Do the Chinese Grain Farmers Maximise Profits?

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I

INTRODUCTION

There is no doubt that the agricultural reforms introduced in China in 1978 have been very successful in improving the country's agricultural production and farmers' income. Recently, concerns have been raised that agricultural growth has been slower in the second post-reform periods of 1985-92 (Lin, 1992). The resurgence of administrative intervention in the markets from late 1985 to 1990 has been argued as a major cause for the agricultural slowdown (Guo, 1995).

Since the first wave of reform (1978-1984), there have been several changes in policies concerning procurement prices and quotas. There were two major policy interventions in agriculture after 1984. First, in 1985, with the objective of reducing the state food subsidies to urban consumers, the government merged the two procurement prices of basic procurement price and the premium producer price into a single procurement price and reduced input subsidies to farmers. As a consequence, the burden of consumer subsidies was shifted from the state to the farmers. Low output prices and increasing costs of production reduced profitability in grain production and eventually reduced incentive to produce efficiently.

Second, due to the mounting pressure, in 1988, the government increased the grain price by 18 per cent and the production quota was increased by more than 10 per cent to ensure that land is not reduced from grain production. Also, input prices were controlled and timely supply was guaranteed. Grain output grew substantially in the following years and the government could not purchase the set quota from farmers by paying them due to shortage of funds. Farmers were issued with IOU for grain delivered to the state and therefore, production incentives and income deteriorated (Guo, 1995). These incidents led to the widening of rural-urban income disparity. The ratio of average annual rural income to urban income per person declined from 2.5 in 1989 to 1.75 in 1993. The main reason for this change was that farmers were not able to receive money from the government for selling their production quotas due to shortage of government funds and they received only credit notes (IOU) which could not be encashed immediately. Thus incentive for farming was reduced and farmers were attracted by non-farm activities.

It is in this context, the objective of this paper is to test the hypothesis of profit maximisation in grain production in China using a recent farm household survey data of 1993 and 1994. Profit maximisation is generally considered as the behavioural assumption for firms (farms) operating under market economic system. Thus one way of verifying how effectively economic reform has facilitated the transformation of the Chinese farmers into market oriented producers is to examine whether they are maximising economic profits. Such an examination can be done by using either production, cost or profit functions. Nevertheless,
both ‘primal’ and ‘dual’ approaches require reliable price data. An important question is: how can one test the profit maximisation hypothesis when there are no price data? In the context of production function analysis, the optimum level of production which yields maximum profit, occurs at the point of tangency of the production function with the price line (Heady, 1952). When firms (farmers) operate at this point, they are economically efficient and maximising profits given the technology they use and the prices they face.

Thus, testing the hypothesis of profit maximisation requires estimation of the production function, price line and the point of tangency on the production function coinciding with the price line. In fact, Farrell (1957) used this concept mainly to decompose economic efficiency into technical and allocative efficiencies. In the absence of price data, how is economic efficiency identified or the profit maximisation hypothesis tested? The argument in this paper is that the production is at the optimum when returns to scale are constant (Carlson, 1956). Therefore, one approach to testing the profit maximisation hypothesis is to model the production process and to identify the point of constant returns to scale in production. Thus the purpose of this paper is to test the profit maximisation hypothesis using its established link with the returns to scale.\(^1\) We specify the production process in a homothetic form, which is more general than the homogeneous form.

Section II briefly describes the characteristics of ray-homothetic production functions in relation to returns to scale. Section III also explains the empirical model with a brief description of the data. Empirical results are analysed in Section IV and the final section contains the conclusions.

II

RAY-HOMOTHETIC PRODUCTION FUNCTIONS, RETURNS TO SCALE
AND PROFIT MAXIMISATION

A firm is said to be maximising its profit, when it produces the optimal level of output from a given set of technology and prices (Carlson, 1956). The point of tangency between the price line and the production function identifies the optimal output. A production function is generally expected to include a range of increasing returns to scale, a point of constant returns to scale and a range of decreasing returns to scale (Heady, 1952). When the point of tangency between the price line and the production function occurs at the point of constant returns to scale on the production function, the optimal output is achieved (Varian, 1993). In the absence of price data, the researcher can estimate the optimal output by identifying the point of constant returns to scale on the production function.

