No: 642

Measurement of Biases of Technological Change and Factor Substitutions for Malaysian Rice Farming, 1980-90

by

Naziruddin Abdullah

September 1995

Measurement of Biases of Technological Change and Factor Substitutions for Malaysian Rice Farming, 1980-90

by

Naziruddin Abdullah

Doctoral Program,
Institute of Socio-Economic Planning,
The University of Tsukuba,
JAPAN

September 1995

Naziruddin Abdullah, "**Measurement of Biases of Technological Change and Factor Substitutions for Malaysian Rice Farming, 1980-90**" (University of Tsukuba, Japan).

Abstract

Using a translog cost function approach we estimated the production structures that are related to technological change biases and factor substitutions of Malaysian rice farming for 1980-90 period. We assumed a priori that the proximity and seasonal factors contributed differently to farmers behaviour towards utilization of factors of production. Our findings seem, however, to suggest that both factors contributed to no significant effect on farmers behaviour towards labour utilization as the technology embodied in all farming classifications was labour-saving. It was also found that, irrespective of granary areas and seasons (i.e., irrespective of proximity and seasonal factors), the relationships between labour and machinery, and to some extent between labour and intermediate inputs, were factor substitutability pairs.

Contact Address:

Naziruddin Abdullah
Doctoral Program,
Institute of Socio-Economic Planning,
The University of Tsukuba,
Tsukuba-Shi,
Ibaraki Ken 305,
JAPAN.

E-mail:

naz@aries.sk.tsukuba.ac.jp

Measurement of Biases of Technological Change and Factor Substitutions for Malaysian Rice Farming, 1980-90

Naziruddin Abdullah*

Doctoral Program, Institute of Socio-Economic Planning, University of Tsukuba, Ibaraki 305, Japan

Abstract

Using a translog cost function approach we estimated the production structures that are related to technological change biases and factor substitutions of Malaysian rice farming for 1980-90 period. We assumed a priori that the proximity and seasonal factors contributed differently to farmers behaviour towards utilization of factors of production. Our findings seem, however, to suggest that both factors contributed to no significant effect on farmers behaviour towards labour utilization as the technology embodied in all farming classifications was labour-saving. It was also found that, irrespective of granary areas and seasons (i.e., irrespective of proximity and seasonal factors), the relationships between labour and machinery, and to some extent between labour and intermediate inputs, were factor substitutability pairs.

key words: translog cost function, factor substitutions, scale bias effect, technological change bias effect, total bias effect, proximity factor and seasonal factor.

1. Introduction

As the case of rice farming in other countries, Malaysian rice farming is without an exception; technological change biases and factor substitutions in rice farming have important effects on and are reciprocally affected by other changes in the economy. To be more precise, first, as can be seen from Figure 1, two out of four major Malaysian rice granary areas are located relatively closer to two major fast growing Malaysian industrial/urban areas. NWSP is less than 90 km away from Klang Valley on which capital city of Malaysia, Kuala Lumpur, and Petaling Jaya and Shah Alam, the main industrial areas in Malaysia, are situated. Meanwhile, KSMP is less than 70 km away from Penang, a place which is best known as among the world largest producers of electrical and electronic products. The difference derives from NWSP and KSMP's proximity to urban/industrial areas is known in this study as proximity factor.

---

* Comments and suggestions by Professor Yoshimi Kuroda, and words of encouragement from Professor Yuji Kubo are greatly appreciated.

Second, it should be mentioned here that in each granary area; MADA, KADA, NWSP and KSMP, there are two growing seasons, the main- and off-seasons. The provision of irrigation facilities by the government to the latter season has made it possible for paddy farmers to cultivate land even during the dry season. With this distinguishable feature between the off- and main-seasons, it provides a strong basis for us to further investigate whether or not such facilities lead to different effects, for instance on factor inputs requirements and the level of rice cultivation technology adopted by these two seasons. This is known as seasonal factor in this study.

Now, as a first step to verify whether the factors, i.e., proximity and seasonal factors, do actually give significant effects on factor inputs requirements we compute, based on the Christensen, Caves and Diewert (1982) proposed procedures, the factor cost shares of each granary area and season for the 1980-1990 period. We then report the results in Appendix 1. As can be seen from the Appendix, the factor cost shares are fairly different among granary areas, and between seasons. First, let us take the proximity factor as the basis for comparison. As evident from appendix 1, while, for example, the labour cost-share of NWSP (main- and off-seasons) takes up between 18.0 - 29.0%, the one of KADA (main- and off-seasons) takes up between 31.0 - 43.0% of the total cost during the 1980-90 period. Second, we take the seasonal factor as the basis for comparison. In the case of KADA while, for example, the machinery cost share of the main-season takes up between 8.0 - 27.0%, the off-season's takes up between 9.0 - 13.0% of the total cost for the same period.

What were the factors behind such differences in the factor cost shares among granary areas and betweeen seasons? Would the differences in locations and seasons lead to substantial contrasts in technological change biases and factor substitutions? Specifically, in the case of proximity factor; with easy access to the industrial/urban areas where job opportunities are abundant, there is a tendency for labour to move out, say from NWSP to Kuala Lumpur or Petaling Jaya in search of more lucrative jobs. As a consequence, the NWSP might be encountering with labour shortage. Would this in turn lead this granary area to adopt different techniques of rice cultivation and factor substitutions compared with another granary area, say MADA whose location is quite a distance from urban/industrial areas? Meanwhile, in the case of seasonal factor; with the introduction of irrigation facilities into the off-season rice cultivation, it is expected that there are some differences in the trend of factor inputs demand, for instance for fertilizers, agri-chemicals and mechanization, compared with the main-season. Would this also lead to substantial contrasts in technological change biases and factor substitutions?

