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Measuring Malaysian Rice Farming Sources of Growth 1980-90: A Translog Cost Function Approach

by

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Measuring Malaysian rice farming sources of growth, 1980-90: a translog cost function approach

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Abstract

Our main objective in undertaking this empirical study was to investigate the sources of Malaysian rice farming growth for the 1980-1990 period. For this reason we established a method which made 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 pointed to the fact that, with the exception of NEW PROJECT, Malaysian rice farming sources of TFP growth for 1980-90 period was that: the source from scale effects outweighed the source from technological change effects.

1. Introduction

Malaysian rice farming is mainly composed of eight (8) granary areas, each being administered by a respective regional government agency. They are; MADA, KADA, NWSP, KSMP, TRANS-PERAK, KEMASIN-SEMERAK, SEBERANG PRAI and BESUT. In each granary area there are two growing seasons, the main- and off-seasons.[1]

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* While my intellectual understanding of production theory was developed by Professor Yuji Kubo, i.e., when I participated in his 1993 summer seminar, my empirical work ability was largely developed by Professor Yoshimi Kuroda, i.e., by virtue of his close supervision and guidance from October 1993 until now. Indeed, I am grateful to both of them. My thanks are due to Dr. Lee Yong-Sun for his insightful advice and time. This paper appears to be in its present form due to their constructive comments and suggestions. Nonetheless, the remaining errors, if any, rest solely on me.

[1] However, in this study we will focus our attention on the first four (4) granary areas which together accounts for more than 80% of Malaysian rice planted area and 85% of Malaysian total rice production. We also note that we divide the observed granary areas and seasons into the following farming classifications: (i) Old Project (OP). It comprises of MADA and KADA. 'Old' refers to the year in which irrigation schemes were initially introduced. In the case of these two areas, the schemes were intoduced in the late 1960s. (ii) New Project (NP). This refers to NWSP and KSMP whose irrigation facilities were extended by the government in the late 1970s. (iii) Main Season (MS). How paddy is being cultivated depends very much on the means of water supply. In MS case it was rain-fed. (iv) Off Season (OS). Unlike MS, paddy planted in OS relies on water from the man-built dam which flows along the irrigation canals.

Hitherto, though quite a number of studies have been undertaken to measure the performance of Malaysian rice farming,[2] none have attempted measuring it using an aggregated (macro-type) data. Instead, they use a sample survey (micro-type data) taken at farm level and apply various functional forms to address several problems related to Malaysian rice farming; 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). 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 or not among the granary areas and between seasons there exist some common features, say in terms of technological change and scale economies. (ii) While macro-type data's results are very informative especially for policy makers because they can be used for policy formulation purposes, micro-type data's are not always. Since this study employs macro-type data, naturally it distinguishes itself from the previously mentioned studies and at the same time the results carry some policy implications.

Specifically, using a pooled-cross section data taken from 4 main granary areas each with 2 growing seasons for the period 1980-1990,[3] a comparison of productivity growth among them will be made. This in turn calls for an application of index-number procedures. Thus, we employ the Christensen-Caves-Diewert (C-C-D, 1982) proposed procedures to compute the neccessary indexes of output and factor inputs for each granary area and season. Hence, this becomes the first objective of this paper.

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[2] For example (Haughton, 1985), (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] With 11 observation years, 4 granary areas and 2 seasons, the overall sample size of this study amounts to 88.

Next, it is interesting to note that thus far we can hardly find an empirical study on Malaysian rice farming which explicitly exhibits quantitatively the source of total factor productivity (TFP) growth experienced by each of the Malaysian granary area and season. As is well known a measurement of an individual production unit using TFP approach provides an explanation on how output changes with respect to changes in factor inputs. If, for example, output growth shows no tendency to decline over a time period we may infer that a sharp decline in the growth of factor inputs implies impressive productivity growth (TFP growth). However, as have been shown by Ohta (1974), Denny, Fuss and Waverman (1983), 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 two major sources of TFP growth. Now, since this study incorporates these two major sources of TFP growth into its analysis of the production technology of Malaysian rice farming, it offers a systematic procedure which links the analysis of TFP to that of production theory. As far as empirical study on Malaysian rice farming is concerned, this study seems to be the first of its kind in making an attempt to compute the TFP growth as well as linking it to the theory of production. To recapitulate, this is the second objective and may be considered as the crux of the paper.

With the exception of Haughton (1986), none of the previously mentioned studies have attempted measuring Malaysian rice farming's productivity growth using Translog functions. His study which mainly focuses on the choice of functional forms applicable to rice cultivation in West Malaysia has shown that at least two functional forms, namely translog restricted profit function and translog production function, to be "disappointing". While the former function shows "poor fit and the share equations are not significant at all", the latter proves to be "awkward to work with as they do not yield price response elasticities analytically (Haughton, 1986 pp. 217)." Since in his study Haughton neither shows nor does he apply translog cost function, the latest methodological framework to measure production technology, introducing this function as an alternative to measure scale economies and technological change for Malaysian rice farming would provide a new dimension of how this sector should be evaluated. This becomes the third objective of the paper.

Given these three objectives, perhaps this study could provide a convincing answer as to how Malaysian rice farming has fared through during the past one decade and leads to more reliable results than obtained by the previous studies.

