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TECHNICAL EFFICIENCY FOR RUBBER SMALLHOLDERS UNDER RISDA'S SUPERVISORY SYSTEM USING STOCHASTIC FRONTIER ANALYSIS

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Abstract: *Stochastic frontier analysis is applied in this study to investigate the relative performance of rubber smallholders in Besut District. The objective of this study is to identify and measure the performance of rubber smallholders under the supervision of the RISDA personnel. This form of top-down supervision is intended to improve smallholder's productivity, efficiency and thus commercialisation prospect. A total of 35 rubber smallholders were investigated and, as expected, their performance varied significantly. 23% of the total cultivators achieved 0.95-1.00 technical efficiency score. The highest number of cultivators (25.7%) was in the category of 0.80-0.85 technical efficiency score. The percentage of rubber cultivators achieving 0.80-1.00 technical efficiency score was larger than those scoring below the average category. About 8.6% of the total cultivators were in the lowest category of 0.60-0.65 technical efficiency score. Variations in tangible and intangible factors such as quantity of fertilizer application, husbandry practice, skill, motivation and experience of operators, management competence of the supervisors, soil fertility, species of the rubber trees and weather conditions might have contributed to this difference.*

KEYWORDS: stochastic frontier analysis, technical efficiency, rubber smallholders

Introduction

The Agriculture Census 2005 reported that a total of 146,251 hectares of land in Malaysia were cultivated with rubber (Department of Statistics Malaysia, 2006). Some 7,061 hectares (4.8%) of these rubber areas were located in the state of Terengganu. Being second next to oil palm, the position of rubber in this country is nevertheless significant because it accounted for 53.4% of the total 273,863 hectares of the area devoted to the industrial crops. In terms of employment, 84,899 planters engaged in rubber cultivation throughout Malaysia while 4,064 rubber planters were found in the state of Terengganu. The state average cultivated area (1.72 hectares per person) compared to the national average of 1.74 hectares did not differ significantly. Surprisingly, the operated farms were relatively small in size and that may have socio-economic implications in terms of productivity and income.

During the 8th Malaysia Plan (2001-2005) agricultural sector grew at 3.2 percent per annum and by 10th Malaysian Plan (2011-2015) this growth rate is projected to further decline to 3.0 percent per annum due to a fall in rubber and sawlogs area (10th Malaysia Plan 2010 pp.41-42). Productivity-led growth of the agriculture sector might be the ultimate solution that could bring structural change and drive the sector's output, productivity and value-added to a significant increase. This is possible through the adoption of new technology, a shift to scale production for commercialisation, expansion of the integrated cultivation system and access to wider commodities market and better prices offered. Rubber is one of those crops that experienced this significant change during the 9th Malaysia Plan (2006-2010). The Rubber Industrial Smallholders Development Authority (RISDA), whose function is to oversee the development of the rubber smallholdings in the country, had succeeded the replanting scheme of 383,010 hectares of rubber integrated with oil palm. The effort was further supported following the replanting programme of high-yielding clones together with the improvement in husbandry practices through the extension works of the RISDA personnel. In the early 9th Malaysian

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Plan the demand for rubber, especially from the Republic of China, had increased, forcing rubber price to rise remarkably but later returning to normal. Following the improvement in rubber replanting scheme and its related supportive programmes, rubber production is stipulated to rise at an estimated 3.9 percent per annum.

The proposed replanting scheme targets to achieve a higher standard of commercialisation. Latex Timber Clone seeds with 4½ years of maturity and low-intensity tapping system (LITS) are recommended for the programme. The financial assistance for replanting is set at RM7,000 per hectare for replanting rubber to integrated rubber and RM4,448 per hectare for replanting rubber to other crops.

With the extensive supervision of the RISDA officials, productivity and efficiency of rubber smallholders would have naturally improved. The question is to what degree has this institutional intervention and supports resulted in higher productivity and improved efficiency among growers? Based on the system, a total of thirteen agricultural assistants were assigned to the thirty-five smallholders in a ratio of 1:3, that is, each supervisor acted as overseer responsible to three rubber smallholders. A significant degree of variation in productivity and efficiency still persists between operators due to the variation in farmers' agricultural backgrounds and the supervisors' skills, expertise and work ethics. This is evident from the statistics which indicated that, out of thirty-five rubber smallholders, thirteen farmers failed to achieve the target yield of 1,500 kg per hectare per year (RISDA 2006)[2/]. The underlying issue is why should there be differences in smallholders' productivity despite the fact that they are being closely supervised by the authority's agricultural assistants? The productivity criteria utilised by the authority in judging smallholders' performance does not reflect the best measurement. Therefore, for a better measure of smallholders' performance, technical efficiency derived from stochastic frontier analysis was utilised in this investigation.

