .$$

As each household is assumed to be identical, it is important to mention here that, given the accuracy of effort metering, in equilibrium each household will offer the same amount of effective labor and, as a consequence, $h_i = h$ and $s_i = 1/N$, for every household.

Taking the accuracy of effort metering and the other households' supplies of effective labor as given, a household i will solve (2) subject to (1), (4), (7), (8), and (9). the first-order condition is the following:

$$(10) \qquad -\frac{\partial U_i/\partial e_i}{\partial U_i/\partial I_i} = s_i \,.\, P \,.\, \partial Q^c/\partial E^c + (1 - s_i) \,.\, A_i \,.\, \left(\frac{Q^c - C}{E^c}\right),$$

$$\text{where } A_i = (E^c/H) \,.\, (\partial h_i/\partial e_i).$$

The left-hand side is the marginal rate of substitution between income and leisure, which is the same expression as that in (5). Nevertheless, the value of marginal income of effort for a household in the cooperative farm is different from that in a household farm. The first term on the right-hand side is the gain from the increase in the production of the cooperative farm, holding the work point share constant, and the second term is the gain from the increase in the work point share. Notice that A_i has the following properties: when $\pi = 0$, $A_i = 0$; when $\pi = 1$, $A_i = 1$; and $\partial A_i/\partial \pi > 0$. If the measurement of effort is perfect, a household gets two compensations for an additional contribution of effective labor. First, it will get a share of the increase in the output. Second, it will get a larger share of the total net income, as now it contributes a larger share of total effective labor, and thus has a larger share of work points. On the other hand, if there is no monitoring, a peasant will not get more work points for his additional contribution of effort. In this case, the return to his increase in effective labor has only one component, namely, a share of the increase in the output. How great the increase in the work point share is for an additional unit of effective labor depends on the degree of accuracy in metering effort. Therefore, a household's optimum level of effort contribution in a cooperative is positively correlated with the degree of accuracy in metering effort in the production process. The higher the degree of accuracy in the measurement of effort, the more effort contributed.

However, effort monitoring is not costless. The management of the cooperative farm thus needs to balance the gains in production due to the increase in total contribution of effective labor and the rise in the costs of monitoring. Other things being equal, the optimum degree of monitoring is higher (lower), if the effort is easier (harder) to monitor in the production process. Therefore, whether each household's optimum level of effort contribution is high or low depends on how difficult and costly the measurement of effort is in the production process.

It has been noticed by many economists that monitoring effort in agricultural operations is particularly difficult because of agricultural production's biological nature and sequential as well as spatial dimensions.[7] Agricultural production is subject to infinite variations in ecological conditions. It constantly requires that individual peasants make on-the-spot decisions in response to slight differences in temperature and soil moisture. In addition, the process of agricultural production typically spans several months over several acres of land. Farming also requires peasants to shift from one kind of job to another throughout the production season. In general, the quality of work provided by a peasant does not become apparent until harvest time. Furthermore, it is impossible to determine each individual's contribution by simply observing the outputs because of the random impacts of nature on production. It is thus extremely costly to meter precisely each household's effort contribution in agricultural production. Consequently, in a cooperative farm primarily engaged in agricultural production, the only practical method is to assign fixed flat work points for each day's work.[8] This amounts to nonexistence of effort metering; however, it is consistent with the fact that monitoring is extremely costly in agricultural production.

The first-order condition (10) can be solved to obtain the effort supply function for each household in the cooperative. In the Nash equilibrium, assuming the solution is unique, the function can be expressed as:

$$(11) \qquad \tilde{e}_i^c = \tilde{e}_i^c(\pi, L, nk, P)$$

Since each household is assumed to be identical, in equilibrium they will all choose the same level of effort and thus contribute the same amount of effective labor.

Comparisons of Household Farms and the Cooperative Farm

This section deliberates on the implications for social efficiency of household decisions in the modeled economy. If there is no monitoring issue, the answer is obvious that the cooperative farm is more efficient than the sum of household farms because of the economies of scale. However, in reality, as argued in the last subsection, the monitoring of effort in a cooperative farm is at most nominal; therefore, it is not particularly interesting or relevant to compare the efficiency of the cooperative farm with the household farm under such an ideal situation. It seems to be a reasonable assumption, for practical purposes, that no monitoring exists in the cooperative farm. Essentially, this is a comparison of two second-best solutions. The cooperative farm captures the economies of scale; however, it suffers from the inefficiency arising from the difficulty of monitoring. Moving to the household farms removes the monitoring issue but sacrifices the gains from the economies of scale. It is well known that such comparisons are generally intractable without resort to closer specification of the underlying functions. The following relatively simple forms will be adopted.[9]

General Cobb-Douglas Production functions:

(1′) $$Q^t = (E^t)^a (K^t)^b, \qquad t = c,\ h.$$

Separable utility functions:

(2′) $$U_i = I_i - e_i L.$$

The comparisons will proceed in three steps: first, the optimum effort contributions by each household in both a household farm and the cooperative farm are derived; then the resulting outputs in the household farms and in the cooperative farm are calculated; and finally, the utility levels attained by each household in the cooperative farm and in the household farm are compared.

