EFFICIENCY ANALYSIS OF RICE FARMING IN JAVA 1977—1983

By: Faisal Kasryno*)

1. Introduction

The primary concern of the Government of Indonesia is the improvement in equity and welfare of farm households and in improving the income levels of the rural population through changes in farm technologies. Policy issues related to this consern include: (a) the price responsiveness of rice production, (b) the productivity of factor inputs, especially labor, (c) the efficiency in the allocation of resources and the impact of government policy on the allocation, and (d) the impact of technological changes on the distribution of income.

The most recent agricultural census (1983) indicated changes in the distribution of cultivated land. There was a trend towards an increase in the average size of cultivated land area and an increase in the number of landless (C.B.S. 1984). During this time there was also a trend towards an increase in real wages in the rural areas, particularly since 1978. The real price of rice showed a slight decline.

Some studies also indicate that a relatively high proportion of rice farmers in Java are using more fertilizer than the recommended levels of application as a result of price subsidies on fertilizers. (Kasryno, 1984). As a consequence of the high fertilizer application rates, together with technological changes, rice production increased at a very rapid rate; averaging nearly 6.5 percent a year between 1978 and 1983. It can be said that Indonesia is on the threshold of achieving self-sufficiency in food production.

The purpose of this paper is to analyze the efficiency of rice farming in Java by using panel (cross-section on time series) analysis in an attempt to answer some of the policy related issues. The analysis will depend heavily on production function analysis.

One of the benefits of using panel data and pooling time series and cross-section data is the ability to control unobservable individual specific effects which may be correlated with independent variables in a model. Let us consider a model.

$$Q_{it} = \beta_j X_{ijt} + \alpha_j Z_{ijt} + e_{it} + \lambda_i + e_t$$

*) Director, Center for Agro Economic Research.

Where Q is a vector of output, X is a matrix of variable factor inputs, Z is a matrix of fixed factor inputs, e and λ are error terms. It is possible that λ_i will be correlated with X and Z variables, therefore estimation of the above equation using the GLS estimator will yield an inconsistent estimate of the parameter β_j. To overcome this problem the λ_i or the unmeasurable individual effects should be eliminated in the sample by transforming the data into deviation from their individual means. In the general formulation of a regression model the e_{it}, e_t and λ_i terms can only be represented by intercep terms as such β_o.

2. Production Function Analysis

Measurement of technical efficiency usually refers to the level of output from a given level of resources or the level of inputs required to produce a given level of output. The usual approach to analyze efficiency is through the application of production function analysis with the following underlying assumptions: (1) profit maximization behavior, (2) equal prices for all producers, and (3) all producers are able to acquire the necessary level of fixed factor inputs.

The production function may be defined as:

$$(1)\quad Q_{it} = \sum_{j=1}^{m} \beta_j X_{ijt} + e_{it} + \lambda_i + e_t$$

where: Q_{it} = rice output of the i^{th} farmer at time t.

X_{ijt} = j^{th} factor input of the i^{th} farmer at time t.

β_j = parameter to be estimated.

e_t = error specific to an individual time period and technological change.

e_{it} = random error for the i^{th} individual farmer at time t with expected mean zero or $E(e_{it}) = 0$.

λ_i = net effect of unmeasured variables for i^{th} individual farmer.

$$(2)\quad Q_{it+1} = \lambda_i + e_{i(t+1)} + e_{t+1} + \sum_{j=1}^{m} \beta_j X_{ijt+1}$$

Subtract (2) from it's individual mean overtime.

$$(3)\quad (Q_{it} - Q_{i.}) = \sum_{j=1}^{m} \beta_j (X_{ijt} - \bar{X}_{ij.}) + (e_{it} - \bar{e}_{i.}) + (e_t - \bar{e})$$

$E(e_{it} - \bar{e}_{i.}) = 0$ since $E(e_{it+1}) = 0$ and $E(e_{it}) = 0$

Equation (3) then can be simplified as:

$$(4) \quad \hat{Q}_{it} = \sum_{j=2}^{m} \beta_j \hat{X}_{ijt}$$

where: $\hat{Q}_{it} = Q_{it} - \bar{Q}_{i.}$

$\hat{X}_{ijt} = X_{ijt} - \bar{X}_{ij.}$

$$\bar{Q}_{i.} = \frac{{}_{t=1}^{T} Q_{it}}{T}$$

$$\bar{X}_{ij.} = \frac{{}_{t=1}^{T} X_{ijt}}{T}$$

β_j = parameter to be estimated.

Panel data (i.e. time series on a cross-section of the farm household) will be used to estimate the parameters for equation (4). An advantage of using this method is it will result in unbiased or consistent estimates of the parameters β_j.

In formulating the model implied in equation (4), it is assumed that the slope coefficients are constant across individuals and over time. It is further assumed that intercept is constant over individuals and varies over time.

In model specification of panel data, which is cross-sectional data for households over time, it is important to identify variations in behavior between the cross-sectional unit as well as any differences over time. In deriving equation (3) it is assumed that the slope β_j is constant over time, with the differences in behavior to be captured by the intercept term λ_i. It is also assumed that distribution of λ_i is independent of X_{ij}, where the λ_i s influence the level of production. The λ_i will reflect the individual farmer's capability, access to various financial services and other factors related to each farmer.

It has been assumed that the slope coefficients are constant while the intercept value varies across households and over time. If this does not hold, i.e. the slope coefficients and intercept term varies across households and over time, the model would need to be rewritten as:

$$(5) \quad Q_{it} = \sum_{j=1}^{m} (\beta_j + U_{ij} + \lambda_{jt}) X_{ijt} + e_{it}$$

For the slope coefficients that vary over time the model in matrix notation can be formulated as:

(6) $\hat{Q} = \beta X + \gamma Z + \alpha D$

where $\hat{Q}$ is a vector of deviation of output from its mean over time period, $\hat{X}$ is matrix m x n of deviation of the factor inputs from the mean over time periods, Z is a diagonal matrix with diagonal element X_i, and D is a dummy variable. We assumed $E(e) = 0$, μ_{ij} to be independently distributed and $E(e_i, e_j) = 0$. The structure of the Z matrix is

$$(7) \quad Z = \begin{bmatrix} X_1 & & & & & & \\ & X_2 & & & & & \\ & & X_3 & & & & \\ & & & \cdot & & & \\ & & & & \cdot & & \\ & & & & & \cdot & \\ & & & & & & X_T \end{bmatrix}$$

where $X_1 = [X_{11}\, X_{12} \ldots\ldots\ldots\, X_1k]$ etc for $k = 1, 2, \ldots\ldots\ldots K$

The matrix Z has the diagonal element X_i, where:

$$\hat{Q}_{it} = Q_{it} - \bar{Q}_i$$

$$\hat{X}_{ijt} = X_{ijt+1} - \bar{X}_{ij}$$

and $X_i = X_{11}, X_{12}, \ldots, X_{ik}$

Since we only have two time periods of cross-sectional household data, estimation of difference in slope coefficients over time can be used through GLS estimation of equation as follows:

Let $\hat{Q}_{it} = Q_{it+1} - \bar{Q}_i$.

