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The efficiency of beef cattle production: A case study in the target area of concentration in Johor, Malaysia

(Kecekapan pengeluaran lembu pedaging: Kajian kes di kawasan tumpuan sasaran di Johor, Malaysia)

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Key words: efficiency, Target Area of Concentration (TAC), technical efficiency, beef cattle, animal unit (AU), translog frontier production function

Abstract

Beef production in Malaysia is inadequate to meet the demand following the rapid increase in consumption and relatively slow growth in the industry. The Target Area Concentration (TAC) project is expected to be a major contributor to boost beef cattle production. This study identified the efficiency of resources used in the beef cattle production in the TAC in Johor, Malaysia. It addressed the issues on productivity and technical efficiency of beef cattle operations and their relationship with management inventory, farm performances, animal husbandry practices, as well as socio-economic and demographic factors. The translog and Cobb-Douglas stochastic frontier production functions were used to examine the issues of technical efficiency in the TAC project. The frontier regression model was estimated using the maximum likelihood estimation (MLE) technique. The translog stochastic frontier model was found to be suitable in representing the sample data and provide better estimates than the Cobb-Douglas model. The results indicated that the beef operation in the TAC has an increasing return to scale, and the average computed technical efficiency for individual farm units is 0.683. The technical efficiency of the majority of the farms (51%) was from 40% to 80%. The total loss in production due to inefficiency was estimated to be 3,094 heads of beef cattle in Animal Unit (AU) per year. The study also found that there was a significant difference in average technical efficiency by TAC location. However, the technical efficiency was not significantly different by farm types, ownership, and sizes. The findings of this study suggest that there is room for expansion, through the adoption of best practice technology and optimal resource allocation. The farm's technical efficiency could be improved with better planning and controlling skills by the farmers/managers, longer experience, proper training, advisory services by extension agents, higher calving rate, involvement of Department of Veterinary Services in breeding and health management services and using cross breed cattle.

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Introduction

The livestock sector plays an important role in Malaysian economy and agriculture development. The sound growth of beef industry will ensure the significant impact of ruminant sub-sector on the livestock sector as a whole. During 1991 to 2001, the Malaysian livestock production grew on average at a rate of 5.8% per annum. The ex-farm value of production in 1992 was estimated to be RM3,249 million and rose to RM5,125 million in 2001, but mainly attributed by the non-ruminant sub-sector (DVS 2004).

The beef industry in Malaysia has been growing slowly since 1961 to 2000, even though there have been efforts by the government to improve the local beef industry through various Malaysian Plans and policies. The local beef industry is slow in its development as compared to the non-ruminant industry such as pig and poultry. The beef and other ruminant enterprises are unable to compete for the available resources and funds.

The rapid development in the industrial sector, and the availability of cheap imported beef from India, further worsened the growth in the local beef industry. However, the government and private sectors have realized this phenomenon and in recent years there are efforts to re-look into investments opportunities in this industry.

The low production of beef has resulted in dependency on the importation of beef from other countries to meet the local demand. The slow growth rate of the local beef industry compared to the growth in consumption has increased import of cheaper beef from other parts of the world. The self-sufficiency rate of beef in Peninsular Malaysia has declined from 31.59% in 1986–1990 to 21.27% in 1991–1995, and further declined from 18.37% in 1996–2000 to 18.08% in 2001–2004 (*Table 1*). This is obviously an unfavourable trend and consequently the long-term government's objective to reduce import bill in the food sector will not be achieved.

Five major types of producers are involved in the production of local beef cattle and buffalo in Malaysia. They are plantation integrators, large farms,

Table 1. Self-sufficiency in beef products in Peninsular Malaysia (1986–2001)

Year	Production (t)	Consumption (t)	Self-sufficiency (%)	Growth of self-sufficiency (%)
1986	12,308	31,240	39.40	–
1987	12,365	34,071	36.29	–7.88
1988	13,487	39,845	33.85	–6.73
1989	11,824	48,594	24.33	–28.11
1990	12,244	50,874	24.07	–1.09
1991	12,704	56,942	22.31	–7.30
1992	13,338	58,619	22.75	1.99
1994	13,527	69,317	19.51	–11.44
1995	15,395	78,019	19.73	1.12
1996	14,915	84,335	17.69	–10.37
1997	15,204	91,933	16.54	–6.49
1998	15,838	81,517	19.43	17.48
1999	17,392	82,973	20.96	7.88
2000	16,630	96,611	17.21	–17.88
2001	18,371	102,121	17.99	4.51
2002	21,366	112,295	17.89	–0.56
2003	23,157	113,630	18.49	3.35
2004	25,044	136,966	17.95	–2.92

Source: DVS (1990, 1992, 1996, 2000, 2003, 2004, 2005) traditional farmers and commercial feedlots. The differences between them are in the number of animals, land sizes and management systems. The traditional farmers own about 84% of cattle and 99% of buffalo population (DVS 2000a). The majority of them have between 5 and 10 heads of beef animals. The systems of rearing are stall feeding, tethering, free grazing and mixed conditions which depends on the availability of fodder, labour, grazing areas, commercial feed such as palm kernel cake (PKC), agro by-products and other supplementary feed.

In recent years rotational grazing under the plantation using electric fencing, is widely practised especially by plantation integrators and farmers operating in FELDA areas. The small and medium scale farmers are the government's main targets in the development programmes, to transform them to be commercially oriented producers.

One of the important government programmes to develop and enhance the beef industry in the county is the 'Pawah' scheme[1]. The programme started in the 1960s targeted towards the small and medium scale farmers. This programme was terminated during the Seventh Malaysia Plan due to the changes in agricultural policy from a heavily subsidized to more competitive agriculture. However, this programme is still practised by most state governments due to the socio-economic and political reasons.