Adopting the specific forms of the structural equations and solving for a household's optimum effort supply in its own household farm (6), we get

(12) $$\tilde{e}_i^h = L^{-1} \cdot (aPk^b)^{1/(1-a)}.$$

Likewise, assuming no metering exists in the cooperative farm, solving (11), we find that the optimum effort supply for each household in this cooperative is:

$$(13) \qquad \tilde{e}_i^c = N^{(a+b-2)/(1-a)} \cdot L^{-1} \cdot (aPk^b)^{1/(1-a)}.$$

Examining expressions (12) and (13), we find that if the "returns to scale" are less than two and the production function is concave with respect to effective labor, a household will contribute more effort in his own household farm than in the cooperative farm.

By substituting (12) into (1), we find that the total social outputs when these N households work independently is

$$(14) \qquad NQ^h = N \cdot (aPk^b)^{a/(1-a)} \cdot k^b.$$

Similarly, the total output of the cooperative is:

$$(15) \qquad Q^c = N^{(b-a)/(1-a)} \cdot (aPk^b)^{a/(1-a)} \cdot k^b.$$

Comparing (14) and (15), we find that if the production function is concave with respect to all its arguments, the total product from these household farms is greater than that produced by the cooperative farm, even the economies of scale are sacrificed in the household farms.[10] The major source of returns to scale comes from the indivisibility of input, however, almost all inputs in agricultural production is divisible (Schultz, chapter 8). It is thus unimaginable that the returns to scale in agricultural production can be greater than two. It is also unimaginable that the condition that the production function is concave with respect to all its arguments will be violated. Therefore, under the condition that monitoring is extremely difficult in agricultural production, it should be safe to predict that a household will provide more quantity of work as well as quality of work in the household farm than in the cooperative farm and thus the total output produced by the household farms is larger than that produced by the cooperative farm.

Although the total output will increase by moving from the cooperative farming system to the household farming system, it is still unclear that such a move is desirable to each household in the cooperative farm as what matters is not the output but the welfare attainable in each institution. However, if the household farming system is Pareto-superior to the cooperative farming system, there should be a consensus for changing from the cooperative farming system to the household farming system when this choice is available to members in the cooperative farm. In this model the welfare attainable for each household in the household farm and in the cooperative farm can be calculated by substituting (12) and (14) into (2′) and substituting (13) and (15) into (2′). For each household the ratio of the utility attainable in the cooperative farm to that in the household farm is

$$(16) \qquad U^c/U^h = [N^{(b-1)/(1-a)} \cdot (1-a/N)]/(1-a).$$

The value of (16) depends on the value of N, a, and b. However, for $N \geq 2$, and $0 < a, b < 1$, it is almost certain that (16) will be less than one in the conceivable technology and thus the change from the cooperative farming system to the household farming system is a Pareto-improvement.[11]

In short, when monitoring is difficult in the production process, a cooperative farm is an inefficient institutional form compared with the household farm both in terms of total output and social welfare criteria.

Although the economies of scale are sacrificed in changing from the cooperative farming system to the household farming system, the increase in the supply of effective labor outweighs the scale effect. Not only does the total output increase as a result but also every household feels happier.

II. DATA SOURCES

Two sets of data--one at the township level and the other at the provincial level--are used in this study. The township data set is gathered from three counties in Chuxian Prefecture, Anhui Province, where the new household farming system originated. The data include the input and output of grain production in every township in Jiashan County, Fengyang County, and Chuxian County. Anhui Province is located in the mid-eastern part of China, about 500 miles south of Beijing and 200 miles west of Shanghai. It is a typical agricultural production area with higher than average multiple-cropping practices. In 1979, its multiple-cropping index was 180; 76.6% of its gross value of agricultural production came from crop cultivation; and 78% of its sown area was for grain production (Editorial Board of China Agriculture Yearbook 1980, pp. 100, 130).[12] Grain in Chinese statistics refers to rice, wheat, corn, soybeans, and tubers. In Anhui Province, the main summer crop is rice, and the main winter crop is wheat. The data used are gross outputs. No attempt is made to adjust for seed.

The specific inputs include farm labor, foodgrain sown area, draft animals, machinery, fertilizer, the ratio of irrigated area to total cultivated area, and the ratio of the disaster-affected area to total sown area (not available for Chuxian County).[13] The buffalo is the main draft animal in these areas. Machinery indicates the total horsepower of farm machines. Fertilizer includes the gross weights of N, P_2O_5, and K_2O. Because grain is the main crop in these areas and also because data on the other crops are not available, all draft animals, machinery, and fertilizer are assumed to be used for grain production. The ratio of the area affected by disaster is included to account for variation in weather. Disaster refers to flood, drought, frost, freezing, typhoons, and hailstorms. The ratio is the area affected by disaster divided by the sown area for grain production in each township.

The data span the years from 1979 to 1983. Jiashan County has 34 townships, Fengyang has 46 (three townships are excluded because of missing irrigation data), and Chuxian has 22. The data on the number of teams in each township that adopted the household responsibility system in each year are not available. Nevertheless, the majority of production teams in Jiashan County were transformed to the new household system in 1980, while the majority of production teams in the other two counties were transformed in 1981 (see Table I). All data in each township are provided by the Office for Rural Policy in each respective county.

Fengyang County is known for being one of the poorest counties in China and the birthplace of the first emperor of the Ming dynasty. Chuxian County is the capital of Chuxian Prefecture. Its economy is more like that of a suburban county near a metropolis. Jiashan County is an average county. The advantages of this data set are that these three counties are located in the same prefecture and are adjacent to one another. Therefore, we can infer from the data without worrying about the differences in local government policies or in extreme natural disturbances. However, these three counties are not randomly selected. The conclusions that are obtained from these three counties cannot be generalized to other counties in China.