The objective of this study is to evaluate the performance of supervised rubber smallholders' productivity and efficiency which is reflected in their technical efficiency estimates obtained from the stochastic production frontier analysis. The technique is related to management performance and is only relevant for the farmers directly involved in the analysis. In other words, the inference of the study is limited to the relative performance of farm operators considered in this study as such comparison with the smallholder's performance outside the study area is rather invalid.

Smallholders Replanting Scheme

The primary objective of establishing RISDA is to assist rubber smallholders in increasing productivity and efficiency via replanting of old rubber trees with new hybrid rubber seeds. Besides this objective, the agency's goal is to create a new generation of farmers that can withstand competition and meet the current commercialisation needs and thus contribute to the future development of the industry and the nation.

The replanting programmes are implemented in three distinctive forms: the commercialisation replanting programme (TSK), integrated replanting programme (TSB), and the individual replanting programme (TSI). In TSK, the smallholders' farms are consolidated to form large-size farming system which is to be developed as an integrated holding by the RISDA subsidiary. The company, named the RISDA Smallholders Plantation Sdn. Bhd. (RSPSB), is appointed by the farmers and responsible for the management of the smallholders' plantations from the point of replanting to the point of production and marketing of their produce.

Under the integrated replanting programme (TSB), the cooperated effort to integrate the small to large-size holdings is initiated by the farmers themselves. This integrated holding is managed cooperatively by the appointed management committees under the advice of the RISDA personnel. This cooperative holding is responsible for replanting, production and marketing with the assistance given by the RISDA top management. When difficulty transpires in consolidating small to larger-size farm holdings because of the absence of rubber smallholdings within a locality or because farm holdings are sparsely located, then fragmented, individual replanting programme (TSI) are implemented with individual advice from the RISDA officials.

The acreage of rubber replanting programmes in Besut district appeared to fluctuate downwards prior to year 2002. A downward trend was first observed during the period 1990 to 1999. The second downward trend occurred after a sharp increase in the replanting area which was estimated at 760 hectares in 2000. During the following year of 2001 it felt to 390 hectares. For the remaining period 2002 onwards the replanting area appeared to be stabilised at slightly over 200 hectares annually. The conspicuous increase in the area of replanting programme in the year 2000 was partly associated with the increase in the rubber price during these years. Rubber replanting provides avenue for the operators to gain an additional source of income due to usefulness of the rubber woods in the furniture industry. With the prospect of rubber woods in the manufacturing of furniture, the demand for rubber has increased and broadened the market opportunity in addition to latex production for tyres, gloves and rubber treats.

Another management programme targeted to have an impact on improving productivity of rubber smallholders of the replanting scheme is the adoption of high-yielding seeds. Figure 1 shows the four types of cloned rubber trees; RRIM P38, PB 280, RRIM 901 and PB 366 recommended for the integrated smallholders whose productivities are considered satisfactory with the tapping system of ½S d/2 Sd/7.

Productivity of clone latex is highest for RRIM P38 with an average yield of 2,310 kg per hectare per year although the variation in yield is also the largest. This is followed by RRIM 901 with the average yield attained per year is 2,030 kg per hectare. The fluctuation in yield is less vigorous and therefore less subject to risk and uncertainty in attainment of rubber output. Productivity of clone PB 280 seems to perform better than PB 366 with their average yields recorded at 1985 kg and 1536 kg per hectare respectively. Apparently, these clone rubber trees exhibit a milder degree of annual variation in yield relative to the former two high-yielding clones.

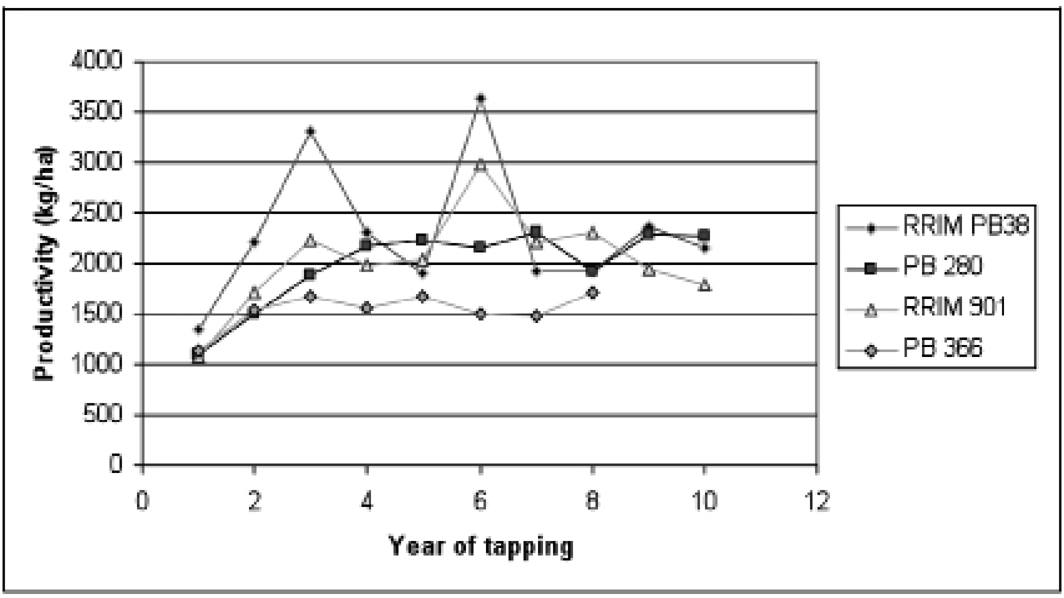

Figure 1. Productivity of Matured Clone Rubber Trees (kg/ha/yr.).