Then:

(8) $$\hat{Q}_{it} = \beta_{jt+1} \sum_{j=1}^{K} X_{ijt+1} + \beta_{jt} \sum_{j=1}^{K} X_{ijt} + (e_{it+1} + e_{it})$$

with $E(e_{it+1} + e_{it}) = 0$ and for two time period t_1 and t_2 the model can be rewritten as:

(9) $$Q_{it} = \sum_{j=1}^{K} \beta_{jt2} X_{ijt2} + \sum_{j=1}^{K} \beta_{jt1} X_{ijt1}$$

Where t_1 refers to 1976/1977 and t_2 refers to 1983/1984 observations. Parameters in equation (9) can be estimated using GLS estimator. Comparisons between a pair of slope coefficients will be made to test whether the slope coefficient varies over time. Intercept will capture neutral technological change.

In order to test allocative efficiency, let us assume that the model in equation (4) is a Cobb-Douglas production function defined as

$$Q = A \prod_{j=1} X_j^{\beta_j}$$

Taking the first derivative of the above production function with respect to X_j.

(10) $$\frac{\partial Q}{X_j} = \beta_j A \pi X_j^{(\beta_j - 1)}$$

since $AX_j^{-1} \beta_j \prod_{j=2} X_j^{\beta_j} = \beta_j \frac{Q}{X_j}$ for all j,

therefore

$$\frac{\partial Q}{X_j} = \frac{\beta_j Q}{X_j} \text{ for all } j = 1, 2, \ldots\ldots.. m.$$

The allocative efficiency for profit maximization behavior requires that:

(11) $$\frac{\partial Q}{X_1} = \frac{P_{X1}}{P_q} = \beta_1 \frac{Q}{X_1}$$

or

(12) $$\frac{X_1 P_{X1}}{Q P_q} = \beta_1$$

Equation (12) implies that factor share must be equal to the output elasticity of the input, if production is in the form of a Cobb-Douglas production function.

The assumptions used in the above analysis include:

(1) Profit maximization behaviour of the farmers.
(2) All farmers face similar prices or markets.
(3) All farmers are able to obtain the necessary fixed factor inputs and
(4) Slope coefficient are constant across households and over time. This assumption will later be relaxed.

The Cobb-Douglas production function will be used. Therefore, the variables are defined in natural logarithmic terms as follows:

$$Q_{it} = \ln H_{it}$$

where H_{it} is gross rice output for the i^{th} farmer at time period t measured in kg of rough rice ("gabah").

$$X_{i1t} = \ln L_{it}$$

where L_{it} is labor used by i^{th} farmer at time t, measured in hours.

$$X_{i2t} = \ln FU_{it}$$

where FU_{it} is the amount of nitrogen fertilizer used by i^{th} farmer at time t measured in kg of Urea (46.0%N).

$$X_{i3t} = \ln FT_{it}$$

where FT_{it} is the amount of phosphate fertilizer used, measured in kg of TSP (triple super phosphate with 46.0% of P_2O_5).

$$X_{i4t} = \ln PES_{it}$$

where PES_{it} is the cost of pesticides for i farmer at time period t.

$$X_{i5t} = \ln CAP_{it}$$

where CAP_{it} is the rental cost of capital (rental service of tractor and animal power) for the i^{th} farmer.

$$X_{i6t} = \ln SW_{it}$$

where SW_{it} is the size of land area cultivated in hectare by the i^{th} farmer at time t.

$$X_{i7t} = \ln TEN_{it}$$

where TEN_{it} is tenancy rate measured by ratio of owned and cultivated land for the i farmer at time t. All the variables are defined in terms of its' deviation from individual means.

The $(Q_{it} - \overline{Q}_i)$ represents deviation of the level of the output from its' mean and $(X_{ijt} - \overline{X}_{ij})$ represents deviation in the level of input used from its' mean.

The production function analysis will be used for testing allocative efficiency:

(1) Constant return to scale.

(2) Profit maximization behavior.

(3) Constant slope coefficients.

Let us rewrite the production function for the variables as defined above as follow:

$$(13) \quad \hat{Q}_{it} = \sum_{j=1}^{m} \beta_j \hat{X}_{ijt} + \sum_{j=1}^{k} \gamma_j D_j \qquad \text{where}$$

$\hat{Q}_{it} = (Q_{it} - \bar{Q}_{i.})$ and $\hat{X}_{ijt} = (X_{ijt} - \bar{X}_{ij.})$

Q_{it} and X_{ijt} as defined above.

For labor input the factor share formulated as:

$$(14) \quad \frac{W_{it}\, L_{it}}{P_{hit}\, H_{it}} = \beta_1$$

It this analysis we have 6 factor inputs: manual labor, animal power, mechanical power, fertilizer, pesticides and land, therefore we have six forms of equation (14).

For estimating β_j we follow the usual, admittedly ad hoc, practice of assuming an additive error with zero expectation ad finite variance for equations (13) and (14). For the same individual, the covariance of the errors of equation (13) and equations (14) is possible to be zero. But, the covariances of the error of either equation corresponding to different individuals are assumed to be zero.

Given the assumption of profit maximizing, price taking and the fixity of land and family labor output and variable factor inputs identified in the model are jointly dependent variables. Therefore, ordinary least squares applied to each equation separately will be less efficient. The more efficient approach will be to estimate equations (13) and (14) jointly.