The second data set consists of each province's agricultural input-output data for 1981, 1982, and 1983. Agricultural production in this study refers to crop cultivation, including foodgrain crops and cash crops. Animal husbandry, forestry, fishery, and sideline production are not included because they are not affected by the shift in the institution as much as crop cultivation.[14] The output of agriculture is measured in the constant prices of 1980. The values of crop cultivation consisted of 64.4%, 62.7%, and 62.1% of the total gross values of agricultural output in 1981, 1982, and 1983, respectively.

The specific input variables that are included in this data set are labor, sown areas, machinery, fertilizer, draft animals, and the ratio of irrigated area to total cultivated area. Land, labor, machinery, fertilizer, and draft animals are all in physical measures. The definitions of these variables are the same as those included in the first data set, except that sown area refers to the area sown for foodgrain crops as well as cash crops and that fertilizer is measured in terms of the weight of efficient ingredients, not in terms of gross weight.

The new household farming system started to appear sporadically at the end of 1978 in Anhui Province. However, for the nation as a whole, it did not emerge as a significant factor until the end of 1980 (see Table II). The ratio of teams to total teams in each province that were transformed to the new household-based farming system are available for

1981, 1982, and 1983. This is the main reason that these three years are focused on. These data enable us to assess directly the impacts on agricultural production of shifting from the old cooperative farming system to the new household farming system.

All data, except for the material on the ratio of teams to total teams that adopted the household-based system in each province, are available in the 1982 to 1984 volumes of the China Agriculture Yearbook. The data on each province's progress in adopting the household responsibility system are provided by the National Research Center for Rural Development in Beijing.

Both levels of data used in this study are official data. Because of the lack of trained personnel and careful sampling frameworks, as well as the present of political intervention, the quality of Chinese official statistics has been a subject of debate. This doubt is not without substance. A footnote under the cultivated land in The Almanac of China's Economy 1981 (p. VI-3) reads, "The figure of cultivated land is underestimated and remains to be verified." Cadres at the local level may under-report certain figures to evade taxes, as in the case of cultivated land, or over-report certain figures to gain political favor, as in the case of tractor-ploughed areas (because this is one of the indicators of modernization in Chinese agriculture). However, in recent years the consensus among those in academic circles involved with Chinese studies seems to be that the Chinese official data are, after all, the best available data. In his introduction to a book that contains examinations of the quality of Chinese statistics by several authorities on the Chinese economy, Robert F. Dernberger sums up their joint findings by saying that "the available official data [in China] do reflect the basic trends of China's economic evolution, even though they contain a margin of error when used as measures of absolute magnitudes in any particular year" (Eckstein 1980, p. 60). Because these data are the only available data and also because the trends of change are the focus of this study, the official statistics are therefore relied on as the sole source of data.

III. ECONOMETRIC FRAMEWORK

The theory in Section I predicts that each household will provide more effective labor and that, as a result, produce more output when the farming institution moves from the cooperative system to the household-based system. To examine these hypotheses, a production function is necessary. As adopted in the specific theoretical model, a general Cobb-Douglas function with effective labor, land, draft animals, machinery, and fertilizer as inputs will be estimated. The production function elasticities are allowed to vary linearly with the percentage of cultivated land that is irrigated. This is an attempt to capture differences in land quality and may also capture some output composition effects, since irrigation is more important for rice than for wheat. In two of the three counties, the areas that were affected by disaster are available; the ratio of the disaster-covered area to the total sown area in each township is included to capture the weather effect in the estimation of these two county's production functions. This specification gives rise to the following estimating equation:

(17) $$\log Q = A + (a_1 + a_2 I)\log L + (a_3 + a_4 I)\log S + (a_5 + a_6 I)\log D + (a_7 + a_8 I)\log M + (a_9 + a_{10} I)\log F + a_{11} I + a_{12} R + \mu,$$

$$\text{with } A \equiv (a_1 + a_2 I)\log e,$$

where L is labor, S is sown area, D is draft animals, M is machinery, F is chemical fertilizer (the above five conventional inputs are measured in the units of average per team in order to reduce the possibility of heteroscedasticity), I is the ratio of irrigated area to total cultivated area, R is the ratio of the disaster-covered area, and μ is the error term.

From expressions (6) and (11), we see that the effort supplied by each household is a function of the exogenously set output price and the predetermined quantity of conventional inputs. The model shows that the quantity of conventional inputs that enter the effort function depends on the farming institutions; therefore, we can use the institution, a cooperative system, or a household system, to denote the physical input level. To be concrete,

