Cost efficiency of Malaysian oleochemical enterprises: A non-parametric frontier analysis evidence

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ABSTRACT

The objectives of the paper are two-folds. First the cost efficiency measure was decomposed into technical and allocative efficiency in Malaysian oleochemical industry. This is undertaken with the explicit aim of evaluating the competitiveness of this industry since early 1990s, The data used were an incomplete panel of annual observations on 12 firms, comprising 80% of the operating oleochemical films which operated between 1990-1996. The second objective of this paper is to show that the application of the deterministic Data Envelopment Analysis (DEA) frontier model could provide good explanation regarding economic relationships over time. The mean cost-inefficiencies of Malaysian oleochemical enterprises for 7 different years (1990 -1996)tended to increase from 1991 to 1996. The mean cost- inefficiencies increased slowly and slightly up to 1995 when there was a sharp decrease. The major contributor to this inefficiency was allocative inefficiency.

INTRODUCTION

Despite problems associated with any new industry, the oleochemical industry has performed well as it surpassed the target of the Industrial Master Plan (IMP) in terms of total production and export revenue. In 1995, the total export revenue was RMl.3 billion with estimated total output of oleochemical raw materials of approximately 750,000 tonnes. Though the above performance gave

cause for satisfaction, there is reasonable apprehension that the industry would grind
itself to stagnation, as it is unable to break away from its present narrow range of basic oleochemical products. Given the industrial development, together with the technological change and availability of raw materials there is a vast polential for the industry to break off from its nutshell and go beyond basic oleochemicals to immediate and end use products. But to take full advantage of this potential, there is a need for the industry to be more proactive and to address fundamental issues that are still causes for concern to the industry .

One of the critical issues that could heavily impact on the future direction of the local oleochemical industry was the rising intense of local, regional and global competition (Bushara, 2001). So far, the Malaysian oleochemical industry had been able to develop rapidly due to its relative low costs of production and availability of cheap local raw material, i.e., palm oil and palm kernel oil. However, this competitive edge is increasingly being eroded because of rising labour and other costs in the industry. The issue of higher labour cost was reported by Yusof *et al.* (1999), Bashir and Abdul Rashid (2000). So it is important to answer a basic question whether this industry is competitive enough to face these local, regional and global challenges. The competitiveness of this industry over time can be measured by efficiency and productivity analyses. From an applied perspective, measuring efficiency is important because this is the first step in a process that might lead to substantial resource savings. These resource saving would have important implication for both policy formulation and firm management.

The objectives of the paper are two -folds. First the cost efficiency measure was decomposed into technical and allocative efficiency in Malaysian oleochemical industry. This is undertaken with the explicit aim of evaluating the competitiveness of this industry since early 1990s. The second objective is to show that the application of the deterministic Data Envelopment Analysis (DEA) frontier model that could provide good explanation regarding economic economic relationships over time.

Frontiers had been estimated using many different methods over the past 44 years (Coelli, 1996). The two principal methods are:

1. Data envelopment methods analysis and
2. Stochastic frontiers

which involve mathematical programming and econometric methods, respectively. In this section we focus on the use of DEA methods and their computations by Data Envelopment. Analysis Programme (DEAP) software Version 2.1. The discussion here provides a very brief introduction to modern efficiency measurement. Modern efficiency measurement began with Farrell (1957) who drew upon the work of Koopmans (1951) to define a simple measure of firm efficiency, which could account for multiple inputs. He proposed that efficiency of a film consisted of two components: namely technical efficiency and allocative efficiency. Technical efficiency reflects the ability of a firm to obtain maximum output from a given set of inputs. Allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. These two measures may then be combined to provide a measure of economic efficiency or cost efficiency. Allocative efficiency requires first or second best pricing of final products; technical efficiency requires cost minimisation by the incumbent firms.

The cost function charts the minimum cost of producing a specified output vector for a given set of input prices. Shephard (1953) proved that the optimal value of the Lagrangian multiplier in the cost minimisation problem was equal to the value of the cost function. If input homotheticity was assumed, then the price index would be independent of output. Thus input homotheticity guarantees that both the input quantity and input price index are independent of the reference output vector.

