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MEASUREMENT OF TOTAL FACTOR PRODUCTIVITY FOR THE MALAYSIAN RICE SECTOR

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Abstract

Our main objective in undertaking this empirical study was to investigate the sources of Malaysian rice farming growth or total factor productivity (TFP) for the 1980 - 1990 period. For this reason we established a method which made it possible for us to firstly, link the TFP analysis with the theory of production and secondly, to disentangle the sources of TFP growth into scale and technological change effects. In pursuing this objective a translog cost function, the latest methodological framework to measure production technology, was employed. The main finding of this study was that with reference to all farming classifications, the sources of TFP growth for the 1980–1990 period showed that the source from technological change effects far outweighed the source from scale effects.

1. Introduction

The Malaysian rice sector basically consists of eight granary areas, each being administered by a regional government agency. They are: the Muda Irrigation Project (MIP), the Kemubu Irrigation Project (KIP), the North-west Selangor Irrigation Project (NWSP), the

Kerian Irrigation Project (KEIP), the Trans-Perak Irrigation Project (TPIP), the Kemasin-Semarak Irrigation Project (KSIP), the Seberang Prai Irrigation Project (SPIP) and the Besut Irrigation Project (BIP). The availability of irrigation facilities have ensured that in each granary area there are two growing seasons, the main- and the off-season.[1]

While such physical facilities have played a key role in enhancing quality and quantity, other sublimal features related to its economic development need to be focused on to ensure continued prosperity in this sector. Hitherto, though quite a number of studies have been undertaken to measure the performance of the Malaysian rice sector,[2] none has attempted to measure it using an aggregated (macro-type) data. Instead, they have used a sample survey (micro-type data) taken at farm level and applied various functional forms to address several problems related to the Malaysian rice sector, for instance, the effectiveness of credit facilities extended by the government to paddy farmers (Davendra and Abdul Aziz, 1994); the effect of government policy in promoting rice self-sufficiency (Tan, 1987); the structure of rice production (Fujimoto, 1980); and the rural poverty phenomenon (Haughton, 1994). One of the objectives of the present paper is to employ a macro-type data to investigate the productivity growth among the various granary areas and between the two seasons. The advantages of using macro-type data over micro-type data, among others, are: (i) the former offers a wide opportunity for us to investigate whether among the granary areas and between the seasons there exist some common features, for instance, in terms of technological change and scale economies; and (ii) macro-type data results are very informative especially for policy makers because they can be used for policy formulation purposes, whereas micro-type data is not always so. Since this study employs macro-type data, it distinguishes itself from the previously mentioned studies and thus the results are significant in that they have implications for policy formulations.

The second objective of this paper is to undertake an empirical study of the Malaysian rice sector which explicitly exhibits the sources of total factor productivity (TFP) growth experienced by each of the granary areas and seasons. As is well known, a measurement of an individual production unit using the TFP approach provides an explanation of how output changes with respect to changes in factor inputs. If, for example, output growth shows no tendency to decline over a time period, it could be inferred that a sharp decline in the growth of factor inputs could lead to impressive productivity growth. However, as shown by Ohta (1974) and Morrison (1993), the Conventional Growth Accounting method of computing TFP is tantamount to measuring the technological change. Recent studies have shown that gains due to economies of scale together with technological change are the two major sources of TFP growth. Since this study will incorporate the two major sources of TFP growth into its analysis of the Malaysian rice sector production technology, it offers a procedure which links the analysis of TFP to that of the production theory.

The third objective of the present paper is to apply a translog cost function to measure the Malaysian rice sector's productivity growth. Since this function, as compared to the Cobb-Douglas function, offers less restrictive assumptions and the fact that this function has not been applied to measure the productivity growth for the Malaysian rice sector means that introducing this function would provide a new dimension of how this sector should be evaluated.

The paper proceeds as follows. In section 2, the measurement of TFP based on the cost function (parametric) and index number procedures is detailed. It further discusses how the two procedures are linked. Section 3 looks at the econometric specification and the sources of data while in section 4, the results of the quantity indexes of output, total input and the sources of TFP growth are reported. Section 5 concludes with a summary and the implications of the findings on policy formulations.

2. The Measurement Of Total Factor Productivity (TFP)

At the very outset it should be noted that there are various ways of measuring the total factor productivity and its sources, namely, the scale and technological change effects. They are broadly classified as: (i) index number procedure; (ii) non-parametric procedure; and (iii) parametric procedure. In this paper, our main concern is with parametric and index number procedures.

2.1 Index Number Procedure

To begin with, we denote the index of output as Y, and the rate of growth as,

$$\frac{\dot{Y}}{Y} = \sum_{i=1}^{n} N_i \frac{\dot{Y}_i}{Y_i} \tag{1}$$

where $N_i = P_i Y_i \Big/ \sum_{i=1}^{n} P_i Y_i = P_i Y_i / R$, and P_i and Y_i are respectively price and quantity of output, i.e., rice; $R = \sum_{i=1}^{n} P_i Y_i$, the total revenue; and $\dot{Y}/Y$, the rates of growth of output. We note that in order to obtain the revenue share (i.e., $P_i Y_i / R$), we have to directly measure the numerator (i.e., $P_i Y_i$) as market sales revenue plus government payments (i.e., price support) [see Ray (1982) and Glass and McKillop (1990)].