Yields (output per hectare) would be constant under constant returns to scale, given the technology, if all inputs were increased by a constant proportion. When all farmers face the same technology and prices, then all profit-maximising farmers will have the same yield. The neo-classical assumption underlying the above arguments is that farmers are technically efficient in the sense that they produce the maximum possible output from a given set of inputs and technology. In other words, the assumption is that all farmers follow the best practice technique of the given technology. The recently established literature on frontier production functions indicate that such an assumption need not be valid and all farmers may not follow the best practice technique of a given technology due to various non-price and organisational factors such as lack of incentive and information (Kalirajan and Shand, 1994).

In such situations, for profit maximising farmers who are operating below the frontier, it
is possible to increase yield by following the best practice technique but without changing the levels of inputs. This aspect of production can be included in the modelling by allowing the production coefficients to vary across farmers implying that production coefficients of farmers following the best practice techniques will be higher than those who do not. Thus differences in productivity among farmers are captured in the modelling through variations in production coefficients.

Profit maximising farmers would not be content with the constant yield levels and would strive for improving the yield levels. Here, those farmers who have been using the best practice technique and producing on the frontier, can increase their yields only by shifting their production frontiers, i.e., by operating on a higher technology. However, the analysis done in this paper is a static one and a dynamic case in which we can study the shifting of the frontier is out of purview of this paper.

There are three modelling procedures to reflect the returns to scale in a production process. Shephard (1953) first discussed a homothetic function in which returns to scale vary with output but not with the input mix. Eichhorn (1965) is the first one to identify a class of ray-homogeneous functions, in which returns to scale vary with the input mix but not with output. Fare (1973), combining the above two characteristics, introduced the ray-homothetic production function in which returns to scale vary with both input mix and output.

All of these approaches force a single response coefficient for each factor across observations. In other words, they implicitly assume that all firms (farmers) follow the same method of application for all inputs and face the same input response coefficients. However, this latter assumption is very restrictive (Heady, 1952). Due to various non-price and organisational factors such as differences in quality and management, there would be variations in the method of application of inputs across firms even though there may be one technical optimum for all. This means that the response coefficients of factor intensities will not be the same across firms. The recently established literature on frontier production functions indicates that farmers following the best practice technique of the given technology will have larger response coefficients than those who do not (Kalirajan and Shand, 1994).

In this paper, the ray-homothetic production function described by Fare is modified to capture differences in productivity among farmers by allowing the production coefficients to vary across farmers.

Let the production function be represented as follows:

\[ y = f(x) \quad \text{(1)} \]

where \( y \) is a \((n\times1)\) vector of output, \( x \) is a \((n\times k)\) matrix of inputs, and \( n \) = number of firms. The ray-homothetic production function is defined as follows:

\[ \phi(\lambda x) = F(\lambda^x \|x\| h(x)) \quad \text{(2)} \]

where \( \|x\| \) is the Euclidean norm of \( x \), \( F \) is a monotonically increasing transformation of \( \lambda^x \|x\| h(x) \), and \( \lambda \geq 0 \). Following Fare and Yoon (1984), but with the assumption that
different methods of application of inputs influence output differently, a linear relationship between output and inputs in the framework of the ray homothetic production function with parameters \( \tau \) and \( \beta \) can be written as:

\[
y_j = \ln \left( \frac{k_{ij}}{\tau \pi x_{ij}} \right) = \ln \left( \frac{\beta_{ij}^{\prime}/x_{ij}^\prime}{\tau \pi} \right)
\]

\( j = 1, 2, \ldots, n. \) .... (3)

The above specification implies that the production response coefficients, \( \beta \)'s, vary across firms (farmers). It is assumed that the \( \beta \)'s vary around their means.\(^5\)

\[
\beta_{ij} = \bar{\beta}_i + u_{ij}
\]

where the mean response of \( y \) to a change in the intensity of the \( i \)-th factor is given by \( \bar{\beta}_i \), while the actual response for the \( j \)-th firm is \( \beta_{ij} \). \( u_{ij} \)'s are the unobserved firm-specific characteristics arising due to various non-price and organisational factors, which influence the method of application of inputs across firms. The presence of \( v_j \) in (3) accounts for the other factors influencing output, such as weather, and \( v_j \) is assumed to be distributed 'normally' across observations.