The input-oriented technical efficiency measure assigned to each observation an efficiency score that indicates how close the observed input vector P^l, was to the isoquant for the observed output vector y^k، along a ray from O to P^l. A score of unity meant that P^1 is actually on the isoquant for y^k.

Allocative efficiency, is concerned with how close a P^l on the isoquant is to the least cost input vector on the isoquant, given input prices p^k (FE) and output vector y^k . The demand for input n at minimisation cost is equal to the partial derivatives of the cost function with respect to P_n (n = l, 2…….,N) The derivative property is known as Shephard's lemma.

An input-oriented efficiency score of, say, 0.8, indicates that the observed input vector P^l, could (at most) be proport-ionally reduced to $0.8P^l$ while still producing y^k. The technical efficiency reflected the ability of a firm to obtain maximum output from a given set of inputs، and the allocative efficiency reflected the ability of a firm to use the inputs in optimal proportions, given their respective prices. These two measures were then combined to provide a measure of overall economic efficiency or also known as cost efficiency (Fig. l).

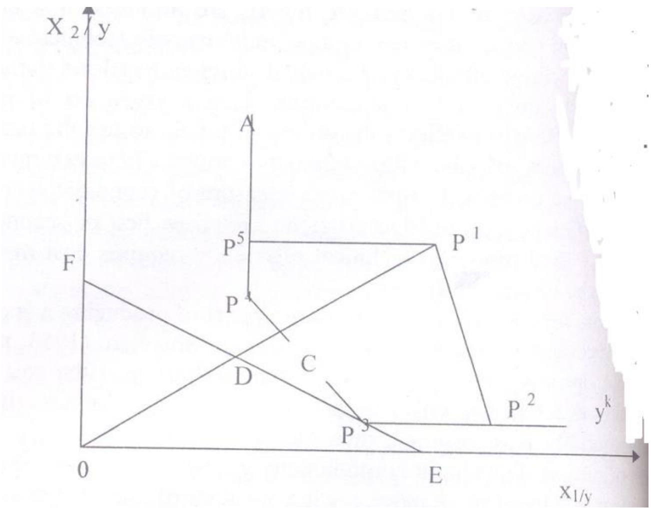

Fig. 1: The DEA unit output isoquant. Source: Fare and Gros- skopf, 1996. Overall efficiency, cost efficiency or economic efficiency are

identical. It is the product of both allocative and technical efficiency and is represented by the ratio $OD/OP^{1} =$ $(OC/O P^{l})$ (OD/OC). Overall inefficiency is show by ratio $1-(OD/OP^{I})$ and represents the extent to which costs exceed their feasible minimum. A C and Y^{k} is the isoquant

It seemed quite reasonable to accept the arguments of Ferrier and Lovell (1990) that slacks might be essentially viewed as allocative inefficiency (Coelli, 1996). The piece-wise linear form of the nonparametric frontier in DEA could cause a few difficulties in efficiency measurement. The problem arose because of the sections of the piecewise linear frontier which ran parallel to the axes which does not occur in most parametric functions. Koopman's(1951) definition of technical efficiency was stricter than Farrell's (1957) definition. The former was equivalent to stating that a firm is technically efficient if it operates on the frontier line and, furthermore, that all associated slacks are zero. In addition to this, it also seemed quite reasonable to accept the arguments of Ferrier and Lovell (1990) that slacks might essentially be viewed as allocative inefficiency (Coelli, 1997). Hence technical efficiency analysis could reasonably concentrate upon the radial efficiency score provided in the first stage of DEAP.

MATERIALS (DATA SOURCES AND VARIABLES)

Farrell (1975) initiated the study of efficiency whether it was technical, price allocative or economic. In general, they needed the input data, i.e., capital, labour, energy and material (KLEM) and their respective prices. The main sources of these data for this study are: (i) the Registrar of Companhes (ROC), (II) Department of Statistics, (iii) National Productivity Cor-poration (NPC), and (iv) Dynaquest Bhd (1997). All the data analysed on oleochemical enterprises have been extracted from their publications, i.e., total income, total cost, capital cost and capital price. The time frame of this study was 1990-1996. The variables used in this study are as follows: I) Output was defined as the total firm gross output and had been deflated by using the Malaysian producer price index (PPI) for locally produced commodities, i.e., animal and vegetable oils and fats. ii) Labour expenditure was defined as the total remuneration (wages, salaries, pension and employee provident fund, EPF) paid by employers. iii) Capital expendi-ture defined as the flow of capital services, which included the

depreciation (i.e., building land, machines, equipment, and furniture and fixtures) plus interest paid (Griliches, 1979). Both labour and capital cost had been deflated by PPI (Ahmed, 1997).

