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Technical efficiency of manufactured rubber product in Malaysia: stochastic frontier analysis

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ABSTRACT

This paper investigates the technical efficiencies of rubber product manufacturing industry in Malaysia. We employed Stochastic Frontier Analysis (SFA). Secondary data from 313 firms that manufacture rubber product was obtained from the Annual Survey Of Manufacturing Industries 2004 by Department of Statistics Malaysia. Variables that are included in this are such as capital (RM), labor, and energy. Results clearly show that the mean technical efficiency of manufactured rubber product industry in Malaysia is 0.70328 or 70.33 percent. Majority of the firms are also fairly efficient in the use of available resources. Some technical assistance such as training programs for the proprietors of the firms and financial support such as subsidies could be offered to boost their production level as rubber is indeed an important component of the manufacturing industry in Malaysia.

Introduction

The rubber product industry has played a crucial role in the early post-independence economic development of the country. Malaysia is currently the third biggest producer of natural rubber in the world and the fifth largest consumer of rubber and among the world's largest exporters of rubber products (Malaysia Rubber Export Council, 2009). As the Malaysian economic focus shifted from primary industries towards manufacturing sector, the rubber industry also underwent major structural changes. Malaysia was the world's largest producer once, but started to lose its spot in the 90s. However, the downward trend in Malaysian production over the last decade showed some reverse trend, commencing 2002 with output rising from 889,830 tonnes to 1.1 million tonnes in 2005. However, Malaysia still maintains its position as the third largest NR producer in the world (Table 1). Meanwhile, with relatively low labor cost and apparently minimal government support, production in India, China and Vietnam are on a steady growth path.

Malaysia's natural rubber production in 2007 amounted to 1.20 million tonnes compared with 1.28 million tonnes in 2006. The major natural rubber consuming industries for 2007 were rubber gloves (63.8%), rubber thread (13.0%) and tyres and tubes (11.8%). The total consumption of these three industries constitutes 88.6% of the overall domestic consumption of natural rubber. The rapid growth of the industry has enabled Malaysia to become the world's largest consumer of natural rubber latex. The rubber products industry comprises 4 major sub-sectors namely the latex products industry, tyres and tyre-related industry, manufacturing of industrial and general rubber products, and manufacturing of rubber footwear products. The Malaysian rubber products industry is made up of more than 510 manufacturers, producing latex products, tyres and tyre-related products, and industrial and general rubber products. The industry employed more than 68,700 workers and contributed RM10.5 billion to the country's export earnings in 2007. Rubber products accounted for 1.7 per cent of Malaysia's total exports and 2.3 per cent of Malaysia exports from the manufacturing sector. Export of rubber products, by value has been increasing since 2001 (Table 2). Export by value surpassed RM 8 billion in 2004 and in 2007 it reached RM 10.5 billion. Latex products constitute the largest sub-sector within the rubber products industry. A total of 163 manufacturers are involved in this sub-sector. Main products include medical devices, household and industrial gloves, latex threads, catheters, balloons, finger stalls and foam products. This sub-sector accounted for RM4.4 billion (79 per cent) of the value of exports in 2000 and increases to RM7.7 billion (74 per cent) in 2007.

There are currently 126 companies in the tyres and tyre-related products sub-sector comprising nine tyre producers while the remaining companies produce retreads, tyre treads for retreading, valves and other accessories. There are three major tyre producers producing passenger car tyres, commercial vehicle tyres and earthmover tyres, and another six manufacturing other types of tyres. Exports values of this sub-sector is RM243.6 million (4.3 per cent) of the value of exports in 2000, RM249.7 million (4.6 per cent) in 2001, RM261.4 million (4.7 per cent) in 2002, RM4.8310.5 million (4.9 per cent) in 2003, RM458.0 million (5.7 per cent) in 2004, RM501.8 million (6.1 per cent) in 2005, RM586.5 million (6.3 per cent) in 2006, and RM950.62 million (9 per cent) in 2007. The industrial and general rubber products sub-sector comprises 194 companies producing a wide range of rubber products such as mountings, beltings, hoses, tubings, seals, and sheetings for the automotive, electrical & electronics, machinery and equipment, and construction industries, largely for the domestic market. Table 2 shows the export value of this sub-sector in Malaysia. This sub-sector accounted for RM6.3 million (11 per cent) of the value of exports in 2000, RM6.1 million (11.2 per cent) in 2001, RM5.9 million (10.7 per cent) in 2002, RM6.8 million (10.8 per cent) in 2003, RM8.4 million (10.5 per cent) in 2004, RM9

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million (11 per cent) in 2005, RM9.5 million (10.2 per cent) in 2006, and RM1.2 billion (11.3 per cent) in 2007.