Beef production in the Target Area of Concentration

The Third National Agricultural Policy (NAP 3) 1992–2010 defines integrated farming as the land use maximization concept that involves rearing beef under oil palm in integrated approach. The strategy of increasing beef production through the integration of cattle with plantation crops in smallholder and plantation sectors was emphasized (MOA 1991). In the revised NAP 3 (1998–2010), the same policies were maintained but the emphasis was more towards transforming the beef producers to be commercially oriented and market driven (MOA 1997).

Realizing that the beef cattle integration under plantation crops has the potential to boost the local beef production in the country, the Department of Veterinary Services (DVS) has decided to focus on the development of the Target Area of Concentration (TAC). The concept of integration has encouraged small ruminants (goat and sheep) to be integrated with rubber plantation, while large ruminants, mainly beef cattle under the oil palm. TAC simply means the area where farms or projects are grouped, based on their location and operating a ruminant project integrated with major crops. The establishment of TAC in any part of the country is dependent upon the number of projects and not the conventional district boundary.

Traditionally, veterinary services were provided by district DVS but due to the lack of manpower, the TAC personnel are now playing a major role. There are 23 TAC in Peninsular Malaysia including seven newly established in 2002 (*Table 2*). Each one of them has more than 15 farms with the average population of 50 beef cattle per farm. DVS has appointed its staffs headed by a TAC manager responsible for the respective area to ensure the successful implementation of the programmes. The number of cattle population in the TAC was actually growing from 1995 to 2002. The average growth in the TAC was 21.4% while the share of the TAC in the total population of cattle has increased from 4.74% in 1995 to 16.85% in 2002 (*Table 3*).

One of the major problems facing the beef industry in this country is the low growth rate in production. One of the factors that directly contributed to the low production is farm inefficiency. At the farm level, the low productivity will be followed by the high cost of production and this result in less competitive beef production. This will eventually affect the development of this industry where investors are not

Table 2. Beef cattle population in the Target Area of Concentration (2002)

	Potential area (ha)	Current area utilized (ha)	Cattle population (heads)
Kuala Muda, Kedah	24,200	1,261	660
Hulu Perak, Perak	25,000	8,750	1,892
Manjung, Perak	29,800	20,500	1,873
Batang Padang, Perak	9,274	7,560	2,573
Jempol, Negeri Sembilan	35,000	19,242	4,298
Segamat, Johor	105,018	60,750	12,805
Kluang, Johor	92,700	28,579	9,184
Kota Tinggi, Johor	51,300	24,188	9,107
Mersing, Johor	40,500	15,369	11,719
Mu'adzam, Pahang	69,471	59,941	13,567
Bera, Pahang	44,610	27,761	1,890
Jengka, Pahang	84,321	18,571	3,540
Lipis, Pahang	25,000	19,808	4,929
Ketengah, Terengganu	25,000	16,185	9,200
Gua Musang, Kelantan	53,000	30,200	10,500
Kemahang, Kelantan	7,233	4,500	1,325
Besut, Terengganu*	15,000	2,500	1,250
Ulu Terengganu*	20,000	18,000	1,818
Kuantan, Pahang*	28,000	11,200	3,900
Cini, Pahang*	35,000	21,000	2,100
Bentong, Pahang*	26,000	1,300	520
Raub, Pahang*	27,000	1,500	515
Muar, Johor*	75,000	25,000	8,860
Total	947,427	443,665	118,025

*Established in 2002/2003
Source: DVS (2004a)

Table 3. Comparison of beef cattle population in the Target Area of Concentration to total population in Peninsular Malaysia

	Total population (heads)	Population in TAC (heads)	Total growth (%)	Growth in TAC (%)	Population in TAC (%)
1995	659,065	31,210	–	–	4.74
1996	647,070	40,127	–1.82	28.6	6.20
1997	643,325	56,178	–0.58	40.0	8.73
1998	660,642	62,919	2.69	12.0	9.52
1999	662,015	70,470	0.21	12.0	10.64
2000	685,388	78,926	3.53	12.0	11.52
2001	676,847	89,186	–1.25	13.0	13.18
2002	700,537	118,025	3.50	32.3	16.85

Sources: DVS (1996, 2000, 2003)

interested to venture into the enterprise and the country will continuously be dependent on excessive import. The low production is related to the productivity and efficiency level in the farm production operation. Generally, inefficiency is the inability of the farm in utilizing and allocating the scare resources to produce the maximum level of output.

The TAC projects are expected to be the major contributor to boost the local beef cattle production. The main question is the efficiency of the current TAC projects and the options for further improvements.

Furthermore, beef production is a complex activity that involves various and diverse protagonists, from small family farms to large commercial farm enterprises. In today's information age, a producer's road to success may depend on applying appropriate decisions at farm level. This means a single decision can easily make a difference between inefficiency and efficiency, which leads to making or losing money. In this context, it is important to understand the way managerial, socio-economic and economic factors affect animal production. Management inventory, which consists of planning, organising, staffing, directing, and controlling, various socio-economic and farm performance are very important factors. These factors are becoming more crucial in the complex production system and the effect of these factors has on farm enterprise efficiency should be studied.

The main objective of this study was to examine the efficiency of beef cattle production in the Target Area of Concentration (TAC) in Johor. It aimed to determine the technical efficiency of the use of resources in the beef cattle production, to analyse the relationship between farm's technical efficiency with demographics and socio-economic factors, management inventory, farm performances and animal husbandry practices, and to suggest recommendations to improve the efficiency of beef cattle production.