In spite of these have become important economic issues, practically speaking, empirical studies which have been undertaken to investigate the proximity and seasonal factors effects on Malaysian rice farming biases of technological change and factor substitutions are still lacking. Goldman and Squire (1982), for example, in their study on MADA granary area's labour use and technical change touch fairly little on the bias aspect and almost nothing on the factor substitutions aspect. Their main finding, among others, is that the technology embodied in this granary area was labour-using. On the other hand, Haughton (1986) though makes quite a comprehensive study on Malaysian rice cultivation, falls short of providing useful information neither about technological change biases nor factor substitutions. His major findings are; output is fairly responsive to price increases; labour demand is quite unresponsive to changes in the wage rate; and the demand for field preparation (mainly tractor hire) and fertilizers is quite price responsive (Haughton, 1986, pp.219). Despite this shortcoming, Haughton raises a very strong point. This can be seen when he concludes "the translog form is likely to be useful if the focus of investigation is the degree of substitution among inputs, or the effect of changes in physical inputs on physical output (pp.222)."

Having said this it is the purpose of this paper to present an empirical study utilizing a translog cost function, the latest methodological framework to measure production structure of a production unit, to investigate the technological change biases and factor substitutions of Malaysian rice farming for the 1980-90 period. We note here that with the inclusion of the proximity and seasonal factors into the analysis, we can now classify Malaysian rice farming into four, namely (i) old project, (ii) new project, (iii) main-season, and (iv) off-season.[1]

Perhaps, with this novel feature of our study it will lead to more reliable results than obtained by past studies and consequently can be taken to represent the technological status of Malaysian rice farming.

The subsequent discussions will be organized as follows. In section 2, we present a theory of measuring biases of technological change, scale bias and factor substitutions using a cost function approach. In this section also the Capalbo and Antle (1988) proposed procedures to compute the total bias effect will be shown. This will be followed in section 3 by discussions on the econometric modeling and the data of the study. While section 4 reports the empirical results, section 5 provides the summary and concluding remarks.

---

[1] (i) Old project comprises of MADA and KADA granary areas. 'Old' refers to the year in which irrigation schemes were initially introduced. In the case of these two granary areas the schemes were introduced in the late 1960s. We note also that this classification is made to distinguish them from NWSP and KSMP whose location is close to industrial/urban areas. (ii) New project. 'New' refers to NWSP and KSMP whose irrigation schemes were extended by the government in the late 1970s. (iii) Main-season How paddy is being cultivated depends very much on the means of water supply. In the case of main-season it was rain-fed. (iv) Off-season. Unlike main-season, paddy planted in off-season relies on water from man-built dam which flows along the irrigation canals.

2. The total cost function

To derive the model used in this study, suppose that the production structure for the case of one output - rice (Y), and four inputs - labour (L), machinery (M), intermediate inputs (U) and land (B), can be expressed in the following form:

$$Y = f(X,T) \tag{1}$$

where X is a vector of m inputs, T is time, which indicates the effect of technological change, and Y denotes output. Assuming that input prices, W_i, where i = (L,M,U,B), are exogenously determined, the dual cost function may be written as

$$C = C(W_L,W_M,W_U,W_B,Y,T) \tag{2}$$

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[2] 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. Applying Shephard's lemma to (2) yields

$$\frac{\partial C(W_L,W_M,W_U,W_B,Y,T)}{\partial W_i} = X_i(W_L,W_M,W_U,W_B,Y,T) \tag{3}$$

---

[2] 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. 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 dealers at market prices.

Then, multiplying both sides of (3) by W_i / C and rearranging, the cost share equations of the i^{th} factor inputs are obtained as

$$\frac{\partial C}{\partial W_i}\frac{W_i}{C} = \frac{W_i X_i}{C} = S_i \qquad , \qquad i = (L,M,U,B) \qquad (4)$$

Note that $\sum_{i=1}^{4}\frac{\partial \ln C}{\partial \ln W_i} = \sum_{i=1}^{4}\frac{\partial C}{\partial W_i}\frac{W_i}{C} = \sum_{i=1}^{4}\frac{W_i X_i}{C} = \sum_{i=1}^{4} S_i = 1$ where $\frac{W_i X_i}{C} = S_i$ denotes the cost share of the i^{th} input.

Next, logarithmically differentiating the right-hand side of (3) with respect to (w.r.t.) time (T) yields

$$\frac{d\ln X_i}{dT} = \frac{\partial \ln X_i}{\partial \ln Y}\frac{\dot{Y}}{Y} + \sum_{k=1}^{4}\frac{\partial \ln X_i}{\partial \ln W_k}\frac{\dot{W}_k}{W_k} + \frac{\partial \ln X_i}{\partial T} \qquad (5)$$

where $i \neq k$, $i,k = L,M,U,B$. The variables with dot on top denote a differentiation w.r.t. time (T). Equation (5) shows that the growth rate of factor inputs can be decomposed into output effects; price effects; and technological change effects.

Now, to obtain a relative change in a factor of say i^{th} input use with respect to change in other factor of say j^{th} inputs use, we express the left-hand side of equation (5) in proportional change form:

$$\frac{(d\ln X_i / d\ln X_j)}{dT} = \frac{d\ln X_i}{dT} - \frac{d\ln X_j}{dT} = \frac{\dot{X}_i}{X_i} - \frac{\dot{X}_j}{X_j} \qquad (6)$$