With the specification of the errors and the above assumptions, it is clear that Zellner's method of seemingly unrelated regressions provides an asymptotically efficient estimation. The efficiency of the estimation can be increased by imposing restrictions on the coefficients in the equations (13) and (14) above.

3. The Data

During 1976-1978 the Agro Economic Survey carried out a study on production structure, employment and income of rural households in six villages in Cimanuk River Basin in West Java and in two villages in East Java. A resurvey of the same rural households was carried out in 1983 to identify changes in technology, income and employment. Therefore, we have panel data i.e. time series on a cross section of rural households. There were 354 sample rural households in the study and 260 of those were rice farmers. All sample farmers are located in predominantly wetland rice areas in the eight sample villages. Four of the villages are located in lowland areas (less than 500 meters above sea level) and the other four are located in upland areas (more than 500 meters above sea level).

The lowland villages are generally more exposed to urban contacts and located near major highways. The upland villages have less contacts with the urban economy and can be reached through gravel and stone roads.

Most of the new improved rice varieties are suitable for the lowland areas. Nearly all of the sample farmers in the lowland areas planted new improved rice varieties resistant to brown planthopper. In upland areas most of the farmers planted traditional rice varieties. All of the farmers planted rice as a wet season crop.

Changes in inputs per hectare of rice crops and prices can be seen in Table 1. On average, rice price increased by 89 percent, however, in real terms (nominal price deflated by the consumer price index) rice price declined from Rp. 64.00 to Rp 52.00 per kg of "gabah" (unmilled rice) at the 1977 constant price. Wage rate in

Table 1. Changes in Inputs per Hectare of Rice Crops and Input-Output Prices in Java for Wet Season 1976/1977 and 1982/1983.

Items	Wet Season 1976/1977	Wet Season 1982/1983	% of changes from 1976/77 to 1982/83
Yield (kgs paddy/ha)	2905	4202	44.6
Paddy price (Rp/kg)	64.0	121.0	89.1
Inputs:			
Fertilizer (kgs/ha)			
a. Urea	219.0	285.0	30.1
b. TSP	83.0	146.0	75.9
Labor (hrs/ha)			
Land preparation	488.7	541.5	10.8
Total preharvest	1049.7	1077.3	2.6
Total labor	1323.7	1409.3	6.5
Animal for land preparation	29.5	16.2	45.0
Tractor	0.0	0.60	—
Real Input Prices (kgs of paddy)			
Fertilizer	1.12	0.72	-35.7
Wage for manual labor (kg/day)	0.98	1.13	15.3
Animal rental rate (kg/day)	12.8	17.6	37.5

terms of rice equivalent increased by 15 percent. Rice output increased by 45 percent. Therefore, in constant 1977 price the gross value of the rice output only increased by 12.0 percent during that period. Since total labor employment was nearly unchanged and as much as 68 percent of the total variable costs was for the payment of hired labor, the cost of rice production increased (see Table 2 for change in factor payment).

It is interesting to note that 42 percent of the total increase in value added of rice output during that period was for the increase in hired labor payment and 58 percent for the increase in return to land, operator surplus and family labor. The rate of increase in rice output between 1976 and 1983 was 6.7 percent per year, where the rate of increase in real*) net income of the owner operator of the rice farm was only 3.5 percent per year. This was mainly due to a decline in the real price of rice and an increase in the real costs of hired labor by nearly 4.0 percent a year.

4. Empirical Results

Since 1978 there has been an indication of an increase in agricultural real wage rate as a result of improvement in job opportunities in non-agricultural sectors of the Indonesia economy. This trend is followed by an increase in the number of hand tractors used for land preparation and in the number of threshers used for harvesting. The number of hand tractor used for rice land increased from 1440 in 1978 to 4950 in 1981, mini tractors increased from 798 to 2950 and power thresher use increased from 310 to 6520 during that period.

The increased uses of capital will increase labor productivity in agriculture. For that reason an attempt was made to include slope coefficient of labor for both time periods and statistical tests were made to test the stability of the coefficients. Slope coefficient for other factor inputs was assumed to be constant, since similar type of fertilizers, pesticides, and animal labor were used, and almost no land improvement took place in the sample villages during period mentioned above.

Dummy variables were used to differentiate location of the villages and cropping seasons, where lowland is an area below 500 meters above sea level and upland is an area more than 500 meters above sea level. Most of the new improved rice varieties are suitable for lowland areas. Nearly all of the sample farmers in the upland areas planted local rice varieties and other older improved rice varieties which already existed and were planted by farmers prior to 1976. In the lowland

*) Real income is nominal deflated by consumer price indexes in rural Java.

areas nearly all of the farmers planted new improved rice varieties resistant to brown planthopper in wet season 1982/1983. The dummy variable for season might be also considered as an indication of technological change between the two time periods.

The level of fertilizer application increased significantly; by 30 percent for urea and by 76 percent for phosphate fertilizer. Total preharvest labor input was nearly unchanged. Animal labor input declined by 45 percent, and tractor service increased. Real price of fertilizers declined by 36 percent due to subsidized prices for fertilizer and an increase in nominal price of rice. Real wages for manual labor increased by about 15 percent and animal rental rate increased by 37.5 percent during that period (see Table 1).

Factor payment for current inputs declined in absolute and relative terms (see Table 2), but the level of chemical fertilizer application increased (Table 1). The decline in the factor payment for the current inputs was due to the decline in input-output price ratios as a result of subsidy on fertilizer price. The share of hired labor in relative and absolute terms increased. This might be due to the increase in the real wages during that period. The share for capital rental (animal and tractor rental) increased in absolute terms, however, it declined in relative terms. In the present condition there is an indication that the increase in the use of power tillers has not yet had an adverse effect on the share of labor. This is also supported by an earlier study (Kasryno, 1984) which indicated that the increased use of power tillers in the densely populated areas of Java was a result of the economizing behavior of the farmers in response to the upward pressure of real wages. In absolute terms the return to management and land increased by about 59 percent and in relative terms it increased by only 3.0 percent annually; which was similar to the increase in the

Table 2. Changes in input Factor Payment and input Factor Share for Wet Land Rice in Java Wet Season per Hectare (1976/1977 - 1983/1984).