Energy has been computed as the aggregate of electricity, fuel and lubricants and had been deflated by the prices of locally produced commodities, i. e. , mineral fuels, lubricants and related materials index (which include petroleum, gas, and electricity).The aggregate price of these commodities could be taken as a proxy for" energy producer price index" Department of Statistics. iv) Material expenditure which constituted the other variable costs had been deflated by (PPI) although some authors used consumer price index (Mansoor, 1987; and Abdullah, 1991). The total cost is the sum of the four deflated input expenditures. The deflator should be sector specific and input specific, however, the only available indices for this sector in the locally produced commodities were (PPI) and energy (PPI) Hence it was seen appropriate to deflate output, labour, capital and material by the (PPI). The price of labour was the total remuneration of labour divided by the total labour force of the firm. The price of capital was the capital expenditure divided by the capital stock (Coelli *et at.*, (1997). The price of material was the producer price index here after material price. Price of energy was the energy producer price indes "here after energy price" (e.g., Akridge, 1986; Greene, 1993).

All prices had been converted to the implicit price indices using 1994= 100 as the base year. Theoretically, deflating the time series data would yield efficient and unbiased estimators. A further advantage of using deflated time series for each firm was that extreme observations would have less effect on the estimation, and would reduce the bias due to those outlying observations. Deflating output, labour material and capital with producer price index and energy with energy producer price index eliminated biases due to inflation and cyclical price movements. Some industrial economists preferred to indices (Abdullah, 1991).

METHODS (COST EFEICIENCY: MODEL)

The production function of the fully efficient firm was not known in practice, and thus must be estimated from observations on a sample of firms in the industry concerned. Here DEA was used to estimate this frontier. The basic assumption was constant returns to scale, which allowed one to represent the technology using a unit isoquant (Farrell,
(1957). Fi{y,x|C,S) (where F_i = Farrell input technical efficiency; y = output vector; x =input vector; C=constant return to scale; S = strong disposability) would then measures constant returns with strong disposability. Equation I was run

Technical efficiency =

$\delta_{i*} \equiv$ Max $\delta_{I \geq 0,}\, \lambda i \geq 0, \ldots.. \lambda i \geq 0, \delta_i \ldots\ldots$ (1)

Subject to $\sum_{j=}^{j} y^i \;\; \lambda_i \geq y^i$;

$$\sum_{j=1}^{J} x_{1^i} \;\lambda i \;\leq x_1^i\, \lambda i \;\leq\; x_1^i \;- \delta\text{i}\, x_1^i\,;$$

$$\sum_{j=1}^{J} x_{1^i} \;\lambda i \;\leq x_2^i\, \lambda i \;\leq\; x_2^i \;- \delta\text{i}\, x_2^i\,; \text{ and}$$

$$\sum_{j=1}^{J} x_{4^i} \;\lambda i \;\leq x_4^i\, \lambda i \;\leq\; x_4^i \;- \delta\text{i}\, x_4^i\,;$$

This linear program solved for convex combination of the J data points that could produce at least observation i output and used at most1- δ_I times the observation i combination of inputs ($x_1^i, x_{2,}^i\, x_3^i, x_4^i$ e.g., capital, Labour, energy and material) λ_J is a vector of constant ones it represents the peers. If largest such δi i s δi* = 0, then input combinations associated with observation i are technically efficient.

