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Economic Analysis of Technological Progress in Malaysian Block Rubber Processing Plants

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This paper presents some preliminary results based on production function analysis of twenty-nine block rubber factories in Peninsular Malaysia. The unrestricted Cobb-Douglas form of production function was used and the least-squares regression technique was used to estimate the coefficients of the production function. Value-added output was used as the dependent variable while labour input and capital service flow were used as the independent variables.

Pooled regressions for the block rubber processing factories indicated that the coefficient for labour elasticity was significant and that there was a discernible tendency for increasing returns to scale. The elasticity of capital coefficient was low and not significantly different from zero. Estimates of technological progress for processing plants of different age groups gave insignificant results with no specific trend of progress evident. The results also suggested that block rubber processing facilities were grossly under-utilised.

Technical advancement in rubber processing particularly in the perfection of processing techniques which made production of the new forms of block rubber possible, has ushered in a new era of product transformation in many rubber producing countries in Asia. With the new processing techniques available considerable progress has been made to place the new product in a better competitive position *vis-a-vis* synthetic rubber. This is especially evident in Malaysia, the world's biggest exporter of natural rubber, where more than one-third of total rubber exported is now in the new presentation form (block rubber).

The introduction of the Standard Malaysian Rubber (SMR) Scheme in 1965 was an important step forward in rubber processing technology. The Scheme made possible the production of quality-controlled standard Malaysian rubber that is tailored to meet the requirements of consumers. As the SMR Scheme was introduced more than a decade ago, it was felt that a preliminary study could now be undertaken on the production function of rubber processing and its related characteristics. Such a study it was felt could provide useful insights to policy makers and research workers on rubber.

Selection of Model

In estimating a production function, decisions have to be made on what is to be estimated and how. These typically involve the choice of:

- The algebraic form of production function
- The variables to be included in the production function and the form in which they are to be included
- A technique for estimating the coefficient of the production function.

The choice of an appropriate functional form, essentially involves selecting the form that will give the best fit, and one which is based on assumptions that are most plausible to the real world. Three functional forms were considered in this study:

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- Transcendental
- Kmenta's Approximation to constant elasticity of substitution (CES)
- The unrestricted Cobb-Douglas production function (*Appendices 1* and *2*).

Estimates based on survey data[1] showed that the transcendental and Kmenta's Approximation to CES forms of the production function gave insignificant results in most cases. The unrestricted Cobb-Douglas form, *i.e.* an equation linear in the logarithms of the variables, was finally chosen partly for its ease of manipulation and interpretation, but mainly for its good fit of data. The coefficients of the production function were estimated using least-squares regression techniques applied to the logarithms of the variables, with 'value added' output as the dependent variable.

Cobb-Douglas Production Function Model

Let the production of block rubber in a processing plant be presented by the following functional form:

$$V = F(L, K)$$

where V is the value added output variable
L is the input cost of labour
K is the input cost of capital services during a given period of production.

The Cobb-Douglas form of the above production function can be written as:

$$V = AL^{\alpha}K^{\beta}e$$

where A is the constant term
α is the elasticity of output for labour
β is the elasticity of output for capital services
e is the random disturbance term independently distributed with zero mean and finite variance.

The use of a Cobb-Douglas production function model merits some consideration. The basic question is whether such a function represents correctly the production function for block rubber processing plants. In other words, the point is associated with substitution possibilities between different inputs. The Cobb-Douglas production function assumes a unitary elasticity of substitution between labour and capital. Studies have shown that such an assumption holds, for example, Hayami[2] and Hayami-Ruttan[3] using intercountry cross-section data found their results to be consistent with unitary elasticity of substitution. Another study by Lau and Yotopoulos[4] fitted data on Indian agriculture to a CES production function directly with a non-linear method. The results indicated that the elasticity of substitution was not significantly different from one. Following Kmenta[5], cross-sectional data for the block rubber processing plants surveyed were tested using a CES production function. The results are presented in *Appendix 3*. On the basis of the results, it was concluded that the hypothesis of the Cobb-Douglas production function representing the data adequately cannot be rejected.

Another property of the Cobb-Douglas production function is that the degree of returns to scale is invariant with the level of output[6] while it is possible to measure and ascertain if the degree of homogeneity of the function is greater than, equal to, or less than one, it is not possible to ascertain if there are additional economies of scale within the output range studied or to ascertain the sources of economies of scale. Griliches[7] also pointed out that for an adequate study of economies of scale the use of a production function not homogenous over at least some range of inputs would be required. Surjit[8] in his study of technical change in wheat production in Punjab (India) suggested that if the sample size was large enough, one way of overcoming this difficulty was to split the sample into a few size groups and fit segments of functions linear in logarithms and observe how the degree of homogeneity behaved for different output ranges.