Using (6), equation (5) can be rewritten as

$$\frac{(d\ln X_i / d\ln X_j)}{dT} = \left[\frac{\partial \ln X_i}{\partial \ln Y}\frac{\dot{Y}}{Y} - \frac{\partial \ln X_j}{\partial \ln Y}\frac{\dot{Y}}{Y}\right] + \left[\sum_{k=1}^{4}\frac{\partial \ln X_i}{\partial \ln W_k}\frac{\dot{W}_k}{W_k} - \sum_{k=1}^{4}\frac{\partial \ln X_j}{\partial \ln W_k}\frac{\dot{W}_k}{W_k}\right] + \left[\frac{\partial \ln X_i}{\partial T} - \frac{\partial \ln X_j}{\partial T}\right] \tag{7}$$

where $i \neq k,j$; i,j,k (=L,M,U,B). From cost shares $W_iX_i / C = S_i$ and $W_jX_j / C = S_j$, where $i \neq j$; i,j (= L,M,U,B), the output effect and the technological effect of (7) may be further decomposed as follows. Taking natural logarithms of both sides of $W_iX_i / C = S_i$ and $W_jX_j / C = S_j$, respectively, and rearranging we obtain

$$\ln X_i = \ln C + \ln S_i - \ln W_i \tag{8a}$$

$$\ln X_j = \ln C + \ln S_j - \ln W_j \tag{8b}$$

Using (8a) and (8b) the following relations are obtained,

$$\frac{\partial \ln X_i}{\partial \ln Y} = \frac{\partial \ln C}{\partial \ln Y} + \frac{\partial \ln S_i}{\partial \ln Y}{}^{3} \tag{9a}$$

$$\frac{\partial \ln X_j}{\partial \ln Y} = \frac{\partial \ln C}{\partial \ln Y} + \frac{\partial \ln S_j}{\partial \ln Y} \tag{9b}$$

and

$$\frac{\partial \ln X_i}{\partial T} = \frac{\partial \ln C}{\partial T} + \frac{\partial \ln S_i}{\partial T} \tag{10a}$$

$$\frac{\partial \ln X_j}{\partial T} = \frac{\partial \ln C}{\partial T} + \frac{\partial \ln S_j}{\partial T} \tag{10b}$$

---

[3] The term which involves a differentiation of W_i w.r.t. Y does not appear here (i.e., in equation 9a) because when we differentiated equation (3) w.r.t. time (T) to obtain equation (5), we assumed that Y and W_i were given. Thus, as a result W_i naturally vanishes from equation (9a). This procedure applies to W_j as well.

Expressing $\partial \ln X_i/\partial \ln W_k = \eta_{ik}$ and $\partial \ln X_j/\partial \ln W_k = \eta_{jk}$, respectively, and then substituting (9a), (9b), (10a) and (10b) into (7) yields

$$\begin{aligned}\frac{(d\ln X_i / d\ln X_j)}{dT} &= [\frac{\partial S_i}{\partial \ln Y} \cdot \frac{1}{S_i}\frac{\dot{Y}}{Y} - \frac{\partial S_j}{\partial \ln Y} \cdot \frac{1}{S_j}\frac{\dot{Y}}{Y}] \\ &+ [\sum_{k=1}^{4} \eta_{ik} \frac{\dot{W}_k}{W_k} - \sum_{k=1}^{4} \eta_{jk} \frac{\dot{W}_k}{W_k}] \qquad (11)^4 \\ &+ [\frac{\partial S_i}{\partial T} \cdot \frac{1}{S_i} - \frac{\partial S_j}{\partial T} \cdot \frac{1}{S_j}]\end{aligned}$$

The first term of the right-hand side of (11) measures the effect of scale change on the relative factor use (the scale effect). The second term measures the effect of factor substitutions due to factor price change (factor substitutions effect). The last term measures the effect of technological change on relative factor use (technological change bias effect).

3. Econometric Modeling

3(i). Translog Cost Function

In order to compute the terms in the decomposition equation (11), we specify the cost function in translog form. Assuming that the translog cost function is represented by

---

[4] The terms $\partial \ln C/\partial \ln Y$ and $\partial \ln C/\partial T$ derived in equations (9a) and (9b), and (10a) and (10b), respectively, do not appear in equation (11) because they are vanished, upon substractions.

$$\ln C = \alpha_0 + \sum_{i=1}^{4} \alpha_i \ln W_i + \alpha_y \ln Y + \alpha_T T + 1/2 \sum_{i=1}^{4} \sum_{j=1}^{4} \gamma_{ij} \ln W_i \ln W_j$$
$$+ 1/2\gamma_{yy} (\ln Y)^2 + 1/2\, \gamma_{TT} (T)^2 + \sum_{i=1}^{4} \gamma_{iy} \ln W_i \ln Y + \sum_{i=1}^{4} \gamma_{iT} \ln W_i\, T$$
$$+ \gamma_{yT} \ln Y\, T \tag{12}$$

The cost-share equations are derived through Shephard's lemma as

$$S_i = \alpha_i + \sum_{i=1}^{4} \gamma_{ij} \ln W_j + \sum_{i=1}^{4} \gamma_{iy} \ln Y + \sum_{i=1}^{4} \gamma_{iT}\, T \tag{13}$$

Using (13), and rearranging, the terms in equation (11) can be reduced to:

$$\frac{(d\ln X_i / d\ln X_j)}{dT} = \left[\frac{\gamma_{iy}}{S_i}\frac{\dot{Y}}{Y} - \frac{\gamma_{jy}}{S_j}\frac{\dot{Y}}{Y}\right] + \left[\frac{\gamma_{iT}}{S_i} - \frac{\gamma_{jT}}{S_j}\right]$$
$$+ \left[\sum_{k=1}^{4} \eta_{ik} \frac{\dot{W}_k}{W_k} - \sum_{k=1}^{4} \eta_{jk} \frac{\dot{W}_k}{W_k}\right] \tag{14}$$

where $i \neq j,k$, $i,j,k = L,M,U,B$. Equation (14) will be used to estimate the production structures related to the ones defined in equation (11). We note further, however, if the first term of the right hand side of equation (14) is added to the second term it will give rise to the definition of total bias effect (CA_i) as proposed by Capalbo and Antle (1988).[5]