(19) $$\log e = \log e(P, IN) = b_0 + b_1(P) + b_2(IN),$$

where P is the relative output price and IN indicate the farming institution, a cooperative, or a household system. As one can see from expressions (12) and (13), the second equality holds when the production function is a Cobb-Douglas function.[15] If the output price does not change and the farming institution in a region changes, then the change in loge comes only from the changes in $b_2(.)$. Then a time dummy, which captures the impacts of the changes in loge on production, can be used to measure the impacts of the institutional change. Conversely, if the farming institution does not change but output price changes, the time dummy will measure the impact of the price change. In the case where the price changes first and the institution changes later, a time dummy will measure the impacts of institutional change and possibly the residual impacts from price change, depending on the functional specification of $b_1(.)$. However, by comparing two regions with a similar policy environment, but one with an institutional change and the other one without, we can infer from these two regions' respective time dummies how much of the impact is due to the institutional change and how much is due to the residual effect of the price change. Since a more than 20% rise in the government procurement price of farm product was announced at the end of 1978 and put into effect at the beginning of 1979, this is the strategy that will be used in the analysis of the first data set. The production function estimated in the first data set is thus,

$$(17') \qquad \log Q = A_0 + a_0T + (a_1 + a_2I)\log L + (a_3 + a_4I)\log S + (a_5 + a_6I)\log D + (a_7 + a_8I)\log M + (a_9 + a_{10}I)\log F + a_{11}I + a_{12}R + \mu,$$

$$\text{with } a_0T \equiv (a_1 + a_2I)\ \Delta\ \log e,$$

where A_0 is a constant term and T is a time dummy, and a_0T measures the magnitude of changes in A.

In the provincial level data, we have the percentage of teams in each province that were transformed to the household-based farming system. In this case, $b_2(.)$ is a function of RT, the ratio of teams to total teams in each province that had adopted the new system. We will hypothesize that $b_2(.)$ has the following simple functional form:

$$(20)\qquad b_2(.) = c_0 + c_1 RT.$$

As the changes in loge, and thus the impacts on production from the changes in the institution in each province, can be assessed from the coefficient of RT in a cross-sectional time series regression, we are left with one degree of freedom. The impacts from the rise in the government procurement price, which was imposed by the government on every part of China at the same time, and the residual effects from this rise on production in each following years can be assessed by the coefficients of time dummies.[16] The production function that will be estimated in the provincial data set is thus,

$$(17'')\qquad \log Q = A_0 + a_0' RT + a_0 T + (a_1 + a_2 I)\log L + (a_3 + a_4 I)\log S + (a_5 + a_6 I)\log D + (a_7 + a_8 I)\log M + (a_9 + a_{10} I)\log F + a_{11} I + \mu,$$

where $a_0' \equiv (a_1 + a_2 I)c_1$.

It should be mentioned that RT itself is an endogenous variable. The transformation from the cooperative farming system to the household farming system in each province can be interpreted as an induced institutional innovation process.[17] Among other things, if an area is more suitable for group farming due to its topology or other reasons, the transformation to the household system will be slower because the gains from this transformation are smaller. Regional characteristic is not observable to econometrician. It is included in the error term of the regression function. Consequently, RT is correlated with the error term. Furthermore, the size of a cooperative farm, the adopted technologies, namely the machinery, draft animals, and fertilizer that are used in a cooperative farm, should also reflect its regional characteristic; therefore, they are not uncorrelated with the error term either. Therefore, the OLS regression will not be able to produce an unbiased estimate of the coefficients. To avoid the time-persistent regional specific effect and obtain an consistent estimate of the coefficients, the fixed-effects model will be used in the fitting of expressions (17') and (17").

IV. RESULTS AND IMPLICATIONS

In this section, we apply the model to analyze the impacts of shifting from the cooperative farming system to the household farming system in the three counties in Anhui Province and in the 29 provinces in China. The estimates of the first data set are based on expression (17') and the second data set on expression (17"). Table III reports the results of fitting the grain production functions in Jiashan County, Fengyang County, and Chuxian County with the fixed-effects model. A F-test is performed to test the hypothesis that all regional intercepts in each regression are equal. The test and its degree of freedom are presented at the bottom of the table as F1. Another F-test is implemented to test the hypothesis that the interaction variables are jointly equal to zero. Its result and associated degree of freedom are presented as F2 at the bottom of the table. The first hypotheses can all be rejected at less than 1% level of confidence. These results confirm our intuition that the fixed-effects model instead of the OLS should be applied to fit the regression functions. However, the second tests show that the interaction variables are jointly insignificant in Jiashan

County. Jiashan County's regression function is thus reestimated with the interaction variables dropped. Its result is presented in the second column of the table.

The productivity changes in each county are estimated by the time dummies. To interpret their implications, the yearly productivity growth in each county is calculated. These estimates, together with the year of major institutional change in each county, are reported in Table IV. From this table we see that Jiashan County had its major institutional change in 1980 and also had the highest productivity growth in 1979-1980. The same story holds for Fengyang and Chuxian Counties. Both counties had their major institutional changes occurred in 1981 and their highest productivity growth was in the period of 1980-1981. In 1979-1980, Jiashan's productivity growth was 15.2% compared to 8.9% and 3.4% in Fengyang and Chuxian.[18] Conversely, in 1980-1981 Fengyang and Chuxian had productivity growth of 16.9% and 22.1% compared with Jiashan's -.7%. Although Jiashan also had a 10.9% productivity growth in 1981-1982 and Chuxian had a 11.4% productivity growth in 1982-1983; they were both preceded by negative productivity growth in the previous periods. It should be safe to conclude from this evidence that the two-digit productivity growth in Jiashan County between 1979 and 1980, and in Fengyang and Chuxian Counties between 1980 and 1981 basically came from the increases in each household's effort contribution as a result of shifting from the cooperative farming system to the household farming system.