Literature review

A non-parametric approach in measuring efficiency began essentially with the work by Farrell (1957). Following Farrell's definition of concept in output-oriented efficiency measurement, various methods have been developed in estimating technical efficiency. These methods can be categorized into four major approaches namely the non-parametric approach (also known as data envelopment analysis), parametric approach, deterministic statistical approach and the frontier production function model. Among these, the frontier production function model is the most popular approach and the method has been extensively used in empirical efficiency estimation model.

Most studies on beef cattle production in Malaysia were in the field of animal health, veterinary medicine, animal nutrition and fertility. Other research which were related to the socio-economic studies are the evaluation of the effectiveness of 'Pawah' scheme of cattle in Pulau Pinang (Zakaria 1991) and the implication of The Uruguay Round Aggrement in Malaysia (Lias 1996). The other research work were also reported by Awaludin (2001), Latif and Mamat (2000) and Yusof (2002).

As very few studies have been conducted on the technical efficiency of beef farming especially in Asia, it is instructive to explore the studies of technical efficiency in the agriculture sector. Most of the studies in technical efficiency applied the method proposed by Aigner et al. (1977) and Jondrow et al. (1982) to estimate the technical efficiency index. The computed technical efficiency of each individual farm was then regressed with some variables which is assumed affecting technical efficiency using various methods such as OLS, Tobit Regression and COLS. Examples of this method include studies by Battese and Cora (1977), Huang and Bagi (1984), LeBel and Stuart (1998), Ekanayake and Jayasuria (1987), Ali and Flinn (1989), Ali and Chaudry (1990), Bravo-Ureta and Rieger (1991), Habibullah and Ismail (1991), Parikh and Shah (1994), Lee and Lee (1995), Belen and Manuel (1997), Rakipova and Gillespie (2000), and Radam and Shamsudin (2001). However, the two-stage estimation procedure is unlikely to provide estimates, which are as efficient as those that could be obtained using a single-stage estimation procedure.

Battese and Coelli (1995) proposed a stochastic frontier model in which the inefficiency effects (Ui) are expressed as an explicit function of a vector of firm-specific variables and a random error. The recent approach, however, still maintained the concept by Aigner et al. (1977). The studies by Yanrui (1995), Shaujie and Zinan (1998), Wilson et al. (1998), Dey et al. (2000), Brummer and Loy (2000), Wilson et al. (2001), Squires et al. (2002) and Seyoum et al. (2000) are among the related literature for extensive reviews.

Methodology

The stochastic production function in this study was constructed by assuming the production function of individual cattle farm is as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_5) \quad (1)$$

Where, Y = Total output per year in Animal Unit (AU)
X_1 = Average number of breeder per year in Animal Unit (AU)
X_2 = Average number of bull per year in Animal Unit (AU)
X_3 = Grazing area in hectares
X_4 = Labour utilization per year in man hours
X_5 = Veterinary inputs per year in Ringgit Malaysia (RM)

The stochastic frontier regression model is estimated using the maximum likelihood estimation (MLE) technique. The software by Coelli (1995) was used as well as several statistical packages which depended on parameters estimated. The Battese and Coelli (1995) model specification was used in this study and expressed as:

$$Y_i = \beta X_i + (V_i - U_i) \text{ ,i=1,...,N} \quad (2)$$

Where Y_i is the output, X_i is the input variables and βs are parameters to be estimated. The V_i is random variables which are assumed to be identical and independently normally distributed [idd $N(0,\sigma_v^2)$]. The V_i is considered to be independent of the U_i which are non-negative random variables, and assumed to account for technical inefficiency in production. The U_i are considered to be independently distributed as truncations at zero of the $N(mi,\sigma_u^2)$ distribution, and assumed as follows:

$$m_i = z_i\delta,$$

Where, z_i = px1 vector of variables which may influence the efficiency of a firm, and
δ = 1xp vector of parameters to be estimated.

Specification of animal unit is following Chadwick (1996) and Osman (1989), as shown in *Table 4*. Referring to Chadwick (1996) and the study of the efficiency of Louisiana beef cattle producer (Rakipova and Gillespie 2000), the general formula of determining the output of each farm in a year period is:

Total output = Output of calf + Output of yearling

Where, Output of calf = (Ending stock of calf – Beginning stock of calf) + (Calf sold in a year – Culf purchased in a year)
Output of yearling = (Ending stock of yearling – Beginning stock of calf) + (Yearling sold in a year – Yearling purchased in a year)

The input variables are defined through straightforward methods. A cattle breeder is considered as one animal unit (AU) and a bull is calculated as 1.2 AU. AU of the other categories of cattle is shown in *Table 4*. Land for grazing areas is measured in hectares and a labourers

Table 4. Specification of Animal Unit

Category	Animal Unit (AU)
Bull (>2 years)	1.20
Breeder (>2 years)	1.00
Male yearling (1–2 years)	0.75
Female yearling (1–2 years)	0.70
Male calf (<1 year)	0.50
Female calf (<1 year)	0.45

Source: Osman (1989) and Chadwick (1996) working in the farm for an hour is defined as one man-hour. Veterinary inputs, farm expenditure of supplement feed, repair and maintenance of fixed assets, utilities, tools, veterinary drugs and medications as well as miscellaneous inputs are measured in Ringgit Malaysia (RM).

The other important stage of the analysis is to indicate the relationship between technical efficiency with socio-economic farm characteristics and management factors. This is done by incorporating all those variables into the stochastic frontier production function, known as inefficiency model. However, the parameter estimates in the inefficiency model (δs) only indicate the direction of the effects of these variables upon inefficiency, where a negative parameter estimate shows that the variable has positive effect on efficiency. The hypothesis testing can be used to indicate combine effects of all those farm performances, animal husbandry practices, demographic, socio-economic and management factors as well as for individual effects.