An analogous index of the quantity of total input, X, is expressed as,

$$\frac{\dot{X}}{X}=\sum_{j=1}^{m}S_j\frac{\dot{X}_j}{X_j} \tag{2}$$

where $S_j = W_jX_j \Big/ \sum_{j=1}^{m} W_jX_j = W_jX_j/C$, and W_j and X_j are respectively the price and quantity of input *j*; $C=\sum_{j=1}^{m}W_jX_j$, the total cost; and $\dot{X}_j/X_j$, the rates of growth of input *j*. These two quantity indexes may be regarded as a family of Divisia quantity indexes.

Next, we define total factor productivity, *P*, as the ratio of total output to the quantity of total input:

$$P=\frac{Y}{X} \tag{3}$$

The rate of growth of TFP ($\dot{P}/P$) is defined as,

$$\frac{\dot{P}}{P}=\frac{\dot{Y}}{Y}-\frac{\dot{X}}{X} \tag{4}$$

While formulas (1) - (4) are in terms of instantaneous changes, the data to be used in this study are gauged at yearly intervals. The most commonly used discrete approximation to the continuous formulas (1) - (4) is given by the Törnqvist approximations:

$$\Delta \ln Y = \ln(Y_T/Y_{T-1}) = 1/2\sum_{i}^{n}(N_{i,T}+N_{i,T-1})\ln(Y_{i,T}/Y_{i,T-1}) \tag{5}$$

$$\Delta \ln X = \ln(X_T/X_{T-1}) = 1/2\sum_{j}^{n}(S_{j,T}+S_{j,T-1})\ln(X_{j,T}/X_{j,T-1}) \tag{6}$$

where N_i and S_j are as defined before and *T* is time. The corresponding discrete approximation to formula (4) is given by,

$$\Delta \ln P = \Delta \ln Y - \Delta \ln X \tag{7}$$

2.2 Parametric Procedure

The characteristics of production that we intend to analyse are related to scale economies and technological change. We assume that the Malaysian rice sector is characterized by a production function satisfying the usual regularity conditions,[3]

$$Y = f(X,T) \tag{8}$$

where X is a vector of m inputs, T is time, which indicates the effect of technological change, and Y denotes output. Note that rice is produced by utilizing labour (L), machinery (M), intermediate inputs (U) and land (B) as factor inputs. Assuming that technically efficient producers act to minimize production costs at any given level of output, the dual cost function can be written as,

$$C = C(W,Y,T) \tag{9}$$

where C (.) is the cost function that defines C as the minimum cost of producing any output Y, given the vector of input prices $W = (W_L, W_M, W_U, W_B)$ and the state of technology, T.

Now, log-differentiating (9) with respect to (w.r.t.) time (T) decomposes the rate of growth of total cost into its source components:

$$\frac{\dot{C}}{C} = \left(\sum_{j=1}^{4} \frac{\partial \ln C}{\partial \ln W_j} \frac{\dot{W}_j}{W_j} \right) + \left(\frac{\partial \ln C}{\partial \ln W_j} \frac{\dot{Y}}{Y} \right) + \left(\frac{\partial \ln C}{\partial T} \right) \tag{10}$$

The variables with a dot on top denote a differentiation w.r.t. time (T). In words, the rate of growth of total cost ($\dot{C}/C$) can be expressed as the cost elasticity weighted average of rates of growth of input prices, plus the scale weighted rate of growth of output, plus the rate of cost diminution due to technological change.

Applying Shephard's lemma to the logarithmic partial derivative appearing in (10), we obtain the following relations:

$$\sum_{j=1}^{4}\frac{\partial lnC}{\partial lnW_j}=\sum_{j=1}^{4}\frac{X_jW_j}{C}=\sum_{j=1}^{4}S_j=1 \qquad (11)$$

where $S_j = X_jW_j/C$ denotes the cost share of the j^{th} input. Next, we define the elasticity of cost w.r.t. output (Y), ε_{cy} as,

$$\frac{\partial lnC}{\partial lnY}=\frac{\partial C}{\partial Y}\frac{Y}{C}=\varepsilon_{cy} \qquad (12)$$

Equation (12) is used in this study as an indicator to measure the returns to scale. The ε_{cy} indicates increasing returns to scale, constant returns to scale, or decreasing returns to scale accordingly, as $\varepsilon_{cy} < 1, \varepsilon_{cy} = 1$, or $\varepsilon_{cy} > 1$.

We define λ as the rate of growth of cost diminution,

$$\frac{\partial lnC}{\partial T}=-\lambda \qquad (13)$$

By collecting (11), (12) and (13), and then substituting them into (10), we obtain,

$$\frac{\dot{C}}{C}=\left(\sum_{j=1}^{4}S_j\frac{\dot{W}_j}{W_j}\right)+\left(\varepsilon_{cy}\frac{\dot{Y}}{Y}\right)-\lambda \qquad (14)$$

Finally, by differentiating total costs, $C=\sum_{j=1}^{4}W_jX_j$, w.r.t. time (T), and dividing by C and rearranging, we obtain,

$$\sum_{j=1}^{4}S_j\frac{\dot{W}_j}{W_j}=\frac{\dot{C}}{C}-\sum_{j=1}^{4}S_j\frac{\dot{X}_j}{X_j} \qquad (15)$$

2.3 The Linkage

Having equations (1) - (4) and (9) - (15) at our disposal, we can now establish a "link" between the index number and parametric procedures. This is done to cross-check the consistency of TFP measurement between the two procedures. By substituting (14) into (15) and rearranging, we obtain,

$$\varepsilon_{cy}\frac{\dot{Y}}{Y} - \lambda - \sum_{j=1}^{4} S_j \frac{\dot{X}_j}{X_j} = 0 \tag{16}$$