Items	Factor Payment (kgs/ha)		Changes 1976/77 to 1983/84 (%)	Factor Shares (%)	
	1976/ 1977	1983/ 1984		1976/ 1977	1983/ 1984
Rice output	2905	4202	44.6	100	100
Factor Payment[a)]					
Current input	407.1	381.5	-6.3	14.0	9.1
Capital[b)]	276.4	307.3	11.2	9.5	7.3
Labor:	1297.2	2045.0	26.3	44.6	48.7
Hired	(895.0)	(1435.0)	(30.0)	(30.8)	(34.1)
Family	(402.2)	(610.0)	(18.1)	(13.8)	(14.6)
Operator surplus and Land	924.3	1468.2	58.8	31.9	34.9

relative share of hired labor. It can also be noted that both farm operators and farm laborers benefited from the subsidy and from technological changes. Since the real*) price of rice has been declining consumers benefited the most.

Data on the changes in income share for input factor owners were presented in Table 3. The data indicated that income for laborers in relative terms remained nearly unchanged as did the income for farm operators. In absolute term income for farmers and farm laborers increased. Perhaps this indicates that technological changes and input subsidy did not have a negative effect on income distribution as a result of changes in the rural labor market reflected by an upward trend in real wages in the rural areas. (Kasryno *et al.*, 1985 and, Mazumdar and Sawit 1985).

Table 3. Changes in Income Share in Kgs of Paddy per Hectare for input Factor Owners in Java, 1976/1977-1982/1983.

	Wet Season 1976/1977	Wet Season 1982/1983
Value Added	2221.5	3513.2
Farmers:		
Family labor	402.2	610.0
Operator surplus and land	924.3(41.6)	1468.2(41.8)
Sub Total	1326.5 (59.7)	2078.2 (59.2)
Hired Labor	895.0 (40.3)	1435.0 (40.8)

Test of Profit Maximization

Estimation of the slope coefficients for three models of the Cobb-Douglas Production function are shown in Table 4. Model A is a general least square (GLS) estimator, model B is an unrestricted Zellners' seemingly unrelated regression and model C is Zellners' method with restriction on profit maximization conditions imposed. The restrictions were formulated as follow: factor share of the variable input is equal to elasticity of the input when the production function is in Cobb-Douglas type. Therefore the restriction can be written as:

a) $$\frac{WL}{P_r Q} = \beta_L$$

b) $$\frac{P_{fu} X_u}{P_r Q} = \beta_{fu}$$

*) Nominal price deflated by the consumer price index in rural Java.

c) $\frac{P_{fp} X_p}{P_r Q} = \beta_{fp}$

d) $\frac{R_{nk} X_{nk}}{P_r Q} = \beta_{nk}$

e) $\frac{R_{ntr} X_{ntr}}{P_r Q} = \beta_{tr}$

f) $\frac{Pest\ C}{P_r Q} = \beta_{pest}$

Table 4. The Slope Coefficients of the Cobb-Douglas Production Function of Rice Farming in Java Using Pooled Cross Section and time series data Wet Season 1976/1977 and Wet Season 1982/1983.

Variables		Models		
		A	B	C
1. Intercept	β_0	5.915	5.889	5.556
2. Manual labor	β_1	0.1608***)	0.1771***)	0.2510***)
		(0.0403)	(0.0389)	(0.0080)
3. Animal power	β_2	-0.0054*)	-0.0024	0.0235***)
		(0.0041)	(0.0039)	(0.0033)
4. Tractor power	β_3	0.0186**)	0.0173***)	0.0169**)
		(0.0068)	(0.0066)	(0.0066)
5. Total fertilizer (Urea + TSP)	β_4	0.1653***)	0.1516***)	0.1135***)
		(0.0206)	(0.0199)	(0.0028)
6. Pesticides	β_5	0.0345***)	0.0323***)	0.0169***)
		(0.0055)	(0.0053)	(0.0052)
7. Land	β_6	0.5993***)	0.6020***)	0.5515***)
		(0.0397)	(0.0366)	(0.0218)
8. Dummy for Season	γ_1	0.2803***)	0.2433***)	0.2634***)
		(0.0528)	(0.05113)	(0.0503)
9. Dummy for Location	γ_2	0.0833***)	0.0599***)	0.0494***)
		(0.0185)	(0.0179)	(0.0176)
	$\Sigma \beta_j$	0.9731	0.9779	0.9733
	R^2	0.845	0.757	0.735
	n	398	398	398

Notes: 1) Model A is GLS estimator.
Model B is Zellner's unrestricted seemingly unrelated regressions.
Model C is Zellner's technique with restriction imposed on profit maximization conditions.
2) Figures in parentheses are standard error of estimates.
*) Significant at 90 percent level.
**) Significant at 95 percent level.
***) Significant at 99 percent level.

where: W = manual labor wage rate

L = total labor use in hours

WL = labor cost

P_{fu} = price of Urea fertilizer per kg

X_u = the level of Urea fertilizer application

P_{fp} = price of phosphate fertilizer (TSP = triple super phosphate) per kg

X_{fp} = the level of TSP fertilizer application in kg

R_{nk} = the animal rental rates per hour

X_{nk} = animal labor use in hours

R_{ntr} = the tractor power rental rate per hour

X_{ntr} = tractor power use in hours

Pest = cost of pesticides

β_j = output elasticity of the input factor

P_r = Price of rice, and Q = Total rice output.

In the models the dummy variable D takes the value of unity for the lowland areas and for wet season 1982/83 and zero for the upland areas and for wet season 1976/77.

As can be seen in Table 4, all of the eight variables identified in the model significantly influenced rice output. About 76 to 85 percent of the variation in rice output can be explained by the variation of the factor inputs or variables identified in the above table. It is also interesting to note that output elasticity with respect to variable input was nearly 0.40 and land as a fixed factor input was still the single most important determinant of rice output. In addition, technological changes between 1976 and 1983 also contributed significantly to the increase in rice output during that period.

The most important variable factor input for rice production is labor then followed by fertilizer. About 60 percent of the variable cost was for wage payment and 25 percent for fertilizer costs and capital rental costs share about 10 percent of the total variable costs.

In Table 5 a statistical test of the relative economic efficiency of rice farming in Java is presented. The data in this table indicate that the use of fertilizer and tractor power were efficient. It is also interesting to note that manual labor use was nearly as efficient where equality between slope coefficient of labor input and labor share of the output can not be rejected at 1% level. The hypothesis of

Table 5. Statistical Test for The Relative Economic Efficiency of Rice Farming in Java Model With Total Fertilizer as Aggregate of Nitrogen and Phosphate.

