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TECHNICAL EFFICIENCY MEASURES FOR THE MALAYSIAN FOOD MANUFACTURING INDUSTRY

K. P. KALIRAJAN
Y. K. TSE

I. INTRODUCTION

Much of the overall economic growth of Malaysia is envisaged to originate from its manufacturing sector during the Fifth Malaysian Plan Period, 1986–90. The emphasis is on private sector participation and on the development of potentially more efficient and dynamic export-oriented industries. In 1983, the government of Malaysia initiated two major studies to identify and overcome structural weakness and to review existing industrial policies and strategies. One of the studies, "The Industrial Master Plan" (IMP), concentrated on establishing general industrial development objectives and a framework of development strategies for major sectors as well as sub-sectors with promising growth potential [9]. IMP identified resource-based industries as one of the sub-sectors with potential growth. Resource-based manufacturing industries still show high potential in terms of growth and forward and backward linkages. These industries are important in the sense that they have the potential to increase the value added in manufacturing as the linkages expand, and foreign exchange savings as further import substitution becomes available. Food manufacturing industries constitute the largest portion of the agricultural resource-based industries.[1]

Within the existing economic framework, the development of the food manufacturing industries appears to be justifiable, but its potential will depend on its viability. Increasing competition in international markets, as well as increasing production costs, emphasize the need to improve and sustain efficiency in food manufacturing industries. Further, with the recent accent on privatization, the importance of improving entrepreneurial ability, which is reflected in the firm's technical efficiency, cannot be overemphasized. The objective of this paper is to provide measures of technical efficiency for the Malaysian food manufacturing industry using panel data.

The following section discusses the conceptual model to measure technical efficiencies and its estimation using panel data. The next section describes the data source and the empirical results. The final section brings out the conclusions of this paper.

[1] During 1987, the share of the food manufactures in the exports of agricultural resource-based manufactures was about 54.1 per cent [2].

II. CONCEPTUAL MODEL

A technically efficient firm is defined as one which produces on its outer-bound production function to obtain the maximum possible output which is feasible using current technology. This concept is consistent with Friedman's theory [6] that an individual's entrepreneurial ability can be specified by a production function which shows the maximum quantity of output which he is capable of producing under given conditions. Thus the technical efficiency of a firm tends to reflect the entrepreneurial efficiency, ceteris paribus. Technical efficiency in this paper is measured as the ratio of actual output to the potential output given by the outer-bound production function as defined by Leibenstein [8] for a given set of inputs and technology. Thus, a firm's actual performance is compared with its own potential performance rather than with the performance of any other firms.[2]

Let the ith firm-specific outer-bound production function, assuming m inputs at the tth period be written as follows:

$$y^*_{it} = f(x_{1it}, x_{2it}, \cdots x_{mit}), \qquad (1)$$
$$i = 1, 2, \cdots n \text{ (firms)}, \qquad t = 1, 2, \cdots T \text{ (time periods)}.$$

The above outer-bound production function of the ith firm, in the neoclassical sense, yields the maximum possible output for the given technology at the tth period.

It is rational to argue that the outer-bound production functions may vary from firm to firm because of the differences in the socioeconomic-physical environment in which the various firms are operating. As a firm may produce either on or below its outer-bound production function, the introduction of a non-negative random variable u in (1) which has the "normal" properties incorporates the above argument and turns the deterministic outer-bound production function (1) into a stochastic outer-bound firm-specific production function. Thus we assume

$$y^*_{it} = f(.) \exp(-u_i). \qquad (2)$$

We define e^{-u_i} as the firm-specific efficiency. u_i takes the value zero when the firm produces on its outer-bound production function (realizing all its technical efficiency potential), and is less than zero when the firm produces below its outer-bound production function (not realizing fully its technical efficiency potential). This might happen due to a number of factors such as risk aversion and self-satisfaction, which may prevent the firm from achieving its full potential.

The measure of technical efficiency varies from 0 to 1 and is not dependent on the level of the factor inputs for the given firm. If an industry's technical efficiency is 0.75, this means that the industry on average, realizes only 75 per cent of its potential output which is feasible in its socioeconomic production environment.