The same procedures are applied to estimate the agricultural production function in China. For the purpose of comparison, this production function is also estimated by the OLS regression. The results form these estimations are reported in column 1 and column 2 of Table V. The difference in the estimated impact of the institutional change on production between these two estimating procedures is very striking. The OLS estimation shows that the change in the farming system did not have any significant impact on agricultural production and the major sources of productivity growth between 1981 and 1983 came from the previous price rise or other policy changes that are captured by the year dummies. However, the fixed-effects estimation shows just the opposite: the major source of productivity growth came from the change in the farming institution, and the other policy changes did not have significant effects. Since prior knowledge indicates that the diffusion of the new household farming system in each province was correlated with its latent specific characteristics and the hypothesis that all provincial interceptions are equal is rejected ($F_{28,44} = 10.88$), the estimate from the fixed-effects model is the correct one. The estimated coefficient of .18 for the RT variable suggests that, due to the increase in each household's effort supply, shifting from the cooperative farming system to the household farming system will result in a 19.7% increase in the total output for given amounts of inputs. Between 1980 and 1983, 83.5% of the total cooperative teams in China were transformed to the household farms (see table II). This institutional change thus implied a 16.4% productivity jump between 1980 and 1983. Measured in 1980's prices, the gross value of crop cultivation grew 26.4% between 1980 and 1983 (State Statistic Bureau 1984, p. 133); therefore, about 62% of this output growth can be attributed to the change in the farming institution alone.

The theoretical model in Section I suggests that, only if the returns to scale are less than two, the shift from the cooperative system to the household system will increase each household's effort supply and thus the total output. To see if this condition holds, the implied output elasticities are calculated from the estimated production functions in Tables III and V and are reported in Table VI. From the last row of Table VI, we find that none of them have returns to scale significantly different from one.

Comparing the estimated coefficients of the fixed-effects model and the OLS in the national agricultural production functions, we find that the labor coefficient has the largest increase in value and the fertilizer coefficient has the largest drop when switching from the OLS model to the fixed-effects model. This evidence suggests that more productive areas use more fertilizer and less labor in their production. This is consistent with Stone's finding about fertilizer application in China. The estimated coefficients of draft animals, machinery, and fertilizer are all not significantly different from zero in the national production function. Since any errors in measurement are magnified in the fixed-effects models, the insignificance in the estimate of these three coefficients may arise from the imprecision associated with the larger aggregation in the provincial data set. In the estimated grain production functions in the county level, these coefficients are all quite significant except for the coefficient of machinery in Jiashan County.

V. SUMMARY AND CONCLUDING REMARKS

This paper examines a household's behaviors in the cooperative farm and in the household farm. The central assumption is that a household utility function exists. This assumption enables us to study each household's optimum effort contributions in these two different institutions and to compare the relative efficiencies of these two institutions. In the cooperative farm, the economies of scale are captured; however, the measurement of each household's effort contribution is required for the purpose of income distribution within the farm. A household farm sacrifices the returns to scale; but it can be saved from the trouble of metering effort. Basically, this is a comparison of two second-best solutions. A question for study is which consideration is more relevant in the real world for a household's decision regarding its effort supply. Since monitoring is extremely difficult and costly in agricultural production, the only practical method in an agricultural cooperative is to assign a peasant flat work points for each day's work without regarding his actual quantity and quality of work. This practice amounts to nonexistence of monitoring. Under the assumption of no monitoring in the cooperative system and the specifications of a general Cobb-Douglas production function and a separable utility function, it is found that, if the returns to scale are less than two, a household will offer more effort in the household farm than in the cooperative farm. As a result, the total output produced will be larger in the household farming system than in the cooperative farming system even though the economies of scale are sacrificed in the household system. In addition, a change from the cooperative system to the household system is very likely to be a Pareto-improvement. In the above discussion, we assume that households are homogeneous. If the endowments preference are different among households, it can be verified that each household will also offer more effort in the household farm than in the cooperative farm and, as a result, more output will be produced in the household farming system. Nevertheless, the shift from the cooperative farming system to the household farming system may not be a Pareto-improvement. For those households that strongly prefer leisure, they are better-off in the cooperative farm than in the household farm.

Data collected from recent rural decollectivization in China is applied to examine the implications of the above model. The evidence from both the township-level data and the province-level data shows that the change from the cooperative farming system to the household farming system has significant effects on agricultural production. It is found that this institutional change has resulted in a 19.7% productivity jump and that over 60% of the agriculture output growth in China between 1980 and 1983 can be attributed to the change in the farming institution.

The laborer is the most dynamic factor in the production process. A laborer not only works but also utilizes the other factors of production. An institution will be an efficient mode of production only if it can provide the laborers with adequate incentives. The producers' cooperative as an institution may be desirable in other industries where monitoring is comparatively easy to perform or returns to scale are extremely large. The cooperative, nevertheless, is not an efficient institution in agriculture. Although a household farm cannot capture the economies of scale, this institution can provide peasants with adequate incentives to work. Therefore, the household farming system is a more efficient institution for the development of agriculture.

FOOTNOTES

This paper is an extension of my dissertation research at the University of Chicago. I would like to thank D. Gale Johnson, Theodore W. Schultz, and Sherwin Rosen, members of my thesis committee, for their inspiration and guidance throughout my graduate studies. I am greatly indebted to Robert F. Dernberger, Robert E. Evenson, Mark R. Rosenzweig, T. N. Srinivansan, John Strauss, George Tolley, Thomas B. Weins for their comments on early drafts of this paper. This paper has also benefited from comments from workshop participants at the University of Chicago and the University of Maryland. The financial support of the Rockefeller Foundation GA PS 8618 is gratefully acknowledged

[1] For a review of earlier literature, see Schiller, chapters 2, 7 and 10; Warriner, chapter 3; Tai, chapter 8. For a review of recent literature, see Bonin and Putterman , chapters 5 and 6.

