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Measuring Productivity/Efficiency in Rubber Estates: A Frontier Cost Function Approach

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The focus of the paper is in the determination of productivity/efficiency in rubber estates and its implications. The concept of frontier production function is utilised to measure the efficiency of an estate's operation. The stochastic cost frontier model is used to measure the deviation of an estate's performance from the frontier. Data from the annual costing and management survey of estates were tested on the model. Empirical result shows that there is no evidence of increasing returns to scale for rubber production in estates, although economies of size exert influences on certain aspects of its operation. The result also indicates that the type of management, the level of fixed cost and yield per hectare contribute towards the efficient operation of an estate.

The plantation system of agriculture is perhaps the single most important factor that accounts for the success of the Malaysian (previously Malayan) economy since the 1850s. Such a system is continuing to play a critical role even today when the Malaysian economy has become more diversified. Within any plantation group itself, the unit of operation is an estate, usually under the charge of an Estate Manager with a complex hierarchy of staff, comprising assistant managers, conductors, *kanganies*, clerical workers and storekeepers. While long-term development plans may be decided by the plantation group headquarters, day-to-day operations and short-run decisions are invariably made by the estate manager himself. This paper takes an estate as the unit of analysis.

A key question in economic study of any industry is the question of efficiency of resource use in that particular industry. Efficiency is an elusive concept to measure in economics, especially in estates where we are dealing with a tree crop. Here, the effect of fertilisers may only be seen after a lag period of several months. There is also the question of obsolescence of the trees as a result of aging and the history of tapping. While in theory, the measurement of efficiency may be simple, being guided by the equi-marginal principle, in practice, the determination of efficiency in tree crops faces practical measurement difficulties.

The focus of this study is the determination of efficiency in estates and its implications. This paper deals with the following:

1. How do we measure efficiency in estates?
2. How is the efficiency measure related to the common data (variables) that are collected from estates? What particular variables determine estate efficiency?
3. What are the policy measures and conclusions that can be drawn from 1) and 2) above?

This paper reviews some methodological issues, discusses some salient features in our data, gives the results from our analyses and discusses the conclusions and policy suggestions.

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METHODOLOGICAL ISSUES

Quantitative measurement of efficiency is a critical step in the process of policy formulation However, the concept of efficiency can be quite difficult to target The classical way to analyse productivity and efficiency in agricultural economics is to first fit production functions, usually regressing yield against various factor inputs Marginal products are then derived for the various factors and compared with their respective opportunity costs, to determine the optimality or otherwise with regards to the use of the different resource factors We can then derive conclusions on the efficiency of resource use

Subsequently, an improvement in the analytical procedure came about with the derivation of profit functions There is a substantial amount of literature, both theoretical and empirical, on this methodology The disadvantage with this approach is the need to have variability in the factor prices for this method to be workable[1,2]

A considerable amount of theoretical and empirical research[3-6] on the measurement of efficiency using the concept of frontier production functions, had been undertaken There is now a consensus among economists that it is the production frontier rather than the fitted 'average' function that corresponds to the textbook definition of the production function as that function that gives the maximum possible output which can be produced from a given set of inputs

It is often useful, from an interfirm comparison view-point, to have a measure of a producer's performance compared with a peer group There are many studies that use the divergence from the frontier production function as a measure of a producer's technical efficiency Philosophical issues aside it is more valid to estimate producer performance in terms of technical efficiency, since to a large extent, measures of technical efficiency rely less on the assumptions of perfect knowledge, perfectly competitive markets and the profit maximisation objective Such stringent assumptions are usually impossible to satisfy under developing country conditions

For our study, we chose the stochastic cost frontier model to measure an estate's performance away from the cost frontier The biggest advantage of the stochastic frontier approach is the introduction of a disturbance term representing noise, measurement error and exogenous shocks that are beyond the control of the production unit In many such studies, an array of input variables is included in the right hand side (RHS) of the frontier function The residual, specified usually as a truncated normal distribution, is then attributed to technical efficiency

Our method of analysis is as follows We first fit the following frontier cost function*

$$\ln C = \ln A + b \ln O + u + v$$

where C is the production cost per kilogramme of rubber in sen (*Variable 19* in *Table 1*)