Literature Review

The stochastic frontier production function referred to as the 'best-practice' technology differs from the normal average production function. Earlier intellectual discourses resulted in a series of papers, including Aigner and Chu (1968), who proposed the use of specific econometric models consistent with the frontier--the 'best-practice' notions of Farrell (1957). Contemporary researchers familiar with econometric modelling would prefer the use of stochastic frontier analysis (SFA) in their efficiency studies (Aigner *et al.* 1977; Meeusen and Broeck 1977). However, in productivity and efficiency analyses, researchers could either choose the stochastic frontier analysis or the nonparametric data envelopment analysis (DEA) which is basically a linear programming technique. Both techniques are exposed to strengths and weaknesses. The stochastic frontier parameters are statistically testable as their confidence levels and the accuracy of the estimated models are known. Data Envelopment Analysis allows estimation of several outputs with ease against multiple inputs. However, researchers with little statistical applications on the multicolinearity problem might be misled by estimating highly-correlated inputs against correlated outputs. The drawback encountered in the application of SFA and DEA depends very much on the accuracy and availability of data.

A study on wheat productivity and efficiency perhaps is most relevant to the present investigation (G. Mustafa and I. Muhammad 2002). They found that wheat productivity differs from one region to another due to variations in land quality, cropping pattern, rainfall, and access to physical infrastructure. They have also disclosed that the intensity of rice double-cropping followed by wheat had resulted in a significant decline in wheat production. Explanation for the lowering of wheat productivity was due to the degradation of land resource caused by continuous cultivation of rice land (Pingali et al. 1997). Rice and wheat rotation dominates the cultivation pattern covering over 72% of the cultivated area in Pakistan (Ashraf 1984-85).

Díaz and Sánchez (2004) investigated the temporary employment and technical efficiency in Spain's productivity growth that occurred between mid 1995 to the end of 2000. Most economists believed that the productivity growth in this country has been attributed to technological innovation. Their findings revealed that changes in productivity were attributed to the adoption of technical innovations which were manifested in the technological progress as well as the human and organisational factors. Since the economy was relying heavily on small and medium enterprises, human and organizational factors would have contributed more towards productivity growth rather than technological innovation.

Díaz and Sánchez (2005) acknowledged the usefulness of SFA developed by Battese and Coelli (1995) which could estimate both technical efficiency scores and simultaneously able to identify factors affecting the level of a firm's inefficiency. They found that inefficiency exists among larger firms that utilised temporary workers. These temporary workers were more attractive to employers because their employment duration was short and the severance payment was low. The difference in payments of temporary and permanent workers is essential in explaining the success of operating firms (Dolado *et al,* 2001). The use of SFA software developed by Battese and Coelli (1995) has been widely applied, not only in manufacturing and agriculture sectors, but also in fisheries studies that wish to compare the performance of firms (see Roy 2002, Basri *et al.* 2006). They should be highly accredited for making this robust computer program freely available to those who wish to use it for teaching and research.

Methodology for Stochastic Frontier

In theory, production function is generally estimated using multiple-input regression yielding the "average" production function. Their mathematical forms and the relationship between explanatory and independent variables are similar to that of the current stochastic production frontier. The glaring difference between the two is reflected in the assumption about the concept of technical efficiency of the firms. According to the average production function, every firm is assumed to be technically efficient. The underlying reason for some firms that do not perform as efficiently as the others is due to inputs misspecification. These inputs are neglected in the estimation and are represented and reflected in the random term. The average production function thus represents the "frontier" production. The stochastic frontier production function defines technical efficiency as the "best practice" firm that becomes the demarcation boundary for the other firms to make reference to as efficient entities (FAO 2006).