The plan of the paper is as follows. In section 2 the discussion will be divided into three (3) subsections: (i) A decomposition analysis of factor inputs based on the cost function approach will be advanced. (ii) A definition of TFP will be made. (iii) A linkage between (i) and (ii) will be established. In this section also we will systematically show how the sources of TFP growth, i.e., scale economies and technological change, are disentangled. In section 3 the translog cost function, econometric models and sources of data will be discussed. Next, in section 4 after applying the C-C-D proposed procedures and the econometric methods outlined in section 3 to the data gathered from Malaysian rice farming, we will present the results of the quantity indexes of output and total input. In addition to this the estimated parameters of the translog cost function and the sources of TFP growth will also be reported. In section 5 the summary and concluding remarks are given.

2. Decomposition analysis

2(i). Decomposition analysis of total cost function

The characteristics of production that we intend to analyse are related to scale economies and technological change. We assume that the Malaysian rice farming is characterized by a production function satisfying the usual regularity conditions,[4]

$$Y = f(X,T) \qquad (1)$$

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 input prices, W_j, where j = (L,M,U,B), are exogenously determined, the dual cost function may be written as

$$C = C(W_L,W_M,W_U,W_B,Y,T) \qquad (2)$$

where production cost (C) is a function of the input prices of labour (W_L), machinery (W_M), intermediate inputs (W_U), and land (W_B), the level of output (Y), and time (T). We assume that factor markets are competitive[5] and that each farm is willing to supply all output demanded at any given price. Thus, input prices and output are treated as exogenous variables while input levels are endogenous.

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[4] For a detail discussion on regularity conditions see for example Binswanger (1974) or Diewert (1978).

[5] In fact, in reality Malaysian rice farming factor markets are indeed competitive. Labour (L) is very competitive as shown by Barnum and Squire (1978, pp.195). As for land (B) Goldman and Squire (1982) have shown that 'land rental payment share decreases sharply' which tends to suggest that land market is functioning well. Furthermore, we note that in the context of Malaysian rice farming the co-existence of three (3) types of farming modes, namely owner-cultivators, tenant-owner cultivators and tenants cultivators clearly shows that it is always supply and demand which determined the price or rental of land. Meanwhile, for machinery (M) the co-existence of private owners and Farmer Cooperatives, the most important suppliers of machinery services to farmers, indicates that this market too is competitive.

Now, logarithmically differentiating (2) with respect to (w.r.t.) time (T), we can decompose the rate of growth of total cost into its source components:

$$\frac{\dot{C}}{C} = \left[\sum_{j=1}^{4} \frac{\partial \ln C}{\partial \ln W_j} \frac{\dot{W}_j}{W_j}\right] + \left[\frac{\partial \ln C}{\partial \ln Y} \frac{\dot{Y}}{Y}\right] + \left[\frac{\partial \ln C}{\partial T}\right] \tag{3}$$

The variables with 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 (3), we then obtain the following relations:

$$\sum_{j=1}^{4} \frac{\partial \ln C}{\partial \ln W_j} = \sum_{j=1}^{4} \frac{X_j W_j}{C} = \sum_{j=1}^{4} S_j = 1 \tag{4}$$

where $S_j = X_j W_j / C$ denotes the cost share of the j^{th} input.

Next, we define the elasticity of cost w.r.t. output (Y), ε_{cy} as

$$\frac{\partial \ln C}{\partial \ln Y} = \frac{\partial C}{\partial Y} \frac{Y}{C} = \varepsilon_{cy} \tag{5}$$

Equation (5) 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 according as $\varepsilon_{cy} \langle 1$, $\varepsilon_{cy} = 1$, or $\varepsilon_{cy} \rangle 1$, respectively.

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

As for intermediate inputs (U), since fertilizers, seeds and irrigation facilities are either fully or partially subsidized by the government, agri-chemicals becomes the most significant determinant components of this factor input. Agri-chemicals products are supplied by private agencies at market prices.

$$\frac{\partial \ln C}{\partial T} = \lambda \tag{6}$$

Hence, collecting (4), (5) and (6), and then substituting them into (3) yields

$$\frac{\dot{C}}{C} = [\sum_{j=1}^{4} S_j \frac{\dot{W}_j}{W_j}] + [\varepsilon_{cy} \frac{\dot{Y}}{Y}] + [\lambda] \tag{7}$$

Finally, given (4), and then differentiating the factor input costs, $C = \sum_{j=1}^{4} W_j X_j$ w.r.t. time (T), dividing by C and rearranging, we get

$$\sum_{j=1}^{4} S_j \frac{\dot{W}_j}{W_j} = \frac{\dot{C}}{C} - \sum_{j=1}^{4} S_j \frac{\dot{X}_j}{X_j} \tag{8}$$

2(ii). Total factor productivity (TFP)

Before proceding further, we introduce the mathematical approach for computing the TFP growth rate and subsequently relate it to (8). To start with, we denote index of output (Y) where the rate of growth of which is expressed as

$$\frac{\dot{Y}}{Y} = \sum_{i=1}^{n} N_i \frac{\dot{Y}_i}{Y_i} \tag{9}$$

where $N_i = P_i Y_i / \sum_{i=1}^{n} P_i Y_i = P_i Y_i / R$, and P_i and Y_i are respectively price and quantity of output i; $R = \sum_{i=1}^{n} P_i Y_i$, the total revenue; and $\dot{Y} / Y$, the rates of growth of output i.

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

$$\frac{\dot{X}}{X} = \sum_{j=1}^{m} S_j \frac{\dot{X}}{X} \tag{10}$$

where $S_j = W_jX_j/\sum_{j=1}^{m} W_jX_j = W_jX_j/C$, 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 $\dot{X} / X$, the rates of growth of input j. These two quantity indexes may be regarded as a family of Divisia quantity indexes.