O is the production output of estate in kilogramme (*Variable 20*, *Table 1*),

u is the truncated normal error term representing asymmetric divergence from the frontier

v is the normal error term representing 'noise' in the system

u and v are independent of each other

ln refers to natural logs

In the above equation, the term u represents the gross productivity, or gross efficiency, of a particular estate, a higher u implying a bigger divergence from the frontier and hence lower productivity and

*The Cobb Douglas form was chosen for the usual reasons despite its well known limitations Also most empirical work with frontier functions use the Cobb Douglas form

TABLE 1. STATISTICS FOR SELECTED VARIABLES

	Variable	Mean	Standard deviation	Coefficient of variation (%)
1	Mature area	489 12 ha	335 40	68 57
2	Average tapping age	13 27 years	3 95	29 77
3.	Management/ supervision	$135 11/ha	42 56	31 50
4.	Field sanitation	$ 52 30 ha	34 16	65 32
5	Field maintenance	$ 15.98 ha	16 13	100 94
6	Other mature area inputs	$ 10 44 ha	10 10	96 74
7	Manuring	$ 54 58/ha	31.26	57 27
8	Stimulation	$ 15 60 ha	14 57	93 40
9	Tapping and collection cost	$687 05/ha	213 19	31 03
10	Other general charges	$134 74/ha	45 32	33.64
11	Fringe benefits (general)	$ 62 34/ha	27 21	43 65
12	Fringe benefits (direct)	$340 85 ha	122 19	35 85
13	Transport and latex collection	$ 52 96/ha	31 30	59 10
14	Yield	$1 439 45/kg	331.91	23 06
15	Mature area profit	$889.07/ha	475 61	53.50
16	Expenditure at estate gate	$1 576 50/ha	332 18	21 07
17	Average yield /tapper/day	21.33 kg	4 59	21.52
18	Average earnings /tappper/day	944.12 sen	186.74	19 78
19	Production cost at estate gate	112.55 sen/kg	24 06	21.38
20	Total estate production	676 373 81 kg	449 954.46	66 52

$ – ringgit

vice versa. We consider u a gross measure of productivity because we have not isolated the effects of various inputs. Any measure of net efficiency is, in our view. fallacious in this case because of the perennial nature of the rubber tree.

The next step is to regress u against a variety of input variables to find the factors affecting it; because we had already eliminated random 'noise' from u, we can have more accurate measurements of the determinants of productivity by this procedure.

Given the heterogeneity in our data and the various reservations about the data that will be discussed later, the frontier function approach, as outlined above, represents a distinct improvement compared to the present techniques used to analyse productivity and efficiency issues in rubber.

DATA

Our data was taken from the samples collected by the Rubber Research Institute of Malaysia (RRIM) in their annual Management and Costing Surveys. Our data is for the years, 1983 to 1986, giving a total sample size of seventy-five cases; because of the small sample size collected in any one given year, the four years' data are treated together. We are therefore assuming the four years as one time period in this study, making the not unreasonable assumption that conditions did not alter that drastically within the four years under consideration. Some selected statistics for our data are shown in *Table 1.*

Cost figures, in our data, were categorised into the following components. What can generally be regarded as fixed cost comprises management and supervision, other general charges and fringe benefits (general). Management and supervision refers to expenses incurred by company secretaries, managers, assistant managers and other supervisory staff, both in the office and in the field. Other general charges refers to office expenses, various rentals, insurance charges, general security and depreciation. Fringe benefits (general) refers to expenses incurred in medical and hospital outfits, estate accommodation, welfare and general amenities.

What can be considered as variable costs are the following:

i. Fringe benefits (direct) which include items like special relief allowance, Employee's Provident Fund contributions, sick pay, *etc.* all of which go to specific individual estate workers

ii. Field sanitation which includes material and labour for the different types of weeding

iii. Other mature area inputs which include expenses incurred in wind damage control, pests and diseases, pruning and thinning, field security and other sundry items

iv. Field maintenance comprises expenses involved in roads, bridges, fences and terracing and soil conservation measures

v. Transport and latex collection refers to cost involved in transporting labourers and latex from field stations to central assembly points, transporting of pails, utensils and miscellaneous expenses

vi. Manuring refers to expenses, both material and labour, incurred in manuring and in foliar and soil analyses that precede a manuring programme

vii. Latex stimulation refers to the expenditure for materials and labour incurred in the application of stimulants to trees to induce greater latex production

viii. Tapping and collection refers to wages and expenses paid to tapping supervisors, labour for tapping, expenses for utensils and materials used and expenses incurred in marking, opening and census of rubber trees. This is by far the most important cost item, accounting for about 50% of average variable costs and about 40% of the average cost of latex production.