As shown by Capalbo and Antle (1988, pp.42) if the technology is homothetic, then the first term will vanish because $\partial \ln S_i / \partial \ln Y = 0$ (or in parametric form $\gamma_{iy} = 0$), for all $i = L,M,U,B$. Meanwhile, in the case of the second term if the technical change is Hick's neutral, then its effects on the proportional change in requirements for two

---

[5] Specifically, according to Capalbo and Antle (1988, pp. 41), the scale effect, i.e., the first term of equation (14), occurs due to the movement along the expansion path, and the bias effect, i.e., the second term, occurs due to the shift in the expansion path.

factor inputs would be identical. However, in this study this term indicates the effect of non-neutral technical change or biased of technological change effect. The third term remains as defined before

If we redefine $NB_i = \gamma_{iy} / S_i$, then the bias due to scale effect is non-homothetically i^{th} factor saving, neutral, or using according as $NB_i < 0$, $NB_i = 0$, or $NB_i > 0$.

Next, if we redefine $TB_i = \gamma_{iT} / S_i$, then the biased technological change effect is i^{th} factor saving, neutral, or using according as $TB_i < 0$, $TB_i = 0$, or $TB_i > 0$.[6]

Finally, if we redefine $CA_i = NB_i + TB_i$, then the total bias effect is i^{th} factor-saving, neutral, or using according as $CA_i < 0$, $CA_i = 0$, or $CA_i > 0$.

Since we are not only interested in computing the parameters related to technological change bias effect, scale bias effect and total bias effect but also of factor substitutions of equation (14), the following procedures to compute the last term parameters of (14) are deemed necessary. Following Berndt and Christensen (1973), the price elasticities of demand for factor inputs can be computed as:

$$\eta_{ii} = S_i \, \sigma_{ii} \qquad (15)$$

$$\eta_{ij} = S_i \, \sigma_{ij} \qquad (16)$$

where σ_{ii} and σ_{ij} are the Allen partial elasticities of substitution and can be obtained by using the method of computation suggested by Binswanger (1974):

---

[6] We note further that these two forms of biases measurement, i.e., NB_i and TB_i, indicate the magnitudes and directions of the effects of non-homotheticity and non-neutral technological change on relative uses of factors of production, respectively (Kuroda, 1987, pp.330).

$$\sigma_{ii} = (\gamma_{ii} + S_i^{\ 2} - S_i)/S_i^2 \tag{17}$$

$$\sigma_{ij} = (\gamma_{ij} + S_iS_j)/S_iS_j \tag{18}$$

Since cost function is used to measure NB_i, TB_i, CA_i and η_{ik}, the function should satisfy the following regularity conditions (Diewert, 1978) to represent a well-behaved technology; (i) linearly homogeneous in input prices, (ii) positive and monotonically increasing in input prices, and (iii) concavity in input prices. These theoritical assumptions require the following restrictions on its parameters:

(1) Linearly homogeneous in input prices:

$$\sum_{i=1}^{4} \alpha_i = 1\ ,\ \sum_{i=1}^{4} \gamma_{ij} = \sum_{j=1}^{4} \gamma_{ji} = 0\ ,\ \sum_{i=1}^{4} \gamma_{iy} = 0 \tag{19}$$

(2) Monotonically increasing in input prices

$$S_i = \frac{d\ln C}{d\ln W_i} \geq 0 \tag{20}$$

where S_i represent the cost shares of each factor input.

(3) Concavity in input prices. A sufficient condition for concavity of the cost function in input prices is that the Hessian matrix of second partial derivatives with respect to factor prices be negative semidefinite. An equivalent test of concavity is that the symmetric matrix of Allen partial elasticities of substitution be negative semidefinite (Nautiyal and Singh, 1986). A necessary condition for the matrix to be negative semidefinite is that all of the own Allen elasticities of substitution be negative.

For econometric estimation, the cross-equations equality and the linear homogeneity restrictions defined in (19) are imposed a priori on the translog cost function (12), and on the cost-share equations (13). 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).

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 is Christensen, Caves and Diewert (1982) proposed procedure.

4. Empirical results

Table 1 reports a complete set results of the parameter estimates of the translog cost function. The R-squared for the cost function and the three cost-share equations - S_L, S_M, S_U, was 0.992, 0.866, 0.621 and 0.600, respectively, indicating a fairly good of fit for the model.

As can be seen from the Table the linear homogeneity and monotonicity conditions are both satisfied by our model. This is shown by $\sum_{i=1}^{4} \alpha_i = 1$ and $\alpha_i \rangle 0$, for all i = L,M,U,B, respectively. The latter condition was estimated at the approximation point.

Table 2 presents the overall overview results of parameter estimates of Allen partial elasticities of substitution. As evident from the Table the concavity condition, as indicated by own Allen partial elasticities of substitution which are all negatives, is also satisfied by our model. Since the model satisfies the basic regularity conditions, we conclude that the estimated cost function represents well-behaved technology.

It is also obvious from Table 2 that three factor inputs are substitutability pairs and they are all statistically significant. They are; labour-machinery pair (σ_{LM}), labour-intermediate inputs pair (σ_{LU}) and machinery-intermediate inputs pair (σ_{MU}). This means that any increase in the price of, for example labour, both machinery and intermediate inputs are possible candidates to be substituted for labour.

We turn our attention to scale bias, technological change bias and total bias effects. Table 3 indicates to us that only two parameters are statistically significant at 5% levels, each representing biased of technological change and total bias effects, respectively. In both cases labour is factor-saving bias. On the other hand, while machinery is factor-using in the case of total and technological change bias, intermediate inputs is factor-saving bias in the case of scale bias. They are all statistically significant at 20% levels. The intermediate inputs factor-saving bias is worth interpreting. In this case it means that, on average, a 1% increase in output resulted in only 0.2% increase in the demand for intermediate inputs.