Subsequently, substituting (2) into (16) yields,

$$\varepsilon_{cy}\frac{\dot{Y}}{Y} - \lambda - \frac{\dot{X}}{X} = 0$$

or

$$\lambda = \varepsilon_{cy}\frac{\dot{Y}}{Y} - \frac{\dot{X}}{X} \tag{17}$$

A comparison between equations (4) and (17) reveals that, under the assumptions of constant returns to scale (i.e., ε_{cy}=1), efficient and optimizing producers, Hick's-neutral type technical change and no measurement errors, the rate of change in TFP (i.e., $\dot{P}/P$) equals the rate of technological change or shift of the production function (i.e., λ). That is:

$$\frac{\dot{P}}{P} = \frac{\dot{Y}}{Y} - \frac{\dot{X}}{X} = \lambda \tag{18}$$

However, if we assume that one of the conditions above does not exist, that is, the technology does not exhibit constant returns to scale (i.e., $\varepsilon_{cy} \neq 1$), then the index number procedure cannot be used to estimate the rate of technological change. This is because the methodology cannot account for the measurement of rate of returns to scale. On the contrary, the parameteric procedure can still serve the purpose as before. Nevertheless, it can be explicitly shown that if the two procedures are linked, a validation concerning the consistency of measuring the TFP growth between them is possible. That is to say, in the presence of the scale effects, the two procedures will come-up with the same TFP value. This can be done by substituting $\dot{P}/P = \dot{Y}/Y - \dot{X}/X$ [(i.e., equation (4)] into equation (17) and rearranging:

$$\frac{\dot{P}}{P} = \left(1 - \varepsilon_{cy}\right)\frac{\dot{Y}}{Y} + \lambda, \qquad (19)$$

where λ is as defined in equation (17). This equation suggests that if the scale effects are present (i.e., $\varepsilon_{cy} \neq 1$), then $\dot{P}/P$ (estimated by index number procedure) equals $\dot{Y}/Y$ (estimated by index number procedure) weighted by (1- ε_{cy}) i.e., estimated by parametric procedure, plus λ [estimated by parametric procedure via equation (17)].[4] Henceforth, equation (19) will be used as the basis to measure the TFP growth and its two major components, namely, the scale and technological change effects, of the Malaysian rice sector.

3. Econometric Specification and Data Sources

3.1 The Translog Cost Function

The translog specification of the generalized cost function as given in equation (9) is,

$$
\begin{aligned}
\ln C = {} & \alpha_0^{rl} + \sum_{j=1}^{4} \alpha_j^{rl} \ln W_j^{rl} + \alpha_Y^{rl} \ln Y^{rl} + \alpha_T^{rl} T^{rl} \\
& + \tfrac{1}{2} \sum_{j=1}^{4} \sum_{k=1}^{4} \gamma_{jk}^{rl} \ln W_j^{rl} \ln W_k^{rl} + \tfrac{1}{2} \gamma_{YY}^{rl} (\ln Y^{rl})^2 \\
& + \sum_{j=1}^{4} \gamma_{jT}^{rl} \ln W_j^{rl} T^{rl} + \sum_{j=1}^{4} \delta_{YT}^{rl} \ln W_j^{rl} \ln Y^{rl} \\
& + \delta_{YT}^{rl} \ln Y^{rl} T^{rl} + \tfrac{1}{2} \gamma_{TT}^{rl} (T^{rl})^2
\end{aligned} \tag{20}
$$

where r = 1, 2, 3, 4, and denote the granary areas under survey; l = 1, 2, and denote the main season and off-season, respectively; with other subscripts remaining as they were before.

The cost-share S_j^{rl} is derived through Shephard's lemma as,

$$S_j^{rl} = \alpha_j^{rl} + \sum_{k=1}^{4} \gamma_{jk}^{rl} \ln W_k^{rl} + \delta_{jY}^{rl} \ln Y^{rl} + \gamma_{jT}^{rl} T^{rl} \tag{21}$$

For any cost function to be sensible, it must satisfy the linear homogeneity in input prices which requires:

$$\sum_{j=1}^{4} \alpha_j^{rl} = 1, \ \sum_{j=1}^{4} \gamma_{kj}^{rl} = \sum_{k=1}^{4} \gamma_{jk}^{rl} = 0, \ \sum_{j=1}^{4} \delta_{jY}^{rl} = 0 \tag{22}$$

Additional regularity conditions which the cost function must satisfy in order to correspond to well-behaved production technology are monotonicity and concavity in factor prices. Adequate conditions for these to hold are positive fitted cost shares (α_j^{rl}) and negative semi-definiteness of the bordered Hessian of the cost function.

For econometric estimation, the cross-equations equality and the linear homogeneity restrictions defined in (22) are imposed a priori on the translog cost function (20), and on the cost-share equations (21) This allows us to drop arbitrarily any one of the four cost-share equations. In this study, the cost-share equation of land was omitted. The estimates of the coefficients of this equation are obtainable by using the parameter relationship of the linear homogeneity restrictions, once the system of the remaining cost-share equations has been estimated. Given this set of conditions, we chose as the estimation method the Iterative Seemingly Unrelated Regression (ISUR).

The cost elasticity is defined as $\varepsilon_{cy} = \partial lnC/\partial lnY$, and if it is applied to equation (20), it will give,

$$\varepsilon_{cy} = \partial lnC/\partial lnY = \alpha_Y^{rl} + \gamma_{YY}^{rl} lnY^{rl} + \delta_{Yj}^{rl} lnW_j^{rl} + \delta_{YT}^{rl} T^{rl} \qquad (23)$$

From equation (23), we can obtain information on returns to scale. If $\alpha_Y^{rl} = 1, \gamma_{YY}^{rl} = 0$ and $\delta_{Yj}^{rl} = 0$ ($j= L, M, U, B$), then $\varepsilon_{cy} = 1$, which signifies constant returns to scale. If, however, $\alpha_Y^{rl} > 1$ or $\alpha_Y^{rl} < 1$ then $\varepsilon_{cy}>1$ or $\varepsilon_{cy} < 1$, signifying decreasing returns to scale or increasing returns to scale, respectively.