Following the argument that the outer-bound firm-specific production function may vary for the same firm over time, it is reasonable to expect that the firm-

[2] The outer-bound production function is analogous to the frontier production function discussed in the literature. For a comprehensive review of the frontier production function see [12].

specific technical efficiency may also vary over time. As the actual firm-specific production Y_{it} varies over time, we assume

$$Y_{it} = Y^*_{it} \exp(v_{it}). \tag{3}$$

However, over a small period of time, the variation may not be statistically significant. A hypothesis tested in this paper is that technical efficiency does not change over time when the period of analysis is less than five years. Further, it is assumed that the outer-bound production function is identical to all the food manufacturing industries in Malaysia.

In order to estimate the firm-specific technical efficiency, it is necessary to specify the distribution of u_i and v_{it}. It is assumed, as suggested by Stevenson [14] that u follows a normal distribution with mean λ and variance σ_u^2, lower truncated at zero, and v_{it} follows a normal distribution with mean zero and variance σ_v^2. u_i and v_{it} are assumed to be independently distributed for all i and t.

The density function of u is defined by

$$f_u(u) = \frac{\exp\left[-\frac{1}{2}(u-\lambda)^2/\sigma_u^2\right]}{\sqrt{2\pi}\,\sigma_u\,[1-\Phi(-\lambda/\sigma_u)]}, \qquad u \geq 0, \tag{4}$$

where Φ is the distribution function of the standard normal variate. This specification of the density function of u_i has been applied by Coelli and Battese [5], which is different from that used by Pitt and Lee [10], Schmidt and Sickles [13] and Kalirajan and Shand [7]. The latter studies assumed a half normal distribution for u, which is a special case of the more general distribution [truncation of $N(\lambda, \sigma_u^2)$] considered in the former study. If the parameter, λ, is zero, then the random variable has half normal distribution, as assumed by Pitt and Lee and Schmidt and Sickles. If λ is positive, then the density function of u increases to a maximum value and then declines asymptotically to zero. If λ is a large negative, then the density function of u may approximate to an exponential distribution.

Specification of density functions of u_i and v_{it} enables one to estimate (3) using maximum likelihood methods. The firm-specific technical efficiencies are then derived from the conditional mean of u, given the combined residual $(v_{it} - u_i)$. We define $e_{it} = v_{it} - u_i$ and $e_i = (e_{i1}, \cdots, e_{iT})'$.

By the convolution formula, the joint density function of e_i can be written as

$$f_{ei}(e_i) = \frac{[1-\Phi(Z)]\cdot M \cdot N}{[(2\pi)^T(\sigma_v^2 + T\sigma_u^2)]^{1/2}\ \sigma_v^{T-1}[1-\Phi(-\lambda/\sigma_u)]}, \tag{5}$$

where $Z = \dfrac{\sigma_u^2 T\bar{e}_i - \sigma_v^2\lambda}{\sigma_u\sigma_v\sqrt{(\sigma_v^2 + T\sigma_u^2)}}$,

$$\bar{e}_i = \frac{1}{T}\sum_1^T e_{it},$$

$$M = \exp\left[-\frac{1}{2}\sum(e_{it}+\lambda)^2/\sigma_v^2\right],$$

$$N=\exp\left[\frac{\sigma_u^2 T^2(\bar{e}_i+\lambda)^2}{2\sigma_v^2(\sigma_v^2+T\sigma_u^2)}\right],$$

specifying that

(i) $\sigma^2=\sigma_u^2+\sigma_v^2$ and
(ii) $\gamma=\sigma_u^2/\sigma^2$.

The density function of Y_i is written as follows:

$$fy(y)=\frac{[1-\Phi(Z)]\exp\left[\dfrac{-\sum_1^T(e_{it}+\lambda)^2}{2(1-\gamma)\sigma^2}\right]\exp\left[\dfrac{T^2\gamma(\bar{e}_i+\lambda)^2}{2(1-\gamma)\sigma^2(1+(T-1)\gamma)}\right]}{\{(2\pi)^T\sigma^2[1+(T-1)\gamma]\}^{1/2}[\sigma^2(1-\gamma)]^{T-1/2}[1-\Phi(-\lambda\sqrt{\gamma\sigma})]}. \tag{6}$$