Next, Table 4 reports the detail scenario of behavioral patterns of each farming classification in terms of Allen partial elasticities of substitution. While the results pertaining to labour-machinery and, to some extent, labour-intermediate inputs pairs are consistent with ones of the overall overview (Table 2), the machinery-intermediate inputs pair is not. In the case of machinery-intermediate inputs pair, the results are split. On the one hand the input pair is complementarity for old and new projects, on the other it is substitutability pair for main season. The results of estimated parameters discussed here are all statistically significant. Thus, we may infer that in both old and new projects any decrease in the price of machinery tends to increase the demand for intermediate inputs.

Finally, Table 5 shows the estimated parameter results related to scale bias, technological change bias and total bias effects of each farming classification. It is obvious from the Table that the results of the technological change bias effect are consistent with the overall overview shown in Table 2 - labour is factor-saving input. Nevertheless, the results of the scale bias effect are split between the off- and main-seasons. While in the off-season intermediate inputs is factor-using, it is factor-saving in the opposite season. Thus, in the former season any increase in rice output will call for an increase demand for intermediate inputs. All results of estimated parameters discussed here are statistically significant. It is worth noting also that when the parameters were computed according to Capalbo and Antle proposed procedures the results have slightly changed. While labour remained as factor-saving input and statistically significant, intermediate inputs in all farming classifications became neutral - statistically insignificant.

5. Summary and concluding remarks

Using a translog cost function approach we estimated the production structures that are related to factor substitutions, scale bias, technological change bias, and total bias effects of Malaysian rice farming. We assumed a priori that the proximity and seasonal factors contributed differently to farmers behaviour towards utilization of factors of production. From the results discussed in section 4 we may extract at least three major findings. They are;

(i). Irrespective of granary area and season (ie. irrespective of proximity and seasonal factors) labour is factor-saving bias. This finding is at variance with one of Goldman and Squire (1982) whose finding indicates that labour was factor-using in MADA granary area. The reason for such a different finding between theirs and ours is possibly due to the time when the study was undertaken. Goldman and Squire undertook the study in the year before 1982 where the data used for the analysis covered the period before 1980. We, however, undertook the study recently and the data used for the analysis covered the 1980-1990 period. Taking these two findings into consideration one might infer that labour utilization has shifted from once being factor-using to then being factor-saving. We may also conclude from this finding that the proximity and seasonal factors contribute indifferently to farmers behaviour towards labour utilization. Labour, to reiterate, is factor-saving in all farming classifications. Perhaps, there are two reasons for this. First, this is due to better education training that the young generation had received which in turn allowed them to seek better job in the urban and industrial areas surrounding as well as quite a distance from the granary areas. Thus, it is left to the old generation to work on paddy fields. Second, with better technique of rice cultivation introduced by the respective regional authority which, among others, is intended to save labour cost has also contributed to labour-saving bias technology adopted by the farmers. Direct seeding which has gradually replaced the older technique, generally known as transplanting, is one of the example. The former technique saved between 20 - 30% of man/hours labour employed, and thus labour cost (Ministry of Agriculture, 1982).

(ii). As evident from Table 4, irrespective of farming classifications machinery and intermediate inputs are labour substitutability pairs. Thus, no matter where the farmers operate their paddy field (i.e., the proximity factor) and no matter when they grow the paddy (i.e., the seasonal factor), facing with such problems, machinery and intermediate inputs can always be substituted for labour.