Null Hypothesis	Test	Model	Computed Fort	Critical Value-at		Result
				1.0%	5.0%	
1. $H_0 .\ \beta_1 = \beta_1^*$	Profit Maximization for manual labor	B	F (1;2375) 5.186	6.63	3.84	Reject H_0 at 5% Do not Reject H_0 at 1%
2. $H_0 .\ \beta_2 = \beta_2^*$	Profit Maximization for animal labor	B	F (1;2375) 144.54	6.63	3.84	Reject H_0
3. $H_0 .\ \beta_3 = \beta_3^*$	Profit Maximization for Mechanical Power (Hand Tractor)	B	F (1;2375) 0.5453	6.63	3.84	Do not Reject H_0
4. $H_0 .\ \beta_4 = \beta_4^*$	Profit Maximization for Fertilizer	B	F (1;2375) 3.568	6.63	3:84	Do not Reject H_0
5. $H_0 .\ \beta_5 = \beta_5^*$	Profit Maximization for Pesticides	B	F (1;2375) 46.171	6.63	3.84	Reject H_0
6. $H_0 \sum_{j=1}^{5} \beta_j = 1.0$	Constant Return to Scale	B	t (2375) 1.48	2.33	1.64	Do not Reject H_0

constant return to scale cannot be rejected impling that rice farming in Java exhibits a constant return to scale of production function.

In Table 6 we present the slope coefficient of the rice farming production function where fertilizer input was disaggregated into nitrogen (in terms of urea) and phosphate (in term of TSP) fertilizer. All variables in the model except animal labor significantly influenced rice production. In Table 7 statistical tests of efficiency in rice farming are shown. The level of nitrogen and phosphate fertilizer

Table 6. The Slope Coefficients of The Cobb-Douglas Production Function of The Rice Farming in Java Using Pooled Cross-Section and Time Series Data Wet Season 1976/1977 and Wet Season 1982/1983 Model with Fertilizer disaggregated Into Urea and TSP.

Variables		Models[1) A]	B	C
1. Intercept	β_0	5.9849	6.0331	5.7845
2. Manual labor	β_1	0.1944***)	0.1751***)	0.2507***)
		(0.0409)	(0.0382)	(0.0079)
3. Animal power	β_2	-0.0043	-0.0017	0.0231***)
		(0.0041)	(0.0038)	(0.0032)
4. Tractor power	β_3	0.0186***)	0.0173***)	0.0169**)
		(0.00584)	(0.0063)	(0.0063)
5. Nitrogen fertilizer Urea	β_4	0.0862***)	0.1008***)	0.0691***)
		(0.0216)	(0.0201)	(0.0032)
6. Phosphate Fertilizer TSP	β_5	0.0465***)	0.0474***)	0.0292***)
		(0.0091)	(0.0085)	(0.0014)
7. Pesticides	β_6	0.0273***)	0.0246***)	0.0283***)
		(0.0058)	(0.0054)	(0.0050)
8. Land	β_7	0.6096***)	0.6153***)	0.5692***)
		(0.0376)	(0.0351)	(0.0213)
9. Dummy for Season	γ_1	0.2692***)	0.2068***)	0.2334***)
		(0.0528)	(0.0492)	(0.0483)
10. Dummy for Location	γ_2	-0.0741***)	-0.0306*)	-0.0282*)
		(0.0186)		(0.0168)
	$\Sigma \beta_j$	0.978	0.979	0.986
	R^2	0.847	0.685	0.660
	n	398	398	398

Notes: [1)] Model A is GLS estimator.
Model B is Zellner's unrestricted seemingly unrelated regressions.
Model C is Zellner's technique with restriction imposed on profit maximization conditions.
[2)] Figures in parentheses are standard error of estimates.
*) Significant at 90 percent level.
**) Significant at 95 percent level.
***) Significant at 99 percent level.

Table 7. Statistical Test for The Relative Economic Efficiency of Rice Farming in Java Model with Fertilizer disaggregated into Urea and TSP.

Null Hypothesis	Test	Model	Computed Fort	Critical Value-at		Result
				1.0%	5.0%	
1. $H_0 .\ \beta_1 = \beta_1^*$	Profit Maximization for manual labor	B	F (1;2771) 5.09	6.63	3.84	Reject H_0 at 5% Do not Reject H_0 at 1%
2. $H_0 .\ \beta_2 = \beta_2^*$	Profit Maximization for animal labor	B	F (1;2771) 149.67	6.63	3.84	Reject H_0
3. $H_0 .\ \beta_3 = \beta_3^*$	Profit Maximization for Mechanical Power (Hand Tractor)	B	F (1;2771) 1.3144	6.63	3.84	Do not Reject H_0
4. $H_0 .\ \beta_4 = \beta_4^*$	Profit Maximization for Urea Fertilizer	B	F (1;2771) 1.063	6.63	3.84	Do not Reject H_0
5. $H_0 .\ \beta_5 = \beta_5^*$	Profit Maximization for TSP Fertilizer	B	F (1;1392) 3.713	6.63	3.84	Do not Reject H_0
6. $H_0 .\ \beta_6 = \beta_6^*$	Profit Maximization for Pesticides	B	F (1;1392) 23.82	6.63	3.84	Reject H_0
7. $H_0\ \sum_{j=1}^{6} \beta_j = 1.0$	Constant Return to Scale	B	t (2771) 1.371	2.33	1.64	Do not Reject H_0

application and tractor power used were efficient, where the manual labor used was nearly efficient. The rice farming production function also exhibited a constant return to scale which means if we double the level of inputs used the output will also increase by nearly 100 percent.

From Tables 4 and 6 it can be clearly seen that land is still the single most important factor input for agricultural production in Java. Since availability of agricultural land in the island is very limited and there is a tendency of a decline in the supply of agricultural land because of competition with industrial and residential users, the supply of rice will most likely become very inelastic. Supply of rice in Java could only be increased through technological changes, and increase in cropping intensities. Where cropping intensities are influenced by the level of comparative advantage of rice to other Crops (i.e food crops, vegetables and fruit crops):

Table 8. Estimates of the Production Elasticities for Different Inputs for Agricultural Production.