The returns to scale can be calculated as follows:

\[
r_j = \frac{1}{y_j} \left( \frac{\sum \beta_i x_{ij}}{\sum x_{ij}} \right)
\]

Equation (4) indicates that returns to scale depend not only on output and factor intensity, but also on the method of application of factor inputs. For the ray-homothetic production function (3), the point of constant returns to scale lies where \( r = 1 \). Therefore, the optimal output is calculated as:

\[
y^* = \left( \frac{\sum \beta_i x_{ij}}{\sum x_{ij}} \right)
\]

Firms are said to be maximising their profits when the ratio of the realised output to the above defined optimal output is one. When the ratio is either greater or less than one, firms are said to be not maximising their profits. This measure of performance concerns the long-run equilibrium of firms. But, if there is no possibility of increasing factor inputs due to some institutional constraints, particularly land in the case of China, then this measure is also applicable at a given point in time.

III

ESTIMATION PROCEDURES

Linear programming methods based on Data Envelopment Analysis (DEA) or statistical methods can be used to estimate the ray homothetic production function given in (3). A major advantage of DEA is that it places no restrictions on the functional form of the production relationships between inputs and outputs (Fare et al., 1985). Another advantage is
that DEA does not impose any distributional assumption on firm-specific effects. However, a principal disadvantage of DEA is that it can be extremely sensitive to selection of variables, to extreme observations, and data errors (Kalirajan and Shand, 1994; Varian, 1985). The approach attributes all deviations from the production frontier to inefficiency without accounting for random influences or statistical errors. Thus the estimated production functions have no statistical properties. Several researchers have shown that if the employed functional form closely corresponds to the given technology, statistical methods outperform DEA (e.g., Gong and Sickles, 1992). Therefore, the functional form of (3) was tested with a RESET test on the sample data.\footnote{6} The chosen functional form was not rejected, which led to the use of statistical estimation methods rather than DEA methods in this paper.

Statistical estimation procedures can be divided into two methods:

Model 1: If it is assumed that all firms follow more or less the same method of application of all inputs, and face the same input response coefficients, then the ray homothetic production function can be estimated using Ordinary Least Squares (OLS).

Model 2: On the other hand, if it is assumed that firms follow different methods of application of inputs and face different input response coefficients, then the ray homothetic production function (3) can be estimated using the statistical estimation procedures followed in Hildreth and Houck (1968) and discussed in Kalirajan and Shand (1994). The ray homothetic production function (3) can be rewritten as:

\[ y_j = \beta_j + \frac{\sum_{i=2}^{k}(\beta_j x_{ij} \ln x_{ij})}{\sum x_{ij}} + v_j \quad j = 1, 2, \ldots, n. \quad \text{.... (6)} \]

where \( \beta_j = \beta + u_j \) and \( \ln (\tau) = \beta_j \) for all \( j \) which represents the intercept term. This formulation allows for quality variations in inputs and heterogeneity in the functional relationships between output and inputs (Kalirajan and Obwona, 1994).

With these assumptions, equation (6) can be rewritten as:

\[ y_j = \beta_j + \frac{\sum_{i=2}^{k}(\beta_j x_{ij} \ln x_{ij})}{\sum x_{ij}} + \left[ u_j + v_j + \frac{\sum_{i=2}^{k} x_{ij} u_{ij} \ln x_{ij}}{\sum x_{ij}} \right] \]

Letting,

\[ w_{ij} = \left[ u_j + v_j + \frac{\sum_{i=2}^{k} x_{ij} u_{ij} \ln x_{ij}}{\sum x_{ij}} \right] \]

we obtain \( E (w_{ij}) = 0 \) for all \( i \) and \( j \),

\[ \text{Var}(w_{ki}) = \sigma_{ui}^2 + \sigma_{vi}^2 + \left[ \sum_{i=2}^{k} \sigma_{x_{ij}}^2 x_{ij}^2 \ln x_{ij} \right] / (\sum x_{ij}^2) \]

\[ \text{COV}(w_{ki}, w_{kj}) = 0 \quad \text{for} \quad k \neq j. \]
Following the methods suggested by Schwallie (1982), estimates of the variances, and covariances can be obtained. After estimating the variances and covariances, and obtaining the estimates of the mean response coefficients, the individual response coefficient estimates of the $\beta_j$ are given by

$$\hat{\beta}_j = \hat{\beta}_j + \left( \frac{\text{Var}(w_k)}{\text{Var}(w_k)} \sum x_i^2 \right) \left( y_j - \hat{\beta}_j - \sum_{i=2}^{k} (\hat{\beta}_i x_i \ln x_i / \sum x_i) \right)$$

These $\hat{\beta}_j$'s are the minimum variance, linear and unbiased estimators for the actual response coefficients $\beta_j$'s.