In addition to the above properties of the Cobb-Douglas production function model, the use of single equation least-squares regression techniques in the present study to estimate the parameters of the production function involves the classic simultaneity problem. This is because the data observed in any production system are generated by profit maximising or cost minimising considerations of the firm and thus the input and output levels are simultaneously determined. The production function is a system of simultaneous equations; single equation estimates are generally biased and inconsistent. To justify the estimation that follows, it is necessary to assume that the observed production relation is disturbed by, or subject to a multiplicative random 'error' or 'disturbance' of the form,

$$V = AL^{\alpha}K^{\beta}e^{\mu}$$

where $E(\mu) = o$, $E(\mu)^2 = \sigma^2$ and $E(\mu \log K) = E(\mu \log L) = 0$ (the last assumption implies that this error is disturbed independently of the levels of capital and labour inputs.) It is possible to assume that capital is largely predetermined and unaffected by current fluctuations in output but such an assumption is much less tenable for labour. If the production function deals with crop production, the error of the disturbance term μ can be interpreted as a measure of the influence of unanticipated weather fluctuation and it can be assumed that L is chosen on the basis of anticipated weather and hence is independent of the particular realisation of μ; but such an assumption is very difficult to maintain in the case of block rubber processing. The importance and implications of introducing error variables in equations of a simultaneous system were first considered by Haavelmo[9]. He emphasised that without defining the statistical properties of all the variables involved, it was not possible to know the meaning of the statistical results obtained by fitting separate equations to the data. The problems of simultaneity in the determination of the inputs and output in a production system were also studied by Marschak and Andrew[10]. They placed emphasis on management to explain the differences among firms and split these differences into those due to differences in the production functions (technical efficiency) and those due to differences in ability to maximise profits (economic efficiency) among firms. By so doing, it was possible to estimate parameters of the Cobb-Douglas production function to a narrow range by imposing certain restrictions. However, unique estimates were still not possible. Subsequently, Hoch[11] suggested using convariance analysis to combine time-series and cross-section data, but this approach could not be used in single cross-section data. In another paper, Hoch[12] showed that under the assumption that disturbances in various equations of the system were independently distributed but the error term e was related to independent variables, the sum of the estimated coefficients had a pronounced tendency towards one regardless of the true sum. This tendency, however, was not so apparent if the assumption of independence of the error term was dropped. Hoch further argued that when the variable input levels were determined for the current period by maximising with respect to anticipated output, the disturbance in the production function affects only the output and not the other variables. As such the simultaneous equation bias was not serious. Griliches[13] in his study of aggregate production function using cross-section data argued that in agricultural production where inputs were largely predetermined due to a considerable lag in production and error being largely weather determined, simultaneous equation bias would be small for well specified production functions.

Another problem related to the estimation of production function is that certain variables cannot be included in the analysis. For example, in the case of the management variable, data relating to this variable are difficult to obtain. Mundlak[14] has shown that exclusion of the management factor could result in biased estimates of the production function parameters. Cognizance of the importance of the management factor in production function analysis can obviate misinterpretation of the results.

The Variables

Three variables: value added, labour, and capital, were eventually selected after investigating a number of different variables deemed to be relevant to the study.

Value added. In the present study, the value added variable was used as the dependent variable in the Cobb-Douglas production function model. The value added variable V is defined as $V = Y - M - C$. Y is the gross revenue generated by the block rubber production plants and the services provided. Material consumption M includes all raw material inputs. Upkeep cost C is the cost of maintaining the plant. The above definition was chosen to give a value added measure that is as close as possible to the value of the work done in the plant, *i.e.* labour working in the plant and the capital item K.

Labour. There are two ways of measuring labour input. The simplest way is to obtain the total number of persons engaged in the processing plant. Another method of measuring labour input is to compute the actual number of production hours put in by the workers. In a block rubber processing plant, the number of persons engaged in processing is not a fair way of measuring labour inputs. This is because a processing plant may operate at varying capacities during the year, depending on the availability of raw material (latex and field coagula). This may lead to underemployment of workers during the wintering and rainy periods when production can fall below half the normal capacity. A more appropriate measurement of labour input will be total labour production hours. Given the data on checkroll and contract labour, the labour input can then be derived.