We move on to define TFP, P, in terms of Divisia index numbers. P is defined as the ratio of total output to the quantity of total input:

$$P = \frac{Y}{X} \tag{11}$$

from which the rate of growth of TFP $[\dot{P} / P]$ is defined as

$$\frac{\dot{P}}{P} = \frac{\dot{Y}}{Y} - \frac{\dot{X}}{X} \tag{12}$$

While the formulas (9) - (12) are in terms of instantaneous changes, the data to be used in this study are at yearly intervals. The most commonly used discrete approximation to the continuous formulas (9) - (12) is given by the Törnqvist approximations.

$$\Delta \ln Y = \ln(Y_T / Y_{T-1}) = 1/2 \sum_{i}^{n} (N_i + N_{i,T-1}) \ln(Y_{iT} / Y_{i,T-1}) \tag{13}$$

$$\Delta \ln X = \ln(X_T / X_{T-1}) = 1/2 \sum_{j}^{m} (S_j + S_{j,T-1}) \ln(X_{jT} / X_{j,T-1}) \tag{14}$$

where N_i, S_j and T are as defined before. The corresponding discrete approximation to formula (12) is given by

$$\Delta \ln P = \Delta \ln Y - \Delta \ln X \tag{15}$$

(13) - (15) will be used when we introduce the econometrics model in section 3.

2(iii). Decomposition analysis and TFP

Having (1) - (12) at our disposal, we can now establish a link between the decomposition analysis and TFP. This can be done by, first, substituting (7) into (8). After rearranging we obtain

$$\varepsilon_{cy}\frac{\dot{Y}}{Y} + \lambda - \sum_{j}^{4} S_j \frac{\dot{X}_j}{X_j} = 0 \qquad (16)$$

Second, substituting (10) into (16), we obtain

$$\varepsilon_{cy}\frac{\dot{Y}}{Y} + \lambda - \frac{\dot{X}}{X} = 0 \qquad (17)$$

Finally, using definition $\frac{\dot{P}}{P} = \frac{\dot{Y}}{Y} - \frac{\dot{X}}{X}$ and rearranging, (17) becomes

$$\frac{\dot{P}}{P} = (1 - \varepsilon_{cy})\frac{\dot{Y}}{Y} - \lambda \qquad (18)$$

If constant returns to scale exist, then $(1 - \varepsilon_{cy}) = 0$, implying $\dot{P} / P = - \lambda$. This expression, as been noted in section 1, is tantamount to the conventional growth accounting measurement of TFP which is equivalent to the negative rate of cost diminution. If, however, we conjecture that scale effects are present $(\varepsilon_{cy} \neq 1)$[6], then it turns out that the conventionally measured estimates of the growth rate of TFP should include both scale effects and technological change effects. This is to say that (18) holds.

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[6] Zaleha and Ariff (1986) have shown, using restricted profit function, that there is some evidence to believe that the production technology of Malaysian rice farming does not succumb to constant returns to scale. Rather, according to them, it subjects to decreasing returns to scale.

Thus far we have systematically shown how the two major sources of TFP are derived and disentangled. Henceforth, equation (18) will be used as a basis to measure the scale effects and technological change effects of Malaysian rice farming.

3. Translog cost function, econometric models and data sources

3(i). Translog cost function and econometric modeling

In order to compute the terms in the decomposition equation (18), we specify the cost funtion in translog form. Assuming that the translog cost function is represented by

$$\begin{aligned}\ln C &= \alpha_0^{rl} + \sum_{j=1}^{4} \alpha_j^{rl} \ln W_j^{rl} + \alpha_Y^{rl} \ln Y^{rl} + \alpha_T^{rl} T^{rl} \\ &+ \tfrac{1}{2} \sum_{j=1}^{4} \sum_{k=1}^{4} \gamma_{jk}^{rl} \ln W_j^{rl} \ln W_k^{rl} + \tfrac{1}{2} \gamma_{YY}^{rl} (\ln Y^{rl})^2 \\ &+ \sum_{j=1}^{4} \gamma_{jT}^{rl} \ln W_j^{rl} T^{rl} + \sum_{j=1}^{4} \delta_{Yj}^{rl} \ln W_j^{rl} \ln Y^{rl} \\ &+ \delta_{YT}^{rl} \ln Y^{rl} T^{rl} + \tfrac{1}{2} \gamma_{TT}^{rl} (T^{rl})^2\end{aligned} \tag{19}$$

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

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

$$S_j^{rl} = \alpha_j^{rl} + \sum_{k=1}^{4} \gamma_{jk}^{rl} \ln W_k^{rl} + \delta_{jY}^{rl} \ln Y^{rl} + \gamma_{jT}^{rl} T^{rl} \tag{20}$$

Any sensible cost function must satisfy the linear homogeneity in input prices which is defined as

$$pq(Y^{rl}, W_L^{rl}, W_M^{rl}, W_U^{rl}, W_B^{rl}, T^{rl}) = q(Y^{rl}, pW_L^{rl}, pW_M^{rl}, pW_U^{rl}, pW_B^{rl}, T^{rl})$$

This requirement implies that

$$\sum_{j=1}^{4}\alpha_j^{rl}=1 \quad , \quad \sum_{j=1}^{4}\gamma_{kj}^{rl}=\sum_{k=1}^{4}\gamma_{jk}^{rl}=0 \quad , \quad \sum_{j=1}^{4}\delta_{Yj}^{rl}=0 \qquad (21)$$

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. Sufficient 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, respectively.