Since this paper will base much of its discussion on the measurement of returns to scale and technological change which are the two major sources of TFP growth, three statistical hypotheses concerning the production structure of the Malaysian rice sector will be tested using the Wald-Chi square test method. They are homotheticity, Hick's neutrality and constant returns to scale.

If the primal production function is homothetic, then the dual cost function can be written as $C = F(Y, T) \,.\, H(W, T)$. This implies the existence of the following set of restrictions on the translog cost function (20): $\delta_{iY}=0$ ($i = L, M, U, B$), signifying that the changes in output level do not have any effect on the cost shares.

If the production function is characterized by Hicks-neutral technological change, the corresponding dual cost function can be written as $C(Y, W, T) = A(T) . f(Y, W)$. This implies the following set of parameter restrictions on the translog cost function: $\delta_{YT} = \gamma_{iT} = 0$ ($i = L, M, U, B$).

Finally , if the primal production function exhibits constant returns to scale, then the cost function can be written as $C(Y, W, T) = Y. H(W, T)$. This implies the following set of parameter restrictions on the translog cost function (20): $\alpha_Y = 1$, $\gamma_{YY} = \delta_{Yi} = \delta_{YT} = 0$ ($i=L,M,U,B$).[5]

3.2 Data Sources

The main sources of data used for the analysis of the study were the published statistics and reports by the development authority of each granary area development authority. The variables required to estimate the cost function model were the total cost, the quantity of output, and the prices and cost-shares of the four factors of production, namely, labour (*L*), machinery (*M*), intermediate inputs (*U*) and land (*L*). We processed the collected data for each granary area and season according to the variable requirements where the basis of such variables indexes computation is the Christensen, Caves and Diewert (1982) procedure. The advantage of using this procedure is that it allows us to extend the Törnqvist approximation method of the Divisia index to the multilateral data and time series of cross-section data. A detailed explanation on how the data were generated is given in Appendix 1.

4. Empirical Results

The result of parameter estimates of the specified translog cost function (20) is reported in Table 1. The R^2 adjusted for degrees of

Table 1: Parameter Estimates of the Translog Cost Function for Malaysian Rice Farming, 1980-90 (with regional dummy)

Coefficient	Estimate	*t*-ratio	Coefficient	Estimate	*t*-ratio
α	3.477	140.287	γ_{LU}	0.447	6.290
α_L	0.342	75.802	γ_{LB}	-0.251	-2.555
α_M	0.131	24.860	γ_{MU}	0.006	0.033
α_U	0.258	65.591	γ_{MB}	0.095	0.507
α_B	0.269	12.133	γ_{UB}	0.024	0.115
α_Y	0.905	41.465	γ_{LT}	-0.029	-4.310
α_T	-0.028	-0.966	γ_{MT}	0.006	0.795
γ_{LL}	-0.348	-4.172	γ_{UT}	0.017	2.256
γ_{MM}	-0.252	-1.351	γ_{BT}	0.005	0.198
γ_{UU}	-0.478	-2.373	δ_{YL}	-0.006	-1.108
γ_{BB}	0.130	0.751	δ_{YM}	0.039	5.790
γ_{YY}	-0.221	-6.377	δ_{YU}	-0.041	-7.794
γ_{TT}	-0.025	-0.445	δ_{YB}	0.008	0.046
γ_{LM}	0.151	1.767	δ_{YT}	-0.088	-3.325
β_D	1.029	2.639	β_{DY}	-0.782	-3.307
β_{DM}	0.110	0.032	β_{DU}	0.843	0.189
β_{DL}	-0.734	-0.468	β_{DT}	-0.067	-0.365

Note: Coefficients for land (*B*) were obtained using the parameter restrictions of linear homogeneity. Coefficients with subscript D indicate that the regression was done using regional dummies.

Estimating Equations	$\bar{R}^2$
Cost Function	0.96
Labour share equation	0.86
Machinery share equation	0.62
Intermediate inputs equation	0.57

freedom for the cost function and the three cost-share equations, namely, labour, machinery and intermediate inputs, were 0.96, 0.86, 0.62 and 0.57, respectively, indicating a fairly good measurement of goodness of fit for the model. The test statistics results for the three hypotheses concerning the production technology of the Malaysian rice sector are as follows: the computed Chi-square statistics for homotheticity, Hick's neutrality and constant returns to scale (with degrees of freedom 3, 3 and 5, respectively) were 54.0, 14.1 and 219.5, and the three hypotheses were strongly rejected at 5% significance level.

The regularity conditions such as: (i) linear homogeneity in input prices; (ii) positive and monotonically increasing in input prices; and (iii) concavity in input prices, were all checked and satisfied by the model. The first condition, which requires a restriction on its parameters, as shown by equation (22) is satisfied by the model. This is indicated in Table 1 by $\sum_{j=1}^{4} \alpha_j = 1$.

The second condition which requires $S_j = \partial lnC/\partial lnW_j \geq 0$ is also satisfied by the model. As can be seen from Table 1, all α_j (estimated at the approximation point), where $j = L, M, U, B$, are all positive. Finally, the third condition, which requires the Hessian matrix of second partial derivatives with respect to factor prices be negative semidefinite, was checked and satisfied by the model. Since the model satisfies all the fundamental regularity conditions, we conclude that the estimated cost function represents well-behaved production technology.