Malaysia's Vision 2020 sets out new goals for the Malaysian rubber industry to enhance productivity and competitiveness, and to modernize the predominant smallholders sector in order to maximize the industry's contribution to the national economy. In line with the increased competitiveness and consumer demands, the Malaysian rubber industry is further consolidated and integrated to cover a wide range of activities with forward and backward linkages in both upstream and downstream rubber industries. In this study, the stochastic frontier production function as proposed bt Battese and Coelli (1992) is used to examine the technical efficiency of rubber product industry in Malaysia, using data from Annual Survey Of Manufacturing Industries 2004 by Department of Statistics Malaysia Following,, a Cobb-Douglass stochastic frontier production function is estimated using data from the Annual Survey Of Manufacturing Industries 2004 by Department of Statistics Malaysia.

This paper is organized as follows. Section 2 reviews some of the related literature. Section 3 presents the econometric methodology albeit the Stochastic Frontier Production Model. In the following section 4, we provide the empirical results of our study, while section 5 concludes.

Literature Review

Assessing the performance of any institution is based on the basis that any inter firm variations in outputs produced, consequences of variations in the quantity and quality of inputs available as mentioned by Johnes (1996). Production theory provides the framework to develop a methodology for measuring efficiency of a firm. Within this framework, production frontier functions are used to measure technical efficiency. The concept on measuring the efficiency of an institution was first proposed by Farrell (1957). He proposed the concept of economic efficiency as to represent total efficiency in an institution, which includes technical efficiency, and allocative efficiency. The first component is technical efficiency was defined as the ability of an institution to produce the maximum level of output from a given set of inputs and technology. Inputs could be resources used such as capital, labour and raw materials.

The second component is called the allocative efficiency. It reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and production technology. A firm can be allocatively inefficient if it selects inputs at prices higher than the current input prices, in order to produce the quantity of output at a cost that is not a minimum cost . Technical efficiency applied in the microeconomics of production is the attainable level of output for a given level of production inputs, given the range of alternative technologies available to the industries. Allocative efficiency refers only to the adjustment of inputs and outputs to reflect relative prices, having chosen the production technology. Economic efficiency is the situation when technical and allocative efficiency are combined. Most empirical studies concentrate on technical inefficiency since technical inefficiency appears to be an important source of under-performance. Technical inefficiency also embodies all the managerial and organizational sources of inefficiency, what Leibenstein (1966) refers as X-inefficiency. The allocative efficiency of an organization is a comparative measure of how well its prices according to its marginal productivity. As a conclusion, allocative efficiency relates to prices whilst technical efficiencies relates to quantities. When comparing between allocative and technical efficiency, its determine that the degree of total economic efficiency. Thus when a firm uses its resources completely and technically efficiently, then it can be said to have achieved total economic efficiency. Similarly, when either allocative or technical inefficiency is present, then the organization will be operating at less than total economic efficiency; Worthington (2004).

This study found that technical efficiency was a major contribution of Total Factor Productivity (TFP) growth. Nik Hashim and Basri (2004) measured (TFP) growth of Malaysian manufacturing sector using stochastic frontier approach with translog production function. They found that between 1990 and 2000 TFP growth was very low for some industries at below unity or even negative for E&E, transport and food industries. The positive growth is achieved in chemical, textiles, rubber, petroleum and wood. Study by Yanrui (2000), using the stochastic frontier approach showed that TFP growth was positive for all countries. This study includes seven APEC developed countries and nine APEC developing countries and found that APEC developed countries performed better in terms pf TFP growth contribution. Mahadevan (2001) however, studied TFP growth using the Malaysian Manufacturing Survey data of 1981-1996. She divided the data into three periods namely 1981-1984, 1987-1990 and 1991-1996. She found that the contribution of input has increased over time but the contribution of TFP growth was negative in the last two periods that due to different reasons. During the second period, the negative contribution of TFP growth was due to a negative contribution of technical progress, whereas during the third period it was due to a negative change in technical efficiency.

There are various factors that contribute to technical inefficiency e.g., socio-economic, demographic and regional responsible for technical efficiencies to be different across provinces. Heru and Subhash (2004) study the factors considered are: inflation, mean years of schooling, regional location, and sectoral differences. In twenty out of twenty six provinces the TFP growth was driven by efficiency changes while in four provinces the TFP growth was driven by technological progress. Sharma, et al. (2003) estimated technical efficiency and total factor productivity growth in fifty U.S. states from 1977 to 2000 and found that, on average, technical efficiency is around 75%. Other studies on regional technical efficiencies that use different methods includes Osiewalski, et al. (2000) and Maudos et al. (2000). Osiewalski et al. (2000) examined productivity disparity between Poland and other Western economies using a Bayesian stochastic frontier. They claimed that at the beginning of Poland's reforms its economy exhibited low technical efficiency. Maudos et al. (2000) employed Data Envelopment Analysis to estimate efficiency in Spanish regions using panel data from 1964 to 1993 and they observed that efficiency varies across sectors and time.