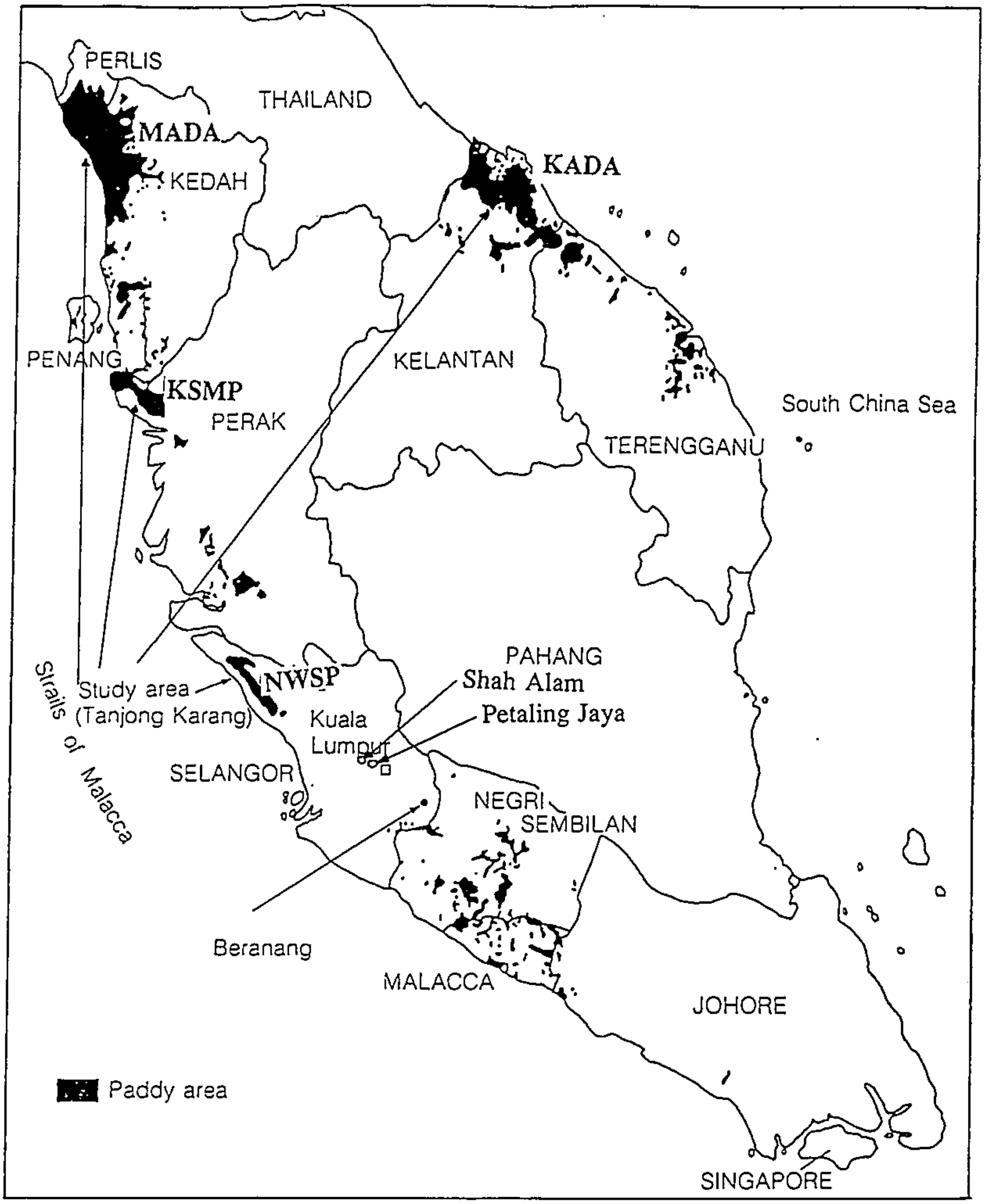
(iii). From the empirical results of scale bias effect, intermediate inputs is found to be factor-using input in the off-season, and factor-saving input in the main-season and old-project. Thus, this tends to suggest that seasonal and, to some extent, proximity factors play a significant role in influencing the farmers behaviour towards intermediate inputs utilization. The finding which suggests that the intermediate inputs is factor-using in off-season is worth elaborating. With this finding the criticism against the Green Revolution seems to be justifiable. Pinstrup and Hazell (1985, pp.10), for example, have pointed out that "the Green Revolution is based on a combination of varieties with high yield potential, fertilizers, irrigation, and in some cases chemical pesticides and mechanization." To put it differently this is nothing but to say that each component of the intermediate inputs; irrigation, HYVs, agri-chemicals and fertilizers, must be utilized all-at-once, and the more output is to be produced (in the off-season) the greater amounts of intermediate inputs are required. In the event where a non-existence of one of the intermediate inputs components, the rice productions will be below the expected level. In many ways, farmers who operate with the land outside the granary areas are disadvantageous mainly because in these areas one of the intermediate input components is unavailable, namely irrigation. Beranang area, as cited by Davendra and Abdul Aziz (1994) is a classic example of such a case.

Given these three findings the following two policy implications are deemed conceivable.

First, since labour has been identified as factor-saving, and machinery and intermediate inputs have been identified as labour substitutability pairs, this could provide a basis for government to implement policies related to the utilization of these factor inputs - labour, machinery and intermediate inputs. For instance, facing with any shortages in labour which is possibly due to increasing demand from the manufacturing and/or construction sectors (i.e., the two main contributors to Malaysian rapid economic growth which had been growing at the rate of more than 8.0% for eight consecutive years), it is either machinery or intermediate inputs which could be used for labour substitutions. However, as has been pointed out by Ayob Sukra (1986), when machinery is used a number of problems might arise, for instance; non-availability of suitable hardware for specific field conditions such as deep water, soft soil, wet harvest, small plot levelling, and dry tillage on heavy clay. These conditions in many ways had hampered the widespread use of machinery services in some of the granary areas. Hence, it seems that the intermediate inputs is in the better position, in some granary areas, to be substituted for labour if the latter input is in shortage.

Second, as indicated by the third finding - intermediate inputs is factor-using in the off-season. Now, if the rice production were to be increased in this season a corresponding increase in the utilization of intermediate inputs was necessary. Thus, a policy which is designed to make a leeway for farmers to have access to more fertilizers, high quality seeds and agri-chemicals inputs (apart from irrigation facilities) during the off-season cultivation is recommended. Since fertilizers and seeds are fully and partially subsidized, respectively, by the government, the only option left is that the agri-chemicals needs to be sold (by private dealers) at a price which is more purchasable by all type of rice cultivators, namely owner-cultivators, tenant-owner cultivators and tenant cultivators.

Figure 1



MADA = Muda Agricultural Development Authority

KADA = Kemubu Agricultural Development Authority

NWSP = North-West Selangor Project

KSMP = Kerian Sungai-Manik Project

Table 1: Parameter estimates of the translog cost function for Malaysian rice farming, 1980-90

Coefficient	Estimate	t - ratio
α	3.300	117.168
α_L	0.342	75.693
α_M	0.131	24.779
α_U	0.258	64.403
α_B	0.269	3.749
α_Y	0.407	5.693
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
γ_{LY}	-0.052	-0.905
γ_{MY}	0.037	5.553
γ_{UY}	-0.039	-7.790
γ_{BY}	0.076	0.044
γ_{YT}	-0.430	-0.103

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

Table 2: Allen partial elasticities of substitution for Malaysian rice farming, 1980 - 1990 (an overall overview)

Parameter	Estimate	t-value	Behavioral Patterns
σ_{LL}	- 5.0388	-19.6128	n.a
σ_{MM}	-34.7364	- 3.0820	n.a
σ_{UU}	-12.3564	- 4.7633	n.a
σ_{BB}	- 0.8800	- 0.2896	n.a
σ_{LM}	5.4267	3.1820	substitutes
σ_{LU}	5.7877	6.4361	substitutes
σ_{LB}	- 1.7732	- 1.2797	complements
σ_{MU}	6.4504	3.0790	substitutes
σ_{MB}	3.8288	0.6606	substitutes
σ_{UB}	1.3284	0.4552	substitutes

Note:

n.a = Not applicable.