The socio-economic and demographic variables can be used directly because their units are quantitative. Variables such as age, years of experience in beef farming, years of education, numbers of training and the number of visits by extension agents in a year can be used directly from the primary data without modifications, while the dummies variable are constructed for the variables such as 'Pawah' scheme and farm credits.

Variables that indicate the farm manager/farmers ability in management are constructed using a set of questions in the survey. These variables are based on the five management functions adapted from Hellriegel et al. (2002). All aspects of management inventory are set in positive and negative questions and are arranged in such a way to facilitate the determination of management inventory.

The farm performance variables such as rate of mortality, calving rate and percentage of breeder replacement from external sources, are calculated directly from farm's statistics. However, dummy variables are constructed for animal husbandry practices such as breeds (1 for cross breeds and 0 for local breeds) and breeding and health management practices (1 for DVS assistance, and 0 for no DVS assistance).

The area of the study is confined to the Target Area of Concentration (TAC) in Johor. The total population of beef cattle in Johor was estimated at about 100,000 heads of which 51.68% (51,675 heads) is in TAC. The data collection was carried out from May to July 2003, based on the farm records from January until December 2002. This study covered 104 farms owned by owner operators, private plantations and group of farmers, who had 10 breeder cattle (minimum) and more than two years in operation. Structured questionnaires were used and several enumerators were employed in each area including the TAC managers.

Result and discussion

A statistical test was carried out to determine whether the form of frontier production function was of a Cobb-Douglas or a translog. The Cobb-Douglas stochastic frontier production function was specified as:

$$\ln Y_i = \alpha_o + \alpha_1 \ln BRD + \alpha_2 \ln BULL + \alpha_3 \, LnGRZ \alpha_4 \ln LBR + \alpha_5 \ln VETIPT + \varepsilon_i \quad (3)$$

The translog stochastic frontier production function was specified as:

$$\text{In } Y_i = h\alpha_o + \sum_{i=1}^{n} \alpha i \text{ In } X_i + \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \text{ In } X_j + \varepsilon_i \quad (4)$$

where i and j represent the inputs used for farm operations, which were identified as breeder, bull, grazing areas, labor and veterinary inputs and expenses and $\varepsilon_i = V_i - U_i$. In both Cobb-Douglas and translog models which include the technical inefficiency effect, U_i, it was specified as:

$$U_i = \delta_0 + \delta' Z_i \quad (5)$$

Where; Z_i is a column vector of technical inefficiency explanatory variables and δs are the parameters, which are to be estimated. The null hypothesis was rejected by the likelihood ratio test at 10% level of significant for both models with and without technical efficiency effects (*Table 5*). It could be concluded that the production function model being analysed seems to be better represented by translog rather than Cobb-Douglas functional form.

Table 6 shows the empirical estimates of regression coefficients with eight significant variables in inefficiency effects model. The estimates of regression coefficients in MLE were different compared to OLS. Furthermore, the signs for some interaction variables (β_{55} and β_{25}) have change in MLE. The numbers of significant variables have also increased in MLE. However, only one interaction variable (β_{55}) was significant either in OLS or in MLE. The value of R^2 in OLS model indicates that about 75.6% of the total variations in the model have been explained by all the production factors while another 24.4% might be caused by unknown factors.

In MLE model, the λ was greater than unity, which indicated that one-sided error (U_t) dominates the symmetric error (V_t). This implies that a greater portion of the residual variation in the output is associated with the variation in technical inefficiency rather than with measurement error, which is associated with uncontrollable factors, related to the production operations.

The value of computed γ was statistically significant (asymptotic t-statistic = 2.374). The $\gamma = \sigma_u^2 / \sigma^2$ measures the total variation in output from the frontier which lead to technical efficiency. The value of γ implies that 87.7% of the discrepancies between the observed values of output and the frontier were due to technical inefficiency. Therefore, the shortfall of realized output from the frontier is because of the factors which will be identified in the next analysis, that are within the control of the farmers.

The test of log-likelihood ratio was further conducted to prove the significant of γ in the selected model. The log-likelihood ratio test for γ explores the null hypothesis that each farm is fully technically efficient and hence those systematic inefficiency effects are zero. According to Coelli (1995) if γ = 0 is involved in the null hypothesis (Ho), then the likelihood ratio statistic has asymptotically a mixed chi-square distribution, if Ho is true. The critical value for this test is taken from Kodde and Palm (1986). The results show that the average response function estimated by OLS (restricted model) that assumes all farms were technically efficient was an inadequate representation of the data, given the specification of the translog frontier and inefficiency model. Therefore, it could be concluded that inefficiency really existed in the sample farms in the study area, which were due to 17 variables identified in the model.