4.1 Quantity Indexes of Total Input, Output and TFP[6]

For reference purposes, we present in Table 2 a complete set of quantity indexes of total input (X) and output (Y) of each granary

Table 2: Quantity Indexes of Total Input (X) and Output (Y) for the Malaysian Rice Sector, 1980-90

Sample No.	Year	X	Y	Sample No.	Year	X	Y
1	1980	48.62	34.91	45	1980	75.46	87.72
2	1981	67.82	69.23	46	1981	56.55	66.53
3	1982	77.44	63.66	47	1982	73.62	73.13
4	1983	79.76	58.81	48	1983	13.18	11.87
5	1984	80.39	76.82	49	1984	65.04	63.93
6	1985	63.52	56.33	50	1985	63.51	72.68
7	1986	75.53	67.71	51	1986	50.12	49.04
8	1987	73.96	67.03	52	1987	70.43	66.58
9	1988	77.83	70.96	53	1988	25.53	19.28
10	1989	82.51	97.53	54	1989	70.53	88.12
11	1990	79.63	92.95	55	1990	66.29	95.75
12	1980	56.95	39.39	56	1980	60.72	58.35
13	1981	57.63	44.28	57	1981	68.02	77.36
14	1982	72.98	69.97	58	1982	65.12	84.71
15	1983	43.88	26.11	59	1983	78.18	74.38
16	1984	78.80	65.95	60	1984	66.95	72.52
17	1985	70.29	63.64	61	1985	63.20	79.11
18	1986	44.49	36.66	62	1986	76.60	67.51
19	1987	74.48	64.79	63	1987	71.11	74.34
20	1988	76.00	68.87	64	1988	88.78	102.67
21	1989	75.08	77.76	65	1989	83.49	111.31
22	1990	81.80	82.98	66	1990	84.23	115.53
23	1980	101.61	100.11	67	1980	75.96	77.05
24	1981	106.95	100.37	68	1981	71.50	65.33
25	1982	104.65	90.62	69	1982	59.80	56.33
26	1983	98.73	53.41	70	1983	65.93	60.83
27	1984	100.39	98.63	71	1984	61.70	72.30
28	1985	103.09	92.68	72	1985	79.89	83.77
29	1986	102.62	94.52	73	1986	78.95	81.15
30	1987	99.25	93.93	74	1987	86.56	89.87
31	1988	103.75	90.77	75	1988	84.28	72.10
32	1989	101.86	102.88	76	1989	69.19	69.34
33	1990	102.15	112.94	77	1990	73.55	69.18
34	1980	92.02	113.67	78	1980	68.75	50.14
35	1981	100.57	111.15	79	1981	58.66	55.52
36	1982	99.79	81.90	80	1982	30.15	25.21
37	1983	86.33	78.02	81	1983	31.60	34.20
38	1984	82.25	75.52	82	1984	50.69	58.23
39	1985	91.43	102.02	83	1985	63.57	64.48
40	1986	96.40	96.35	84	1986	51.23	57.05
41	1987	82.89	66.33	85	1987	75.98	79.18
42	1988	94.29	82.16	86	1988	64.42	55.08
43	1989	94.97	97.51	87	1989	49.14	46.56
44	1990	96.40	107.14	88	1990	52.71	53.93

Note: The overall sample size is 88 which consisted of 11 observation years, 4 granary areas and 2 seasons. The benchmark for the initial and terminal years was 1980 and 1990, respectively. We arranged the data sets in the following order:

Sample No.	Year	Granary Area	Season	Farming Classification
1-11	'80-'90	NWSP	Main season	New Project
12-22	'80-'90	NWSP	Off season	New Project
23-33	'80-'90	MIP	Main season	Old Project
34-44	'80-'90	MIP	Off season	Old Project
45-55	'80-'90	KIP	Main season	Old Project
56-66	'80-'90	KIP	Off season	Old Project
67-77	'80-'90	KEIP	Main season	New Project
78-88	'80-'90	KEIP	Off season	New Project