IV

DATA, EMPIRICAL RESULTS AND ANALYSIS

As a part of a major study on China's grain production, consumption and marketing financed by the Australian Centre for International Agricultural Research, the Chinese Economy Research Unit at the University of Adelaide and the Chinese Ministry of Agriculture conducted surveys of farm households in 1993 and 1994. These surveys provide data for the empirical analysis carried out in this paper. In the survey area, rice is predominantly grown in Guangdong, Jiangxi and Sichuan; and wheat in Sichuan and Shandong. Characteristics of core production variables and sample households are given in the Appendix. The above cited modified ray homothetic function was estimated in this study separately for rice, and wheat.

The variables are:

- $y =$ grain (rice/wheat) output measured in kg,
- $l =$ labour measured in number of days,
- $f =$ fertiliser measured in kg,
- $c =$ other costs,
- $a =$ land area operated measured in mu ($15$ mu = 1 hectare).

All the variables are presented in index form with respect to their levels in 1993. Model 1 is estimated by OLS. In Model 2, the computer package TERAN was used to estimate the mean and the actual response coefficients. A comparison of results from Model 1 and Model 2 indicates that the coefficients and their standard errors in Model 1 are higher than those in Model 2. The Breusch-Pagan (1979) LM test statistic for random coefficient variation produced a Chi-square value of 11.28 (rice) and 13.20 (wheat) with 4 degrees of freedom, which are significant at 1 per cent level. This implies that Model 2 with the random coefficients specification fits the given data best and therefore, the results of Model 2 are used for further analysis. Coefficient estimates for Model 2 are shown in Table 1.

Estimates of actual response coefficients, which are not shown here, vary substantially across farms. This means that the use of mean response coefficients in earlier studies does not provide meaningful and reliable results. All the mean response coefficients in this paper are statistically significant (Table 1).
TABLE 1. ESTIMATES OF RAY HOMOTHETIC (MEAN COEFFICIENTS) PRODUCTION FUNCTIONS FOR RICE AND WHEAT IN CHINA, 1994

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients of</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Rice</td>
<td>Wheat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model 2 (2)</td>
<td>Model 2 (3)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>12.0425</td>
<td>2.4076</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.8452)</td>
<td>(0.4235)</td>
<td></td>
</tr>
<tr>
<td>Labour</td>
<td>2.4640</td>
<td>0.6201</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.6114)</td>
<td>(0.1208)</td>
<td></td>
</tr>
<tr>
<td>Fertiliser</td>
<td>2.9016</td>
<td>0.7725</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.7005)</td>
<td>(0.1325)</td>
<td></td>
</tr>
<tr>
<td>Other costs</td>
<td>2.7805</td>
<td>0.5846</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.6253)</td>
<td>(0.1048)</td>
<td></td>
</tr>
<tr>
<td>Land</td>
<td>108.668</td>
<td>32.0655</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(12.406)</td>
<td>(6.5569)</td>
<td></td>
</tr>
<tr>
<td>Sichuan dummy</td>
<td>2.7885</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.8256)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Figures in parentheses are standard errors of estimates. All the estimates are significant at 1 per cent level.

The estimated returns to scale are presented in a frequency form for the two crops in Table 2. Considering the frequency of constant returns to scale, it may be noted that only about 21 per cent and 18 per cent of firms seem to be maximising their profits in producing rice and wheat respectively. This implies that majority of sample farmers are not in equilibrium in the period of analysis. The analysis is based on the assumption that firms sampled at a given point in time will be in long-run equilibrium. This assumption is valid in the present context because the possibility of increasing factor inputs, particularly land, is very limited due to institutional constraints in China. Also, the sample period used in this study was normal without any natural or other external shocks in the surveyed area.

The results also show that majority of sample farmers appear to be producing rice and wheat with increasing returns to scale. It may be that, with increasing employment opportunities in rural industries, farmers are satisfied to produce grains for self-consumption and for fulfilling quota requirements and concentrate on earning higher income from employment in rural industries (Byrd and Lin, 1990).

