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Livestock Production Systems and Technical Inefficiency of Feedlot Cattle Farms in Thailand

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Abstract

The primary purpose of this study is to measure and investigate factors affecting technical inefficiency of feedlot cattle farms in Thailand. This study applies a stochastic frontier production function approach to measure farm-specific technical inefficiency using the 2004 farm-level cross-sectional survey data of Thai feedlot cattle farms in a single estimation technique applying the maximum likelihood estimation method. The non-negative technical inefficiency effects are modeled as a function of farm-specific socio-economic and production management factors. The empirical results suggest two important findings. First, there is confirmation that producer's education and experience, belonging to farmer groups, the number of farm visits per year, farm size, the difference in concentrated feed used, rough feed and the considerable variability of cattle shelters have influenced the technical inefficiency of cattle farms. Second, producer's age and the considerable variability of cattle breeds do not have different impacts on technical inefficiency in Thai cattle production in different farms.

Keywords: Technical Inefficiency, Stochastic Frontier, Cattle Farms, Thailand, Livestock Production Systems

1. Introduction

Cattle raising has been identified as 1 of 14 main products in Thai agriculture. In 2003, there were 0.99 million cow farms and 5.90 million head of cows, and there was a growth rate of 57,000 farms per annum (around 7 per cent) and 0.27 million head per annum (5.20 per cent) during the period of 1999-2003. Although, the growth rates of cattle farms and heads have been recognised, beef production in Thailand has not been sufficient for domestic consumption. During the period of 1999-2003, the average total import of beef products was USD 219.50 million per annum (Ministry of Agriculture and Cooperatives, 2004). Therefore, production improvement is the main concern of this sector.

There are at least four causes for worry concerning the future development of cattle production in Thailand. First, cattle are normally raised by small farmers. Second, the majority of beef/cattle comes from the Northeast, which is also the poorest region of Thailand. Third, a few studies indicate that, at the farm level, the key constraints are the availability of livestock production systems, inputs and disease problems. Finally, the Thai government has significantly influenced Thai agriculture through a variety of policies over the past three decades. These could cause imperfect competition in those inputs and in output markets. Because of the above factors, economists and policy makers have raised the question of the technical efficiency of cattle production in Thailand, especially at the farm level.

The main purpose of this study is to measure and investigate factors affecting technical inefficiency of cattle farms in Thailand. To estimate efficiency scores, the stochastic frontier production function approach is applied to the 2004 farm-level cross-sectional survey data of cattle farms in two districts of two provinces in the Southern Region of Thailand. Previous studies have investigated economic efficiency and its components at both the farm and aggregate levels in Thai agriculture (e.g. Krasachat, 2000, 2001a, 2001b, 2004a, 2004b). However, this study, to the best of my knowledge, has been the first application of stochastic frontier production function in order to measure and explain technical inefficiency of feedlot cattle farms in Thailand. This enables a more detailed understanding of the nature of technical efficiency in cattle production in Thailand.

This paper is organised into five sections. Following the introduction, the methodology is described. Next, the data and sources utilized are provided. The last two sections cover the empirical findings of this study, and conclusions.

2. Methodology

The stochastic frontier production function was independently introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). This function contains a disturbance term that comprises two components: one to account for technical inefficiency and the other to permit random events impacting production. Coelli (1995), among others, indicated that the stochastic frontier production function approach has two main advantages in estimating efficiency scores. First, it deals with stochastic noise and second, it permits statistical tests of hypotheses pertaining to production structure and the degree of inefficiency.

The firm's technology is represented by a stochastic frontier production function as follows:

$$y_i = f(x_i;\beta) + \varepsilon_i \qquad i = 1, 2, ..., \mathrm{N} \tag{1}$$

where y_i is the output of the ith firm, x_i is a vector of input quantities used by ith firm, β is a vector of parameters to be estimated and ε_i is the composed error term. Following Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977), ε_i is defined as:

$$\varepsilon_i = v_i - u_i \tag{2}$$

where v_i accounts for random variations in production due to factors outside of the control of the producers, as mentioned earlier, and is assumed to be independently and identically distributed $N(0,\sigma_v^2)$ random errors and u_i accounts for technical inefficiency in production and is assumed to be an independent and identical half-normal distribution [see Greene (1993) and Coelli et al. (2005), for alternative distributional assumptions].