However, in view of a low validity of the asymptotic t-statistic under the maximum likelihood estimation procedure, further test is required to validate the insignificance of some technical inefficiency

Table 5. Likelihood ratio test for selection of functional forms

	Null hypothesis	Log-likelihood		χ^2	Critical value at 10%	Decision
		Cobb-Douglas	Translog			
With technical inefficiency effect	$\beta_{ii} = \beta_{ij} = 0$	−6.346	6.147	24.986	22.307	Reject H_0
Without technical inefficiency effect	$\beta_{ii} = \beta_{ij} = 0$	−41.097	−27.397	27.400	22.307	Reject H_0

Table 6. Estimated translog stochastic frontier production function and inefficiency effect model

Variables	Parameters	OLS		MLE	
Constant	α_0	4.695	(0.659)	7.650	(1.667)**
$\ln X_1$ (breeder)	β_1	1.274	(0.639)	2.453	(1.927)**
$\ln X_2$ (bull)	β_2	–0.629	(–0.288)	–0.144	(–0.105)
$\ln X_3$ (grazing areas)	β_3	–0.391	(–0.340)	–1.001	(–1.352)*
$\ln X_4$ (labor)	β_4	–0.880	(–0.577)	–1.537	(–1.494)*
$\ln X_5$ (veterinary input and expenses)	β_5	–0.449	(–0.590)	–0.372	(–0.819)
$\ln X_1 \ln X_1$	β_{11}	0.283	(–0.816)	0.239	(1.122)
$\ln X_1$ lnX2	β_{12}	–0.282	(–0.555)	–0.276	(–0.743)
$\ln X_1 \ln X_3$	β_{13}	0.292	(0.975)	0.088	(0.475)
$\ln X_1 \ln X_4$	β_{14}	–0.292	(–0.961)	–0.293	(–1.769)**
$\ln X_1 \ln X_5$	β_{15}	–0.266	(–1.093)	–0.213	(–1.417)*
$\ln X_2 \ln X_2$	β_{22}	0.166	(0.647)	0.185	(0.950)
$\ln X_2 \ln X_3$	β_{23}	–0.237	(–0.835)	–0.161	(–0.869)
$\ln X_2 \ln X_4$	β_{24}	0.093	(0.275)	0.250	(1.250)
$\ln X_2 \ln X_5$	β_{25}	0.097	(0.463)	–0.005	(–0.040)
$\ln X_3 \ln X_3$	β_{33}	0.063	(0.583)	0.147	(1.859)**
$\ln X_3 \ln X_4$	β_{34}	–0.315	(–1.480)*	–0.225	(–1.767)**
$\ln X_3 \ln X_5$	β_{35}	0.167	(1.393)*	0.124	(1.799)**
$\ln X_4 \ln X_4$	β_{44}	0.253	(1.870)**	0.207	(2.248)**
$\ln X_4 \ln X_5$	β_{45}	–0.003	(–0.017)	0.071	(0.854)
$\ln X_5 \ln X_5$	B_{55}	0.027	(1.341)*	–0.003	(–0.224)
Inefficiency model					
Constant	δ_0			3.850	(4.189)**
Planning	δ_1			–0.055	(–2.376)***
Organising	δ_2			0.007	(0.025)
Staffing	δ_3			0.002	(0.077)
Directing	δ_4			0.007	(–0.019)
Controlling	δ_5			–0.006	(–2.478)***
Age	δ_6			–0.006	(–0.979)
Experience	δ_7			–0.022	(–1.373)*
Education	δ_8			–0.171	(–0.529)
Training	δ_9			–0.029	(–1.319)*
Visits	δ_{10}			–0.032	(–1.765)**
Farm's credit	δ_{11}			0.056	(0.282)
"Pawah"	δ_{12}			–0.022	(0.282)
Calving rate	δ_{13}			–0.004	(–1.330)*
Mortality rate	δ_{14}			0.005	(0.648)
Replacement	δ_{15}			–0.037	(–0.252)
Health and breeding	δ_{16}			–0.207	(–1.842)**
Breeds	δ_{17}			–0.140	(–1.437)*
Variance parameters					
R-squared	R^2	0.7564			
Log likelihood		–42.636		6.147	6.147
Sigma-squared	σ^2			0.094	(3.629)***
Gamma	γ			0.877	(10.415)***
Lambda	λ			2.612	2.612

Numbers in parenthesis are t-ratios

*Significant at 10% ($\alpha = 0.1$ with 84 degree of freedom)

**Significant at 5% ($\alpha = 0.05$ with 84 degree of freedom)

***Significant at 1% ($\alpha = 0.01$ with 84 degree of freedom) variables (Sharma and Leung 1998). Therefore, the generalized likelihood ratio test was conducted to determine the effects of specific inefficiency effect variables on technical efficiency. As shown in generalized likelihood ratio test (*Table 7*), all the inefficiency effect variables which were not significant under t-statistic, were also not significant in likelihood ratio test at the same significant level (α = 0.1). Thus, all those significant variables were considered as the determinants of inefficiency.

In *Table 6*, the variables with positive impact on efficiency are planning, directing and controlling, which represent management inventory, and age, experience, education, training, visits, farm's credits and 'Pawah' which represent socio-economic and demographic factors. The other factors were calving rate, breeder replacement, breeding and health management and cattle breeds, which represent farm performances and animal husbandry practices. However, the coefficients of organising, staffing, directing, age, education, 'Pawah', and breeder replacement, were insignificant at 10% significant level (Asymptotic t-statistic = 1.289). The insignificance of farm's credit to the level of efficiency was consistent with the study by Brummer and Loy (2000). However, the result of the Malaysian gill net artisanal fishery (Squires et al. 2002) did not provide evidence that participation in training programmes by captains increases technical efficiency.

The results of insignificant positive relationship between age and years of education with technical efficiency were inconsistent with the findings of the study done by Jamison and Moock (1981), Dey et al. (2000) and Rakipova and Gillespie (2000). However, Parikh and Shah (1994) found a negative influence of age on farm efficiency. The relationship between technical efficiency and farmer's education level was also inconsistent with the findings of Kalirajan and Flinn (1981) and Lingard et al. (1983). Meanwhile, the positive significant relationship between farmer's experience and technical efficiency was consistent with the findings by Wilson et al. (2001) and Squires et al. (2002).