The cost items in the RRIM Survey are given both in terms of ringgit per hectare of mature rubber (some estates having large areas under immature rubber) and ringgit per kilogramme of rubber produced. The relationship between cost per hectare and cost per kilogramme is easily clarified thus:

Total expenses = (cost/ha)(total ha)

Total expenses = (cost/kg)(total kg produced)

Since total expenses is the same in both cases, we get:

(cost/ha) = (cost/kg)(total kg/total ha),

where (total kg/total ha) is the average yield per hectare.

This gives the simple relationship that if the yield per hectare is low, then the cost on a per kilogramme basis will be high and *vice versa*.

Some qualifications with regards to our data must be recognised. These reservations are:

i. The average age may not be a reliable indicator of yield profile. It is possible that one estate may have a wide dispersion of age while another one may have ages clustering together, with both estates therefore having the same average. Rubber yields in these two estates are obviously going to be different, even if their average ages are the same.

ii. The quality of rubber is not considered here. Certain estates may have a higher percentage of lower grade rubber compared to other estates. The quality of rubber is dependent to a large extent on the labour input involved in the rubber collecting and processing stages.

iii. The percentage of immature rubber is not considered. Certain estates also have oil palm cultivation. Thus, the management and supervisory cost does not pertain only to the quantity of rubber produced. Unfortunately, we were unable to proportionate the cost that pertains to rubber only in the data available.

iv. Soil and climatic variabilities are not taken into consideration. Unfortunately, the environmental factor is very critical in influencing rubber yield. Since the RRIM data were collected over a large area where environmental differences were bound to occur, the errors could be large.

The sizes of the coefficient of variation for the various variables give us an idea of the heterogeneity of the data. Only the last four variables in *Table 1* have reasonable coefficients of about 20%. Inputs like stimulation, manuring, field maintenance and other mature inputs have very high variability, most of them with coefficients of over 50%. It should be emphasised that the Management and Costing Surveys conducted by the RRIM are carried out more for inter-estate comparison purposes rather than for farm-management type analyses. The quality of the data therefore leaves much to be desired, given our objectives in this paper.

EMPIRICAL RESULTS

The estimated results for the frontier cost function are as given in *Table 2*. We used the LIMDEP software[7] to obtain the results.

From the values of lambda and sigma, we computed that the noise or random error in the system is 12.55%, with the remaining 87.45% being due to asymmetric variation. The divergence from the cost frontier, or u,

TABLE 2. ESTIMATES FOR FRONTIER COST FUNCTION

Variable	Coefficient	Standard error	t ratio
Constant	3.9479	0.4118	9.587
Output	0.0414	0.0305	1.359
Lambda	2.6428	0.9806	2.695
Sigma	0.2863	0.0329	8.692

Lambda refers to r_u/r_v, where r is the standard deviation. Sigma refers to the sum of the variances for u and v.

can be converted to percentage deviation as follows:

$$u = \ln Y - \ln \overline{Y}$$

where Y is the observed value and $\overline{Y}$ the estimated value;

$$Y/\overline{Y} = e^{u}$$

$$\text{Therefore, \% deviation} = [(Y-\overline{Y})/(\overline{Y})](100)$$

$$= (Y/\overline{Y} - 1)(100)$$

The percentage deviations from the cost frontier, for the different estates, are shown in *Table 3*. The average cost of production is also given, for comparison purposes.

In this case, ranking by the frontier cost approach (fourth column, *Table 3*) and ranking by the ordinary average cost (second column, *Table 3*) give the same ranks. This is because there is constant returns to scale, in our results, as shown by the insignificant coefficient for output in *Table 2*. The superiority of this approach, in non-constant returns-to-scale situations, could not therefore be shown in this case.