A number of studies have explored the determinants of technical efficiency by using the two-stage estimation procedure (e.g., Parikh and Shah, 1994; Sharma, Leung and Zaleski, 1999). In the first stage, u_i is estimated from the stochastic frontier production function. In the second stage, the calculated values of u_i from the first stage are regressed against firm-specific factors that are assumed to explain the differences in u_i between firms. Battese and Coelli (1995) indicated that these firm-specific factors should be incorporated directly in the estimation of the production frontier because they may have a direct impact on efficiency. To overcome this problem, the parameters of the stochastic production frontier and the inefficiency model are estimated simultaneously given that the technical inefficiency effects are stochastic. In this case, the u_i are assumed to be non-negative random variables, independently distributed and arising from the truncation at zero of the normal distribution with variance, σ^2, and mean, $z_i\sigma$, where z_i is a vector of firm-specific factors assumed to explain technical inefficiency and σ is a vector of parameters to be estimated (Wilson et al., 1998).

Several previous studies have specified a Cobb-Douglas production function to represent the frontier function (e.g., Son, Coelli and Fleming, 1993; Sharma, Leung and Zaleski, 1999). Wilson et al. (1998) indicated that the Cobb-Douglas function imposes severe a priori restrictions on the firm's technology by imposing the production elasticities to be constant and the elasticities of input substitution to unity. Flexible functional forms, such as the translog, do not have those restrictions and have been used in a number of recent studies (e.g., Wilson et al., 1998; Brummer and Loy, 2000). In addition, the Cobb-Douglas function is a restricted form of the translog. This implies that the choice of an appropriate functional form between these two functions can be selected based on statistical tests. Thus, in this study, the stochastic frontier production function of the Thai feedlot cattle farms is specified as:

$$\ln y_i = \beta_0 + \sum_{k=1}^{6} \beta_k \ln x_{ki} + \tfrac{1}{2}\sum_{k=1}^{6}\sum_{j=1}^{6} \beta_{kj} \ln x_{ki} \ln x_{ji} + v_i - u_i \tag{3}$$

where y and x are variables as defined in Table 1, β s are parameters to be estimated and v_i is a random noise term assumed to be distributed as $N\left(0,\sigma_v^2\right)$. u_i is a farm-specific inefficiency effect term assumed to be satisfied by the truncation (at zero) of the $N\left(\mu_i,\sigma_u^2\right)$ where the firm-specific mean, μ_i , is specified as:

$$\mu_i = \delta_0 + \sum_{p=1}^{12} \delta_p z_i \tag{4}$$

where the δ s are parameters to be estimated and z_i is a vector of firm-specific factors assumed to explain technical inefficiency defined in Table 2.

Note that the maximum likelihood estimation proposed by Battese and Coelli (1995) is used to simultaneously estimate the parameters of the stochastic production frontier and the technical inefficiency effects model using the computer program, FRONTIER Version 4.1 described in Coelli (1996).

3. Data

The data used in this study is based on a direct interview survey of 100 randomly selected cattle farm households in two districts of two provinces in the Southern Region of Thailand. The selected districts were Cha-am (Phetchaburi) and Pran Buri (Prachuap Khiri Khan) which are predominantly cattle producing areas in the Southern Region of Thailand. The data were for 2004. The farms selected were owner operated and had faced a similar economic and marketing environment for inputs and outputs.

One output and six inputs are used in the empirical application of this study. The six inputs groups are concentrated feed, rough feed, feeder cattle, family labour, land and “other inputs”. Several farm-specific factors are analysed to assess their influence on productive efficiency. The farmer’s age is defined in terms of years while education is derived from a farmer’s years of schooling. The farmer’s experience of cattle raising is also defined in terms of years. In addition, the amount of agricultural extension received by farmers is defined in terms of the number of farm visits per year. The number of cattle per farm is used in order to examine the impact of farm size on the technical inefficiency of the cattle farms in Thailand while dummy variables are introduced as a proxy for cattle breeds and are employed in order to investigate the effects of differences in cattle breeds on the technical inefficiencies of cattle farms. In addition, dummy variables are introduced as a proxy for the differences in types of concentrated feed and rough feed used in different farms. In addition, the sample cattle farms also differ in terms of belonging to farmer groups which is represented by a dummy variable (1 for belonging to a farmer group, 0 for not belonging to a farmer group. Finally, dummy variables introduced as a proxy for cattle shelters are employed in order to investigate the effects of differences in cattle shelters on the technical inefficiencies of cattle farms.