In the aspect of management, Wilson et al. (2001) also found that the management objective of profit maximizing was significant in determining farm technical efficiency. This was consistent with this finding, which revealed that the management aspects (i.e. planning and controlling) were significantly affecting efficiency. Although the variables used in this study were slightly different, the possible explanation was that farmers who effectively planned and controlled their farm operations, would be better in setting their objectives, thus practised more efficient use of inputs than those who were less skilful in planning and controlling. The insignificance of organizing and staffing might be due to the fact that most of the respondents especially the owner operators were employing limited number of labour in their low input low output farm operations. This make their management skills in those aspects remain unexplored.

The analysis also showed that farms with high calving rate, breeding and health programme assisted with skilful personnel and keeping crossbreed cattle were more efficient than farms with low calving rate, managing health and breeding programme by themselves and keeping only local breed of cattle (Kedah-Kelantan). In the aspect of breed, the positive significant impact of crossbred cattle to technical efficiency is consistent with the study by Rakipova and Gillespie (2000).

The elasticity of outputs with respect to each of the inputs was calculated using means of the data since the translog production function do not have any direct interpretation. The elasticity could be obtained by partial differentiation of the translog production function with respect to the appropriate inputs (Greene 2003). The estimate of return to scale (RTS), defined as the percentage change in input due to a proportional increase of all inputs, is calculated as the sum of these output

Table 7. Generalized likelihood ratio test of hypothesis for δ parameters of the stochastic frontier production function and inefficiency effect model

Test of null hypothesis	Log likelihood under Ho*	Test statistic (λ) **	DF	Critical χ^2 value at 90%	Decision
1. No technical inefficiency effect Ho: $\delta_j = 0$; $_j = 0,\ldots 17$	–27.397	67.088	17	24.769	Reject Ho
2. No planning effect Ho: $\delta_1 = 0$	1.225	9.844	1	2.70	Reject Ho
3. No organizing effect Ho: $\delta_2 = 0$	6.146	0.002	1	2.70	Fail to reject Ho
4. No staffing effect Ho: $\delta_3 = 0$	6.142	0.01	1	2.70	Fail to reject Ho
5. No directing effect Ho: $\delta_4 = 0$	6.146	0.002	1	2.70	Fail to reject Ho
6. No controlling effect Ho: $\delta_5 = 0$	2.309	7.676	1	2.70	Reject Ho
7. No age effect Ho: $\delta_6 = 0$	5.540	1.214	1	2.70	Fail to reject Ho
8. No experience effect Ho: $\delta_7 = 0$	4.676	2.942	1	2.70	Reject Ho
9. No education effect Ho: $\delta_8 = 0$	5.929	0.436	1	2.70	Fail to reject Ho
10. No training effect Ho: $\delta_9 = 0$	4.732	2.830	1	2.70	Reject Ho
11. No visits effect Ho: $\delta_{10} = 0$	3.676	4.942	1	2.70	Reject Ho
12. No farm's credit effect Ho: $\delta_{11} = 0$	6.095	0.052	1	2.70	Fail to reject Ho
13. No "pawah" effect Ho: $\delta_{12} = 0$	6.125	0.044	1	2.70	Fail to reject Ho
14. No calving rate effect Ho: $\delta_{13} = 0$	3.892	4.510	1	2.70	Reject Ho
15. No mortality rate effect Ho: $\delta_{14} = 0$	5.665	0.964	1	2.70	Fail to reject Ho
16. No replacement effect Ho: $\delta_{15} = 0$	6.108	0.039	1	2.70	Fail to reject Ho
17. No health and breeding effect Ho: $\delta_{16} = 0$	4.1667	3.961	1	2.70	Reject Ho
18. No breeds effect Ho: $\delta_{17} = 0$	4.620	3.054	1	2.70	Reject Ho

*The value of log-likelihood function under the specification of alternative hypothesis (unrestricted model) is 6.147

**$\lambda = 2(\ln L_1 - \ln L_o)$ where $\ln L_o$ is the value of the log-likelihood under the null hypothesis and $\ln L_1$ the corresponding value under the alternative hypothesis elasticity. None of the individual elasticity was reaching the condition of increasing to scale (elasticity of greater than one) (*Table 8*).

The negative output elasticity of labour indicates that the farms in the studied area used too many labours (in man-hours). A one per cent increase in labours would reduce the output of beef cattle by 0.05%. This result might be due to the employment of unskilled, untrained and inexperience workers in many farms. Family and group's labour might also be the reasons for this phenomenon. They spent longer working hours in their own farm than it should be, without taking into account the productivity since there was no farm obligation in paying them.

However, the return to scale, which is the sum of all individual output elasticity, was found to exceed unity indicating that the production of beef cattle in the area of study was increasing return to scale. The beef farming effort in the area of study had not passed the maximum sustainable yield. There was still room for improvement and expansion for the farms in beef production to the most efficient level.

For comparison, a case study by Brummer and Loy (2000), in North Germany for dairy farmers showed that the return to scale of 0.984, indicating that most of the participating farms were in the stage of decreasing return to scale. Agriculture projects which were operating on a small scale and with low level of technology were normally in the stage of decreasing return to scale than the industry with high level of technology and capital intensive (Rani and Abdullah 1991).

The value of technical efficiency, that is the ratio of actual to potential output, was calculated for each of the 104 farms. The technical efficiency for each individual farms ranged from 0.162 to 0.977 with the mean of 0.683 (*Table 9*). The farms surveyed display a wide spread of technical efficiency achieved in the year 2002. About 61.5% of the farms achieved less than 80% technical efficiency while only limited number of farms (10.6%) display substantially lower level of technical efficiency (below 40%). The cross tabulation analysis shows that, about 63.6% farms with the lower level of technical efficiency index (<40%), were represented by farms from plantation sector. Following the specification by Jondrow et al. (1982), the output losses due to inefficiency could be calculated as maximum output from frontier, which was estimated by MLE, multiply by farm specific inefficiency level. The total losses in production due to inefficiency were estimated to be 3,094 heads of beef cattle (in AU).