When input prices are included, as was true in this study, the cost efficiency of each observation could be calculated by solving the J additional linear programs as blew:

Minx $_1^i \geq 0, x_2^i \geq 0 x_3^i \geq o, x_4^i \geq 0, \sum_{m=1}^{4} w_{m^i}\, x_m^i \frac{nx}{1!} + \frac{n(n-1)x^2}{2!} \ldots 2$

Subject to $y^i \leq \sum_{j=1}^{J} \lambda_J\ y^i$

$x_1^i \geq \sum_{j=1}^{J} \lambda_J\ x_1^i;$

$x_2^i \geq \sum_{j=1}^{J} \lambda_J\ x_2^i;$

$x_3^i \geq \sum_{j=1}^{J} \lambda_J\ x_3^i;$

$x_4^i \geq \sum_{j=1}^{J} \lambda_J\ x_4^i;$

and

$\lambda_j \geq 0$ for all j

The solution vector $x^i *$ of (2) is the cost minimizing level of the inputs, given input prices w^i_m m 1...4, and output level y^i. The technical efficiency score ($\delta_i *$)derived from the linear programming problem I could be combined with the solution to the cost-minimising linear programming problems 2 to form measures of the cost and allocative efficiency of each firm. Specifically, cost efficiency index may be solved by dividing the costs that would be faced by a firm if it used the cost—minimising level of inputs by its actual costs. Thus cost efficiency is given by: Cost efficiency for the ith observation

$$= \frac{\sum_{m=1}^{4} w_m^i x_m^i *}{\sum_{m=1}^{4} w_m^i x_m^i} \text{..........................} \quad (3)$$

A score of one for this index would indicate that a firmis cost-efficient. Allocative efficiency was calculated by dividing the costs of the firm , assuming it used the cost-minimising level of inputs, by the costs involved under the assumption that the firm used the technically efficient level of inputs. Thus, Allocative efficiency of the ith observation

$$= \frac{\sum_{m=1}^{4} w_m^i x_m^i *}{\delta i * \sum_{m=1}^{4} w_m^i x_m^i} \quad \text{.......................... (4)}$$

where was the technical efficiency score derived from the linear program problem l. From equation 4 it could be seen and its that cost-efficiency is the product of its allocative efficiency technical efficiency. That is؛

Cost—efficiency allocative efficiency x technical efficiency.

It was also possible to modify the specification of the linear programming to enable technical efficiency to be decompose into an appropriate scale-efficiency, an ability to dispose of "surplus" inputs (congestion inefficiency) and "pure" technical inefficiency.

Zero and one bound all of these three measures. All of them were measured along a ray from the origin to the observed production point. Hence they hold the relative proportions of inputs (or outputs) constant. One advantage of such radial efficiency measures is that they are unit invariant. That is, changing the units of measurement (e.g. measuring quantity of labour in person hours instead of person years) would not change the value of the efficiency measure (Coeli 1996). Furthermore, the new DEAP software Version 2.1 was used to compute the results.

RESULTS AND DISCUSSION

The cost, allocative and technical efficiency predictions for the DEA model were calculated by DEAP computer program Version 2.1, and the results are listed in Tables l, 2 and 3 and also plotted in Fig. 2 and 3. The cost inefficiency ranged from low (zero) to high (96.9%) for 12 Malaysian oleochemical enterprises (Table l). The overall mean for these firms was 55.6 %. This cost-inefficiency was due to overall technical inefficiency of 26.5% and allocative inefficiency of 38% (Table 2).

Table l. Cost efficiency components (DEA)of Malaysian oleochemical enterprises (1990-1996): (Results from DEAP Version 2.1).

Firm no.	year	Technical efficiency	Allocative efficiency	Cost efficiency
2	1990	0.535	1.000	0.535
4		1.000	O .461	0.461
5		0.579	0.797	0.461
8		1.000	1.000	1.000
10		0.833	0.072	0.060
12		1.000	0.465	0.465
Mean		0.825	0.632	0.497
1	1991	0.171	1.000	0.171
2		0.364	O. 642	0.234
3		0.385	0.241	0.093
4		0.892	0.176	0.157
5		0.447	0.411	0.184
6		0.538	0.430	0.232
7		1.000	1.000	1.000
8		1.000	0.368	0.368
9		0.750	o. 123	0.092
10		0.833	0.037	0.031
11		1.000	0.561	0.561
12		1.000	0.194	0.194
Mean		0.698	0.432	0.276
1	1992	0.199	1.000	0.199
2		0.310	0.942	0.292
3		0.259	0.583	0.151
4		0.732	0.335	0.245
5		0.417	0.449	0.187
6		0.512	0.642	0.329
7		1.000	1.000	I .000
8		1.000	0.677	0.677
9		0.750	0.180	0.135
10		0.833	0.074	0.061
11		1.000	0.998	0.998
12		1.000	0.567	0.567
Mean		0.668	0.620	0.403
1	1993	0.132	0.993	0.131
2		0.401	0.677	0.271
3		0.266	0.629	0.167
4		0.529	0.504	0.266
5		0.425	0.400	0.170