[2]The coefficient of economies of scale estimated by Griliches for the United States' agriculture was about 1.3. The coefficient estimated by Hayami and Ruttan for the developed countries was also about 1.3 (See, Hayami and Ruttan, p. 147).

[3]From what I know, the only paper that goes beyond the simple cross-tabulation and correlation is Carter's. Even in the literature that compares the industrial cooperative firm with the traditional firm, rigorous econometric studies also very limited. Jones and Svejnar criticize that the other researchers' evidence about the relative efficiency of a cooperative firm is derived from an ad hoc inclusion of the relevant institutional variables into a production framework;

however, they do not explain why the institutional variables should be included in the production function of their own study.

[4]This subsection draws on Lin, 1987b.

[5]h(.) is assumed to be a nonstochastic function in this paper. At first glance, it might appear to be preferable to make it stochastic. However, the work point share, s_i, would become a ration of two random variables. The expectation of s_i as well as I_i might fail to exist. Consequently, the problem become unsolvable without making other more strained assumptions. The same argument also applies to the production function, Q(.). If Q(.) is stochastic, the comparisons of relative efficiency, in next subsection, between the cooperative farm and the household farm will become a ratio of two random variables.

[6]The same assumption is adopted by Calvo and Wellisz. This is also the practice generally used in the Chinese production team. A male worker is credited for 10 work points for each day's work no matter how hard he actually works.

[7]See for example, Schultz chapter 8; Hayami and Kikuchi chapter 2; Brewster; and Binswanger and Rosenzweig.

[8]It is widely documented in both Chinese and Western literature that a peasant got fixed work points for each day's work due to the difficulty of monitoring. See, for example, Chen; Perkins and Yusuf. The same situation also occurs in Soviet collective farms. See Johnson and Brooks, p. 179; and Bradley and Clark.

[9]The same specifications are adopted by Lucas in his comparisons of the efficiency between wage and share tenancy.

[10]$(15)/(14) = N^{(b-1)/(1-a)} < 1$ if $b < 1$, $a < 1$.

[11]Readers can verify that (16) < 1 will not hold only when b is very close to one. When $N = 5$ and $b \leq .8$ the utility index in the household farm will be higher than that in the cooperative farm no matter what value a takes. Even when $N = 2$, the utility index is still higher in the household farm for $b \leq .6$.

[12]For the nation as a whole, 66.9% of its gross value of agricultural output came from crop cultivation and 80.3% of its sown area was for foodgrain production. The multiple cropping index was 149% (Editorial Board of China Agriculture Yearbook 1980, pp. 100, 130).

[13]In Chinese statistics the disaster-affected area refers to the sown area that is affected by natural disturbances and resulted in a reduction of 30% or more output compared with that of a normal year (State Statistical Bureau, 1981, p.201).

[14]The main activity of a production team was cropping. Most of the animal husbandry and household sideline production was engaged in by individual households even before the household responsibility system was instituted. Fisheries and forestries are not important for most provinces. For China as a whole, their combined weight in total value of agricultural output was only 5.3% in 1980 (Editorial Board of China Agricultural Yearbook, 1981).

[15] This separability is extremely useful in the estimation. If we have two instruments, one for the price change and one for the institutional change, we will be able to estimate their respective effects even though the price change and the institutional change happened simultaneously.

[16] The time dummies in (17") will also pick up the effects from other regional-invariance but time-variance changes, such as changes in the weather. Nevertheless, the weather seems to be very stable in these three years. The disaster-affected areas were 125 million, 107 million, and 108 million hectares, respectively (State Statistic Bureau, p. 190).

[17] For a detailed discussion of the diffusion process of the new household-based farming system and a test of the induced institutional innovation hypothesis, see Lin 1987a.

[18] Fengyang county's productivity growth in 1979-1980 was also fairly high; this might be due to the fact that about 50% of its production teams was transformed to the household system between April and November of 1979 (see Table I). If a high percentage of these teams was changed before the summer crop season, its impacts productivity growth would also show up in the 1979-1980 period.

REFERENCES

Binswanger, Hans P. and Mark R. Rosenzweig, "Behavioral and Material Determinants of Production Relations in Agriculture," Journal of Development Studies, April 1986, 22, 504-39.

Bonin, John P. and Louis Putterman, Economics of Cooperation and the Labor-managed Economy. Department of Economics, Brown University, Working Paper No. 86-4, 1986.

Bradley, Michael E., and M. Gardner Clark, "Supervision and Efficiency in Socialized Agriculture." Soviet Studies, January 1972, 23, 465-73.

Brewster, John M., "The Machine Process in Agriculture and Industry," Journal of Farm Economics, February 1950, 32, 69-81.

Calvo, Guillermo A. and Stanislaw Wellisz, "Supervision, Loss of control, and the Optimum Size of the Firm," Journal of Political Economy, October 1978, 86, 943-52.

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

Chen, Yizi, "The Dawn for the Rural Area, the Hope for China: Report of a Survey on the Implementing of 'Baochan Daohu' in the Rural Area in Anhui Province," in Rural Area, Economics and Society, collected papers, Beijing: Institute of Rural Development Problems in China, 1981.