Given sample values of ys, the logarithm of the likelihood function is given by

$$\begin{aligned}L^*(y)=&-\frac{N}{2}T\ln(2\pi)-\frac{N}{2}(T-1)\ln[(1-\gamma)\sigma^2]\\&-\frac{N}{2}\ln\{\sigma^2[1+(T-1)\gamma]\}-N\ln[1-\Phi(-\lambda/\sqrt{\gamma\sigma})]\\&+\sum_1^N\ln[1-\Phi(Z)]-\frac{1}{2(1-\gamma)\sigma^2}\sum_1^N\sum_1^T(e_{it}+\lambda)^2\\&+\frac{T^2\lambda\sum_I^N(\bar{e}_i+\lambda)^2}{2(1-\gamma)[1+(T-1)\gamma]\sigma^2},\end{aligned} \tag{7}$$

where $Z=\dfrac{(T\bar{e}_i+\lambda)\gamma-\lambda}{\sqrt{\gamma(1-\gamma)[1+(T-1)\gamma]\sigma^2}}$.

The maximum likelihood (ML) estimators, maximizing the above likelihood function are obtained by setting the first order partial derivatives of the likelihood function with respect to σ^2, γ, λ_i and the parameters of $f(.)$ to zero and solving them simultaneously. The mean technical efficiency measure is[3]

$$E[(\exp(-u_i)]=\frac{1-\Phi(\sigma_u-\lambda/\sigma_u)}{1-\Phi(-\lambda/\sigma_u)}\exp(-\lambda+\sigma_u^2). \tag{8}$$

The measures of individual firm-specific technical efficiencies are calculated from the conditional distribution of u_i, given the joint distribution of e_{it}, given the joint distribution of e_{it}. The conditional distribution of u_i, given $\bar{e}_i$, the lower truncated normal distribution (at zero) with mean

$$\lambda^*_i=\left(-\bar{e}_i\sigma_u^2+\frac{1}{T}\lambda\sigma_v^2\right)\left(\sigma_u^2+\frac{1}{T}\sigma_v^2\right)^{-1},$$

and variance $\sigma_*^2=\sigma_u^2\sigma_v^2(\sigma_v^2+T\sigma_u^2)^{-1}$. (9)

[3] See [5].

Thus the ith firm-specific technical efficiency is calculated using the conditional expectation

$$E[\exp(-u_i)/\bar{e}_i]=\frac{1-\Phi(\sigma_*-M^*_i/\sigma_*)}{1-\Phi(-M^*_i/\sigma_*)}\ \exp\left(-M^*_i+\frac{\sigma_*^2}{2}\right) \qquad (10)$$

where M^*_i is the counterpart of λ^*_i in (9), given the sample mean $\bar{e}_i$. In (10) all quantities are evaluated at the ML estimates.

III. DATA AND EMPIRICAL RESULTS

Secondary panel data were used in this paper. Panel data are data from cross-section observations (firms) over several years with the same firms appearing in all years. The Department of Statistics (West Malaysia, Kuala Lumpur) conducts a survey of manufacturing annually, thus providing the necessary data base. Of relevance are the volumes of *Survey of Manufacturing Industries,* 1974, 1975, and 1976. These volumes supply detailed figures of manufacturing for about 115 selected groups of manufacturing firms. However, there are few limitations with the data. The figures revealed are on manufacturing establishments as a group and not on individual firms. Data on industrial structure is based on the International Standard Industrial Classification (ISIC) which classifies firms into industries, the latter drawn up on the basis of the use of common raw materials, or a common manufacturing process. Such groups may not correspond to an economic definition of "market" which is a product grouping comprising goods among which there is a significant positive coefficient for cross-elasticity of demand [11].

The following variables were used in this paper to measure firm-specific technical efficiencies: gross output is the dependent variable and cost of inputs, number of full time workers, and fixed assets are the independent variables. The sample studied comprised eighteen food manufacturing firms, and therefore the total number of observations for the three periods worked out to be fifty-four. A translog type of production function which is a more general production function in many respects, was assumed for the present study. By imposing appropriate restrictions on the translog production function, it is possible to develop tests of theory of production that do not employ additivity and homogeneity properties. Thus the translog function permits a greater variety of substitution and transformation patterns than functions based on constant elasticities of substitution and transformation [3]. The model is

$$\begin{aligned}\ln y=\alpha_0+\sum_i^3\alpha_i\ln x_i+\ln x_1(\beta_{11}\ln x_1+\beta_{12}\ln x_2+\beta_{13}\ln x_3)\\ +\ln x_2(\beta_{22}\ln x_2+\beta_{23}\ln x_3)+\beta_{33}(\ln x_3)^2-u+v,\end{aligned} \qquad (11)$$

where y = gross output in Malaysian dollars,
x_1 = cost of inputs in Malaysian dollars,[4]

[4] During the period of analysis (1974–76), the average annual rate of growth of the consumer price index (CPI) for Peninsular Malaysia (1967=100) did not change significantly [1].