There are some previous researcher utilized the stochastic frontier in examining technical efficiency includes previous studies of Aigner et al. (1977), use the stochastic frontier production function to state that the analysis of the U.S agricultural data. Battese and Corra (1977) applied the technique to the pastoral zone of Eastern Australia. More recently, empirical applications of the technique in efficiency analysis have been reported by Battese et al. (1993); Ajibefun and Abdulkadri (1999); Ojo and Ajibefun (2000). In addition, Shazali et al. (2004) that examined the technical efficiency of

Malaysia Furniture Industry using stochastic frontier production model found that actual firm output is 20 per cent less than maximal output which can be achieved from the existing level of inputs.Kumbhakar et al. (1991) conclude that both technical and allocative inefficiencies decrease with an increase in the level of education of the farmer. This is similar to the conclusion reached by Ajibefun and Daramola (2003), that education is an important policy variable and could be used by policy makers to improve both technical and allocative efficiency.

Methodology

There are two basic methods of measuring technical efficiency: the classical and the frontier approach. Controversies and dissatisfaction with the shortcomings of the classical approach led economists to develop advanced econometric, statistical and linear programming techniques aimed at analyzing technical efficiency related issues. All of these techniques have in common, the concept of a frontier. This implies that efficient firms are those operating on the production frontier, while inefficient firms are those operating below the production frontier. This paper adopts the stochastic frontier production approach. This approach was originally proposed by Farrell (1957), came to prominence in the late 1970s as a result of the work of Aigner et al. (1997), and Meeusen and van den Broeck (1977) based on an econometric specification of a production frontier and is used in the estimation of technical efficiency.

For this study purpose, a stochastic frontier production as proposed by Battese and Coelli (1992) can be defined as :

$$Yi = f(Xi, \beta)\, e^{\varepsilon} \quad (1)$$

Y_i is output vector for the i th firm, Xi is a vector of inputs, β is a vector of parameter and ε_i is an error term. In this model, a production frontier defines output as a function of a given set of inputs, together with technical inefficiency effects. The stochastic frontier is also known as composed error model, because it postulate that the error term ε_i composed of two independent error components.

$$\varepsilon_i = v_i + u_i \quad (2)$$

$v_i \sim N(0,\sigma_v^2)$ represent any stochastic factors beyond the firms control affecting the ability to produce on the frontier such as luck and weather, where a symmetric component normally distributed. It can also account for measurement error in Y_i or minor omitted variables. The asymmetric component, in this case distributed as a half-normal, $u_i \sim | N(0,\sigma_v^2) |$, $u_i \geq 0$, can be interpreted as pure technical inefficiency. This component has also been interpreted as an unobservable or latent variable, and in most cases representing managerial ability.

The parameters of v and u can be estimated by maximizing the log-likehood function as shown follows :

$$\ln(Y \sim \beta,\lambda,\sigma^2) = \frac{N}{2}\left(\ln\frac{2}{\Pi}\right) - N\ln\sigma + \sum_{i=1}^{N}\ln(1 - F(\varepsilon_i,\lambda,\sigma^{-1})) - \frac{1}{2}\sigma^2\sum_{i=1}^{N}\varepsilon_i^2 \quad (3)$$

where ;

$$\varepsilon_i = Y - f((X_i ; \beta)$$

$$\sigma^2 = \sigma_u^v + \sigma_v^2$$

$$\lambda = \frac{\sigma_u}{\sigma_v}$$

$$\sigma = \sqrt{\sigma_u^2 + \sigma_v^2}$$

F = The standard normal distribution function

N = Number of observation

Given the assumption on the distribution of v and u, Jondrow et al. (1982) showed that the conditional mean of u given ε is equal to

$$E(u_i \varepsilon_i) = \frac{\sigma_u \sigma_v}{\sigma}\left[\frac{f(\varepsilon_i \lambda\sigma)}{1 - f(\varepsilon_i \lambda\sigma)} - \frac{\varepsilon_i \lambda}{\sigma}\right] \quad (4)$$

where f and F the standard normal density and distribution function evaluation at $\varepsilon_i\lambda/\sigma$. Measures of technical efficiency (TE_i) for each firms can be calculated as;

$$TE_i = \exp(-E[u_i|\varepsilon_i]) \quad \text{so that} \quad 0 \leq TE_i \leq 1 \quad (5)$$