For econometric estimation, the cross-equations equality and the linear homogeneity restrictions defined in (21) are imposed a priori on the translog cost function (19), and on the cost-share equations (20). This allows us to drop arbitrarily any one of the four (4) 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 relationships of the linear homogeneity restrictions, once the system of the remaining cost-share equations have been estimated. Given this set of conditions, we choose as the estimation method the Iterative Seemingly Unrelated Regression (ISUR).

Next, cost elasticity is defined as $\varepsilon_{CY}=\partial\ln C/\partial\ln Y$ and if applied to equation (19) will give

$$\varepsilon_{CY}=\partial\ln C/\partial\ln Y=\alpha_Y^{rl}+\gamma_{YY}^{rl}\ln Y^{rl}+\delta_{Yj}^{rl}\ln W_j^{rl}+\delta_{YT}^{rl}T^{rl} \qquad (22)$$

Equation (22) provides 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 $\varepsilon_{CY}=1$, signifying constant returns to scale. If, however, $\alpha_y^{rl} \rangle 1$ or $\alpha_y^{rl} \langle 1$ then $\varepsilon_{cy} \rangle 1$ or $\varepsilon_{cy} \langle 1$, signifying decreasing returns to scale or increasing returns to scale, respectively.

3(ii). Data

The main sources of data used for the analysis of the study were gathered from the published statistics and reports by each granary area development authority. The variables required to estimate the cost function model are 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, to reiterate, is C-C-D (1982) proposed procedure.

4. Empirical results

A complete set of parameter estimates of the specified translog cost function (19) is reported in Table 1. The R^2,s adjusted for degrees of freedom for the cost function and the three cost-share equations, namely labour, machinery and intermediate inputs, was 0.988, 0.857, 0.600 and 0.565, respectively, indicating a rather modest but fairly acceptable measurement of goodness of fit of a model.

Next, the regularity conditions such as; (i) linear homogeneity in input prices, (ii) positive and monotonically increasing in input prices, (iii) concavity in input prices, were all checked and satisfied by our model. The first condition which requires a restriction on its parameters, as shown by equation (21), is satisfied by our model. This is indicated in Table 1 by $\sum_{j=1}^{4} \alpha_j = 1$. Next, the second condition which requires $S_j = d\ln C / d\ln W_j \geq 0$ is also satisfied by our 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(i). Quantity indexes of total input and its components, and output

To facilitate the understanding and for reference purposes we present a complete set of quantity indexes of total input (X_{SUM}) and its components [(X_L), machinery (X_M), intermediate inputs (X_U) and land (X_B)], and output (Y) of each granary area and season computed based on C-C-D (1982) proposed procedures in appendix 1. As can be seen from the appendix, samples (23 - 33) and (34 - 44) have some peculiar features compared with other samples in terms of indexes of X_L, X_M, X_U, X_B, X_{SUM} and Y. The reason for this is that this granary area (i.e., MADA, the main- and off-seasons alike) if measured in hectarage is about 3.25 times larger than the next biggest granary area, KADA. Bearing this in mind the result, for example, of quantity labour index of this granary area (MADA) is 3.25 times larger than other granary areas' indexes should be expected. However, the result of TFP index (i.e., TFP = Y/X_{SUM}) of this and other granary areas are comparable because the indexes are in the range of between 0.7 and 1.4.

4(ii). Scale effects

The sources of TFP growth rate of Malaysian rice farming for the 1980-1990 period is shown in Table 2. The scale economies, defined as $1-\varepsilon_{CY}$, is positive for every farming classification for 1980-1990 period. This suggests that the underlying production technology of Malaysian rice farming exhibited substantial increasing returns to scale. This result is obviously at variance with one found by Zaleha and Ariff (1986) whose finding suggests that Malaysian rice farming subjects to decreasing returns to scale (see also note 6). To be more precise, our finding tends to suggest that the ε_{CY} of 0.4 for AVERAGE farming classification means that, on average, a 1%

increase in output resulted in a 0.4% increase in total cost. Thus, the positive value of $1-\varepsilon_{CY}$ of each farming classification also suggests that they could further exploit the scale economies through expansion of the size of its operation.

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

4(iii). Technological change effects

The estimates of gains due to technological change effects are residually computed.[7] As evident from Table 2 technological change of NEW PROJECT is positive and largest compared with other farming classsifications. This points to the fact that the adoption of new cultivation techniques in NWSP and KSMP, both in the main- and off-seasons, is relatively rapid compared with other granary areas. However, when the classification was made in such a manner that all off-seasons and main-seasons of all granary areas were grouped together, the scenario changes quite dramatically. The technological change effects became negative.

The positive technological change effects of the OLD and NEW PROJECTS could have been resulted from the following factors: First, machinery, especially tractors meant for paddy cultivation with small capacity, has been 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. Second, government-supported output price from time to time shows an increasing trend. Starting from RM

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[7] It should be noted here that since the estimates of technological effects are residually computed they bear the following remarks. First, the estimated technological change includes also errors resulting from the estimation of scale economies. Second, as with any residual, it represents a quantitative expression of our ignorance.