The input and output variables are defined in Table 1 while the variables selected for use to investigate inefficiency effects and the summary statistics of data sample of all variables are in Tables 2 and 3, respectively.

Table 1 Variable Definitions and Measurement

Variables	Units	Definitions
Cattle output (y)	Metric tonnes	Quantity of cattle produced per farm
Concentrated feed (x_1)	Metric tonnes	Quantity of concentrated feed
Rough feed (x_2)	Metric tonnes	Quantity of rough feed (such as by products of pineapple)
Feeder cattle (x_3)	Metric tonnes	Quantity of feeder cattle
Family labour (x_4)	Man-days	Quantity of family labour used
Land (x_5)	Hectare	Area used for cattle raising per farm
Other inputs (x_6)	USD	Total costs incurred for using hired labour, capital, hormones, petrol and all variable expenses, except the above inputs

Table 2 Variable Definitions for Inefficiency Effects

Variables	Definitions
AGE	Producer's age
EDU	Producer's years of schooling
EXP	Producer's experience of cattle raising
MEM	Dummy variable proxied for a producer who is a member of a farmer group
EXT	Number of farm visits per year received by a producer
SIZE	Number of cattle per farm
BREED1	Dummy variable proxied for native cattle
BREED2	Dummy variable proxied for Brahman mixed cattle
FEED	Dummy variable with a value of one if producer has used ready mixed cattle feed and zero otherwise
PINE	Dummy variable with a value of one if producer has used the by product of crushed pineapple for cattle feed and zero otherwise
SHELTER1	Dummy variable with a value of one if cattle shelter was made off wood and zero otherwise
SHELTER2	Dummy variable with a value of one if cattle shelter was made off wood and concrete and zero otherwise

Table 3 Summary Statistics of Data Sample

Variables	Minimum	Maximum	Mean	Std. Deviation
Cattle output	4.80	106.00	19.08	15.79
Concentrated feed	7.50	288.00	45.60	44.26
Rough feed	10.00	750.00	113.67	124.55
Feeder cattle	2.00	112.00	21.83	17.87
Family labour	0.01	208.75	47.27	28.23
Land	0.04	3.20	0.25	0.41
Other inputs	33.68	28,274.00	1,373.60	3,548.45
AGE	24.00	75.00	45.53	11.07
EDU	6.00	16.00	7.72	2.51
EXP	1.00	40.00	5.35	4.69
MEM	0.00	1.00	0.32	0.47
EXT	0.00	30.00	2.95	5.50
SIZE	2.00	300.00	43.48	46.06
BREED1	0.00	1.00	0.02	0.14
BREED2	0.00	1.00	0.97	0.17
FEED	0.00	1.00	0.88	0.33
PINE	0.00	1.00	0.37	0.49
SHELTER1	0.00	1.00	0.35	0.48
SHELTER2	0.00	1.00	0.62	0.49

4. Empirical Results

The parameter estimates of the translog stochastic production frontier and the technical inefficiency effects model are reported in Table 4. Approximately one third of the estimated parameter values are at least twice higher than their corresponding standard errors. This indicates that the goodness of fit of the model is fair.

Table 4 Maximum Likelihood Estimation Results

Variables	Coefficients	Standard Errors
Stochastic frontier:		
Constant	0.002	0.543
$\ln x_1$	-0.327	0.678
$\ln x_2$	0.308	0.688
$\ln x_3$	-0.059	0.573
$\ln x_4$	0.237	0.184
$\ln x_5$	-0.190	0.274
$\ln x_6$	0.252	0.225
$\ln x_1 \times \ln x_1$	0.165	0.365
$\ln x_2 \times \ln x_2$	-0.050	0.091
$\ln x_3 \times \ln x_3$	-0.026	0.305
$\ln x_4 \times \ln x_4$	-0.028	0.013
$\ln x_5 \times \ln x_5$	0.110	0.062
$\ln x_6 \times \ln x_6$	-0.035	0.030
$\ln x_1 \times \ln x_2$	-0.148	0.456
$\ln x_1 \times \ln x_3$	-0.182	0.478
$\ln x_1 \times \ln x_4$	0.306	0.363
$\ln x_1 \times \ln x_5$	0.109	0.261
$\ln x_1 \times \ln x_6$	0.088	0.201
$\ln x_2 \times \ln x_3$	0.287	0.426
$\ln x_2 \times \ln x_4$	-0.208	0.231
$\ln x_2 \times \ln x_5$	0.154	0.156
$\ln x_2 \times \ln x_6$	0.123	0.129
$\ln x_3 \times \ln x_4$	0.194	0.253
$\ln x_3 \times \ln x_5$	-0.345	0.242
$\ln x_3 \times \ln x_6$	-0.099	0.189
$\ln x_4 \times \ln x_5$	0.109	0.106
$\ln x_4 \times \ln x_6$	-0.165	0.112
$\ln x_5 \times \ln x_6$	0.039	0.053
Inefficiency model:		
Constant	-0.358	0.254
AGE	0.232	0.003
EDU	0.076	0.010
EXP	-0.022	0.003
MEM	-0.393	0.046
EXT	0.004	0.001
SIZE	0.001	0.001