Capital. The capital service flow concept was adopted in this study. The value of capital assets was first computed from the survey data. Using the concept of capital service flow[15] *(Appendix 4)* the values of annual service flow from capital assets were then derived. Only capital assets which were directly involved in the production process within the plant were included in the computation. They included buildings, processing machinery, processing utensils, driers, ancilliary equipment and other miscellaneous items directly involved in the production processes within the plant.

Empirical Results and Interpretation

The results of the least-square estimates are summarised in *Table 1*. The pooled regression for the block rubber processing plants indicated that the coefficient for labour elasticity was significant and that there was a tendency for increasing returns to scale. The elasticity of capital coefficient was low and not significantly different from zero. Attempts to estimate the results using Kmenta's Approximation to CES led to no real improvement in the results. The mean square error for the plants as a whole was about 0.15 implying that the average standard deviation of residuals was about 40%. There is therefore great variability in the data which is not adequately explained by the variables in the present study.

The returns to labour are relatively high when compared to capital investment. This is mainly due to the fact that labour is more fully employed than capital assets in a processing plant. For example, in a processing plant, the work schedule is normally divided into three eight-hour shifts. Labour

TABLE 1. PRODUCTION FUNCTION ESTIMATES FOR BLOCK RUBBER PROCESSING PLANTS IN PENINSULAR MALAYSIA (1975)

Form of equation	Constant A	Capital elasticity	Labour elasticity	Return to scale	R^2	MSE
CD	0.367 (1.791)	0.149 (0.167)	0.937** (0.48)	1.086	0.74	0.159
Kmenta approx. for CES	0.303 (1.751)	0.187 (0.166)	0.912** (0.146)	1.098	0.71	0.151
CD with plants less than four years old	3.483 (3.372)	0.047 (0.167)	0.787* (0.298)	0.834	0.69	0.079
CD with plants between four and eight years old	−1.445 (2.885)	0.763* (0.310)	0.489* (0.258)	1.252	0.78	0.145
CD with plants more than eight years old	5.065 (4.289)	−0.576 (0.429)	1.249** (0.279)	0.673	0.78	0.165

R^2 = Coefficient of determination
MSE = Mean square error
CD = Coob-Douglas function: $\text{Log } V = A + \alpha \text{ Log } L + \beta \text{ Log } K$
Figures within brackets are the estimated standard errors of the respective coefficients.
Kmenta approx.: The equation is the same as CD with $[\log (K/L)]^2$ term added
CES = $\text{Log } V = A + (1 + h) \log [\delta L^{-\rho} + (1-\delta)(k)^{-\rho}]^{-1/\rho}$ and $\sigma = \frac{1}{1+\rho}$ = coefficient of substitution
* Coefficient significant at 5% level
**Coefficient significant at 1% level

is only employed when the plant is in operation. In most of the plants surveyed, however, maximum capital service utilisation was not achieved because the plant manager could not obtain sufficient raw material (latex and field coagula) for three shifts, leading to under-utilisation of machinery. This is reflected in the capital coefficient estimates in both the Cobb-Douglas and Kmenta model. There is evidence to show that processing plants in Peninsular Malaysia operate only around half their maximum throughput capacity due to the lack of raw materials[1]. Most of the plants in the east coast operated at about a quarter of their maximum throughput capacity, while those in the west coast were running at half their maximum throughput capacity. This may help explain the low and insignificant results obtained in the estimates of the capital coefficient.

To study the effect of technological progress in block rubber processing, processing plants established in different years were grouped by different technological strata. Three technological strata were defined[1]. Plants established before 1967 constituted the oldest group. This group of processing plants were the early innovators and they were still using the original processing techniques which they had first adopted. Plants established between 1967 and 1970 formed the middle group. This group adopted the better crumbling units and more efficient driers that were available to them during this period. Plants established after 1971 were treated as part of the new technological group. They represented the newly established group embodying the latest processing technologies. The results, using the Cobb-Douglas model, are shown in *Table 1*. No specific trends were indicated from the processing plants on the basis of the three technological strata. Labour elasticities were significant in all the three cases. This further confirmed that labour services were utilised more optimally, which was also shown by the pooled regression estimates. Mean square error for plants less than four years old was the lowest (0.079) while the other two older technological groups had mean square errors of around 0.150 which was comparable to the pooled results. The fit, in terms of standard deviation of residuals for the first group was about 28% while that for the other two groups was about 40%.