Table 3: Technological change bias effect (TB_i), scale bias effect (NB_i) and total bias effect (CA_i) for Malaysian rice farming, 1980-90 (an overall overview)

Parameter	Estimate	t-value	Classification of bias effects
TB_L	-0.0872	-3.4845	factor-saving
TB_M	0.0743	1.4181	factor-using
TB_U	0.0554	0.3432	factor-using
TB_B	0.0217	0.1372	factor-using
NB_L	-0.0016	-0.0313	factor-saving
NB_M	0.0296	0.5044	factor-using
NB_U	-0.0160	-1.3658	factor-saving
NB_B	0.0029	0.0436	factor-using
CA_L	-0.0873	-3.6913	factor-saving
CA_M	0.0773	1.4383	factor-using
CA_U	0.0538	0.3333	factor-using
CA_B	0.0219	0.1397	factor-using

Note: Parameters of (CA_i) were computed by adding the parameter estimates of (TB_i) to (NB_i)

Table 4: Allen partial elasticities of substitution for Malaysian rice farming, 1980 - 1990 (a detail overview)

Parameter	Behavioral Patterns	
	Complements	Substitutes
σ_{LM}	n.a	MS*, OP*, NP*, OS
σ_{LU}	OP	MS*, OS*, NP*
σ_{LB}	OS, OP, NP, MS	n.a
σ_{MU}	OP*, OS, NP*	MS*
σ_{MB}	n.a	OS, OP, NP, MS
σ_{UB}	OP	MS, OS, NP

Note:

OS = Off-Season MS = Main-Season NP = New Project OP = Old Project

* Indicates the coefficients are statistically significant at least at 10% levels.

n.a= Not applicable

Table 5: Technological change bias effect (TB_i), scale bias effect (NB_i) and total bias effect (CA_i) for Malaysian rice farming, 1980-90
(a detail overview)

Parameter			Classification of bias effects		
TB_i	NB_i	CA_i#	TB_i	NB_i	CA_i
TB_L^1	NB_L^1	CA_L^1	factor-saving*	factor-using	factor-saving**
TB_M	NB_M	CA_M	factor-using	factor-saving	factor-using
TB_U	NB_U	CA_U	factor-using	factor-saving**	factor-using
TB_B	NB_B	CA_B	factor-saving	factor-using	factor-saving
TB_L^2	NB_L^2	CA_L^2	factor-saving*	factor-saving	factor-saving*
TB_M	NB_M	CA_M	factor-saving	factor-using	factor-saving
TB_U	NB_U	CA_U	factor-using	factor-using	factor-using
TB_B	NB_B	CA_B	factor-using	factor-saving	factor-using
TB_L^3	NB_L^3	CA_L^3	factor-saving*	factor-using	factor-saving*
TB_M	NB_M	CA_M	factor-using**	factor-using	factor-using**
TB_U	NB_U	CA_U	factor-using	factor-saving*	factor-using
TB_B	NB_B	CA_B	factor-using	factor-using	factor-using
TB_L^4	NB_L^4	CA_L^4	factor-saving*	factor-using	factor-saving*
TB_M	NB_M	CA_M	factor-saving	factor-saving	factor-saving
TB_U	NB_U	CA_U	factor-using	factor-using*	factor-using
TB_B	NB_B	CA_B	factor-using	factor-saving	factor-using

Note: (1) = Old Project (2) = New Project (3) = Main-Season (4) = Off-Season

Parameters of the third column for all farming classifications were computed by adding the parameters of the first to the second column.

* and **= The coefficients are statistically significant at 5% and 20% levels, respectively.

Appendix 1

Factor cost shares of Malaysian rice farming, 1980 - 1990

Observation Year	Labour	Machinery	Intermediate Inputs	Land
1980	0.3278	0.1439	0.3115	0.2172
1981	0.3022	0.1509	0.2911	0.2558
1982	0.2384	0.1225	0.2921	0.3324
1983	0.2380	0.1210	0.2823	0.3208
1984	0.2235	0.1299	0.2848	0.3261
1985	0.2662	0.1205	0.3257	0.3035
1986	0.2374	0.1079	0.3148	0.3245
1987	0.2480	0.1173	0.3407	0.3195
1988	0.2528	0.1208	0.3629	0.3014
1989	0.2265	0.1336	0.4068	0.2585
1990	0.1812	0.1508	0.3922	0.2979
1980	0.3390	0.1227	0.2888	0.2609
1981	0.3108	0.1455	0.2998	0.2708
1982	0.2820	0.1131	0.3049	0.3131
1983	0.2414	0.1233	0.2862	0.3185
1984	0.2294	0.1220	0.2959	0.3248
1985	0.2146	0.1093	0.3114	0.3548
1986	0.2646	0.1161	0.3066	0.2902
1987	0.2532	0.1235	0.3320	0.3092
1988	0.2753	0.1340	0.3544	0.2869
1989	0.2128	0.1614	0.3674	0.2941
1990	0.1854	0.1472	0.4007	0.2867
1980	0.3043	0.2073	0.1734	0.3207
1981	0.2936	0.2198	0.1604	0.3262
1982	0.2718	0.2177	0.1627	0.3477
1983	0.2133	0.2186	0.1778	0.3904
1984	0.2419	0.2144	0.1707	0.3729
1985	0.2276	0.2308	0.1660	0.3756
1986	0.2120	0.2318	0.1815	0.3747
1987	0.1884	0.2354	0.1883	0.3880
1988	0.2133	0.2907	0.2217	0.2743
1989	0.2342	0.2891	0.2508	0.2260
1990	0.2290	0.2975	0.2592	0.2144
1980	0.3108	0.1966	0.1850	0.3075
1981	0.2916	0.2255	0.1664	0.2164
1982	0.2888	0.2096	0.1609	0.3408
1983	0.1875	0.2310	0.1955	0.3860
1984	0.2095	0.2266	0.1805	0.3834
1985	0.2189	0.2250	0.1787	0.3774
1986	0.2157	0.2347	0.1748	0.3749
1987	0.1587	0.2393	0.1980	0.4040
1988	0.2048	0.2901	0.2435	0.2616
1989	0.2220	0.2953	0.2467	0.2360
1990	0.2334	0.2957	0.2533	0.2176
1980	0.4357	0.0930	0.2058	0.2655
1981	0.3766	0.1523	0.2400	0.2311
1982	0.3948	0.1080	0.2370	0.2602
1983	0.3107	0.2719	0.1992	0.2182
1984	0.3923	0.1247	0.2460	0.2384
1985	0.4122	0.0961	0.2455	0.2462
1986	0.4008	0.1403	0.2304	0.2286
1987	0.4235	0.0814	0.2485	0.2467
1988	0.3458	0.2204	0.2207	0.2131