TABLE I

MAXIMUM LIKELIHOOD ESTIMATES OF THE OUTER-BOUND PRODUCTION FUNCTION OF THE MALAYSIAN FOOD MANUFACTURING INDUSTRY, 1974–76

Variable	Parameter	ML Estimates
Constant	α_0	5.2812 (1.0216)
$\ln x_1$	α_1	0.3215 (0.1011)
$\ln x_2$	α_2	0.2910 (0.1208)
$\ln x_3$	α_3	0.4416 (0.2014)
$(\ln x_1)^2$	β_{11}	−0.0310 (0.0106)
$(\ln x_1)(\ln x_2)$	β_{12}	0.0085 (0.0025)
$(\ln x_1)(\ln x_3)$	β_{13}	0.0109 (0.0036)
$(\ln x_2)^2$	β_{22}	−0.0297 (0.0103)
$(\ln x_2)(\ln x_3)$	β_{23}	0.0070 (0.0035)
$(\ln x_3)^2$	β_{33}	−0.0183 (0.0067)
Total variability	σ^2	0.4281 (0.1602)
Firm specific variability / Total variability	γ	0.7815 (0.2014)
Log likelihood function		−31.7816

Note: Figures in parentheses are standard errors of the estimates.

x_2 = number of full time workers,
x_3 = fixed assets in Malaysian dollars,
u = industry-specific technical efficiency related variable, and
v = statistical random variable.

The maximum likelihood (ML) estimates of (11) are reported in Table I. The maximum likelihood estimates converged at about the 1526th iteration. As the derivatives of the logarithm of the likelihood function (8) were complicated, iterative methods were used to approximate the ML estimates. The Newton-Raphson method which uses the second derivatives of the logarithm of the likelihood function was used to approximate the maxima of the function. The ratio of

The CPI for 1974 (1967=100) was 137.8, while for 1975 and 1976 respectively was 144 and 147.7. Further, the objective here is to measure technical efficiency given the technology and the economic situation faced by firms in the industry, with the assumption that technical efficiency does not change within the period of analysis. So, using absolute prices to measure the cost of inputs may be justified.

industry-specific variability to total variability which is given by γ is 0.7815 and is significant at the 1 per cent level. This means that the observed output variability is mainly due to firm-specific performance and not just to statistical random variability. All the coefficients are significant at the 5 per cent level and they do have theoretically acceptable signs.

In the testing of the translog model, the following sequence is adopted: in the beginning, the hypothesis of constant returns to scale (CRTS) which implies a set of restrictions on the parameters of the function, is tested, i.e.,

$$\sum \alpha_i = 1 \text{ and } \sum_i \beta_{ij} = 0, \ \sum_j \beta_{ij} = 0, \ \sum_i \sum_j \beta_{ij} = 0$$

Following this test, monotonicity, which requires that

$$\frac{\partial y}{\partial x_1} > 0, \ \frac{\partial y}{\partial x_i} > 0, \text{ and } \frac{\partial y}{\partial x_3} > 0$$

and quasi-concavity, which requires that the bordered Hessian matrix be negative definite, are tested. Then, testing for the separability conditions is done as follows: first, the restrictions are tested for complete global separability. If these conditions are satisfied, then all the three sets of separability are said to be valid; second, if this hypothesis is rejected, then the test involves examining whether any one of the three sets of linear restrictions is satisfied; third, when the three sets of linear restrictions are rejected, then any one of the non-linear separability conditions is examined; finally, if these are rejected, then it leads to the conclusion that none of the separability conditions is satisfied.

In the case of translog production function with three inputs, three sets of separability may prevail: first, the functional separability of x_1 and x_2 from x_3, which means that $f(x_1, x_2, x_3) = g[(x_1, x_2), x_3]$ [denoted by (1, 2)3]; second, the separability of x_1 and x_3 from x_2 which means that $f(x_1, x_2, x_3) = g[(x_1, x_3), x_2]$ [denoted by (1, 3)2; third, the separability of x_2 and x_3 from x_1, which means that $f(x_1, x_2, x_3) = g[(x_2, x_3), x_1]$ [denoted by (2, 3)1].