In this study, the stochastic frontier production function as proposed bt Battese and Coelli (1992) is used to examine the technical efficiency of rubber product industry in Malaysia. Then, a Cobb-Douglass stochastic frontier production function is estimated using data from Annual Survey Of Manufacturing Industries 2004 by Department of Statistics Malaysia. A Cobb-Douglas functional form which includes both the conventional inputs and exogenous factors affecting inefficiency was the one considered in our analysis. Despite its restrictive assumptions, we found the Cobb-Douglas functional form to better fit the data. The Cobb-Douglas stochastic frontier production function in logarithm form is as follows:

$$\ln Y_i = \ln \beta_0 + \beta_1 \ln C_i + \beta_2 \ln L_i + \beta_3 \ln E + \varepsilon_i \quad (6)$$

Where Y represent value of output (RM) per year. Independent variables are C (capital, RM), L (numbers of labor) and E (energy, RM). Parameter β_0 denotes the technical efficiency level and β_1 are elasticity of the various inputs with respects to level of output.

The advantage of using the stochastic production frontier model is the introduction of a disturbance term representing noise, measurement error, and exogenous shock beyond the control of production unit in addition to the efficiency component.

Result and Discussion

The discussion of the results begins with descriptive statistics of data which consist the outputs and inputs of rubber industry in Malaysia (Table 3), consisting 314 firms of manufactured rubber product industry. These firms could be differentiated from each class by total output, value added, raw material and total asset as well as other variables such as labor, wage, and energy. The average of value-added output was found to be RM 15.64 million with standard deviation equivalent to RM 27.357 million. The empirical estimates of stochastic production frontier for manufactured rubber product industry in Malaysia are presented in Table 4. For comparison purposes, the average production function were estimated by using both Ordinary Least Square (OLS) method and Maximum Likelihood Estimation (MLE). All variable in MLE are significant at 1 percent level. Positive signs were obtained for all the coefficients, implying that an increase in an input ultimately will increase the output level. Summation of the elasticity of production indicates the return to the scale for both the estimation methods, albeit the OLS and MLE, and is almost identical, approximately 1.02 percent. In this case, a 1 percent increase in all inputs resulted in an increase of 1.02 percent in output level for stochastic frontier.

A direct comparison of the parameter estimated for OLS and MLE show the presence of close similarity between the intercepts and inputs coefficients, as in Table 4. The intercept differences between the two production functions suggest that MLE represent neutral shift from the OLS. On the other hand, the slope of coefficient displays slight difference between the two functions might be due to the inefficient estimates of OLS. Furthermore, by the specification of likelihood function, the difference between both production functions estimated by the OLS and MLE can statistically be shown by the significance of the λ. It implies that there exists a significant difference between the two production functions. The significance of the parameter λ is able to show that there exists sufficient evidence to suggest technical efficiency is present in the data. As shown in Table 4, the estimate of the error variance σ_u^2 and σ_v^2 are 0.20396 and 0.27577 respectively.

According to Battese and Cora (1977), we can also estimate the total variation in output from frontier that is attributable to technical efficiency using the parameter Ω , where Ω equal σ_u^2 / σ^2. After calculating using this formula, the Ω is 0.42519. This means, 42.5% of the discrepancies between observed output and frontier output are due to technical inefficiency. Technical efficiency index using Jondorow *et al* (1982) procedure presented in Table 5. The maximum estimated efficiency is 86.11 percent while the minimum is 32.62 percent, and the mean level of technical efficiency is 70.33 percent. The average technical efficiency is 0.7033 which menas that these sampled of rubber industry in Malaysia had an average efficiency of 70.33 percent of their potential output given by the best performance of the industry. According to Grabowski *et al* (1990), a firm is considered technically inefficient even if the firm registered a technical efficiency index of 82 percent. By this standard, the number of firms considered technically efficient is only 5.10 percent of total firms in SMEs.

Conclusion

A Cobb Douglas Stochastic Production Frontier is estimated in order to assess the level of technical efficiency for rubber product industry in Malaysia. The study found that the rubber industry in Malaysia, even thought show significant increasing in their production over the years, the level of production still at low level of efficiency. All coefficient in the stochastic production frontier are estimated to be positive and significant. The results indicate that the mean technical efficiency of all firms is 0.70328 or 70.33 percent. To further improve the operation of these rubber industries, some actions need to be taken from the government. Some technical assistances like training programs for the owner of rubber firm and financial support such as subsidies could be offered to boost their production level as rubber are important component in manufacturing industries in Malaysia. These efforts will improve the efficiency of rubber product industry in this country.