X = index of total input; Y = index of output

Figures 1(a) and 1(b): Index of TFP for Malaysian Rice Sector

Figure 1(a): Main Season

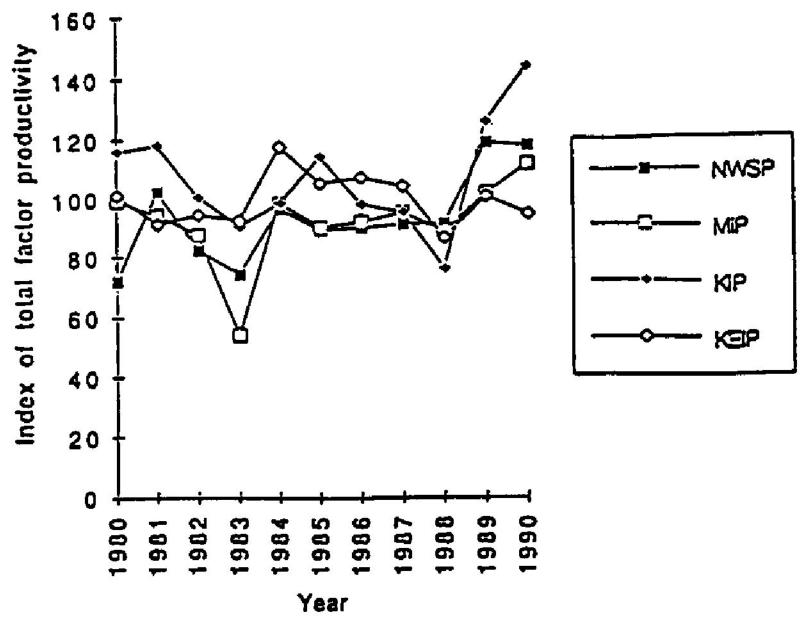
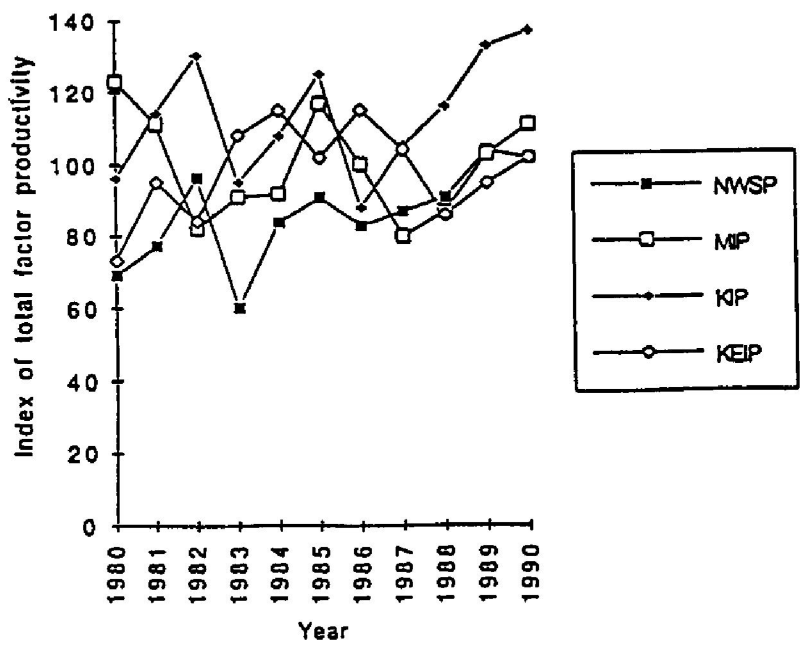


Figure 1(b): Off Season



area and the two seasons computed based on the C-C-D (1982) procedure. As for the index of total factor productivity, the results are presented in Figures 1(a) - main season and 1(b) - off season. As can be seen from Figure 1(a), except for a few observations, the period between 1984 and 1987 shows that the index of total factor productivity of all the granary areas was fairly stable. Then, in 1988 through 1990, the index shows an increasing trend. The reason behind such TFP index movements can be associated with the launching of the National Agricultural Policy (NAP) in 1984. In the NAP policy guidelines, the government has reaffirmed its commitment to further develop the rice sector by, among others: improving the water and irrigation facilities; introducing new high yielding varieties; and increasing the crop intensity. These factors might have influenced the level of rice productivity.

A closer look at Figure 1(b) shows that, except for 1987, there is not any specific trend for TFP index among the granary areas in the 1980-90 period. This was due to the unconducive weather conditions (i.e., drought) which led to the shortage of water supply from the dam to the paddy fields in all the granary areas. This has resulted in a significant reduction in the areas planted with paddy and consequently the rice productivity also fell. The implication of such a phenomenon will be discussed in more detail in section 4.4.

4.2 Decomposition of Total Factor Productivity

As shown in Table 3, there are two methods of computing the TFP growth. They are: (i) $\dot{TFP}^a$, which was computed using the Törnqvist index number procedure via equation (4); and (ii) $\dot{TFP}^b$, which was computed using the parametric procedure via the right-hand side of equation (19). It is interesting to note that, if a comparison

Table 3: Sources of TFP Growth for Malaysian Rice Farming*

(Unit: %)

Farming** Classifications	$(1-\varepsilon_{CY})$ (1)	$(1-\varepsilon_{CY})\dot{Y}/Y$ (2)	λ (3)	$\dot{TFP}^a$ (4)	$\dot{TFP}^b$ (5)=(2)+(3)
Old Project	0.11	0.37 (24.7)***	1.13 (75.3)	1.50	1.50 (100.0)
New Project	0.24	1.03 (46.4)	1.19 (53.6)	2.22	2.22 (100.0)
Main Season	0.12	0.29 (23.6)	0.94 (76.4)	1.23	1.23 (100.0)
Off Season	0.06	0.21 (14.0)	1.29 (86.0)	1.50	1.50 (100.0)
Average	0.10	0.29 (21.2)	1.08 (78.8)	1.37	1.37 (100.0)

Note: * The computation of average annual growth rate of output ($\dot{Y}/Y$) was done by fitting $ln\ Y = k + qT$, where Y is the Törnqvist index of output; T is the index of time; and k and q are parameters to be estimated. The same procedure was applied to compute the average annual growth rate of total input ($\dot{X}/X$).

** See note (1) and Table 2 for a detailed explanation regarding the farming classifications and how the data sets were arranged.

*** Figures in the parantheses are the sources of TFP growth rate; the scale and technological change effects, measured in percentage (%). The former was computed by dividing (2) by (5), and the latter was computed by dividing (3) by (5).

λ was computed using equation (17).

TFP[a] was computed using equation (4).