Restrictions for global separability mean that the parameter estimates satisfy certain conditions [3]:

(1, 2)3 implies that $\alpha_1\beta_{23} - \alpha_2\beta_{13} = 0$,
(1, 3)2 implies that $\alpha_1\beta_{23} - \alpha_3\beta_{12} = 0$,
(2, 3)1 implies that $\alpha_2\beta_{13} - \alpha_3\beta_{12} = 0$.

Therefore, the linear separability conditions[5] for (1, 2)3 are that $\beta_{13} = 0 = \beta_{23}$.

[5] Alternatively, these separability conditions can be verified by examining whether the Allen partial elasticities of substitution (AES) satisfy the following conditions [4]:
(1,2)3 implies that $\sigma_{13} = \sigma_{23}$,
(2,3)2 implies that $\sigma_{12} = \sigma_{23}$,
(2,3)1 implies that $\sigma_{12} = \sigma_{13}$,
where σ refers to AES which may be obtained from the cost share equations. The cost share equations are obtained by differentiating the translog production function with respect to each input. Since our primary concern is to estimate the industry-specific entrepreneurial efficiencies, the cost share equations were not estimated in this paper.

TABLE II

DERIVED PRODUCTION ELASTICITIES FOR THE MALAYSIAN FOOD MANUFACTURING INDUSTRY, 1974–76

Variable	Elasticity Estimate (η)
Inputs	0.3006 (0.0915)
Full-time workers	0.2718 (0.0823)
Fixed assets	0.4312 (0.1310)

Notes: 1. Elasticity measures were derived in the following way, using the mean input levels:

$$\eta_i = \frac{\partial y}{\partial x_i} \cdot \frac{x_i}{y} = \frac{\partial \ln y}{\partial \ln x_i} = \alpha_i + \sum_j \beta_{ij} \ln x_j, \quad i=1,2,3.$$

2. Figures in parentheses are standard errors of estimates. Standard errors were calculated in the following way:

$$\mathrm{Var}(\eta_i) = \mathrm{Var}(\alpha) + \sum (\ln x_j)^2 \ \mathrm{Var}(\beta_{ij}) + 2\sum \ln x_j \ \mathrm{cov}(\alpha_i, \beta_{ij})$$
$$+ 2\sum \ln x_k \ \ln x_j \ \mathrm{cov}(\beta_{ij}, \beta_{ik}).$$

Similarly, the linear separability conditions for (1, 3)2 and (2, 3)1 are respectively that $\beta_{13} = 0 = \beta_{23}$ and $\beta_{13} = 0 = \beta_{12}$.

For the present study, the CRTS could not be rejected at the 1 per cent level. The case with monotonicity and quasi-concavity is similar. The null hypothesis of linear and non-linear separability were rejected at the 1 per cent level. This means that complete global separability is rejected, which implies that the production technology cannot be significantly represented by Cobb Douglas. The rejection of all non-linear separabilities is equivalent to assuming that constant elasticity substitution type of functions are not suitable to describe the production methods of the sample data. The rejection of complete global separability implies that all the three inputs considered in this study are needed to produce output in the Malaysian food manufacturing industries.

The direct estimates of the coefficients of (11) do not bear any economic meaning on them. The output elasticities with respect to inputs are derived from these estimates and are reported in Table II. All the coefficients have a positive relationship to output. If the number of permanent workers is increased by 10 per cent, with the prevailing wage structure there seems to be a possibility of increasing output by about 3 per cent.

The statistical significance of the inclusion of the industry-specific performance variable u in (11) has been examined by jointly testing the parameters $\lambda = 0 = \gamma$, using the generalized likelihood ratio. The negative of twice the logarithm of the likelihood ratio has approximately χ^2-distribution with degrees of freedom equal to two. The value of the test statistic works out to be 17.2 which is significant at the 1 per cent level. This implies that the null hypothesis can be rejected. This further means that variations in observed output levels are not due to random shocks but can be explained by differences in firm-specific performances.