Eckstein, Alexander, ed., Quantitative Measures of China's Economic Output, Ann Arbor: University of Michigan Press, 1980.

Economic Research Center, State Council of the People's Republic of China, Almanac of China's Economy, 1981, Beijing: Economic Journal Press.

Editorial Board of China Agriculture Yearbook, Agricultural Yearbook of China, 1980, 1981, 1982, 1983, 1984, Beijing: Agricultural Press.

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

Hayami, Yujiro, and Masao Kikuchi, Asian Village Economy at the Crossroads: An Economic Approach to Institutional Change, Baltimore: Johns Hopkins University Press, 1981.

Hayami, Y., and V. W. Ruttan, Agricultural Development: An International Perspective. Baltimore: Johns Hopkins University Press, 1985.

Israelsen, L. Dwight, "Collectives, Communes, and Incentives," Journal of Comparative Economics, June 1980, 4, 99-124.

Jingjixue zhoubao (Economic weekly), A weekly Chinese periodical published in Beijing (January 11, 1982).

Johnson, D. Gale, and Karen M. Brooks, Prospects for Soviet Agriculture in the 1980s, Bloomington: Indiana University Press, 1983.

Jones, Derek C., and Jan Svejnar, "Participation, Profit Sharing, Worker Ownership and Efficiency in Italian Producer Cooperatives," Economica, November 1985, 449-65.

Leibenstein, Harvey, "Allocative Efficiency and X-Efficiency," American Economic Review, 1966, 56, 392-415.

Lin, Justin Yifu, "The Household Responsibility System Reform in China: A Peasant's Institutional Choice" Forthcoming in American Journal of Agricultural Economics, May 1987. (a)

Lin, Justin Yifu, "Supervision, Incentives, and the Optimum Size of A Labor-managed Firm," Economic Growth Center, Yale University, Discussion Paper No. 525, 1987 (b).

Lucas, Robert E. B., "Sharing, Monitoring and Incentives: Marshalling Misallocation Reassessed," Journal of Political Economy, June 1979, 87, 501-21.

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

Putterman, Louis, "Voluntary Collectivization: a Model of Producer's Institution Choice," Journal of Comparative Economics, June 1980, 4, 125-57.

Schiller, Otto M., Cooperation and Integration in Agricultural Production, London: Asia Publishing House, 1969.

Schultz, Theodore W., Transforming Traditional Agriculture, New Haven: Yale University Press, 1964.

Sen, Amarya K., "Labor Allocation in a Cooperative Enterprise," Review of Economic Studies, October 1966, 33, 361-71.

State Statistical Bureau, People's Republic of China, Statistical Yearbook of China, 1981, 1983, and 1984, Beijing: Chinese Statistical Press. (English editions published by Economic Information & Agency, Hong Kong).

Stone, Bruce, "Chinese Fertilizer Application in the 1980s and 1990s: Issues of Growth, Balance, Allocation, Efficiency and Response," in US Congress Joint Economic Committee ed., Chinese Economy Looks Toward the Year 2000, Vol. 1: The Four Modernizations, Washington D.C.: US Government Publishing Office, 1986.

Tai, Hung-Chao, Land Reform and Politics: A Comparative Analysis, Berkeley: University of California Press, 1974.

Warriner, Doreen, Land Reform in Principle and Practice, Oxford: Clarendon Press, 1969.

TABLE I

Progress in the Household Responsibility System in Jiashan, Fengyang, and Chuxian Counties, 1979-1981

Date	Jiashan No. of Teams Changed (%)	Fengyang No. of Teams Changed (%)	Chuxian No. of Teams Changed (%)
1979:			
Jan.	0	2 (0.05)	1
Aug.	7 (0.2)	2 (0.05)	1
Dec.	209 (6.2)	2 (0.05)	129 (7.7)
1980:			
Feb.	2,330 (64.2)	2 (0.05)	267 (15.2)
Apr.	2,978 (82.0)	740 (19.8)	397 (22.3)
Nov.	3,554 (96.8)	2,592 (68.3)	968 (54.4)
1981:			
Mar.	3,651 (99.1)	3,730 (98.6)	1,659 (93.0)
June	3,647 (99.0)	3,765 (99.5)	1,718 (96.0)

SOURCES: Data are provided by the Research Office for Rural Policy of Chuxian Prefecture.

TABLE II

Progress in the Household Responsibility System in China, 1980-1983

	1980		1981		1982	1983
	Jan.	Dec.	July	Oct.	Dec.	Dec.
Proportion of teams (%)	1.02	14.4	28.2	45.1	80.4	97.9

SOURCES: The data concerning 1980-1981 are from <u>Jingjixue zhoubao</u> (Economic weekly) (January 11, 1982). Figures for 1982 and 1983 are from the <u>China Agriculture Yearbook</u> (1983 and 1984).