Capital coefficients were significant at the 5% level for the middle group and insignificant for the other two groups. In fact, the capital coefficient for the oldest technological group was negative indicating the inconsistency of the capital elasticity estimates with technological progress. Hence, the impact of technological progress in block rubber processing cannot be assessed in this way. Such inconsistent estimates may well be due to the small sample size. However, although the sample size of the pooled regression was large enough, the effect of returns to capital investment in block rubber processing was still not significant. This may be because the effect of technological advancement during the last decade was not adequately reflected by the existing state of plant operation. From the technological point of view, it can be seen that plants established after 1971, *i.e.* the new technological group, represent the latest technological advancement in processing. The fact that the capital elasticity estimate was low and insignificant clearly suggests under-utilisation of capital investment.

There are many factors that can lead to under-utilisation of capital investment or non-profit maximisation behaviour in block rubber processing. In the first place, mention should be made of the fact that most existing processing plants were set up by estates to cater for their own crop though some plants are increasingly processing latex for other estates as well. Typically, however, such a plant is not operated as an independent entity but as an integral part of an estate's operation. Under such circumstances the plant only operates when there is enough crop available. Little or no attempt is made on the part of the estate management to utilise the plant's facilities to an optimum level. Secondly, seasonal variation of rubber production can result in very low crops as in wintering months. This again affects the planning of plant operations to reach the optimum level. The final constraint is the availability of raw material supply from surrounding estates and smallholdings. If the surrounding estates belong to different owners or agency houses, they would normally have their own processing facilities. Even when there are smallholders in the vicinity, these are likely to be scattered over a large area, making purchasing of latex difficult. Constraints such as these probably explain to a large extent the under-utilisation of capital investment in processing plants. There is clearly a need, and this is brought out in the empirical results, to increase the utilisation of capital services in block rubber processing, if the benefits of the considerable advances in the technology of block rubber processing are to be maximised.

CONCLUSION

Quantitative assessment of technological progress in block rubber processing indicated a tendency towards increasing returns to scale. In general, investment in block rubber processing plants was highly capital intensive and returns to capital investment were found to be insignificant. This was attributed mainly to the under-utilisation of plant machinery and equipment. Management and planning on the part of managers and policy makers to ensure an adequate supply of raw materials (latex and field coagula) are necessary if processing plants are to remain viable. Empirical results show no significant differences in efficiency between old and new processing plants. The under-utilisation of plants and the inefficient state of the processing sector call for urgent attention to device policy measures that will increase returns from investing in block rubber processing plants.

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REFERENCES

1. YEE, Y.L. (1977) Economic Analysis of Block Rubber Production in Peninsular Malaysia. Master of Agricultural Science, University of Malaya.
2. HAYAMI (1970) On the Use of Cobb-Douglas Production Function on the Cross-country Analysis of Agriculture Production. *Am. J. Agric. Econ.*, **52**, 327.
3. HAYAMI AND RUTTAN, V.W. (1971) *Agriculture Development: an International Perspective.* Baltimore: The John Hopkin Press.
4. LAU, L.J. AND YOTOPOULUS, P.A. (1971) A Test for Relative Economic Efficiency and Application to Indian Agriculture. *Am. Econ Rev.*, **61**, 94.
5. KMENTA, J. (1967) On Estimation of the CES Production Functions. *Int. Econ. Rep.*, **8(2)**, 181.
6. NERLOVE, M. (1965) *Estimation and Identification of Cobb-Douglas Production Function.* Chicago: Rand McNally and Company.
7. GRILICHES, Z. (1963) Sources of Measured Productivity Growth: United States Agriculture, 1940–60. *J. Pol. Econ.*, **71**, 331.
8. SURJIT, S.S. (1974) Economics of Technical Change in Wheat Production in the Indian Punjab. *Am. J. Agric. Econ.*, **52(2)**, 217.
9. HAAVELMO, T. (1943) The Statistical Implications of a System of Simultaneous Equations. *Econometrica*, **11**, 1.
10. MARSCHAK, J. AND ANDREWS, W. JR. (1944) Random Simultaneous Equations and the Theory of Production. *Econometrica*, **12**, 143.
11. HOCH, I. (1955) Estimation of Production Function Parameters and Testing for Efficiency. *Econometrica*, **23**, 325.
12. HOCH, I. (1958) Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function. *Econometrica*, **26**, 566.
13. GRILICHES, Z. (1963) Estimate of the Aggregate Agricultural Production Function from Cross-section Data. *J. Fm Econ.*, **41**, 49.
14. MUNDLAK, Y. (1961) Empirical Production Function Free of Management Bias. *J. Fm Econ.*, **43**, 44.
15. YOTOPOULUS, P.A. (1967) Farm Stock to Flow Inputs for Agricultural Production Functions: a Microanalytic Approach. *J. Fm Econ.*, **49(2)**, 476.