Table III gives the industry-specific technical efficiency measures, along with

TABLE III

FIRM-SPECIFIC TECHNICAL EFFICIENCY MEASURES FOR THE MALAYSIAN FOOD MANUFACTURING INDUSTRY, 1974–76

S/No.	Firm	Technical Efficiency Estimate (%)	Rank[a]
1.	Canning of fruits and vegetables	75	5
2.	Canning of fish and similar foods	73	6.5
3.	Coconut oil manufacturing	72	8.5
4.	Small rice mills	60	17.5
5.	Large rice mills	60	17.5
6.	Sago and tapioca factories	78	3
7.	Other grain milling	77	4
8.	Biscuit factories	68	13.5
9.	Manufacture of cocoa	82	1
10.	Ice factories	66	16
11.	Coffee factories	69	11.5
12.	Noodles and related products	71	10
13.	Spices and curry powder	81	2
14.	Manufacture of prepared animal foods	67	15
15.	Tobacco manufactures	69	11.5
16.	Other vegetable and animal oils and fats	68	13.5
17.	Bakeries	72	8.5
18.	Dairy products	73	6.5
	Mean level	73	

[a] The ranking has taken into account ties in the sample.

the mean technical efficiency for the entire food manufacturing industry. The results show that there is a wide variation in technical efficiencies among the sample firms.

The mean technical efficiency of the food manufacturing industry can be calculated using the formula given in (10).

The calculated value is 0.7340. On average, the firms within the food manufacturing industries tend to realize about 73 per cent of their technical abilities. Thus, the analysis shows that about a quarter of the technical potential of the food manufacturing industry is not realized, and this needs attention from the point of view of policy.

The estimates of firm-specific technical efficiencies (Table III) range from 60 to 82 per cent. Among the sample firms in food manufacturing industries, manufactures of cocoa and related products, spices and curry powder, seem to have realized the maximum proportion of their technical efficiency. International trade in intermediate cocoa products tends to grow continuously and this presents cocoa producing countries like Malaysia with export opportunities for its domestically processed cocoa products. In order to exploit these export opportunities, it becomes necessary to improve the technical skills of firms manufacturing and processing cocoa and its related products. The small and large rice mills appear to be operating with only about 60 per cent of their entrepreneurial abilities realized. The sago and tapioca factories rank third in terms of achieving entrepreneurial efficiency. Malaysia has been a net exporter of tapioca products for many years, but faces strong competition from Thailand, which is the largest exporter of tapioca products in the world. This situation emphasizes the need for improving and sustaining technical efficiency in producing tapioca products, so that Malaysian products remain competitive with products from Thailand.

The above empirical results show that it is necessary to improve the technical efficiency of the Malaysian food manufacturing industry to achieve the objectives set by the Fifth Malaysian Plan. Even though, on average the industry realizes about 73 per cent of its technical efficiency, some of the individual firms realize much lower than the industry average. It is interesting and useful to identify the factors causing such variations in technical efficiency among the firms. Due to data constraints, this could not be attempted here.

IV. CONCLUSIONS

Analysis of the question as to why some firms are successful while others are not, is crucial to the understanding of economic development. Many theoretical models attribute success and failure almost entirely to material factors. Empirical findings, however, indicate a significant residual factor which mainly depends on differences in efficiency rather than the quantity of factors used in production. It is reasonable to assume that differences in the efficiency of factor use is attributable to differences in the entrepreneurial talents of firms. Thus, the measurement of technical efficiency plays a vital role in production economics.

This paper, using the concept of outer-bound production function discussed by Leibenstein, has measured the technical efficiency of the Malaysian food manufacturing industry. The food manufacturing industry plays an important role in the overall development of the industrial sector of the Malaysian economy in terms of employment generation, savings of foreign exchange, and increasing rural income. The empirical results show that, on average, the Malaysian food manufacturing industry has been achieving about 73 per cent of its potential output. This means that there are still ways and means for improvement in the food manufacturing industry so as to fully achieve the potential output (100 per cent). This study also points out that there are wide variations in the performances of individual firms within the food manufacturing industry.

The limitations of this study should be borne in mind while analyzing the empirical results. The major limitation is that firms selected for analysis within the Malaysian food manufacturing industry are not individual firms per se, they are groups of firms having the same SITC numbers given in the survey. If individual firms were used, the results could be more effective. Nevertheless the present results can be interpreted as the mean technical efficiency measures of the individual groups of firms within the food manufacturing industry.

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