In deriving the concept of technical efficiency (TE_i), the frontier production (y_i) in its inputs (**X**) specification would include the stochastic (white noise) random error (v_i) and an additional term representing the technical inefficiency (u_i). The Cobb-Douglas production function in terms of natural logarithm transformation is generally used to explain the concept of technical efficiency although other functional forms, such as the transcendental logarithmic (Translog) and constant elasticity of substitution (CES) functions which are derived from the Taylor's series, are usually used in the actual estimation of the technical efficiency studies (see FAO 2006 p. 3). The stochastic frontier production presented in natural logarithmic equation becomes

(1) $\ln y_i = \boldsymbol{\beta} \ln \mathbf{X} + v_i - u_i$

where, y_i is the output of the firm i

- $\boldsymbol{\beta}$ is the vector of the unknown input coefficients
- $\mathbf{X}$ is the matrix of input variables
- v_i is the random error i
- u_i is the technical inefficiency i

Both v_i and u_i are assumed to be independently and identically distributed (iid) with variance σ_v^2 and σ_u^2 respectively. The technical inefficiency is assumed to be distributed half-normal with one sided-error (Coelli, Rao and Battese 1998). For the stochastic frontier firm (y*) representing the best practice firm it is technically efficient with u_i=0 and is presented in equation (2) below,

(2) $\ln y_i^* = \boldsymbol{\beta} \ln \mathbf{X} + v_i$

Technical efficiency of the i^{th} firm in two dimension space with isoquant of x_2 and x_1 as inputs is defined as the distance of the inefficient firms emanating from the origin divided by the distance of an efficient frontier firm. Thus, subtracting the estimated stochastic production frontier of equation (1) from a frontier production firm representing the "best practice" firm in equation (2), we obtain the estimate of technical efficiency for firm i,

(3) $\ln TE_i = \ln y_i - \ln y_i^* = -u_i$
$TE_i = \exp(-u_i)$

The value of technical efficiency would range from 1 to 0, where 1 represents the best practice frontier firm and zero represents the least technically-efficient firm in relation to the frontier firm. The distribution of the technical inefficiency term is half-normal with the mode at zero implying that, "a high proportion of the firms being examined are perfectly efficient," (FAO 2006 p.4). According to Coelli *et al.* (1998 p.200) some critics addressed the possibility of more general forms of distribution such as the truncated-normal (Stevenson 1980) and the two-parameter gamma (Greene 1990). The answers to these enquiries are illustrated in Figure 9.1 of the above text when μ are varied accordingly at -2, -1, 0, 1 and 2.

Model Specification for Rubber Smallholders

The present study is based on the stochastic frontier model developed above using production function as the basis for analysis. The technical efficiency effect production frontier together with the technical inefficiency estimates were utilised. The two model specifications normally adopted in stochastic frontier studies are presented in Cobb-Douglas function (4) and Translog function (5) as

(4) $\ln y_i = \beta_0 + \sum_{j=1}^{n} \beta_j \ln X_{ij} + v_i - \{\delta_0 + \sum_{k=1}^{m} \delta_k \ln Z_{ik}\}$

(5) $\ln y_i = \beta_0 + \sum_{j=1}^{n} \beta_j \ln X_{ij} + \frac{1}{2} \sum_{r}^{s} \sum_{t}^{n} \beta_{r,t} \ln X_{ir,t} \ln X_{ir,t}$
$+ v_i - \{\delta_0 + \sum_{k=1}^{m} \delta_k \ln Z_{ik}\}$

Where δ_k are the coefficients of the Z_{ik} representing the technical inefficiency variables of the k^{th}

smallholders, $\mu = \delta_0 + \sum_{k=1}^{m} \delta_k \ln Z_{ik}$ is the technical inefficiency term. While δ_k for $k=1,2,...,4$ are the coefficients of technical inefficiency variables. Other notations are defined as above.

In equation (4) the subscript *i*, refers to the number of firms analysed as in the current study there are 35 rubber smallholder production entities (in DEA they are referred to as the decision-making units). The subscripts *j* and *k* refer to the number of input variables used in the rubber production function and technical inefficiency variables of the production model respectively.

The two production inputs utilised to produce rubber product (y), that is, latex, are the cultivated area (X_1) measured in hectares and tapping intensity (X_2) measured in number of tapping days. An increase in the cultivated area is expected to boost production of latex (in weight). Similarly, latex production is stipulated to rise with the intensity of tapping. Technical inefficiency effects comprise the productivity achievement target (Z_1); 1=achieved the target average yield of total production, 0=otherwise, a proxy for capital-land ratio (Z_2) represented by the number of rubber trees per hectare of the cultivated area, the yield-tapping ratio (Z_3) represented by the yield per rubber tree tapped in kg, and the years of tapping experience (Z_4), represented by number of years of first tapping to the year 2006.