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APPENDIX

Table 1 : World major producing countries of natural rubber (1990-2005)

	Production ('000 tonnes)									% of 2005 Total
Country	1990	1991	1995	2000	2001	2002	2003	2004	2005	
Thailand	1,271.0	1,341.2	1,804.8	2,346.4	2,319.6	2,615.1	2,876.0	2984.3	2937.2	33.4
Indonesia	1,262.0	1,284.0	1,454.5	1,501.1	1,607.3	1,630.0	1,792.0	2066.2	2271.0	25.8
Malaysia	1,291.0	1,255.7	1,089.3	927.6	882.1	889.7	985.6	1168.7	1126.0	12.8
India	323.5	360.2	499.6	629.0	631.5	640.3	707.1	742.6	771.5	8.8
China P.R	264.2	269.0	424.0	445.0	464.0	468.0	480.0	486.0	428.0	4.9
Vietnam	102.0	64.5	155.0	290.8	312.6	331.4	363.5	402.7	509.0	5.8
Africa	319.3	318.0	279.3	361.7	377.0	369.0	364.8	379.4	597.1	6.8
Sri Lanka	113.1	104.5	105.7	87.6	86.2	90.5	92.1	94.1	104.4	1.2
Cambodia	32.0	30.5	38.0	42.2	46.5	43.0	45.0	43.0	44.5	0.5

Source : Statistics on Commodities 2006, Ministry of Plantation Industries and Commodities.

Table 2: Malaysia's Export of Rubber Products (Million RM), 2000 – 2007

	Latex Products Industries	Tyres and Tyre-related Industries	Manufacture of Industrial and General Rubber Products	Manufacture of Rubber Footwear Products	Total
2000	4,480.80	257.20	630.7	313.5	5,682.20
2001	4,272.20	265.30	611.2	288.2	5,436.90
2002	4,361.20	278.70	590.5	303.1	5,533.50
2003	4,841.20	326.30	684.3	460.2	6,312.00
2004	5,832.20	481.10	843.6	860.3	8,017.20
2005	6,207.00	528.30	960.2	466.2	8,161.70
2006	7,121.50	611.80	1051.4	568.8	9,353.50
2007	7,744.42	978.62	1188.13	558.67	10,469.84

Source : Department of statistic Malaysia

Table 3 Summary of Data Used

	Minimum	Maximum	Mean	Standard Deviation
Manufacturing Rubber Firm (n=313)				
Total output (RM mil)	0.10	718.04	44.27	76.51
Value added (RM mil)	0.02	210.90	15.64	27.36
Raw material (RM mil)	0.02	665.74	28.62	57.98
Total asset (RM mil)	0.00	296.02	13.93	31.80
Labor	3.00	1,719.00	225.00	315.81
Wage (RM mil)	0.03	42.20	3.52	5.48
Energy (RM mil)	0.01	97.63	4.74	9.50

Source : Annual Survey Of Manufacturing Industries 2004 by Department of Statistics Malaysia.

Table 4 Empirical Estimates of Ordinary Least Square (OLS) and Maximum Likelihood Estimation (MLE)

	OLS Estimate		ML Estimate	
	Coefficient	Std. Error	Coefficient	Std. Error
Constant	6.7865	0.3312*	7.2277	0.4010*
Ln(Capital)	0.0933	0.0265*	0.0901	0.0258*
Ln(Labor)	0.5734	0.0530*	0.5754	0.0504*
Ln(Energy)	0.3553	0.0320*	0.3520	0.0268*
R^2		0.8786		
$\lambda = \frac{\sigma_v}{\sigma_u}$			0.8600	0.4760*
$\sigma = \sqrt{\sigma_v^2 + \sigma_u^2}$			0.6926	0.0837*
Log likelihood function			-279.4987	
σ_v^2			0.27577	
σ_u^2			0.20396	
σ_v			0.52514	
σ_u			0.45162	

Note : *Significant at 1 percent level.

Table 5 Firm Specific Technical Efficiencies in Stochastic Production Frontier

	Rubber Industries	
	Frequency	%
Less than 10%	0	0
10.00-19.99%	0	0
20.00-29.99%	0	0
30.00-39.99%	2	0.64
40.00-49.99%	4	1.28
50.00-59.99%	27	8.62
60.00-69.99%	113	36.10
70.00-79.99%	133	42.50
80.00-89.99%	34	10.86
90.00-99.99%	0	0
TOTAL	313	100
Mean		70.33
Std. Deviation		8.43
Minimun		32.62
Maximum		86.11