APPENDIX 1

PRODUCTION FUNCTION ESTIMATES USING GROSS REVENUE AS DEPENDENT VARIABLE

Form of equation	Constant	Capital elasticity	Labour elasticity	Returns to scale	R^2	MSE
Cobb-Douglas	4.399 (1.747)	−0.156 (0.118)	1.048** (0.119)	1.09	0.77	0.129
Transcedental	1.269 (5.539)	−0.107 (0.249)	1.293** (0.394)	1.09	0.78	0.137
Kmenta approx. to CES	4.561 (1.771)	−0.146 (0.121)	1.036* (0.123)	1.11	0.77	0.131

The above estimates using gross revenue as dependent variable do not show any improvement from that of *Table 1*, capital elasticities in all cases are still negative.

* Significant at 5% level
**Significant at 1% level
Figures within brackets indicate standard error.

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Form of equation	Constant	Capital elasticity	Labour elasticity	Returns to scale	R^2	MSE
Cobb-Douglas	2.456 (1.925)	−0.122 (0.130)	1.039 (0.131)	1.160	0.74	0.158
Transcendental[a]	−0.098 (6.098)	−0.142 (0.275)	1.304** (0.434)	1.162	0.74	0.169
Kmenta approx. to CES	2.517 (1.831)	−0.136 (0.143)	1.021 (0.141)	1.157	0.76	0.151

The results presented above are from the first trial. The only exception from the main result is that the capital variable is computed using the capital stock concept. In all the cases, it was found that the elasticity of output with respect to capital is negative and no meaningful conclusion can be derived.
[a]Given by $\log V = \log A + \alpha_1 \log K + \beta_1 \log L + \alpha_2 K + \beta_2 L$
**Significant at 1% level

APPENDIX 3

TEST FOR MAINTAINED COBB-DOUGLAS HYPOTHESIS

The CES (Constant Elasticity of Substitution) Production function with non-constant returns to scale is given by:

$$V = \alpha(\delta L^{-\rho} + (1 + \delta) K^{-\rho})^{-\mu/\rho} \qquad \ldots 1$$

where V = value added

L = total man-hours

K = capital services

α = the efficiency parameter

δ = labour intensity parameter

μ = degree of homogeneity of the function or the degree of returns to scale and

ρ = defines the elasticity of substitution as $\alpha = \frac{1}{1+\rho}$

Following Kmenta (1967), a logarithmic approximation of *Equation 1* up to the second order can be obtained by discarding terms of higher order as follows:

$$\text{Log } V = \text{Log } \alpha + \mu\delta \text{ Log } L + \mu(1-\delta) \log K - \frac{\mu\rho}{2} \delta(1-\delta)(\text{Log } L - \text{Log } K)^2 + V \quad \ldots 2$$

where V = measure of the neglected higher order terms.

In *Equation 2*, the term involving the square of the logarithm of labour – capital ratio makes it different from the usual two-input Cobb-Douglas production function. If α is different from one, ρ should be significantly different from zero and the coefficient of the square of the logarithm of the labour-capital ratio should show up as significant.

The results from *Equation 2* are presented as:

$$\underset{}{\text{Log } V} = \underset{(1.75138)}{0.30338} + \underset{(0.14577)}{0.91145 \text{ Log } L} + \underset{(0.16577)}{0.18705\, k} - \underset{(0.15719)}{0.22669} \left(\log \left\{\frac{L}{k}\right\}^2 \right. \quad \ldots 3$$

$$R^2 = 0.76$$

In *Equation 3* figures in brackets are the standard errors of residuals.

The coefficient for $(\log \left\{\frac{L}{k}\right\})^2$ is not significantly different from zero at normally accepted significant levels. From the above data, the hypothesis is that elasticity of substitution between labour and capital cannot be rejected. This implies that the Cobb-Douglas form should provide adequate representation for it.

APPENDIX 4

ESTIMATION OF CAPITAL SERVICE FLOW USING YOTOPOULUS METHOD

The microanalytic approach for estimating the current service flow of capital assets was adopted from the model used by Yotopoulus[15]. The formula for estimating current service flow of capital assets is:

$$\bar{R}_i = \frac{rV_{oi}}{1-e^{rT_i}}$$

where $\bar{R}_i$ is the constant annual service flow from capital asset i
V_{oi} is the original (underpreciated) market value of the asset i
T_i is the life span of capital equipment
r is the rate of discount

Using the above formula, an approximate capital service flow variables was constructed from the available data. Discussions with plant managers and machinery operators indicated that the life span of ten years could be used for plant building and machinery. The overall rate of discount adopted here was 10%.