Appendix 1 ....continue

Observation Year	Labour	Machinery	Intermediate Inputs	Land
1989	0.4178	0.1027	0.2417	0.2377
1990	0.3843	0.1118	0.2511	0.2526
1980	0.4238	0.1303	0.1631	0.2829
1981	0.3958	0.1194	0.2468	0.2380
1982	0.3485	0.1259	0.2649	0.2607
1983	0.3890	0.1089	0.3449	0.2573
1984	0.3863	0.1049	0.2510	0.2578
1985	0.4172	0.1102	0.2322	0.2404
1986	0.4246	0.0900	0.2421	0.2435
1987	0.4169	0.1027	0.2450	0.2355
1988	0.4261	0.0876	0.2455	0.2407
1989	0.4115	0.1026	0.2462	0.2397
1990	0.3840	0.0991	0.2555	0.2615
1980	0.6251	0.0102	0.2252	0.1395
1981	0.5916	0.0091	0.2132	0.1862
1982	0.4780	0.0120	0.2423	0.2677
1983	0.5159	0.0136	0.2690	0.2015
1984	0.4940	0.0135	0.2605	0.2321
1985	0.4811	0.0197	0.2911	0.2082
1986	0.4698	0.0490	0.2838	0.1975
1987	0.4629	0.0489	0.2944	0.1939
1988	0.4539	0.0468	0.2948	0.2045
1989	0.4437	0.0550	0.2951	0.2066
1990	0.4509	0.0436	0.3031	0.2024
1980	0.6088	0.0083	0.2309	0.1520
1981	0.5680	0.0184	0.2154	0.1983
1982	0.4766	0.0244	0.2542	0.2448
1983	0.4828	0.0255	0.2742	0.2175
1984	0.4781	0.0260	0.2645	0.2314
1985	0.4587	0.0340	0.2881	0.2137
1986	0.4704	0.0414	0.2945	0.1938
1987	0.4609	0.0487	0.2975	0.1928
1988	0.4483	0.0470	0.3125	0.1923
1989	0.4368	0.0537	0.3107	0.1988
1990	0.4353	0.0529	0.3308	0.1810

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

References

Ayob, S., (1986) Mechanization of Malaysian food crops production: some considerations, in: Aziz, Abu Bakar and Chan (eds) *Mechanization in Agriculture in Malaysia* (Kuala Lumpur, Proceedings of the Seminar on Mechanization in Agriculture).

Berndt, E.R. and Christensen, L.R., (1973) The translog function and the substitution of equipment, structures, and labor in U.S. manufacturing, 1929 - 68, *Journal of Econometrics,* 1, pp.81 - 113.

Binswanger, H.P., (1974) A cost function approach to the measurement of elasticities factor demand and elasticities of substitutions, *American Journal of Agricultural Economics* , 56, pp.377-386.

Capalbo, S.M. and Antle, J.M., (1988) *Agricultural Productivity: Measurement and Explanation* (Washington D.C., Resources for the future)

Caves, D.W., Christensen, L.R., and Diewert, W.E., (1982) Multilateral comparison of output, input, and productivity using superlative index numbers, *Economic Journal* , 92, pp.73 - 86.

Devendra, P.Y. and Abdul Aziz, A.R., (1994) Credit, technology, and paddy farm production: a case of Tanjong Karang and Beranang, Malaysia, *The Developing Economies,* 32, pp.67-83.

Diewert, W.E., (1978) Superlative index numbers and consistency in aggregation, *Econometrica,* 46, pp.883-900.

Goldman, R.H. and Squire, L., (1982) Technical change, labor use, and income distribution in the Muda irrigation project, *Economic Development and Cultural Change* , 30, pp.754 - 775.

Haughton, J., (1986) Farm price responsiveness and the choice of functional form: an application to rice cultivation in West Malaysia, *Journal of Development Economics,* 24, pp.203-223.

Kuroda, Y., (1987) The production structure and demand for labor in postwar Japanese agriculture, 1952 - 1982, *American Journal of Agricultural Economics,* 69, pp.328-337.

Ministry of Agriculture, (1982) Paddy Direct Seeding Technology: Some Economic Considerations and Prospects in Project Barat-Laut Selangor (NWSP), *Department Publication* No: PBLS/J/8.

Nautiyal, J.C. and Singh, B.K., (1986) Long-term productivity and factor demand in the Canadian pulp and paper industry, *Canadian Journal of Agricultural Economics*, 34, pp.21-43.

Pinstrup, A. and Hazell, P.B.R., (1985) *The Impacts of the Green Revolution and the Prospects for the Future,* (Washington D.C., International Food Policy Research Institute).