TFP[b] was computed using the right hand side of equation (19).

between the first procedure (column 4) and the second procedure (column 5) is made, the computed TFP growth would be equal. In the case of the New Project, for example, the values of $\dot{TFP}^a$ and $\dot{TFP}^b$ were 2.22%. The result tends to suggest that the two procedures are equivalent and that each serves as complementary to the other. In other words the measure of TFP growth derived from the index number procedure can be said to have captured the technological change and scale effects. But, to what extent is the actual contribution of each to TFP growth is not explicitly known. Nevertheless, the parametric procedure, which as mentioned above serves as a complementary to index number procedure, can be used to decompose as well as to distinguish the actual contribution of each effect to TFP growth. For example, using the parametric procedure (i.e., $\dot{TFP}^b$), the TFP growth of the New Project can be decomposed into scale and technological effects. While the former effect contributed 1.03%, the latter contributed 1.19% to TFP growth. The sum of the two effects is 2.22% which is equal to the estimated value of TFP growth using index number procedure (i.e., $\dot{TFP}^a = 2.22\%$).

4.3 Scale Effects

Total factor productivity (TFP), which measures the real resource cost of producing a unit of output, is positive for all farming classifications with the New Project being the highest achiever. The TFP growth of the Malaysian rice sector for the 1980-1990 period together with its sources is shown in Table 3. The sources, namely, the scale and technological change effects, were computed using equation (19). Table 3 shows that the average productivity growth for the Malaysian rice sector is 1.37% of which 1.08% comes from the technological change effect and the remaining 0.29% comes from the scale effect. The scale economies, defined as 1 - ε_{CY}, is positive for every farming classification for the 1980-90 period. This suggests that the underlying production technology of the Malaysian rice sector exhibits an increasing returns to scale. The result is obviously at variance with that of Zaleha and Ariff (1986). Their finding suggests that the Malaysian rice sector is subject to decreasing returns to scale. To be more precise, our finding tends to suggest that the ε_{CY} of 0.9 for Average farming classification means, on average, a 1% increase in output resulted in a 0.9% increase in total cost. Thus, the positive value of 1 - ε_{CY} of each farming classification also suggests that they could further exploit the scale economies through expansion of the size of its operation. Judging by the smallness of ε_{CY} among the farming classifications, it seems that there is still much room for farmers in the New Project to expand their farm size as compared to others. The ε_{CY} for this farming classification which is only 0.76 implies that a 1% increase in output resulted in a 0.76% increase in the total cost.

Perhaps, with this finding, Tan's (1987, p. 33) remark that, "According to MIP experts, yields have reached their maximum under the present state of technology," seems to be erroneous.

4.4 Technological Change Effects

The estimates of gains due to the technological change effects of all farming classifications were computed using equation (17). As presented in Table 3, the technological change (λ) of all farming classifications is positive. This implies that the adoption of new cultivation techniques is taking place in all granary areas and during both seasons. A closer scrutiny, however, shows that it is relatively more rapid in the Off Season (1.29%) than in the Main Season (0.94%).

A similar comparison shows that it is more rapid in the New Project (1.19%) than in the Old Project (1.13%), though the difference is fairly small.

The positive technological change effects of all farming classifications could have resulted from the following factors: (i) Machinery, especially tractors of smaller capacity meant for paddy cultivation, was widely introduced during the 1980-1990 period. According to MARDI Report no.131 (1990), the number of imported tractors sold by local dealers in the years 1982, 1983, 1984, 1985 and 1986 were significant, i.e., 440, 266, 379, 535 and 935 units, respectively. (ii) Government-supported output price from time to time shows an increasing trend. Starting from RM 33.00 per metric ton before 1980, the price support has since then increased twice, in 1980 and again in 1990, where the rate was set at RM 165.00 and RM 247.50 per metric ton, respectively. Due to immediate monetary gains, this policy seemed to have encouraged farmers to produce more rice and thus enabled them to adopt new farming techniques. (iii) During this period, a better technique for planting seeds was introduced, initially in NWSP before being gradually adopted by farmers in other granary areas. This so-called "direct seeding" technique has gradually replaced the older "transplanting" technique, mainly through "demonstration effects". Whereas the latter technique is generally known to be labour-intensive, the former is labour-saving (in terms of man-hours) and thus a cost-saving technique. Thus, combined together, these three factors have contributed to the downward shift of the cost curve of all farming classifications.

4.5 Relative Contributions of Scale and Technological Change Effects

Table 3 also provides information on the relative contributions of the scale and technological change effects to the TFP growth. They are measured in terms of percentage (%). As evident from the table, if the contributions of the scale and technological change effects to the TFP growth are compared, with the exception of the New Project, the former's contribution is found to be relatively smaller. It is in the range of 14 - 25% with the Off-Season's being the smallest. The reason for the relatively small contribution of scale effects of the Off-Season to TFP growth can be attributed to the shortage of water supply from the dam to the paddy fields of all the granary areas (as discussed in section 4.1). This has resulted in a significant reduction in the paddy planted areas of each granary area during the 1980-90 period. It occured twice in every granary area: NWSP (1983 and 1986), MIP (1983 and 1984), KIP (1983 and 1988) and KEIP (1982 and 1983). As a remedy, a new seeding culture which can grow in dry soil conditions was introduced. The advantage of this technique is that it requires less water and thus the field will dry quickly. Since this makes the soil more compact, it permits the use of harvesters during the harvesting season. Hence, it can be said that the dry seeding culture is a machinery-dependent and labour-saving technique.

To sum up, as it appears in Table 3, we may conclude that the Malaysian rice sector's major source of TFP growth for the 1980-90 period can be attributed to the technological change effect.

5. Summary and Policy Implications

Our main objective in undertaking this empirical study was to measure the total factor productivity (TFP) growth and its sources for the Malaysian rice sector for the 1980-1990 period. To this end, we used two different procedures to measure the TFP growth.

The major findings of this study may be summarized as follows:

(i) The average productivity growth for the Malaysian rice sector was 1.37% of which 1.08% was contributed by the technological change effect and 0.29% by the scale effect.