33.00 per metric tonne before the year 1980, the price support has since then increased twice. First, in 1980 and then in 1990 where the rate was set at RM 165.00 and RM 247.50 per metric tonne, respectively. Due to immediate monetary gains, this policy seems to encourage farmers to produce more rice and as a result makes them affordable to adopt new farming technique. Third, in this period a better technique of seeds planting was introduced in NWSP before being gradually adopted by farmers in other granary areas. The 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-using, the former is labour-saving (in terms of man-hours) and thus cost-saving technique. Fourth, fertilizers, seeds and irrigation facilities extended by the government at either full or partial rate had encouraged farmers to continue producing rice at cheaper cost. Thus, combined together these four factors, they have contributed to the downward shift of the cost curve particularly of the NEW PROJECT.

4(iv). Relative contributions of scale and technological change effects

Table 2 also provides information on the relative contributions of scale and technological change effects to TFP growth rate measured in percentage (%). As reported in Table 2, with the exception of NEW PROJECT, the scale effects was the major source of TFP growth rate. For example, scale effects contributed 138.29% and 104.05% to TFP growth rate in the MAIN- AND OFF-SEASONS, respectively. Thus, based on this result, we conclude that Malaysian rice farming major source of TFP growth rate for the 1980-1990 period was due to scale effects.

Now, having identified the major source of Malaysian rice farming TFP growth rate which was largely due to scale effects, it is interesting to further investigate the forces behind it. This will call for a further decomposition of scale effects into its several components. Returns to scale from which the scale economies $(1-\varepsilon_{CY})$ was computed, as shown in equation (22), is composed of three (3) components: output (Y), factor input prices (W_j) and time (T) components, respectively. Hence, the strong forces behind the influence of scale economies on TFP growth rate are now identified to be; (i) Output changes of scale economies; (ii) Factor prices changes of scale economies; (iii) Technological change of scale economies (SCE). Using this decompostion of SCE we will analyse each component impact on the SCE.

4(iv.a). Output and factor input prices changes components of scale economies

Using (22) we can compute the output and factor input prices components of scale economies, respectively. First, the output component is computed as

$$\frac{\partial SCE}{\partial \ln Y} = \frac{\partial(1-\varepsilon_{cy})}{\partial \ln Y} = -\frac{\partial \varepsilon_{cy}}{\partial \ln Y} = -\gamma_{yy}^{rl} \qquad (23)$$

Second, the factor input prices component is computed as

$$\frac{\partial SCE}{\partial \ln W_j} = \frac{\partial(1-\varepsilon_{cy})}{\partial \ln W_j} = -\frac{\partial \varepsilon_{cy}}{\partial \ln W_j} = -\delta_{jy}^{rl} \qquad (24)$$

In both cases any positive (negative) values indicate that increases in the corresponding variable lead to higher (lower) scale economies. The results of the parameter estimates based on equations (23) and (24) are reported in Table 3.

As can be seen from Table 3 the $\partial SCE / \partial \ln Y$ value for every farming classification is positive, implying that each can benefit from a higher level of scale economies by expanding the output level.

Meanwhile, except for MAIN SEASON's, other farming classifications $\partial SCE / \partial \ln W_j$ appeared to be positive, suggesting a positive impact that this variable gives on scale economies. While the intermediate inputs and land prices impacts were different from one farming classification to another, the impact of machinery price on SCE showed negative values in all farming classifications. The latter impact suggests that any increase in the price of machinery would lower the scale economies.

In essence, the implication of relative price movements of different factor input, as shown in Table 3, have led to different contribution of scale economies to Malaysian rice farming TFP growth rate.

4(iv.b). Technological change component of scale economies

The objective of this subsection is two-fold. First, the technological change component of SCE will be derived. Two, this component impact on SCE will then be compared with Efficient Scale (ES).

The technological change component of SCE is derived by differentiating (22) w.r.t. time (T) to yield

$$\frac{\partial \mathrm{SCE}}{\partial \mathrm{T}} = \frac{\partial(1-\varepsilon_{cy})}{\partial \mathrm{T}} = -\frac{\partial \varepsilon_{cy}}{\partial \mathrm{T}}$$

$$= -(\alpha_{\mathrm{Y}}^{rl} + \gamma_{\mathrm{YY}}^{rl} \ln \mathrm{Y}^{rl} + \delta_{\mathrm{Yj}}^{rl} \ln \mathrm{W}_{j}^{rl} + \delta_{\mathrm{YT}}^{rl} \mathrm{T}^{rl}) / \mathrm{T} \qquad (25)$$

In order to derive efficient scale we add the following information i.e., the efficient scale, at which average cost reaches its minimun and returns to scale equals 1 $(\varepsilon_{CY} = 1)$, to equation (22) and rearranging will give

$$\ln \mathrm{Y} = 1 - \alpha_{\mathrm{Y}}^{rl} - \delta_{\mathrm{Yj}}^{rl} \ln \mathrm{W}_{j}^{rl} + \delta_{\mathrm{YT}}^{rl} \mathrm{T}^{rl} / \gamma_{\mathrm{YY}}^{rl} \qquad (26)$$

Next, differentiating (26) w.r.t. time (T) yields

$$\frac{\partial \ln Y}{\partial T} = \frac{\delta^{rl}_{Yj}}{\gamma^{rl}_{YY}} \qquad (27)$$

The efficient scale, as shown in (27) grows by a proportional rate $\delta^{rl}_{Yj} / \gamma^{rl}_{YY}$. In our model ES of AVERAGE farming classification, for example, is computable from the parameter estimates as reported in Table 1. The results of $\partial SCE / \partial T$ and ES are reported in Table 4.