Table 4 Maximum Likelihood Estimation Results (continued)

Variables	**Coefficients**	**Standard Errors**
BREED1	0.386	0.212
BREED2	0.067	0.192
FEED	-0.043	0.063
PINE	-0.206	0.031
SHELTER1	-0.029	0.108
SHELTER2	-0.364	0.109
Variance parameters:		
$\sigma_s^2 = \sigma_u^2 + \sigma_v^2$	0.023	0.002
$\gamma = \sigma_u^2 / \sigma_s^2$	0.935	0.002
Log-Likelihood	140.297	

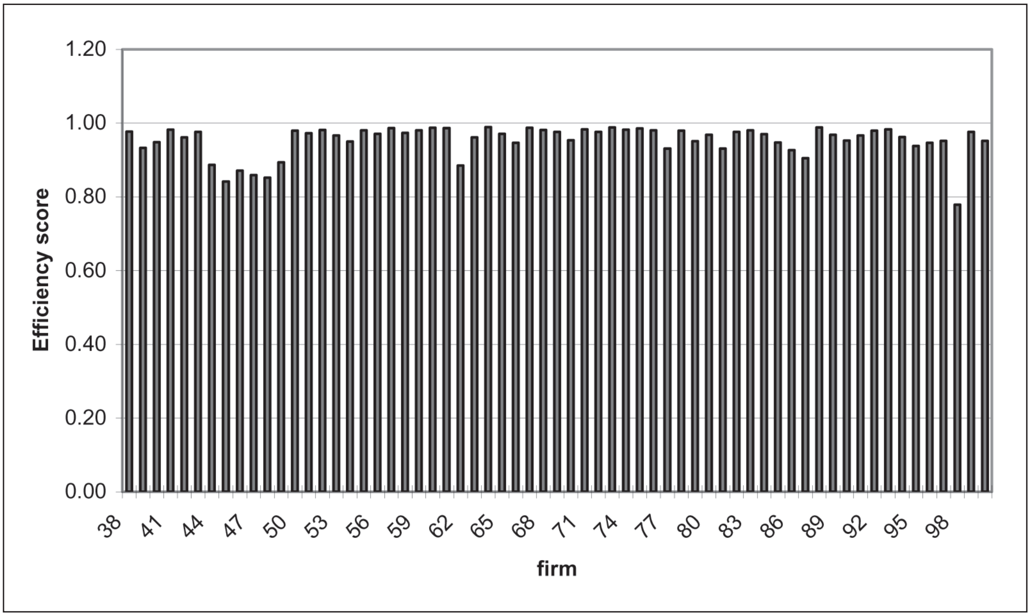
Hypothesis test results are presented in Table 5. Likelihood ratio tests are used in all cases. The null hypothesis is that the Cobb-Douglas form is an adequate representation of the frontier production function against the alternative translog specification. The empirical results suggest that the null hypothesis is rejected. This implies that the translog form is an appropriate functional form for the stochastic frontier production function of Thai feedlot cattle farms. In the second test, the null hypothesis explored specifies that each cattle farm is operating on the technically efficient frontier and that the systematic and random technical inefficiency effects are zero. It is rejected and this implies that inefficiency effects exist in Thai cattle farms. The third test is to determine whether the variables included in the inefficiency effects model have no impact on the level of technical efficiency in Thai cattle farms. This null hypothesis is also rejected confirming that the joint influence of the variables on technical inefficiency is statistically significant. The final test is to examine whether the differences in livestock production systems (i.e., types of concentrated feed used, rough feed used, cattle breeds and cattle shelters) have no impact on the level of technical inefficiency in Thai cattle farms. This null hypothesis is also rejected confirming that the joint influence of the livestock production systems on technical inefficiency is statistically significant.