The analysis in *Table 10* found that the TAC Mersing was statistically higher than the average efficiencies in the TAC

Table 8. Output elasticity of translog stochastic frontier production function

Input	Elasticity
Breeder	0.6869
Bull	0.0534
Grazing areas	0.4409
Labour	–0.0535
Veterinary input and expenses	0.0174
Return to scale	1.1452

Table 9. Technical efficiency of beef cattle farms in TAC, Johor

Efficiency index	Frequency	%	Cumulative (%)
0.10–0.20	1	0.96	0.96
0.20–0.30	1	0.96	1.92
0.30–0.40	9	8.65	10.57
0.40–0.50	11	10.58	21.15
0.50–0.60	14	13.46	34.61
0.60–0.70	17	16.35	50.96
0.70–0.80	11	10.58	61.54
0.80–0.90	18	17.31	78.85
More than 0.90	22	21.15	100.0
Total	104	100.0	
Mean	0.6829		
Minimum	0.1615		
Maximum	0.9767		
Std. deviation	0.2049		

Kluang and the TAC Kota Tinggi but not statistically different with the TAC Segamat/ Muar. Meanwhile, the average efficiency in the TAC Segamat/Muar was statistically higher than in the TAC Kota Tinggi and Kluang. There was not enough evidence to prove any significant difference in the average efficiency between the TAC Kluang and Kota Tinggi. All tests were conducted at critical value of 90% ($\alpha = 0.1$).

It was also found that there was no evidence from the sample of beef producer in the studied area examined, to suggest with confidence that there exists a significant difference of efficiency level according to the types of farm, farm ownership and farm size ($\alpha = 0.1$).

Table 10. Test of hypothesis for μ parameter technical efficiency

Hypothesis	Test statistic (t or F value)	DF	Critical value at 90%	Decision
By farms location				
1. No mean different between TAC*	3.121*	$N_1 = 3$,	2.14	Reject Ho
Ho: $\mu_1 = \mu_2 = \mu_3 = \mu_4$		$N_2 = 100$		
H_1: At least one different				
2. Ho: $\mu_1 = \mu_2$ H_1: $\mu_1 < \mu_2$	–1.944	48	–1.677	Reject Ho
3. Ho: $\mu_1 = \mu_3$ H_1: $\mu_1 > \mu_3$	0.488	41	1.684	Fail to reject Ho
4. Ho: $\mu_1 = \mu_4$ H_1: $\mu_1 < \mu_4$	–1.790	57	–1.671	Reject Ho
5. Ho: $\mu_2 = \mu_3$ H_1: $\mu_2 > \mu_3$	2.362	43	1.688	Reject Ho
6. Ho: $\mu_2 = \mu_4$ H_1: $\mu_2 > \mu_4$	0.381	59	1.671	Fail to reject Ho
7. Ho: $\mu_3 = \mu_4$ H_1: $\mu_3 < \mu_4$	–2.332	52	–1.671	Reject Ho
By types of farms				
1. No mean different between types of farms*	0.841*	$N_1 = 2$, $N_2 = 101$	2.35	Fail to reject Ho
Ho: $\mu_1 = \mu_2 = \mu_3$				
H_1: At least one different				
2. Ho: $\mu_1 = \mu_2$ H_1: $\mu_1 > \mu_2$	0.908	70	1.671	Fail to reject Ho
3. Ho: $\mu_1 = \mu_3$ H_1: $\mu_1 < \mu_3$	–0.387	72	–1.664	Fail to reject Ho
4. Ho: $\mu_2 = \mu_3$ H_1: $\mu_2 < \mu_3$	–1.121	60	–1.671	Fail to reject Ho
By farm ownership				
Ho: $\mu_1 = \mu_2$				
H_1: $\mu_1 < \mu_2$	–1.091	102	1.665	Fail to reject Ho
By farm size**	(t value)			
Ho: $\mu_1 = \mu_2$				
H_1: $\mu_1 < \mu_2$	–0.287	102	–1.665	Fail to reject Ho

*F-test
**A benchmark of 50 breeders was used to differentiate between small and large farms

Conclusion and recommendations

The findings of this study suggest that there exists a possibility of expansion and improvement of the majority of the farms by adopting the technology of the best-practiced farm and through optimal resource allocation.

The following recommendations are suggested to improve the efficiency level of beef cattle production in the studied area:

- At least 85% calving rate per year should be the main target of each farm since the direct impact of high calving rate against the level of efficiency. Therefore farms should focus on the management of breeding practices, fertility, and health to improve calving rate. This will relate to the requirement of skill and semi-skilled personnel, which in turn impact extra costs. However, since return to scale (RTS) was slightly greater than unity, it is still worth to invest in human resources and not depend solely on DVS (TAC personnel) in those aspects of farm management. These factors supported with proper nutritional practice, good animal husbandry practices, and veterinary inputs will further improve the farms efficiency.
- The excess labour in farm operation should be reduced by moving them to the other enterprises within farm business. This is because more than half of the operators were not full time operators and had other farm enterprises within their control and made their off farm earning still important. The removal of excess labour forces is important in terms of input-output optimization.
- Empirical results showed that the majority of farms in plantation group were comparatively inefficient in the allocation of farm inputs to maximize the output. However, focus on future planning should also be on this group of farms due to the availability of their farm inputs such as grazing areas and capital as well as animal stocks. The emphasis should be more on breeding programme and related activities such as nutrition and better quality bulls because there were still rooms for improvements in management to enhance technical efficiency.
- By implication of the increasing return to scale concluded from this study, development of large farm operation would need to be promoted to exploit cost reduction. Hence, the involvement of plantations and similar organisations such as cooperatives in large farm operations, need to be encouraged. However optimal utilization of all resources might need some considerations. For example, increasing the size of breeding stock with proposed 1:20 male female ratio and matching the full utilization of available grazing areas. Trained and skilful personnel are needed crucially in these operations together with support available from veterinary services.
- The enlargement of the project size is possible for the technically efficient farms. The agriculture and micro credit should be more directed towards assisting the efficient farms with some modifications of the present credit's regulations. The implementation of 'Pawah' scheme should be revised in terms of the selection of farmers, since farms which received the scheme were not necessarily efficient in beef cattle production. The new approach of 'Pawah' scheme TRUST[2] may give more significant impact in efficiency. At the same time, DVS technical and advisory services should be directed more to the present 'Pawah' receivers to improve efficiency.
- The managerial ability of the farmers/ farm managers should be improved especially in the aspects of planning and controlling skills. This can be achieved through systematic training in animal husbandry, veterinary skills, and farm management. Attention should be given

to the private plantations in providing them the structured training.

- Advisory services through scheduled visits must be increased especially to the inefficient farms to improve their productivity. The extension agents should acquire sufficient knowledge and skill for effective advisory services.
- Experience farmers should be given preference in the strategic planning of beef cattle entrepreneurship development since experience has a significant influence to farm efficiency.
- At farm level, the effort from DVS in health and breeding management is still crucial. The assistance by DVS in these aspects has a significant impact to farm efficiency. However, in the long term farmers should be more self-reliance in these aspects of animal husbandry management.
- Farmers should be encouraged in rearing crossbreeds preferably Brahman crosses, or the combination of local breeds and crossbred cattle since local breed of cattle is associated with the farm's inefficiency.

Finally, further studies are proposed to determine the productivity and efficiency level of the beef industry in general since the cattle population outside the TAC account for about 84% of the total cattle population in the country.

Notes

1. In the 'Pawah' scheme, pregnant heifers were distributed to selected farmers. The farmer has to return the female calves born from each breeder to the government, which would be bred to pregnant. These pregnant heifers were distributed to other farmers waiting in the scheme. The high quality bulls for breeding were also given to the farmers on rotational basis.
2. TRUST is Entrepreneur Transformation Scheme for Cattle Rearing. Under the scheme, farmers were given 10 cows each to rear, with the capital cost to be repaid by the farmers within seven years with the collaboration with Bank Pertanian Malaysia (Agrobank). The government had allocated RM4.5 million to initiate the scheme in Kedah in 2002. It was hoped that this scheme would be able to replace the 40-year-old profit-sharing (Pawah) system.

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Abstrak

Pengeluaran daging lembu di Malaysia tidak dapat memenuhi permintaan kerana peningkatan penggunaan dan pertumbuhan yang perlahan dalam industri ini. Projek Kawasan Tumpuan Sasaran (KTS) dijangkakan akan menjadi penyumbang utama untuk mempertingkatkan pengeluaran. Kajian ini bertujuan mengenal pasti kecekapan penggunaan sumber-sumber dalam pengeluaran lembu pedaging di kawasan KTS di negeri Johor, Malaysia. Ia juga mengkaji isu mengenai produktiviti dan kecekapan teknikal dan hubungannya dengan inventori pengurusan, prestasi ladang, amalan pengurusan ternakan, faktor sosioekonomi serta demografi. Fungsi pengeluaran sempadan 'stochastic' translog dan Cobb-Douglas digunakan untuk mengkaji isu kecekapan teknikal pengeluaran lembu pedaging di kawasan KTS. Model regresi tersebut dianggarkan menggunakan teknik 'maximum likelihood estimation' (MLE). Model translog didapati sesuai berdasarkan data daripada sampel kajian dan memberikan anggaran yang lebih baik daripada model Cobb-Douglas. Penemuan kajian menunjukkan operasi pengeluaran lembu pedaging sedang berada pada tahap pulangan mengikut skala yang bertambah. Kecekapan teknikal yang dikira untuk setiap unit ladang menunjukkan nilai purata 0.683. Majoriti ladang (51%) mencapai kecekapan teknikal antara 40% sehingga 80%. Jumlah kerugian akibat ketidakcekapan dianggarkan sebanyak 3,094 ekor lembu pedaging dalam kiraan Unit Ternakan setahun. Kajian ini juga menunjukkan terdapat perbezaan dalam purata kecekapan teknikal mengikut lokasi KTS. Bagaimanapun, tiada perbezaan kecekapan teknikal yang signifikan berasaskan jenis ladang, pemilikan ladang dan saiz ladang. Penemuan kajian ini mencadangkan masih wujud ruang untuk peningkatan pengeluaran dengan menggunakan teknologi terbaik yang perlu diamalkan dan pengagihan sumber secara optimum. Kecekapan teknikal ladang boleh diperbaik dengan kemahiran perancangan dan kawalan yang lebih baik oleh penternak/pengurus ladang, pengalaman yang lebih lama, latihan yang mencukupi, khidmat nasihat daripada agen pengembangan, kadar kelahiran anak lembu yang lebih tinggi, penglibatan dari Jabatan Perkhidmatan Veterinar dalam perkhidmatan pengurusan kesihatan dan pembiakan serta penggunaan baka lembu kacukan.