The divergence from the frontier is a measure of the gross productivity of an estate in relation to the frontier, with a higher divergence indicating a less productive estate and *vice versa*. The gross productivity index derived in this way provides a quick and accurate way to rank estates. The problem of how to rank estates has been a long-standing problem among researchers concerned with productivity issues in rubber holdings. Which variable do we use to rank estates? This depends on the purpose for ranking estates. Use of variables such as yield per hectare, profit per hectare, average cost of production per hectare, *etc.* can be misleading because these variables measure specific aspects of the productivity problem. A high profit estate is not necessarily a high yielding estate. Similarly, a high profit estate is not necessarily a low average cost estate. The average cost of production per kilogramme of rubber is the final summary of all the factors, both technical and management type factors, that are important in estate management. This final summary is what counts ultimately in the long-term survival of an estate and by inference the plantation system. This average cost of production per kilogramme of rubber should therefore be a good way to rank estates. The divergence from the frontier compares one's position with what could theoretically be achieved.

From our results above, it is interesting to note that there is no evidence of increasing returns to scale for rubber production in estates. Conventional wisdom has it that the superiority of estates, compared to smallholdings, stems from the economies of scale inherent in estates. This wisdom must be heavily qualified. It may be true that economies of scale exists in the rubber processing stage or even in the pre-rubber production stage, which is not considered here. However, no such economies exist in the rubber tapping (production) stage. If it requires one tapper to tap a task size of 350 trees per day, then two tappers will be required to tap about 700 trees. Some economies of scale may be possible in the rubber collection stage. However, since tapping wage comprises the main bulk of variable cost, such economies in the rubber collection stage become difficult to isolate. Thus, our result of constant returns to scale in rubber production (excluding processing) appears plausible.

We proceed to investigate the factors that affect the size of the divergence from the cost frontier For this, we regressed the u against an array of factor inputs. The best result obtained, from the view-point of logic and various statistical criteria, is given by the following regression:

$$\ln u = \ln a + b1 \ln \text{AREA} + b2 \ln \text{AGE} - b3 \ln \text{MGT} + b4 \ln \text{FIX} + b5 \ln \text{VAR} + b6 \ln \text{YLD} + e$$

where u is divergence from frontier
a is the constant term
AREA is the size of the mature area of the estate
AGE is the tapping age of estate

TABLE 3 PERCENTAGE DEVIATION FROM COST FRONTIER

Estate number (randomly assigned)	Production cost/kg (nat logs)	Deviation in u	Deviation in % $(Y/\bar{Y} - 1)(100)$
1	4 51	0 1970	21 77
2	4 66	0.3792	46 11
3	4 80	0 5176	67 80
4	4 37 (3rd)	0 1308	13.97 (3rd)
5	4 63	0 3972	48 77
6	4 77	0 5069	66 01
7	4 44 (5th)	0.1653	17 97 (5th)
8	4 80	0.5163	67.58
9	4.78	0 5020	65.20
10	4 63	0 3309	39.22
11	5 15	0.8855	142 42
12	4.83	0 5851	79 52
13	4.95	0 6731	96 03
14	4 73	0.4269	53.25
15	4 84	0 5577	74.67
16	4 75	0 5308	70.03
17	4 67	0.4393	55 16
18	4 74	0 4874	62.81
19	4 59	0 3379	40.20
20	4 57	0.2915	33 84
21	4 49	0.1969	21.76
22	4 82	0 5378	71.22
23	4 62	0.3166	37 25
24	5 10	0 7958	121.62
25	5 25	0 9771	165 67
26	5.32	1.0501	185.79
27	4 76	0.4983	64.59
28	4 67	0 4487	56.63
29	4 56	0 3121	36.63
30	4.65	0.3449	41.18
31	4 86	0.5802	78.64
32	4 92	0 6333	88.38
33	4 61	0 3458	41.31
34	4.53	0.2638	30.19
35	4 74	0 4594	58.31
36	4 56	0.3491	41.78
37	4.42 (4th)	0 1354	14.50 (4th)
38	4.71	0 4568	57.90
39	4 58	0.2866	33 19
40	4.56	0 3004	35.04
41	4.71	0.4448	56.02
42	4.65	0.4441	55.91
43	4 60	0.2896	33.59
44	5 01	0 7707	116 13

TABLE 3. PERCENTAGE DEVIATION FROM COST FRONTIER (CONTD.)