In theory, production function assumes that output (measured in kg of solid latex) depends on the intensity of inputs use. In this case, one of the production inputs is the area of the land cultivated. Land represents the key factor of production without which production would not be possible. However, insight analysis reveals that land is directly a representation of capital input since an increase in the cultivated area warrants a proportionate increase in the number of rubber trees in the production. The immediate recognition of an increase in latex output is the number of rubber trees associated with that production. The higher the number of rubber trees, the greater is the expected volume of latex. However, rubber land can be made more productive with the application of fertilizer which is a proxy for capital investment in infertile land. The second input of tapping intensity represents the amount of labour-days applied in the production of latex. Both of these factors of production are expected to directly contribute to the increased latex production with the increase in their respective quantities. From the Cobb-Douglas production frontier, the sum of the capital (land area) and labour (days) coefficients would indicate the return to scale. The limitation of using Cobb-Douglas function is that, unlike the Translog production frontier, it has a unitary elasticity of substitution. The limitation of Translog function is the loss in the degree of freedom that would be serious when the number of farms or smallholdings considered in the analysis is small.

The underlying reason for considering the productivity achievement target in the inefficiency model is to find out whether such target could motivate rubber smallholders to increase their yield above the average productivity of their counterparts. Human factor may play an important role when there is competition and to what extent existing incumbent supervision can be a deterrent or a motivating factor to the current management system. As for capital-land ratio, the hypothesis is self-explanatory. That is, the higher the number of rubber trees planted per unit of land, the higher the production. The likely enquiry is whether the current capital-land ratio contributes directly to the improvement in technical efficiency. The inclusion of yield-labour ratio is a reflection of the use of technology versus the intensity of labour utilisation on rubber smallholdings and it tells us the proportion of productivity derived from technological use per unit of labour. When the proportion attributable to technological use becomes smaller, perhaps technical inefficiency begins to be clearly apparent as intensity of labour utilisation increases. Experience as denoted by years of tapping experience is directly associated with increasing productivity and could improve technical efficiency.

Besides getting the appropriate theoretical construct for model specification, the results obtained from using FRONTIER 4.1 need to be verified for validity. First, the hypotheses testing will include whether the maximum likelihood estimate (MLE) of the stochastic frontier production functions significantly differs from the original ordinary least square (OLS) estimate. Second, the use of the technical variables in the inefficient model should be necessarily based on the theoretical construct developed above. Their inclusions have to be justified. Third, for the choice of the best functional form that could provide satisfactory answers to the issue in hand, that is, ranking of the smallholders performance between individual planters and supervisors. The answer to this problem is given by the test of the likelihood ratio (LR) between Cobb-Douglas and the Translog frontier production functions. The statistical test of likelihood ratio is given as

$$LR = -2 \{\ln[L(H_0)/L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[(H_1)]\}$$

where $L(H_0)$ and $L(H_1)$ refer to the values of the likelihood function under the null and alternative hypotheses, H_0 and H_1 respectively (Coelli *et al.*, 1998). The necessary tests with respect to other estimated parameters of the variables will be performed as in the case of the normal analyses.

Results and Discussion

This section discusses results obtained from the production frontier analyses, namely the Cobb-Douglas and the Translog production functions Data collected from records of RISDA supervised smallholders during 2006 were used. The data source is particularly relevant in order to choose the best frontier production that can be used in the approximation of technical efficiency scores. The following section discusses the result of technical efficiency scores among the supervised smallholders and ranks them accordingly for comparison and socio-economic implications.

Stochastic Production Frontier

The results of the computer analysis using FRONTIER 4.1 are presented in Table 1. All coefficients of X's based on the maximum likelihood estimates for the stochastic production frontier inefficiency model of the Cobb-Douglas function are significantly different from zero at very high probability levels of 0.05. With reference to production elasticity of rubber-cultivated area, one percent increase in land area would necessitate about the same percentage of production of latex. The production elasticity for tapping intensity is also high, estimated at 0.986 which means that return to scale would amount to approximately 1.986, indicating an increasing return to scale exists in the current production. In other words, there is sufficient room for further production and productivity improvement in the rubber smallholder estate with the increase of these two factors.

The tests for null hypothesis that there are no technical inefficiency effects (δ_k=0) in the models are rejected for both Cobb-Douglas and the Translogs MLE production functions. The estimated likelihood ratios for these production functions are shown in Table 1 and are equal to 111.8 and 55.8 respectively, indicating that these estimates are much higher than the critical table values and are highly significant at 0.01 probability level. The results disclose the fact that, while some deltas may not be significantly different from zero, the whole technical inefficiency model is relevant in explaining the smallholder estate technical inefficiency. From the statistical point of view, the capital-land ratio (Z_2) and the yield-labour ratio (Z_3) appear to contribute significantly to the technical inefficiency of the rubber smallholdings.

The positive coefficient of capital-land ratio represented by the number of rubber trees cultivated per hectare denotes intensity of cultivation such that an increase in the intensity of trees will reduce latex production per hectare. Optimal spacing for planted trees has been a common practice among smallholders under the supervision of RISDA extension workers. The negative coefficient value of the yield-tapping ratio representing the yield attainment per tree tapped would elevate latex production with every additional increase of projected yield. Productivity achievement target set by the authority appears to have a positive impact on production but unfortunately the coefficient is not significantly different from zero. Also found not significant is the smallholders' years of tapping experience which is too negligible to have a meaningful impact on latex production.