TABLE III
Grain Production Functions: Fixed-Effects Models

Variables	Jiashan County (1)	(2)	Fengyang County (3)	Chuxian County (4)
Labor	1.23	.33	.52	1.28
	(.77)	(.23)	(.20)	(.72)
Labor x irr.	-1.25		-.37	-1.17
	(.96)		(.28)	(.89)
Sown area	.10	.38	.31	-.95
	(.42)	(.20)	(.15)	(.50)
Sown area x irr.	.67		-.19	1.39
	(.58)		(.23)	(.64)
Draft animals	.19	.25	.20	.12
	(.22)	(.13)	(.16)	(.45)
Draft animals x irr.	-.20		-.22	.17
	(.38)		(.25)	(.54)
Machinery	-.02	.14	-.06	.27
	(.20)	(.07)	(.07)	(.16)
Machinery x irr.	.28		.25	-.25
	(.28)		(.13)	(.19)
Fertilizer	-.02	.14	.05	-.09
	(.11)	(.05)	(.06)	(.12)
Fertilizer x irr.	.28		.19	.20
	(.18)		(.09)	(.14)
Irrigation	.14	.20	1.88	-3.88
	(3.03)	(.19)	(1.37)	(4.26)
Disaster	-.41	-.47	-.75	
	(.14)	(.14)	(.15)	
Y1	.16	.14	.09	.03
	(.05)	(.05)	(.03)	(.02)
Y2	.16	.14	.24	.23
	(.06)	(.06)	(.04)	(.03)
Y3	.29	.24	.31	.23
	(.07)	(.07)	(.05)	(.04)
Y4	.19	.14	.33	.34
	(.09)	(.09)	(.06)	(.04)
R^2	.70	.70	.90	.94
F1	3.02		3.90	13.48
	[33,120]		[43,156]	[21,73]
F2	.85		2.16	2.87
	[5,120]		[5,156]	[5,73]

Note: Conventional variables are measured with team as unit. Standard errors are in parentheses. F1 tests for the hypothesis that intercepts are equal across regions. F2 tests for the hypothesis that interaction variables are jointly zero. Degrees of freedom are in square brackets. Constant terms are suppressed.

TABLE IV

Year of Major Institutional Change and Estimated Yearly Productivity Growth

	Year of Major Institutional Change	Yearly Productivity Growth (%)			
		1979-1980	1980-1981	1981-1982	1982-1983
Jiashan County	1980	15.2 (4.7)	-.7 (5.5)	10.9 (4.6)	-9.5 (4.3)
Fengyang County	1981	8.9 (3.2)	16.9 (3.0)	6.6 (2.9)	3.2 (2.6)
Chuxian County	1981	3.4 (2.5)	22.1 (2.5)	-.1 (2.6)	11.4 (2.0)

NOTE: Figures in parentheses are standard errors. Jiashan County's yearly growth is calculated from column 2 of Table III, Fengyang County's from column 3, and Chuxian County's from column 4. Chuxian County's estimated growth for 1980-1981 and 1982-1983 is over-estimated and for 1981-1982 is under-estimated, as the information on the disaster-covered areas for each township in Chuxian County is not available. As for the county as a whole, the areas affected by disaster were 155,585 mu for 1979; 137,200 mu for 1980; 9,821 mu for 1981; 71,987 mu for 1982; and 25,229 mu for 1983.

TABLE V

Estimates of Agricultural Production Function in China

Variables	Fixed-Effects Model (1)	OLS (2)
Labor	1.25	-.78
	(.58)	(.30)
Labor x irr.	-1.70	2.41
	(1.12)	(.57)
Sown area	1.50	.61
	(.73)	(.12)
Sown area x irr.	-1.58	.35
	(1.14)	(.23)
Draft animals	-.40	-.15
	(.30)	(.07)
Draft animals x irr.	1.13	-.01
	(.45)	(.09)
Machinery	-.14	.13
	(.25)	(.13)
Machinery x irr.	.35	-.52
	(.54)	(.23)
Fertilizer	.18	.60
	(.14)	(.08)
Fertilizer x irr.	-.34	-.78
	(.24)	(.14)
Irrigation	12.43	-8.82
	(5.80)	(2.20)
RT	.18	.04
	(.05)	(.08)
Y1	.04	.09
	(.03)	(.04)
Y2	.03	.15
	(.04)	(.06)
R^2	.80	.95
F1	10.88	
	[28,44]	
F2	3.42	
	[5,44]	

Note: Conventional variables are measured with team as unit. Standard errors are in parentheses. F1 tests for the hypothesis that intercepts are equal across regions. F2 tests for the hypothesis that interaction variables are jointly zero. Degrees of freedom are in square brackets. Constant terms are suppressed.

TABLE VI

Estimated Output Elasticities

Input	Jiashan County	Fengyang County	Chuxian County	Nation (FE)	Nation (OLS)
Labor	.33	.31	.38	.50	.27
	(.23)	(.10)	(.15)	(.31)	(.11)
Sown Area	.38	.20	.14	.81	.77
	(.20)	(.09)	(.13)	(.40)	(.06)
Draft Animal	.25	.08	.25	.09	-.15
	(.13)	(.05)	(.08)	(.19)	(.04)
Machinery	.14	.09	.08	.02	-.09
	(.17)	(.05)	(.03)	(.18)	(.05)
Fertilizer	.14	.16	.07	.03	.25
	(.05)	(.04)	(.03)	(.04)	(.03)
Sum	1.24	.84	.92	1.45	1.05
	(.19)	(.08)	(.12)	(.32)	(.11)

Note: Standard errors are in parentheses. Jiashan County's elasticities are copied from column 2, Table III. Fengyang's and Chuxian's are calculated from columns 3 and 4 in Table III, while the nation's are calculated from columns 1 and 2 in Table IV. The weights used in the calculation are the geometric average of the ratios of irrigated land to total cultivated land in 1983. They are .594 for Fengyang County, .778 for Chuxian County, and .437 for the nation.