First, it is worth interpreting the parameter estimates of $\partial SCE / \partial T$ before comparing it with Efficient Scale. Converse to the interpretations of $\partial SCE / \partial \ln Y$ and $\partial SCE / \partial \ln W_j$, the interpretation of $\partial SCE / \partial T$ is as follows. A negative (positive) value of $\partial SCE / \partial T$ indicates that an increase in technological change leads to higher (lower) degree of scale economies. As shown in Table 4, the $\partial SCE / \partial T$ of NEW PROJECT and OFF-SEASON shows a negative value, implying that technological change contributes to higher degree of scale economies.[8]

Now we compare the parameter estimates obtained for $\partial SCE / \partial T$ and Efficient Scale. According to Greene (1983) any negative values of the derivative $\partial SCE / \partial T$ below the ES and positive values above the ES imply reduction in the slope of the cost curve.[9] As evident from Table 4, all except AVERAGE farming classifications, the $\partial SCE / \partial T$ satisfies Greene's conditions. Thus, we may infer that Malaysian rice farming production technology has the tendency to operate on the flatter average cost curve which, overtime, will most likely produce output under constant returns to scale.

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[8] We note further that the magnitude of $\partial SCE / \partial T$ in absolute values may be used as a measure of the speed of enlargement (if it is positive) or exploitation (if it is negative) of scale economies when technological changes occur (Kuroda, 1989, pp.169).

[9] As been pointed out by Greene (1983), Stevenson's (1980) interpretation of $TS_c = \partial SCE / \partial T$ which the latter author uses to measure the technological scale bias was misleading. Changes in ε_{cy}, according to Greene, is related more closely to changes in slope of the average cost curve than to changes in its location.

5. Summary and concluding remarks

Our main objective in undertaking this empirical study was to investigate the sources of Malaysian rice farming growth for the 1980-1990 period. For this reason we established a method which made 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 major findings of this study may be summarized as follows. First, it is obvious from the computed average growth rates of output ($\dot{Y} / Y$) and total input ($\dot{X} / X$) of Malaysian rice farming that the NEW PROJECT and OFF-SEASON showed a better performance than other farming classifications. This has resulted in a relatively higher TFP growth rate ($\dot{P} / P$) of these two farming classifications than others. Second, the result of our empirical analysis shows that the production technology of Malaysian rice farming for 1980-1990 period was bound by increasing returns to scale. Finally, the result of this study points to the fact that, in all except NEW PROJECT farming classifications, the main source of TFP growth rate for 1980-1990 period was due to scale effects.

Combining the second and third findings, three generalized policy implications can be deduced. First, the findings have provided some basis for us to believe that Malaysian rice farmers can still further expand the size of their farm operations. As implied by the production technology which was bound by increasing returns to scale, every 1% increase in output will be followed by less than 1% increase in total cost. Thus, judging from this fact it seems plausible for the government to confidently proceed with its policy of consolidating the rice farms into mini-estate.

Second, owing to the following phenomena; (i) many young generations, who were attracted by more lucrative pays offered by the urban/industrial sector; (ii) many landlords abandoned their paddy fields to establish new and permanent life in urban areas, idle paddy land has since late 1970s become a national problem (Sivalingam, 1993). Now, given our findings it seems very likely that this problem could be resolved. Specifically, farmers can now be encouraged to expand their farming operations beyond the present modes. This can be done either by allowing them to purchase the existing idle paddy land at reasonable price or by letting them to rent the land at reasonable rate.

Third, our finding leads to another policy implication. A land-extensive technique seems now possible to be undertaken. While this method of cultivation requires farmers to use proportionately more land than other factor inputs (for example fertilizers and agri-chemicals), the present technique which is generally known as land-intensive technique requires farmers to use proportionately more of the latter inputs than land. With our proposed technique while on the one hand the problem of idle paddy land can be resolved, on the other mini-estates project could be undertaken .

Table 1 : Parameter estimates of the translog cost function

Coefficient	Estimate	t - ratio
α	3.300	117.168
α_Y	0.407	5.693
α_L	0.342	75.886
α_M	0.131	24.779
α_U	0.258	64.403
α_B	0.269	3.749
α_T	-0.010	-0.345
γ_{LL}	-0.366	-4.608
γ_{MM}	-0.482	-2.804
γ_{UU}	-0.629	-3.253
γ_{BB}	0.133	0.637
γ_{YY}	-0.263	-3.442
γ_{TT}	0.098	2.373
γ_{LM}	0.199	2.604
γ_{LU}	0.422	5.974
γ_{LB}	-0.255	-2.275
γ_{MU}	0.184	1.068
γ_{MB}	0.099	0.499
γ_{UB}	0.022	0.112
γ_{LT}	-0.030	-4.346
γ_{MT}	0.097	1.140
γ_{UT}	0.014	1.920
γ_{BT}	0.583	0.137
δ_{YL}	-0.052	-0.905
δ_{YM}	0.037	5.553
δ_{YU}	-0.039	-7.790
δ_{YB}	0.076	0.044
δ_{YT}	-0.430	-0.103

Note : coefficients for land (B)were obtained using the parameter restrictions of linear homogeneity

Table 2 : Sources of total factor productivity (TFP) growth rate for Malaysian rice farming, 1980-90*