Table 1. Maximum Likelihood Estimates of Stochastic Production Frontier of Rubber Smallholders' Estate of Besut District 2006.

	Cobb-Douglas Production Function	Translog Production Function
Frontier Model:		
Constant	2.6020417	-30.4686634
	(10.89113)***	(35.654117)***
Cultivated Area $\ln X_1$ (ha)	1.0013036	5.7014317
	(59.85617)***	(6.4036159)***
Tapping Intensity $\ln X_2$ (days)	0.9859453	14.742035
	(19.77415)***	(42.729266)***
$\frac{1}{2}(\ln X_1)^2$		0.12781156
		(3.3689122)**
$\frac{1}{2}(\ln X_2)^2$		-2.8559324
		(-37.958571)***
$\ln X_1 * \ln X_2$		-1.0094679
		(-5.3353628)***
Inefficiency Model:		
Yield Achievement Target (du) Z_1	-0.00529725	-0.030046467
	(-0.272018)^{NS}	(-0.96770569)^{NS}
Rubber Trees per Area (no), $\ln Z_2$	0.46028777	0.34944760
	(18.12769)***	(4.5295450)***
Yield per Tapping Tree (kg), $\ln Z_3$	-0.95983552	-0.67535864
	(-17.05084)***	(-9.5066594)***
Tapping Experience (years), $\ln Z_4$	0.00128016	-0.03432171
	(0.1047957)^{NS}	(-0.55601205)^{NS}
Sigma-squared	0.00092579	0.006723106
	(4.7999108)	(6.9489621)
Gamma	0.21253465	0.99907965
	(1.0016601)	(197.676703)
Log Likelihood Ratio of One Sided Error	111.825660	55.826891

Figures in parentheses denote the value of t-ratios.
*** significant at 0.01probability level,
** significant at 0.05 probability level,
^{NS} not significant.

The other hypothesis of importance is the choice between the two estimated models of Cobb-Douglas and the Translog function. Using the log likelihood function estimate of Cobb-Douglas of 19.2044 and the estimate of log likelihood function of Translog of 21.0839, the calculated likelihood ratio (LR) of -2{19.2004 – (21.0839)} is 3.759. The test is useful for justifying the inclusion of the last three X variables of the Translog model. The upper 5 percent value of Table of Chi-squares with five restrictions or ten degrees of freedom is 18.307. The result shows that the X coefficients (β_j=0) of the three included variables in the Translog model are not significantly different from zero. Therefore, the null hypothesis that the Cobb-Douglas is an adequate representation of data in relation to specification of the Translog is accepted (see Coelli et al. 1998, p.218). In short, the Cobb-Douglas relative to Translog frontier could have explained better the relationship between the y-output and X-inputs considered in the analysis.

Technical Efficiency Score

Table 2 shows the technical efficiency scores for both the Cobb-Douglas and Translog stochastic frontier estimates of rubber smallholders' estate of Besut. The average technical efficiency scores for the whole estate are 0.832 (Cobb-Douglas) and 0.817 (Translog). These technical efficiency estimates are obtained using FRONTIER 4.1.

Using Translog there is only one best farm with technical efficiency close to a perfect score of 0.993 for operator *number 32 M. Zain Man*. This finding is somewhat different from those obtained using Cobb-Douglas frontier estimates with four of such farms scoring about 0.99 including *number 3, 6, 32 and 4*. The best farm practice goes to *number 3 Mustapha Muhamad* with the score of 0.998 followed by *number 6 Hamiah Ibrahim* with a score 0.996. Clearly there is a significant difference as regards the technical efficiency results obtained between Cobb-Douglas frontier and the Translog frontier estimate which have disclosed that the later estimate is more superior in explaining technical efficiency of rubber smallholders' study. Technical efficiency scores of Translog frontier are generally slightly lower than the scores of Cobb-Douglas frontier. Henceforth, the Cobb-Douglas stochastic frontier will be the focus for the remaining discussion.

Variations in the technical efficiency achieved using Cobb-Douglas production frontier for the thirty-five rubber-smallholding operators of the district of Besut, Terengganu are illustrated in Figure 2. Eight of the smallholders are efficient rubber planters as shown by their performance as achievement are exceptionally close to the upper bound score of one. Four of the rubber cultivators score below par but above the lower bound of sixty percent of the best farm practice. Those below average performers include *number 20 Mat Jusoh Hamat* with the technical efficiency score of 0.618, *number 35 Zawiah Boto'* (0.644), *number 18 Muhamad Muda* (0.645) and *number 19 Mariam Ismail* (0.673). It would be interesting if further investigation could reveal possible causes why these cultivators failed to keep up with the average performers. In the same spirit, it is very important to disclose the possible reasons leading to the success of the best practice performers. Apparently, gender difference is not the contributing factor, since both sexes were found in below average and the best farm operators.