Table 5 Likelihood Ratio Tests (at 5% significance)

Null Hypothesis	λ	**Critical Value**	**Results**
1. H_0: $\beta_{kj} = 0$	51.44	32.67	Reject H_0
2. H_0: $\gamma = \delta_0 = \ldots = \delta_{12} = 0$	51.47	23.68	Reject H_0
3. H_0: $\delta_1 = \delta_2 = \ldots = \delta_{12} = 0$	523.68	21.02	Reject H_0
4. H_0: $\delta_7 = \delta_8 = \ldots = \delta_{12} = 0$	274.30	12.59	Reject H_0

Following Coelli et al. (2005), the technical efficiency of ith farm is calculated and shown in Figure 1. The minimum estimated efficiency score is 0.47, the maximum score is 0.99 and the mean score is 0.94 with a standard deviation of 0.09. This indicates that there are possibilities to increase efficiency levels in Thai feedlot cattle farms.

Figure 1 Predicted Technical Efficiency



Wilson et al. (1998) indicated that, given the difference in efficiency levels among production units, it is valuable to question why some producers can achieve relatively high efficiency while others are technically less efficient. Variation in the technical efficiency of producers may arise from farm-specific socio-economic and management factors that impact the ability of the producer to adequately use the existing technology. The parameter estimates for the inefficiency effects model shown in Table 4 suggest six important findings. First, the estimated coefficients of years of experience, the membership of a farmer group and the dummy variables of types of concentrated feed, rough feed used and cattle shelters are negative. This implies that producers with more years of experience, who are members of a farmer group and used ready mixed cattle feed, a by product of crushed pineapple for rough cattle feed and wood and concrete for cattle shelters achieved higher levels of technical efficiency. In other words, producers with the above characteristics and livestock production systems are likely to get higher levels of technical efficiency in their farm management. Second, the empirical results indicate that the farmer's age has a positive effect on technical inefficiency. This suggests that younger farmers are more technically efficient than their older counterparts are. A similar result is also reported by Llewelyn and Williams (1996). Third, producers with more years of schooling achieved lower levels of technical efficiency, which is unexpected. That is, the more educated farmers are less likely to be as efficient when compared to their less educated counterparts. This may be due to higher skills, access to information and good cattle farm planning which stemmed more from farm practices than formal education. Fourth, the coefficient of the number of farm visits per year received by producers is estimated to be positive indicating that the producers with a greater number of farm visits tend to be more technically inefficient in Thai cattle production which is unexpected. This may be due to a lack of practical information from farm visits received by producers. Fifth, the estimated coefficient of number of cattle per farm is positive. This implies that the producers who raised a higher number of cattle achieved a lower level of technical efficiency. This may be because a smaller farm is likely to be technically more efficient compared to a larger one. Finally, there is no confirmation that the differences in cattle breeds have influenced the technical inefficiency of cattle farms. This implies that the considerable variability of cattle breeds does not have different impacts on technical efficiency in Thai cattle production in different farms.

5. Conclusions

This study applied a stochastic frontier production function approach to measure farm-specific technical inefficiency using the 2004 farm-level cross-sectional survey data of Thai feedlot cattle farms in a single estimation technique applying the maximum likelihood estimation method.

The empirical results indicate that there are possibilities that would increase efficiency levels in Thai cattle farms. Producers with more years of experience, who are members of a farmer group and use ready mixed cattle feed, a by product of crushed pineapple for rough cattle feed and wood and concrete for cattle shelters achieved higher levels of technical efficiency. In addition, the producers with more years of age and schooling, who had a greater number of farm visits and who raised higher a number of cattle achieved a lower level of technical efficiency. Finally, there is no confirmation that the differences in cattle breeds have influenced the technical inefficiency of cattle farms. However, the results must be viewed with caution due to the small sample of the data set.

The results indicate advantages in increasing experience, belonging to a farmer group and using the ready mixed cattle feed, a by product of crushed pineapple for rough cattle feed and wood and concrete for cattle shelters in Thai feedlot cattle farms. Therefore, development policies in the above areas should be used to increase the technical efficiencies of these inefficient farms in Thailand. That is, policies for training in farm management would increase famers' experience, encourage farmer group activities for exchanging farmers' experience and suggestions for the farmers to use the ready mixed cattle feed, the by- product of crushed pineapple for rough cattle feed and wood and concrete for cattle shelters in Thai feedlot cattle farms are recommended in order to increase technical efficiency in feedlot cattle production in Thailand.

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