Estate number (randomly assigned)	Production cost/kg (nat. logs)	Deviation in u	Deviation in % $(Y/\bar{Y} - 1)(100)$
45	4.67	0.4162	51.62
46	4.84	0.5244	68.94
47	4.55	0.2650	30.34
48	4.80	0.5218	68.51
49	4.46	0.2392	27.02
50	4.61	0.3222	38.02
51	4.64	0.3362	39.96
52	4.70	0.3884	47.46
53	4.69	0.4432	55.77
54	4.56	0.3534	42.39
55	4.70	0.3846	46.90
56	4.33 (2nd)	0.1075	11.35 (2nd)
57	4.85	0.6080	83.68
58	4.55	0.3288	38.93
59	4.52	0.2618	29.93
60	4.70	0.4453	56.10
61	4.66	0.3616	43.56
62	4.78	0.5665	76.21
63	5.20	0.9992	171.61
64	4.26 (1st)	0.0535	5.50 (1st)
65	4.91	0.6765	96.70
66	4.72	0.4992	64.74
67	4.82	0.5470	72.81
68	4.70	0.4027	49.59
69	4.54	0.2519	28.65
70	4.55	0.2959	34.43
71	4.76	0.5324	70.30
72	4.81	0.5148	67.33
73	4.77	0.4962	64.25
74	4.62	0.3421	40.79
75	4.62	0.3183	37.48

1st, 2nd, 3rd, 4th and 5th show ranking

MGT is the management cost per hectare

FIX is the fixed cost in ringgit per hectare for the estate

VAR is the variable cost in ringgit per hectare for the estate

YLD is the yield in kilogramme per hectare for the estate

e is the usual error term assumed n.i.d.

ln refers to natural logs

The results of our regression are shown in *Table 4*. Our results were derived using the LIMDEP software package.

From *Table 4*, it can be seen that the variables that are significant in explaining

TABLE 4 RESULTS FOR ln U REGRESSION

Variable	Coefficient	Std. error	t value
Constant	1 5463	0 4963	3 1154
ln AREA	0 0227	0 0186	1.2187
ln AGE	0.0546	0.0410	1.3323
ln MGT	0.1720	0.0471	3.6520
ln FIX	0.1894	0.0274	6 9017
ln VAR	0.0024	0 0069	– 0.3465
ln YLD	– 0.4152	0 0553	– 7 5025

R-squared = 0.6776
Adjusted R-Square = 0.6491
F-statistic = 23 82

the deviation of an estate's average cost of production from the cost frontier are MGT (management), FIX (fixed cost) and YLD (yield per hectare). A 1% increase in yield will reduce the deviation of average cost of production by 0.4%. A 1% increase in fixed cost will increase the deviation of average cost by 0.19%. The surprising result is that for management cost. Contrary to expectations, an increase of 1% in management cost increases, not decreases, the deviation of average cost of production by 0.17%. This implies either that management has been excessively applied way beyond what is optimal, or that the long-term benefits of management in terms of replanting, infrastructure development and research have not been captured in our model. We believe the latter reason to be the more likely explanation. The average cost of production in a cross-sectional analysis cannot possibly quantify the long-term benefits accruing from superior management. A high management cost can also arise from the need to manage large areas of immature rubber or even other crops, for quite a number of estates are involved in the cultivation of other crops besides rubber.

What determines YLD (yield per hectare)? From our other regressions which we have not included in this paper, the important variables that determine yield are age and clonal type, with management cost, fixed cost, and variable cost being not significant. There seems to be no effect from using fertilisers or stimulants, contrary to expectations. It is possible that the lagged effect of fertilisers was not captured in our model. Another likely explanation could be that the data were collected over a wide area and are therefore too heterogeneous to show the effect of variable cost.

We also regressed the ordinary average cost per kilogramme variable against the same array of factors that were used in the *u* regression, using OLS, for comparison purposes. The results are shown in *Table 5*.

The coefficient for AREA is significant in *Table 5*, whereas it is not significant for the *u* regression in *Table 4*. Significance implies that the average cost of production per kilogramme of rubber goes up with increase in size of the estate. This suggests that there is dis-economy of scale. However, the more likely interpretation is that the variable has picked up the effect of random 'noise' in the system. Dis-economy of scale is a difficult thing to rationalise in any economic system. In most production function studies in the literature, it is common to find constant

TABLE 5 COST PER KILOGRAMME REGRESSED AGAINST VARIOUS FACTORS (OLS)

Variable	Coefficient	Std error	t value
Constant	5 2775	0 4922	10 72
ln AREA	0 0610	0 0183	3 34
ln AGE	0 0592	0 0401	1 48
ln MGT	0 1726	0 0463	3 73
ln FIX	0 1862	0 0274	6 79
ln VAR	0 0047	0 0061	0 78
ln YLD	0 3763	0 0552	6 82