Farming** Classification	Output $\dot{Y}/Y$ (1)	Total Input $\dot{X}/X$ (2)	Returns To Scales $(1-\varepsilon_{cy})$ (3)	Scale Effects $(1-\varepsilon_{cy})\dot{Y}/Y$ (4) = (1) x (3)	Technological Change $(-\lambda)$ (5) = (6) - (4)	TFP Growth Rate $\dot{P}/P$ (6) = (1) - (2)
OLD PROJECT	1.60	0.8	0.28	0.45 (56.25)***	0.35 (43.75)	0.80 (100.0)
NEW PROJECT	4.41	2.06	0.16	0.71 (30.21)	1.64 (69.79)	2.35 (100.0)
MAIN-SEASON	2.41	1.00	0.81	1.95 (138.29)	-0.54 (-38.29)	1.41 (100.0)
OFF-SEASON	3.60	1.87	0.50	1.80 (104.05)	-0.07 (-4.05)	1.73 (100.0)
AVERAGE	3.01	1.44	0.60	1.81 (115.27)	-0.24 (-15.27)	1.57 (100.0)

note:

* The computation of avearge annual growth rate of output was done by fitting $\ln Y = k + qT$, where Y is the Torqvist 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.

** See note (1) for a detail explanation on each farming classification.

*** Figures in parenthesis are the sources of TFP growth rate; the scale and technological change effects, measured in percentage (%). While the former was computed by dividing (4) by (6), the latter was computed by dividing (5) by (6).

Table 3 : Effects of changes in output and price of factor inputs on scale economies

Farming Classification	$\frac{\partial \varepsilon_{cy}}{\partial \ln Y}$	$\frac{\partial \varepsilon_{cy}}{\partial \ln W_L}$	$\frac{\partial \varepsilon_{cy}}{\partial \ln W_M}$	$\frac{\partial \varepsilon_{cy}}{\partial \ln W_U}$	$\frac{\partial \varepsilon_{cy}}{\partial \ln W_B}$
OLD PROJECT	0.856	0.071	-0.053	-0.027	0.096
NEW PROJECT	0.482	0.032	-0.016	-0.012	0.010
MAIN-SEASON	9.493	-0.084	-0.696	1.066	-0.286
OFF-SEASON	0.864	0.076	-0.246	0.186	-0.016
AVERAGE	1.584	0.031	-0.225	0.239	-0.046

Table 4 : Effects of technological change on scale economies (∂SCE / ∂T) and a comparison with efficient scale (ES)

Farming Clssification	$\frac{\partial \varepsilon_{cy}}{\partial T}$	Efficient Scale
OLD PROJECT	0.066	0.047
NEW PROJECT	-0.036	0.302
MAIN-SEASON	2.082	0.390
OFF-SEASON	-0.337	0.170
AVERAGE	0.026	0.164

Appendix 1

Quantity indexes of total input and its components, and output for Malaysian rice farming, 1980-90

Year	X_L	X_M	X_U	X_B	X_{SUM}	Y
1980	0.4862	0.6492	0.5872	0.3896	0.4862	0.3491
1981	0.6550	1.0632	0.8142	0.5663	0.6782	0.6923
1982	0.7146	1.1150	1.0179	0.6693	0.7744	0.6366
1983	0.7853	1.0995	1.0070	0.6865	0.7976	0.5881
1984	0.7504	1.1944	1.0350	0.6891	0.8039	0.7682
1985	0.5404	0.8196	0.8878	0.5754	0.6352	0.5633
1986	0.6765	0.9033	1.0537	0.6823	0.7553	0.6771
1987	0.5680	0.9300	1.1044	0.6904	0.7396	0.6703
1988	0.5781	1.0020	1.2205	0.6887	0.7783	0.7096
1989	0.4931	1.2023	1.4307	0.7110	0.8251	0.9753
1990	0.3940	1.3613	1.4120	0.7110	0.7963	0.9295
1980	0.6090	0.7410	0.6806	0.4770	0.5695	0.3939
1981	0.5311	0.8848	0.7228	0.4911	0.5763	0.4428
1982	0.6776	0.9177	0.9483	0.6690	0.7298	0.6997
1983	0.4213	0.6111	0.5549	0.3684	0.4388	0.2611
1984	0.7251	1.0920	1.0496	0.6838	0.7880	0.6595
1985	0.5749	0.8815	1.0118	0.6588	0.7029	0.6364
1986	0.4352	0.5503	0.5840	0.3821	0.4449	0.3666
1987	0.5961	0.9707	1.0762	0.6849	0.7448	0.6479
1988	0.5701	1.0546	1.1313	0.6851	0.7600	0.6887
1989	0.4015	1.3405	1.2007	0.7110	0.7508	0.7776
1990	0.4170	1.3522	1.4727	0.7110	0.8180	0.8298
1980	4.1687	9.4208	2.9357	3.7145	4.0645	5.0059
1981	4.4310	10.7914	2.9728	3.6931	4.2780	5.0188
1982	4.1444	10.7270	3.0224	3.6888	4.1862	4.5311
1983	2.3593	7.7504	2.4300	2.8888	2.9620	2.6704
1984	3.6218	10.2062	3.1649	3.7000	4.0157	4.9314
1985	3.5384	11.3163	3.2233	3.7193	4.1237	4.6341
1986	3.2798	11.2317	3.4984	3.7195	4.1050	4.7262
1987	2.8322	10.9986	3.5889	3.7248	3.9702	4.6969
1988	2.8041	11.7960	3.6467	3.7597	4.1500	4.5388
1989	2.5441	11.5322	3.9249	3.7629	4.0746	5.1441
1990	2.4447	11.5829	4.0377	3.7634	4.0860	5.6473
1980	3.8292	7.8813	2.7241	3.4668	3.6811	4.5469
1981	4.0465	10.1786	2.8567	3.4955	4.0229	4.4462
1982	4.1846	9.8033	2.8369	3.4691	3.9918	3.2760
1983	2.3670	9.3486	3.0643	3.4577	3.4532	3.1209
1984	2.5407	8.7372	2.7032	3.2203	3.2890	3.0211
1985	2.9452	9.5461	2.9971	3.5142	3.6575	4.0810
1986	3.1158	10.6180	3.1368	3.5250	3.8561	3.8541
1987	1.9650	9.2090	3.0707	3.4471	3.3159	2.6531
1988	2.3659	10.3452	3.5253	3.5736	3.7719	3.2865
1989	2.2583	11.0295	3.6220	3.5824	3.7990	3.9003
1990	2.3521	10.8693	3.7276	3.6019	3.8561	4.2858
1980	0.9656	0.6690	0.5719	0.8622	0.7546	0.8772
1981	0.6243	0.8172	0.5005	0.8172	0.5655	0.6653
1982	0.8680	0.7605	0.6245	0.8240	0.7362	0.7313
1983	0.1196	0.3352	0.0932	0.3352	0.1318	0.1187
1984	0.7520	0.7508	0.5839	0.6743	0.6504	0.6393
1985	0.7746	0.5685	0.5637	0.6902	0.6351	0.7268
1986	0.5961	0.6526	0.4184	0.4964	0.5012	0.4904
1987	0.8877	0.5284	0.6562	0.7422	0.7043	0.6658
1988	0.2611	0.5133	0.2076	0.2279	0.2553	0.1928
1989	0.7970	0.7168	0.6650	0.7632	0.7053	0.8812
1990	0.6850	0.7261	0.6514	0.7582	0.6629	0.9575