6		0.519	0.469	O. 243
7		0. 964	0.601	0.579
8		1.000	0.451	0.451
9		0.750	0.170	0.127
10		0.833	0.066	0.055
11		1.000	1.000	1.000
12		1.000	0.342	0.342
Mean		0.652	0.525	0.317
1	1994	0.273	1.000	0.273
2		0.547	0.794	0.434
3		0.278	0.518	0.144
4		0.499	0.635	0.317
5		0.425	0.572	0.243
6		0.544	0.978	0.532
7		0.772	0.652	0.503
8		1.000	0.692	0.692
9		0.750	0.285	0.214
10		0.833	0.083	0.069
11		1.000	1.000	1.000
12		1.000	0.513	0.513
Mean		0.660	O. 643	0.411
1	1995	0.110	1.000	0.110
2		0.541	0.956	0.517
3		0.273	0.636	0.173
4		1.000	0.939	0.939
5		0.455	0.779	0.354
6		0.545	0.887	0.484
7		1.000	0.661	0.661
9		0.818	0.296	0.242
10		0.909	0.093	0.084
11		1.000	1.000	I .000
Mean		0.665	0.725	0.456
1	1996	0.903	0.699	0.632
6		1.000	0.746	0.746
9		1.000	0.607	0.607
11		1.000	1.000	I .000
Mean		0.976	0.763	0.746
G. Mean		0.735	0.620	0.444

Table 2. Technical, allocative and cost efficiencies: summary of annual means of Malaysian oleochemical enterprises (1990-1996):(DEAP 2.1)

Year	Technical efficiency	Allocative efficiency	Cost efficiency
1990	0.825	O. 632	0.497
1991	0.698	0.432	0.276
1992	0.668	0.620	0.403
1993	0.652	0.525	0.317
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1995	0.665	0.725	0.456
1996	0.976	0.763	0.746
Mean	0.735	0.620	0.444

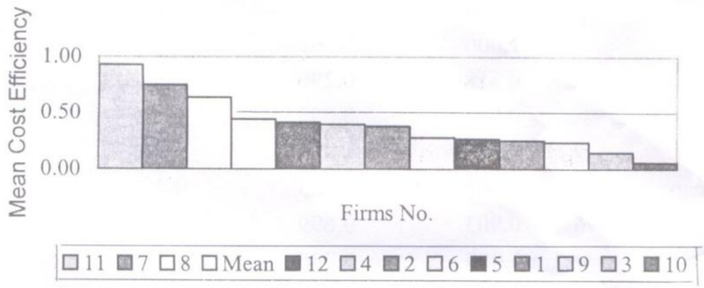

Fig. 2. Mean cost efficiency of Malaysian oleochemical enterprises (1990- 1996).

This result was consistent with Ferrier and Lovell (1990) and Bushara (2001) who found separately that efficiency obtained by using econometric approach was smaller than that obtained with the DEA approach. About 25 % of these firms had economic inefficiencies less than the overall cost-inefficiency with firm number I l as the best. The cost inefficiencies of the remaining 75% of the firms ranged between low (58.46%) of firm number 12 to high (96%) of firm number 10 (Table 3 and Fig. 3).