Figure 3 illustrates the percentage of technical efficiency achieved by the rubber smallholders of Besut District. The figure shows that 22.9 percent of the thirty-five cultivators achieved 95 to 100% technical efficiency score category. The highest number of cultivators (25.7%) is in the category of 80 to 85% technical efficiency score. The percentage of rubber cultivators achieving 80 to 100% technical efficiency score is larger than those scoring below the average category. About 8.6 percent of the cultivators are in the lowest category of 60 to 65% technical efficiency score. In general, although the distribution of cultivators categorised as efficient workers is skewed to the higher bound, there exists some degree of fluctuation among the range of 60 to 100% technical efficiency score. This phenomenon appears to suggest that despite close supervision given by the agency's personnel, variations in their performance still persist. Human factors such as motivation, knowledge, technical skills, and non-human factors outside their control like weather conditions, financial assistance and the expertise of the supervisors themselves also differ. However, a significant improvement in productivity and efficiency due to supervisory system as experienced by smallholders has been realised by all cultivators. This changing management system is an achievement that might have far-reaching socio-economic implications on the cultivators. For the higher achievers of technical efficiency, the change may have contributed to an increase in their income level, improve their family needs, health and productivity, expenditure and consumption set and an improvement in their quality of life.

It should be reminded that data for the current study may not reflect the true nature of the rubber smallholders' actual performance because this is

Table 2. Technical Efficiency Scores Estimated from Cobb-Douglas (CD) and Translog (TL) Stochastic Frontier Functions for Rubber Smallholders' Estate in Besut 2006.

	Rubber Smallhoding Operators (DMU)	CD Stochastic Frontier	TL Stocastic Frontier
1	Ibrahim Muda	0.819	0.810
2	Lipah Abdullah*	0.986	0.879
3	Mustapha Muhamad	0.998	0.931
4	Abdul Rahman Sulaiman	0.992	0.961
5	Zubaidah Ibrahim*	0.832	0.975
6	Hamiah Ibrahim*	0.996	0.979
7	Aris Mat Hassan	0.730	0.687
8	Embong Mohamad	0.759	0.705
9	Marzanah Ismail*	0.759	0.736
10	Ab Rashid Yaacob	0.805	0.811
11	Ami Selamah Besar*	0.709	0.708
12	Malek Idris	0.833	0.738
13	Muda Ishak	0.773	0.690
14	Abdullah Daud	0.835	0.814
15	Isa @Putih Abd Rahman	0.801	0.820
16	M Zain Salleh	0.931	0.915
17	Zakaria Sulaiman	0.969	0.966
18	Muhamad Muda	0.645	0.649
19	Meriam Ismail*	0.673	0.654
20	Mat Jusoh Hamat	0.618	0.609
21	Mohd Daud	0.871	0.919
22	Hamzah Ali	0.817	0.760
23	Adam Awang	0.933	0.917
24	Normah Muhamad*	0.750	0.742
25	Deraman Jenal	0.848	0.920
26	Jusoh Harun	0.963	0.806
27	Hashim Awang	0.854	0.847
28	Salleh Noh	0.832	0.829
29	Hussin Mamat	0.889	0.876
30	Hamzah Yaacob	0.731	0.707
31	Mohd Zin Man	0.983	0.956
32	M. Zain Man	0.995	0.993
33	Ismail Mat	0.854	0.841
34	Salimin Mohamad	0.705	0.785
35	Zawiah Boto*	0.644	0.663
	Average TE Score	0.832	0.817

Note: Name with asterisk (*) denotes the operator is a female while name without asterisk denotes male operator.

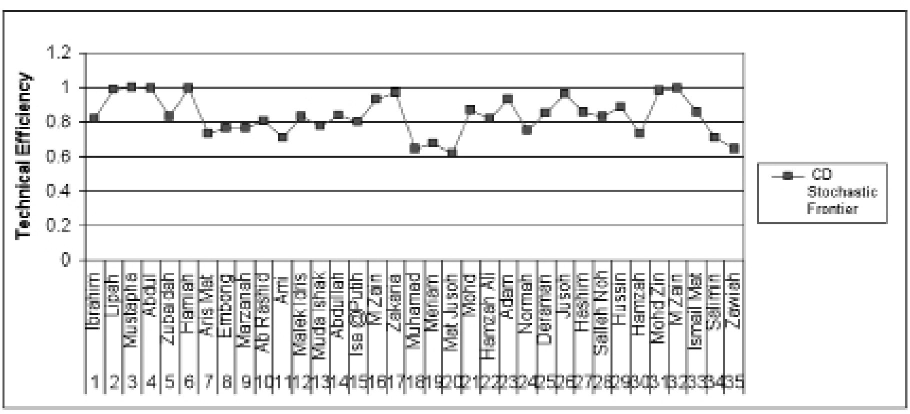

Figure 2. Technical Efficiency Scores of Rubber Smallholders Derived from Cobb-Douglas Stochastic Frontier--Besut 2006.