Appendix 1.................continue

Year	X_L	X_M	X_U	X_B	X_{SUM}	Y
1980	0.7515	0.7499	0.3665	0.7300	0.6072	0.5835
1981	0.7934	0.7702	0.6155	0.6929	0.6802	0.7736
1982	0.6780	0.7864	0.6196	0.7255	0.6512	0.8471
1983	0.9083	0.8127	0.6993	0.8508	0.7818	0.7438
1984	0.7633	0.6603	0.6147	0.7443	0.6695	0.7252
1985	0.7842	0.6523	0.5281	0.6623	0.6320	0.7911
1986	0.9737	0.6443	0.6772	0.8014	0.7660	0.6751
1987	0.8816	0.6737	0.6561	0.7076	0.7111	0.7434
1988	1.1341	0.7183	0.8163	0.9017	0.8878	1.0267
1989	0.9273	0.8486	0.8045	0.9087	0.8349	1.1131
1990	0.8703	0.8191	0.8461	0.9937	0.8423	1.1553
1980	1.2943	0.0690	0.5932	0.8603	0.7596	0.7705
1981	1.2230	0.0612	0.5697	0.8128	0.7150	0.6533
1982	0.8650	0.0703	0.5406	0.8087	0.5980	0.5633
1983	0.9552	0.0809	0.6265	0.8515	0.6593	0.6083
1984	0.8850	0.0767	0.5853	0.8077	0.6170	0.7230
1985	1.1144	0.1438	0.8511	0.9016	0.7989	0.8377
1986	1.0447	0.3411	0.7855	0.8452	0.7895	0.8115
1987	1.1254	0.3691	0.9078	0.9106	0.8656	0.8987
1988	1.0860	0.3453	0.8836	0.9138	0.8428	0.7210
1989	0.7837	0.3544	0.7501	0.8348	0.6919	0.6934
1990	0.8414	0.2967	0.8231	0.9026	0.7355	0.6918
1980	1.1722	0.0526	0.5687	0.7790	0.6875	0.5014
1981	0.9523	0.1003	0.4693	0.6328	0.5866	0.5552
1982	0.4138	0.0683	0.2740	0.3869	0.3015	0.2521
1983	0.4299	0.0728	0.3098	0.3832	0.3160	0.3420
1984	0.6903	0.1192	0.4815	0.6300	0.5069	0.5823
1985	0.8399	0.2284	0.6681	0.6795	0.6357	0.6448
1986	0.6784	0.1869	0.5327	0.5489	0.5123	0.5705
1987	0.9826	0.3231	0.8077	0.7950	0.7598	0.7918
1988	0.8086	0.2613	0.7084	0.6943	0.6442	0.5508
1989	0.5472	0.2469	0.5623	0.5756	0.4914	0.4656
1990	0.5741	0.2545	0.6368	0.6077	0.5271	0.5393

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 year was 1980 and 1990, respectively. We arrange the data sets in the following order:

Sample	Year	Granary Area	Season
1 - 11	1980-90	NWSP	Main-season
12 - 22	1980-90	NWSP	Off-season
23 - 33	1980-90	MADA	Main-season
34 - 44	1980-90	MADA	Off-season
45 - 55	1980-90	KADA	Main-season
56 - 66	1980-90	KADA	Off-season
67 - 77	1980-90	KSMP	Main-season
78 - 88	1980-90	KSMP	Off-season

X_L = index of labour
X_M = index of machinery
X_U = index of intermediate inputs
X_B = index of land
X_{SUM} = index of total input
Y = index of output

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