Ta le 3. Technical, allocative and cost efficiencies: summary of firm mean of C Malaysian oleochemical enterprises (1990-1996): (DEAP 2.1)

Firm no.	Technical efficiency	Allocative efficiency	Cost efficiency
1	0.298*	0.949	0.253
2	0.450	0.835	0.381
3	0.292	0.521	O. 146
4	0.775	0.508	0.398
5	0.458	0.568	0.267
6	0.610	0.692	0.428
7	0.947	0.783	0.749
8	1.000	0.638	0.638
9	0.803	0.277	0.236
10	0.846	0.071	0.060
11	1.000	0.927	0.927
12	I .000	0.416	0.416
Mean	0.735	0.620	0.444

*The figures has been rounded from seven-digit to three- digit so they are not necessarily reflecting exactly the equation that cost efficiency =allocative efficiency into technical efficiency.

This means that the Malaysian oleochemical industry has the potential to cut their cost of production by 55.6% and still produce the same output, provided that they work cost efficiently. Furthermore, the technical inefficiency had already been decomposed into its components: pure technical inefficiency and scale inefficiency. This task has peen described by Bushara(2001) and the study had proven that pure inefficiency was not the problem but instead the scale-inefficiency was the cause.

The mean cost-inefficiencies of the Malaysian oleochemical enterprise for 7 different years (1990- 1996) tended to increase from 1991to 1996 . The mean cost- inefficiencies increased slowly and slightly to 1995 when there was a sharp decrease. The major contributor to this efficiency was allocative inefficiency (Fig. 3).

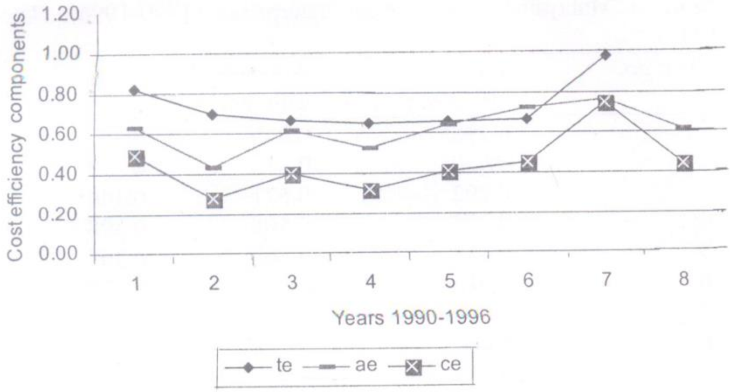

Fig. 3: Mean cost efficiency components of Malaysian oleochemical enterprises (1990-1996).

SUMMARY AND CONCLUSION

In this paper specification and estimation of cost, technical and allocative efficiencies were considered, together, in a cost-minimising framework using unbalanced panel data of 12 Malaysian oleochemical enterprises for the period (1990- 1996). Equations 1, 2, 3 and 4 were estimated. The basic assumption was constant return to scale. The cost-inefficiency ranged from low (zero) to high (99.9%) for Malaysian 12 oleochemical enterprises (Table l) The overall mean for these firms was 55.6. This cost-inefficacy was due to overall technical inefficiency of 26.5% and allocative inefficiency of 38% (Table 2).

This result was consistent with that of Ferrier and Lovell (1990) and Bushara (2001) who found separately that efficiency achieved through econometric approach was smaller than that from the DEA approach. The mean cost-inefficiencies of Malaysian oleochemical enterprises for 7 different years (1990- 1996) tended to increase from 1991 to 1996. The mean cost inefficiencies increased slowly and slightly up 1995when there was a sharp decrease. The major contributor to this inefficiency was allocative in efficiency (Fig.3). Furthermore since there was technical inefficiency, it already had been decomposed into its components i.e. pure technical inefficiency and scale: inefficiency. This task has been described by Bushara (2001) and his study had proven that pure-inefficiency was not the problem but instead scale-inefficiency was the cause.

It is clear that the competitiveness of this industry was improving overtime. However, there was a room for better performance and competitiveness by achieving better prices for their outputs, efficient allocation of resources and high productivity growth by individual firms of this industry. Therefore it could be concluded that allocative efficiency requires first or second best pricing of final products; scale efficiency requires limitation on sub-optimal entry to the industry technical efficiency requires cost minimisation by the serving firms, and product choice and dynamic efficiency require innovation by incumbents and applicants.

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