(ii) The result of the empirical analysis suggests that the production technology of the Malaysian rice sector for 1980-1990 period was bound by increasing returns to scale. This implies that an expansion of the farm size operation is still possible.

The second finding provides a strong basis for us to believe that Malaysian rice farmers can further expand the size of their farm operations. As implied by the production technology which was bound by increasing returns to scale, a 1% increase in output will result in less than 1% increase in total cost. Judging from this fact, it seems plausible for the government to confidently proceed with its policy of consolidating the rice farms into mini-estates, as is currently being implemented in the North-West Selangor Project. Since the formation of mini-estates initiated by the government is on a voluntary basis, i.e., those who have small plots of land are encouraged to join forces to form larger-sized farms such that economies of scale can be derived, legal implications which might otherwise require the present land laws to be revised, do not arise.

End Notes

1. In this study however, we will focus our attention on the first four granary areas which together account for more than 70% of the rice cultivated areas in Malaysia and 75% of Malaysia's total rice production. We would also like to point out that we have segregated the granary areas under observation and seasons into the following farming classifications: (i) Old Project (OP) which comprises MIP and KIP. 'Old' refers to the year in which irrigation schemes were initially introduced. In the case of these two areas, the schemes were introduced in the late 1960s; (ii) New Project (NP) which refers to NWSP and KEIP whose irrigation facilities were expanded by the government in the late 1970s; (iii) Since whether paddy can be cultivated depends very much on

the water supply, in the Main Season (MS), it was mainly dependent on the rain; (iv) Unlike the MS, paddy planted in the off-season (OS) mainly relies on water from the man-built dam which flows along the irrigation canals.

2. For example (Haughton,1986), (Brown,1973), (Barnum and Squire, 1978, 1979), (Huang, 1975), (Zaleha and Ariff, 1986), (Singh, Squire and Strauss, 1986), (Goldman and Squire, 1982) and (Mokhtar 1979).

3. For a detailed discussion on regularity conditions, see for example, Binswanger (1974).

4. The way in which this was computed is similar to that of Kwon (1986).

5. If the null hypothesis of homotheticity is rejected, it implies that the changes in output level (or scale) affect the cost shares. If the null hypothesis of Hick's neutrality is rejected, it implies the biased impacts of technological change on relative uses of factor inputs. Finally, if the null hypothesis of constant returns to scale is rejected, it implies that economies (diseconomies) of scale exist in the rice production.

6. In the true sense of the word, factor markets of the Malaysian rice sector are not all competitive. In particular, labour and land are not competitive. Therefore, the computed results of TFP obtained here might cause some biases. The degree and direction of the biases resulting from this estimation can be estimated using a method which allows us to compute the shadow values of labour and land (Naziruddin, Kubo and Kuroda, *Asian Economic Journal*, forthcoming). The results can be compared with the actual wage rates and land prices to know the extent of the bias.

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APPENDIX I

Data Generation

The variables required to estimate the cost function are the total cost, the revenue, the quantity of output, the prices and the cost shares of the four factors of production, namely, labour, machinery, intermediate inputs and land.

Quantity and Price Indexes of Output

The revenue was computed by multipyling the price of per ton of paddy sold to either the National Rice Board Authority or private rice millers or wholesalers, with the total production of each farming area. The quantity and price indexes of output (Y and P) were computed using the price and quantity data as reported by the respective farming area authority.

Quantity and Price Indexes of Factor Inputs

The cost of labour input ($W_L X_L$) was obtained in the following manner. The expenditures incurred by each farming area on paying labour services (family and hired labours) were multiplied by the cultivated paddy land of each farming area. The data related to the expenditures and cultivated paddy land were extracted from the annual reports of the respective farming area, namely, Muda Irrigation project (MIP), North-West Selangor Project (NWSP), Krian Irrigation Project (KEIP) and Kemubu Irrigation Project) KIP. This and other factor input costs were expressed in millions of Ringgit Malaysia (RM) per season. The quantity and price indexes of labour input (X_L and W_L) were computed using the price and quantity data of labour.

The cost of intermediate input ($W_U X_U$) was defined as the sum of the expenditures on fertilizers, seeds, agri-chemicals and irrigation costs. The quantity and price indexes (X_U and W_U) of this input were computed using the data set of the expenditures or prices of the four components of the factor input as reported by the respective farming area authority.

Most Malaysian rice farmers do not possess for themselves either a unit of tractor or harvester to do the jobs of ploughing or harvesting. They resort to either private individuals or the Farmers' Organization Cooperatives to acquire ploughing and harvesting services. Under such circumtances, we computed the quantity and price indexes of machinery based cn the user cost concept. The cost of machinery input ($W_M X_M$) was defined as the sum of the expenditures on harvesting and ploughing per hectare of cultivated paddy land. To obtain the total cost of machinery, this value was then multiplied by the total cultivated paddy land of each farming area. The quantity and price indexes for machinery (W_M and X_M) were obtained using the data set of the expenditures of the two components of the input as reported by each farming area authority.

The cost of land input ($W_B X_B$) was obtained as follows. The paddy cultivated areas of each farming area were multiplied by the rental rate of per hectare of paddy land. This gave rise to the definition of total cost of land. The quantity and price indexes of land (X_B and W_B) were computed for each farming area using the data set of the expenditures on the input as reported by each farming area authority.

All variables were transformed into multilateral indexes using the Caves-Christensen-Diewert (1982) method. This method is an extension of the Törnqvist approximation method of the Divisia index to multilateral data and time series of cross-section data.