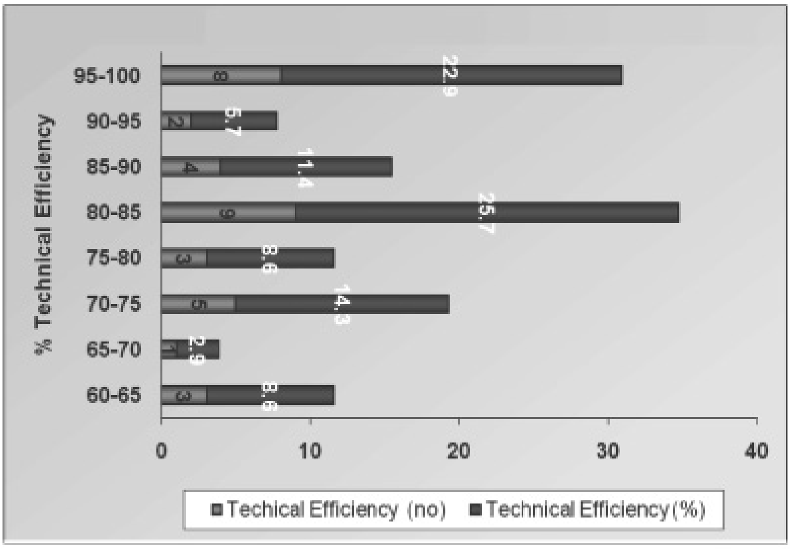

Figure 3. Technical Efficiency for Rubber Smallholders in Besut, Terengganu 2006.

just a one-time analysis. Several studies on the same rubber cultivators should be carried out to detect those lagging behind cultivators in relation to the best achievers and who have consistently shown poor performance in the succeeding analyses. Based on the current analysis, a further study can further be conducted to shed light on reasons for those poor and best achievers.

Conclusion

Stochastic frontier analysis is applied to illustrate the performance of rubber smallholding cultivators' productivity and efficiency under the supervision of the state's Rubber Industrial Smallholders Development Authority (RISDA) in Besut, Terengganu. All the 35 smallholding operators under RISDA supervisors were analysed as a case study to identify their relative performance. At the time of data collection, their actual names were recorded as presented for identification purpose. The authority has utilised their names for productivity comparison based on latex yield per hectare and the current SFA would certainly provide a better option based on the technical efficiency analysis. Retaining their names in the current stochastic analysis would be useful for identifying those below-average performers so that corrective actions can be taken. Operators with higher performance scores could be investigated for their specialties as a smallholder's model.

Another reason for undertaking this analysis is the need to analyse existing study slightly more technically as an advisory report for the advancement of the agriculture sector. The data are always available at the farm level but there is slim possibility that they will be used by the people in authority except for the direct consumption of data normally in the old-fashioned way. The output of this study will be useful for agricultural planners and for those decision-makers on the farm because the usual labour productivity method may not yield the right decision needed.

This investigation is to test whether or not variation still persists pertaining to the productivity and efficiency performance of the rubber smallholders, despite the fact that the small parcels of rubber land cultivated by individuals were consolidated into a larger and more potential entity, managed and supervised institutionally. Increased productivity and efficiency that could have an impact on cultivator's income is the final goal of this programme such that they can sustain rubber smallholders' operators and thus gain a competitive edge in the ever-growing global business arena. Our finding seems to support such consolidation effort because, with the turning of small-size parcels of rubber land into larger and more potential operational size units, the smallholders' estate becomes more viable. Based on the return to scale estimate, there is ample room for further increment in both production and productivity. Hitherto, the cultivated rubber land exhibits an increasing return to scale estimated at 1.985 despite the fact that already several smallholders (22.9%) are categorised as efficient or the best farm practice operators as indicated by their 95 to 100% technical efficiency score. This is further supported by the outstanding result of those cultivators who have passed the productivity achievement target of 1,500 kg per hectare per year set by the RISDA management authority.

Unfortunately this is just one snap shot study and additional information on the best practice farm and the below-average performance farm operators needs to be collected and analysed from time to time so that the best farm operators can be differentiated from the poorer ones for meaningful analysis. Alternatively, a research team can be formed to study and gather necessary weekly, monthly or even annually data that can be done practically by adopting the rubber smallholders as part of the University's research projects in this particular area. If time-series data are available, econometric forecasting techniques can be applied and further information can be analysed to estimate the total factor productivity growth that decompose sources of growth in the current rubber industry. Until more data are available, these useful techniques cannot be practically applied to predict and estimate their decomposed sources of growth. Sources of growth could be due to the change in scale of production, improvement in management in terms of resource allocation, changes in technical efficiency and other variables not captured in the model as indicated by the disturbance term over the years.

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