TABLE 2. RETURNS TO SCALE IN THE PRODUCTION OF RICE AND WHEAT IN CHINA, 1994

<table>
<thead>
<tr>
<th>Returns to scale</th>
<th>Number of sample farms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rice (2)</td>
</tr>
<tr>
<td>Increasing</td>
<td>203 (62)</td>
</tr>
<tr>
<td>Constant</td>
<td>68 (21)</td>
</tr>
<tr>
<td>Decreasing</td>
<td>54 (17)</td>
</tr>
<tr>
<td>Total</td>
<td>325</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses are percentages to the total.
Increasing returns to scale in grain production raise several issues relating to farmers' decision-making processes. A major factor may be the risk stemming from earlier experience with grain production, particularly during mid-1980s when due to increased production, grain prices were low. Consequently, it is rational for grain farmers in China to have a mixed objective function in which output for self-consumption dominates over profit maximisation.

A statistical analysis of why farmers are not maximising their profits in grain production is attempted using the following variables that cause variations in economic efficiency: formal education, main profession, total arable land, size of the household, and ratio of non-crop income to total income. These variables influence directly the decision-making process which determines the application of inputs which in turn determine the level of efficiency, but their influence on output is indirect and following Johnson's (1967) arguments, these variables are used in the second stage. A linear function was estimated for rice and wheat, using as the dependent variable, economic inefficiency, which is measured as the absolute difference between 1 and the ratio of actual to optimum outputs. OLS with a heteroscedasticity-consistent covariance matrix is used for estimation. The results are given in Table 3. Both equations exhibit reasonably high explanatory powers and most of the coefficients are statistically significant.

### TABLE 3. DETERMINANTS OF ECONOMIC INEFFECTIVENESS IN THE PRODUCTION OF RICE AND WHEAT IN CHINA, 1994

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>OLS estimates of coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rice</td>
</tr>
<tr>
<td>Education</td>
<td>0.0520* (**, 0.0214)</td>
</tr>
<tr>
<td>Family size</td>
<td>-0.0725* (**, 0.0284)</td>
</tr>
<tr>
<td>Profession</td>
<td>0.1408** (0.0644)</td>
</tr>
<tr>
<td>Share of non-crop income in total income</td>
<td>0.3529* (0.1205)</td>
</tr>
<tr>
<td>Arable land area of the household</td>
<td>0.1536* (0.0482)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.2856* (0.1008)</td>
</tr>
<tr>
<td>R²</td>
<td>0.5765</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses are standard errors of estimates. * and ** denote Significance at 1 and 5 per cent level respectively.

In the case of rice and wheat, education increases economic inefficiency significantly. This could be because the level of formal education increases the probability of gaining employment in the non-agricultural sector, particularly in rural industries, which might discourage farmers from being efficient in grain production.

The results show that with the increasing size of the family, economic inefficiency appears to be significantly decreasing in the production of rice and wheat. With more people in the family, division of labour becomes easier which is an important factor facilitating improvement in efficiency.
The main profession of the head of the household has significant impact on economic inefficiency in the production of rice, but not of wheat. If farming is not the main occupation of the rice producer, economic inefficiency tends to increase. This result emphasises the findings of Rosenzweig and Wolpin (1985) for Indian farmers that the understanding of the farm-specific characteristics is an important factor in determining productive efficiency which influences intergenerational land transfers in developing countries.

The coefficient of arable land is highly significant with positive values, which means that inefficiency increases with large arable land. Given the earlier finding that the majority of sample farmers produce with increasing returns to scale, the positive coefficient of arable land in this regression should be interpreted differently. The result could mean that the proportion of infertile land increases with the increase in arable land and this consequently increases inefficiency.

As expected, the ratio of non-crop income to total income has positive significant influence on inefficiency in grain production. With more and more opportunities to earn income from non-agricultural activities, farmers are discouraged from applying the technology effectively. This result is in conformity with the off-farm income literature which had its ‘peak’ season in the early eighties (see for example, Shand, 1987).

V

CONCLUSION

After several years of agricultural reforms in China, a recent concern is about the slowdown in agricultural growth and income from farming. Using the 1993 and 1994 farm household survey data, this paper tested the hypothesis of profit maximisation of grain farmers in China. The testing procedure is different from the conventional approach followed in the literature. In the absence of reliable price data, drawing on the neo-classical theoretical arguments of returns to scale and optimal production of firms, this paper suggests a simple method to examine whether firms (farmers) are economically efficient and maximising their profits. Though the suggested measure of performance concerns the long-run equilibrium of firms, it is also applicable in the short run, if there is no possibility of increasing factor inputs due to some institutional constraints.