Inputs	China	Japan	Malaysia	Taiwan	Thailand
Labor	0.26	0.28	0.18	0.44	0.30
Animal Input	—	—	0.02	0.02	0.05
Mechanical Inputs	—	—	0.04	0.00	0.07
Chemical	—	0.22	0.05	0.10	0.06
Capital	0.10	0.22	0.05	0.03	0.24
Land	0.46	0.37	0.65	0.41	0.29
Total	0.82	1.09	0.99	1.00	1.01

Source: Yotopoulus, P.A. and L.J. Law (Editors). Resource Use in Agriculture: Applications of the Profit Function to Selected Countries Food Res. Inst. Stud. XVII, No. 1, 1979.

Table 8 present estimates of production elasticities for factor inputs in agriculture for several countries. Differences in production elasticities for different countries are due to variation in resource endowment, aggregation of agricultural production in the model, and technology. For Malaysia only rice in the Muda River Basin was included, for others the commodity was anaggregation of agricultural products.

In general it can be noted that production elasticity of the variable inputs presented in Tables 4 and 6 are similar to those in Table 8. Therefore, land is the most important factor of production with production elasticity 0.60 and the elasticities are 0.25 and 0.11 for manual labor and fertilizer, respectively.

Test of Difference Slope Coefficients

In Tables 9 and 10 Slope Coefficient of two types of the Cobb Douglass production function are shown. Statistical tests indicated that both slopes of manual labor and fertilizer were similar for 1976/1977 and 1982/1983 wet seasons. Therefore, technological changes which took place were neutral. However, the marginal productivity of labor slightly increased from 0.41 kgs of gabah in 1976/1977 to 0.54 kgs of gabah in the wet season 1982/1983 and the marginal productivity of fertilizer (in terms of urea and TSP) was nearly unchanged at 1.46 kgs of gabah (Table 11).

Even though marginal productivity of labor increased from 1976 to 1983, labor use was still not yet efficient in the sense that marginal productivity of manual labor is lower than unit cost of manual labor. This was also true for animal labor use. However, the marginal productivity of power tillers was higher than rental cost of the power tiller. In real terms (in kgs. of rice equivalent) the rental

Table 9. The Slope Coefficients of the Cobb-Douglas Production of Rice Farming in Java for Pooling Cross Section and time series data (Wet Seasons 1976/1977 and Wet Season 1982/1983). Testing for difference in slope coefficient for manual labor.

Variables		Models A	Models B
1. Intercept	β_0	6.247	6.332
2. Manual labor:			
a. Wet Season 1982/83	β_{1t1}	0.1110***)	0.1328***)
b. Wet Season 1976/77	β_{1t0}	0.1333***)	0.1559***)
3. Animal power	β_2	-0.0039	-0.0021
4. Tractor power	β_3	0.0144**)	0.0141**)
5. Total fertilizer (Urea + TSP)	β_4	0.1235***)	0.1186***)
6. Pesticides	β_5	0.0403***)	0.0385***)
7. Land	β_6	0.6500***)	0.6442***)
8. Dummy for Season	γ_1	0.1094**)	0.0992**)
9. Dummy for Location	γ_2	-0.0124	-0.0017
	$\Sigma \beta_j$	1.0686	1.102
	R^2	0.866	0.732
	n	398	398

Notes: 1) Model A is GLS estimator.
Model B is Zellner's unrestricted seemingly unrelated regressions.
Model C is Zellner's technique with restriction imposed on profit maximization conditions.
2) Figures in parentheses are standard error of estimates.
*) Significant at 90 percent level.
**) Significant at 95 percent level.
***) Significant at 99 percent level.

costs of the power tiller remained nearly unchanged, where the rental cost for animal labor increased. Perhaps the failure of the labor market to equate its marginal productivity with its marginal costs was due to some institutional factors such as the existence of various type of labor contracts and arrangements. In addition, improved technology or services and the new technology that can reduce labor may not yet be available at the farm level, or available at relatively higher costs.

Table 10. The Slope Coefficient of Cobb-Douglas Production of Rice Farming in Java for Pooling Cross Section and Time Series Data (Wet Season 1976/1977 and Wet Season 1982/1983). Testing for difference in Slope Coefficient for Fertilizer.

Variables		Models	
		A .	B
1. Intercept	β_0	6.4322	6.3655
2. Manual Labor	β_1	0.1223***)	0.1380***)
3. Animal power	β_2	-0.0039	-0.0002
4. Tractor power	β_3	0.0139**)	0.0113**)
5. Total fertilizer			
a. Wet Season 1982/1983	β_{4t1}	0.1233***)	0.1189***)
b. Wet Season 1976/1977	β_{4t0}	0.1235***)	0.1201***)
6. Pesticides	β_5	0.0403***)	0.0379***)
7. Land	β_6	0.6503***)	0.6479***)
8. Dummy for Season	γ_1	0.1053**)	0.0742**)
9. Dummy for Location	γ_2	-0.01206	-0.0039
	$\Sigma \beta_j$	1.0697	1.0739
	R^2	0.866	0.7360
	n	398	398

Notes: [1] Model A is GLS estimator.
Model B is Zellner's unrestricted seemingly unrelated regressions.
Model C is Zellner's technique with restriction imposed on profit maximization conditions.
[2] Figures in parentheses are standard error of estimates.
*) Significant at 90 percent level.
**) Significant at 95 percent level.
***) Significant at 99 percent level.

The use of fertilizers and pesticides were efficient where the share of these factor inputs were similar to their output elasticity. The lower price of fertilizers as a result of price subsidy, has induced rice farmers to increase and to economize the level of fertilizer application (Table 1). The share or output elasticity with respect to land increases, indicating increase in shadow price of land. The use of land resources was not yet efficient where its value of marginal product was higher than return to land or land rent. This also reflects a high pressure on land.

Although the use of land and labor were not yet efficient, the trend indicates that it moves towards efficiency as indicated by an increase in marginal productivity of these inputs larger than the increase in their respective share between 1976 and 1983 (Table 11).

Total preharvest labor used per hectare was nearly unchanged; that is 1.050 hours in 1976 and 1.075 hours in 1983. However, the use of hired labor slightly declined from 687 hours in 1976 to 665 hours per hectare in 1983. This indicates that farmers attempted to economize the use of labor by substituting hired labor for family labor and capital.