R-squared = 0 6789

Adjusted R-squared = 0 6506

F-statistic = 23 97

The independent variables are as in the *u* regression in *Table 4*

returns to scale and even sometimes increasing returns to scale. It is difficult to explain why a firm should produce in a regime of decreasing returns to scale Hence from the view-point of logic, the *u* regression gives more plausible results, compared to the OLS function in *Table 5*

CONCLUSION

Classical production function analysis of the Chenna Reddy[8] and Hopper[9] types usually do not give good results for tree crops like rubber This is because of a variety of reasons, the most important being the problem of data heterogeneity[10,11]. The problem of measuring the effect due to the environment is particularly troublesome Climatic and soil differences are important determinants of yield The effect of fertilisers, stimulants and other short-run factors often pale in comparison to environmental factors Thus, the effect of variable cost is usually not significant in cross-sectional type analyses, especially for analyses using samples collected from a wide area. One way to overcome this problem is to restrict the sample to a relatively homogeneous area However, we would then face the problem of insufficient sample size.

The frontier function approach represents an improvement in the analytical techniques used to study productivity and efficiency. This approach has its theoretical underpinnings in the seminal paper by Farrell[12]. This frontier approach is increasingly being applied in agricultural economics studies The prospects of applying this approach to analyse tree crops appears to be good. For example, the frontier cost function approach offers a neat way to rank estates, in terms of overall productivity Production cost per kilogramme is the overall summation of both technical and management aspects of the production problem. Hitherto, comparison of the average cost of production among different estates represents perhaps the best way to rank the different estates in terms of gross productivity However, using the cost frontier approach gives a better solution, at least theoretically. By deriving the frontier cost function which represents the 'best achievement possible', and comparing an estate's cost with this 'theoretical maximum', we can determine an estate's performance, at its particular level of output. The superiority of this frontier approach compared to an 'average cost comparison approach' will become obvious in situations of non-constant returns to scale. Another advantage is that the deviation from the frontier is now cleansed of exogenous 'noise' and hence regressions using this deviation regressed against factor inputs, should produce more accurate results with regards to the factors causing an estate's performance compared to the frontier. We have shown this in the paper, with regards to the coefficient for AREA.

Our analysis, using the frontier cost function approach, as outlined above, produced plausible results. Exogenous noise was estimated at about 12.55%. The deviation of an estate from the cost frontier is positively related to management and fixed cost and inversely related to yield per hectare. The effect of variable cost comprising items like fertilisers and stimulants is not significant, mainly because of data inadequacies. The difference between good and bad management in estates only becomes apparent in the long run, when the effects of poor agronomic practices, improper tapping methods, *etc.* have had time to show their cumulative deleterious effects. At any single point in time, or even over a short period of time as in our study, the quality of management is impossible or difficult to ascertain. Quality of estate management can only be properly measured over the complete life of a tree crop.

The most significant variable that explains an estate's deviation from the average cost frontier is yield per hectare. Yield per hectare is itself determined mainly by age and clonal type.

The policy implications of our study are as follows. One begins to wonder if it is meaningful to discuss productivity/efficiency at a given point in time for the case of perennial tree crops. Surely, the entire life cycle of the tree crop should be considered in such productivity/efficiency studies. For perennial crops, cross-sectional studies can be considered essentially to be a one-time snapshot technique that is not suitable for analysing what is in reality a long-run problem. For example, a particular tapping system may for a given period only, result in high yields. However, this system cannot in any way be recommended if there are subsequent ill effects in terms of, for example, weakening of the trees. Thus, the limitations of cross-sectional studies for analyses of resource allocation efficiency in perennial crops should be recognised.

Hence, estate management can be looked upon in terms of two separate problems* – a short-run problem of allocation of variable inputs and the mobilisation of labour to collect the output; and, a long-run problem of infrastructure development and the planting of appropriate rubber clones. Inefficiency in the short-run allocation of resources is difficult to detect in cross-sectional analyses. Efficiency or otherwise in allocation of resources over the long term can be detected, perhaps, through the use of cost benefit ratios or some such criteria.

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*The two problems interact with one another. We are artificially separating them more for expositional convenience and clarity than for anything else.

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