The empirical results show that the majority of grain farmers in China are not maximising their profits. The share of non-crop income in total income of farmers has been identified as an important factor contributing to economic inefficiency. A major policy implication is that the impact of economic reform on rural industries combined with recent reversal of agricultural reforms (Watson and Findlay, 1995), particularly in the grain sector (which were introduced in 1985, the year in which the growth of farm output and income began to slow down), has discouraged farmers from maximising their profits. Such a production behaviour has the potential to contribute to the widening of rural-urban income disparity.

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APPENDIX

<table>
<thead>
<tr>
<th>Production variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>Total grain output of the household by crop, rice, and wheat (kg per year),</td>
</tr>
<tr>
<td>Labour</td>
<td>Labour input in grain production by crop, rice, and wheat (days per year),</td>
</tr>
<tr>
<td>Other costs</td>
<td>Other costs in grain production include costs on inputs like machinery renting, use of seeds and pesticides (excluding fertilisers) (yuan per crop per year),</td>
</tr>
<tr>
<td>Fertilisers</td>
<td>Use of fertilisers converted to the net weights of N, K$_2$O and P$_2$O$_5$ (kg per crop per year).</td>
</tr>
<tr>
<td>Planting area</td>
<td>Planting areas for individual grain crops (mu). (15 mu = 1 hectare).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household head</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDU</td>
<td>Household head’s education level: 1 = below primary school level, 2 junior primary school level, 3 senior primary school level, 4 junior high school level, 5 senior high school level, 6 professional school, and 7 above senior high or professional school level.</td>
</tr>
<tr>
<td>DPRF</td>
<td>Household head’s profession, = 0 if farmer and =1 if others;</td>
</tr>
<tr>
<td>POP</td>
<td>Household size</td>
</tr>
<tr>
<td>RINCOME</td>
<td>Share of non-crop income in total income</td>
</tr>
<tr>
<td>RHIREP</td>
<td>Proportion of hired labour in total agricultural labour use.</td>
</tr>
</tbody>
</table>

NOTES

1. For a comprehensive review of rural economic reform in China, see Lin (1992), and for the recent changes in policies, see Guo (1995). 
2. The merged procurement price was still lower than the free market price. For example, in Guangdong, the ratio of free market price to the procurement price increased from 1.3 in 1984 to 1.9 in 1988. 
3. Though the decomposition of economic efficiency into technical and allocative efficiencies suggested by Farrell (1957) is useful, it is beyond the purview of this paper. 
4. The conventional homogeneous functions are special cases of the ray homothetic functions. For details, see Fare (1973). 
5. This may be an over-simplification of the behaviour of the $\beta$'s if there is a priori reason to believe that $\beta$'s vary in a systematic way with some quantifiable variables. In the absence of such information, the present assumption is reasonable. 
6. The calculated F-statistics were 1.76 (rice) and 1.84 (wheat) which are not statistically significant at 5 per cent level. 
7. In the case of rice, a preliminary analysis showed that there is no significant difference in production process between Jianxi and Guangdong. Therefore, only one dummy is introduced in the empirical function to differentiate the production process in Sichuan from Guangdong and Jianxi. In the case of wheat, no dummy variable is introduced, as there is no significant difference between Sichuan and Shandong. 
8. There is a possibility of contemporaneous correlation between some of the explanatory variables and the disturbance terms (e.g., between weather and fertiliser, as pointed out by the referee). In such cases, the ideal solution will be to use the ‘dual’ profit function. But, estimation of the profit function requires price data. The main objective of this paper is how does one test the profit maximisation hypothesis when there are no price data. Therefore, profit function approach could not be followed in this paper. However, while estimating a ‘primal’ production function, we use ex-post rather than ex-ante variables and so the contemporaneous correlation is avoided. Also, following the arguments of Zellner et al. (1966) by assuming that farmers maximise expected profits, the specification problem is avoided. 
9. Education and profession variables are not highly correlated. The simple correlation coefficient that was calculated between these variables worked out to be 0.2368. 
10. Further, a production function shows a purely technical relationship between output and core inputs. Therefore, socio-economic variables such as education, size of the household cannot be included in the production function meaningfully.
REFERENCES