Table 11. Value of The Marginal Product of Factor Inputs and Their Unit Costs for 1977 and 1983 in Java.

Factor Input	Value of marginal product (Kgs of "gabah")		Unit costs (Kgs of gabah)	
	1977	1983	1977	1983
1. Manual Labor (Kgs/hr)	0.41	0.54	0.98	1.13
2. Animal Labor (Kgs/hr)	2.65	6.00	12.8	17.60
3. Power teller (Hand tractor) (Kgs/hr)	—	30.04	—	18.90
4. Fertilizer (Kgs/kgs)	1.46	1.48	1.12	0.72
a. Nitrogen Fertilizer (Urea) (Kg/kgs)	1.33	1.49	1.12	0.72
b. Phosphate Fertilizer (TSP) (Kg/kgs)	1.66	1.36	1.12	0.72
5. Land (Kg/ha)	1,749.0	2,529.0	1,000	1,500

Test of Constant Returns to Scale

The hypothesis of constant returns to scale cannot be rejected. This means that if we double all the inputs, variable and fixed, simultaneously then the level of output will also be double (Tables 5 and 7). Whether there is substantial evidence of increasing returns to scale in agricultural production is an extremely important determinant of the optimum form of organization for agricultural production. The economic argument for consolidation of plots and farms will be quite strong wherever agricultural production exhibits an increasing return to scale. However, if there are constant returns to scale, land or farm consolidation will have to be argued for on other than productivity grounds such as an over all efficiency of services and linkages with other sectors of the economy; especially the industrial sector. It is possible that noneconomic considerations may be relevant in the choice of an optimum form of farm organization to achieve better living in rural areas and contribute to regional and national development.

Labor Productivity

A statistical test was also carried out to identify whether the slope coefficients for manual labor were constant over time. This hypothesis cannot be rejected. This means that the slope coefficients were the same over time. Marginal productivity of labor increased as the result of the improvement in farm technology and the increased use of capital. A previous study (Kasryno, 1984) also noted the increase in real wages in agriculture since 1978. Even though the marginal value productivity of labor is still below its unit cost, the gap is declining and efficiency in rice farming in Java is improving. Perhaps some institutional factors exist which restricts the achievement of efficiency. However, in general it can be concluded that efficiency in rice farming in Java is improving and farmers are attempting to maximize profit.

As mentioned earlier, the use of power tillers increased, while the marginal value productivity of the tiller was higher than its unit costs. In other words it was relatively cheap. The use of animal power is declining very rapidly, and the use of animals was not efficient. Therefore, the increased use of power tillers is a substitute for animal labor. The study also indicated that small farmers also hired the service of power tillers in the lowland areas. Comparing various alternatives of land preparation (i.e. manual labor, animal labor and power tiller) rental service of power tillers was the lowest among the three alternatives of land preparation (Kasryno, 1984) as can be seen in Table 12.

Both in the upland and the lowland areas the use of animal labor was declining as a result of shortages in the supply of animal labor reflected by the increase in the real rental cost of animal labor. However, the real rental cost of power tiller service was nearly unchanged (Kasryno, 1984). In the lowland areas farmers were substituting animal labor with tractor services in an attempt to reduce costs of rice

Table 12. Factor Share in Rice Production Using Three Alternative Technologist, in Kg of Gabah per Hectare, West Java 1981.

Production Factor	Tractor User		Animal Power User		Manual Labor Only	
	Kg. of gabah	(%)	Kg. of gabah	(%)	Kg. of gabah	(%)
1. Production	4127	100	4095	100	3741	100
2. Production Factor	1931	46.8	1937	47.4	1880	50.3
a. Total labor	1253	30.4	1440	35.2	1474	39.5
— Family	155	3.8	225	5.5	362	9.7
— Hired	1098	26.6	1215	29.7	1114	29.8
b. Farm inputs (seeds, fertilizer, etc.)	387	9.4	338	8.3	340	9.1
c. Capital	291	7.1	159	3.9	64	1.7
3. Land and Management (Residual)	2196	53.1	2158	52.6	1861	49.7

production. As presented in Table 1 animal labor use declined by 45 percent and average tractor use increased to 4.6 hrs per hectare in the wet season 1982/1983. There were no farmers using power tillers in the wet season 1976/1977.

In the upland villages all farmers planted nearly the same traditional local rice varieties during the two time periods, therefore the increase in rice production was the result of the increased use of fertilizer and pesticides. In Table 13 we present changes in inputs and outputs of rice farming in the upland villages. Between 1976 and 1983 in the upland villages total fertilizer application per unit of area increased by about 32 percent and the real price of fertilizer declined by 36 percent. This made fertilizer input payment per hectare in terms of rice decline from 330 kgs of gabah (rough rice) to 279 kgs of gabah or a 15 percent decline (Tables 1 and 2).

In the upland areas the average size of land owned was smaller when compared to the lowlands (Table 13 and 14), and size of rice field plots was also small, making it difficult to use the power tiller. In addition, there is no pressure from the tightness of water scheduling and it is possible for farmers to plant rice anytime of the year. In this area irrigation water is usually provided by small scale irrigation and drainage is relative good.

The increase in wage rate also reflects shortages in labor supply in rural areas as a result of improvement in employment opportunities in the other sectors of the economy. As the agricultural wage rate increases, operator surplus as a payment for management and family labor declines, and imputed wage for family labor declines. In addition the increase in rural wage rate means opportunity cost for family labor will also increase. All these factors remove advantages for small farmers.

Table 13. Changes in Input per Hectare and Output of Rice Farm In Java Wet Season 1976/1977 and 1982/1983 for Upland Areas.

Items	Wet Season		% of Changes 1976/77 to 1982/83
	1976/77	1982/83	
1. Yield (kgs of paddy/ha)	3070	3660	19.0
2. Size of land cultivated (ha)	0.350	0.390	11.0
3. Fertilizer used			
a. Urea (kgs/ha)	210	270	29
b. TSP (kgs/ha)	85	118	39
4. Labor			
a. Total labor	1345	1445	7.3
Manual labor (hrs/ha)			
Hired labor	(860)	(1075)	—
Family labor	(485)	(370)	—
b. Animal labor (hrs/ha)	12.5	10	-20
c. Tractor Power (hrs/ha)	0.0	0.0	—

The increase in the wage rate for manual labor induces the use of farm machinery. Agricultural mechanization will make land consolidation possible, through renting, leasehold, or purchase of agriculture land.

Migration of rural labor forces out of agriculture will ease pressure on land or reduce its demand, and together with the increase use of capital this will reduce the share of land rent, and marginal value product of labor will be equal to its marginal cost.

Table 14. Changes in Inputs per Hectare and Output of Rice Farm in Java Wet Season 1976/1977 for Lowland Areas.

Items	Wet Season		% of Changes 1976/77 to 1982/83
	1976/77	1982/83	
1. Yield (kgs of paddy/ha)	2430	4670	92
2. Size of land cultivated (ha)	0.610	0.625	2.5
3. Fertilizer used			
a. Urea (kgs/ha)	196	275	40
b. TSP (kgs/ha)	40	110	175
4. Labor used			
a. Total			
Manual labor (hrs/ha)	1140	1270	11
Hired labor	(815)	(960)	—
Family labor	(325)	(310)	—
b. Animal labor (hrs/ha)	12.3	6.7	-45
c. Tractor Power (hrs/ha)	0.0	4.6	—

Technological Changes

If we examine again equation (9) the intercept term will represent technological changes, improvement in soil over time, and improvement in management and skill of the farmers. Between 1976 and 1983 there was nearly no improvement in irrigation systems in the sample villages, almost all sample farmers cultivated the same piece(s) of land and the average size of cultivated land was nearly unchanged (see Tables 13 and 14). Effects of improvement in skill and management are assumed to be marginal as compared to other effects. Therefore, it is logical enough to assume that the intercept term in equation (9) will represent technological changes.

For the panel data analysis (i.e. time series on a cross section of rural households) using the Cobb-Douglas production function approach, the intercept term can be disaggregated using the dummy variable method, where dummy variables for season will represent the contribution of technological changes to the level of increase in output (see pages 6-9 for explanation).

From Tables 13-14 it can be concluded that technological changes were more rapid in lowland areas. Therefore, in the upland areas most of the increase in rice production was due to the increase in fertilizer application, labor inputs and land (Tables 13 and 14 for input changes). In the lowland areas the major contribution to the increase in rice production was due mainly to technological changes, and then the rest of factor inputs include fertilizer, labor input, farm machinery (Tables 13 and 14 for changes in factor input).

As mentioned earlier nearly all the lowland villages sample farmers planted new improved rice varieties resistant to brown planthopper. These new rice varieties were released after 1978.

It was estimated from this study (Table 4-10) that fertilizer contributed about 15.0 percent, to the increase in rice production changes in labor inputs and capital contributed about 10 percent and technological changes contributed about 65 percent. Other unexplained factors in the model such as weather, and water management contributed about 10 percent. In the uplands fertilizer contribution to the increase in production was about 15 percent, change in labor input contributed only five percent, and changes in land cultivated contributed as much as 16 percent, other inputs such as pesticides and animal power contributed about 24 percent, where technology was nearly stagnant in the upland areas.

5. Conclusion

Panel data i.e. time series of a cross-section of farm households were used in the analysis. One of the benefits of using the panel data is the ability of control unobservable individual specific effects which may be correlated with independent variables in the model. Cobb-Douglas production function analysis was used. Judging from the result of the analysis, it is clearly seen that the panel data analysis with Zellner seemingly unrelated equations method provides a useful tool for the analysis of agriculture production functions.

One central hypothesis of the economic theory of production is profit maximization behaviour on the part of the farmers. The hypothesis of profit maximization is explicitly tested.

When there is no social or institutional barriers existing that restrict market forces, the farmers behave as profit maximizers. The hypothesis of profit maximization cannot be rejected for current inputs such as chemical fertilizers and pesticides. However, the use of labor input is not yet efficient i.e. marginal value product of labor below its marginal costs. Over time the gap is declining, therefore efficiency and productivity of labor is improving. The way to economize labor use and increase labor productivity is to reduce the employment in rice production and improve farm technology by using improved farm tools and implements. It also can be concluded that for a package of technology to be implemented it should include farm mechanization. The Indonesian government has already indicated the importance of farm mechanization to be able to improve labor productivity and to reduce or eliminate drudgery (Fourth Five Year Development Planning of REPELITA IV). Ultimately cost of production can also be reduced by using appropriate farm mechanization.

In the last five years or so there has been a trend of increasing real wage rate. However the analysis noted that the marginal productivity of labor was still below its marginal cost or an indication of labor surplus. This is because there exists some institutional factors in the rural areas such as labor contracts and factor market interlinkages that put restrictions on the labor market. But, the gap between marginal productivity and marginal cost of labor declined over time. Besides, improved technology or services of the new technology that can reduce labor use, may not yet be available at the farm level, or available at higher costs.

The use of land for rice production was not yet efficient where its marginal productivity was higher than its marginal cost. With the increase in labor productivity through adoption of improved farm technology including farm machinery, land productivity tended to decline. Ultimately the gap between land productivity and its marginal cost will decline. In addition, the use of farm machinery will induce farm size to increase. The recent agricultural census (1983) indicated a decline in number of households cultivating less than 0.50 hectare of agricultural land.

Even though hypothesis of constant returns to scale can not be rejected, land consolidation will induce efficiency of labor and land. Furthermore, appropriate farm technology and farm mechanization can easily be adopted and cost of production can be reduced. With the increase in labor productivity and higher wage rate, the advantage of small farmers will disappear. Real price of rice has declined. To keep rice farming profitable the cost of production must decline. The decline in rice price will benefit consumers and farm laboring households. If efficiency of rice farming cannot be improved and cost of production cannot be reduced then producing rice becomes an unprofitable business.

The most important factor contributing to the increase in rice output is technological change, the contribution was estimated at 65 percent. Therefore the rapid increase in rice output of 6.5 percent a year between 1978 - 1983, was mainly due to technological changes, namely new improved rice varieties resistant to brown planthopper together with the increased used of chemical fertilizers. However, the estimated contribution of fertilizer was around 15 percent.

Considering the contribution of fertilizer to the level of the increase in output and output elasticity of fertilizer as relatively low, it might be reasonable to reduce or eliminate price subsidy on fertilizers. There is also an indication of a decline in the marginal productivity of fertilizer, and perhaps the high level of fertilizer application influenced quality of paddy produced.

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