Technical Inefficiency of Chili Farms in Thailand

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Abstract

The primary purpose of this study is to measure and investigate factors affecting technical inefficiency of chili farms in Thailand. This study applies a stochastic frontier production function approach to measure farm-specific technical inefficiency using the 2013 farm-level cross-sectional survey data of Thai chili 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 management and socio-economic factors. The empirical results suggest two important findings. First, there is confirmation that the difference in variety used has influenced the technical inefficiency of chili farms. Second, good agricultural practice (GAP) also has different impacts on technical inefficiency in Thai chili production in different farms.

Keywords: technical inefficiency; stochastic frontier production function; chili farms; Thailand; Good Agricultural Practice

JEL code: Q12

1. Introduction

Chili is a signature of Thai cuisine. The Ministry of Public Health reported Thai's chili consumption of approximately 5 grams per day or 1 teaspoon (Ooraikul et al., 2011). In addition, chili is a high value crop and also a major source of income for small scale farmers in Thailand (Athipanyakul and Pak-Uthai, 2012). In 2013, 55,766 hectares were planted to chili (Ministry of Agriculture and Cooperatives, 2014). However, chili farmers have overused pesticides both pre and post-harvest to control pests, protect the crops from disease, and meet high production targets (Athipanyakul and Pak-Uthai, 2012). To reduce the use of pesticides, good agricultural practice (GAP) has been promoted in the fruit and vegetables production system (including chili) in Thailand since 2003 by the Ministry of Agriculture and Cooperatives. Therefore, production improvement is the main concern of this sector.

There are at least two causes for worry concerning the future development of chili production in Thailand. First, Chili is normally cultivated by small farmers. Second, 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 chili production in Thailand, especially at farm level.

The main purpose of this study is to measure and investigate factors affecting technical inefficiency of chili farms in Thailand. Previous studies have investigated technical efficiency at both the farm and aggregate levels in Thai agriculture (e.g., Krasachat, 2000, 2001a, 2001b, 2004a, 2004b, 2008). However, this study, to the best of our knowledge, has been the first application of stochastic frontier production function in order to measure and explain technical inefficiency of chili farms in Thailand. Valuable information on the technical efficiency is necessary for policy makers to enable them to choose the appropriate direction of development planning to increase productivity and food security.

This paper is organised into five sections. Following this introduction, the methodology is described. Next, data and their sources are described. 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 to impact production. Coelli (1995), among many others, indicated that the stochastic frontier production function approach has two main advantages in estimating efficiency scores. That is, it deals with stochastic noise and 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:

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

where y_i is the output of the *i*th firm, x_i is a vector of input quantities used by *i*th 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 $N\left(0,\sigma_v^2\right)$ 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 chili farms is specified as:

$$\ln y_i = \beta_0 + \sum_{k=1}^{4}\beta_k \ln x_{ki} + \frac{1}{2}\sum_{k=1}^{4}\sum_{j=1}^{4}\beta_{kj} \ln x_{ki} \ln x_{ji} + v_i - u_i \qquad (3)$$

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

$$\mu_i = \delta_0 + \sum_{p=1}^{5} \delta_p z_i \tag{4}$$

where the δs 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 are based on a direct interview survey of 107 randomly selected chili farm households in the Northeastern region of Thailand. The data were for 2013. The farms selected were owner operated and had faced a similar economic and marketing environment for inputs and outputs.

One output and four inputs are used in the empirical application of this study. The four inputs groups are land, labour, chemical fertiliser, and “other inputs”. Several farm-specific factors are analysed to assess their influence on productive efficiency. The variety variable is intended to examine the impact of differences in chili variety on the technical inefficiency of the chili farms in Thailand while a dummy variable introduced as proxy for good agricultural practice (GAP) is employed to investigate the effect of differences in farm practice on the inefficiencies of chili farms.

The farmer’s experience of cultivation is also defined in terms of years. In addition, a dummy variable introduced as proxy for farmer gender is employed to investigate the effect of gender differences on the inefficiencies of chili farms. Finally, a dummy variable introduced as proxy for farm size is used to examine the impact of differences in farm size on the technical inefficiency of the chili farms in Thailand.

The input and output variables are defined in Table 1 whilst 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
Chili output (y)	Kilograms	Quantity of chili produced per farm
Land (x_1)	Rais	Land area planted per farm (1 rai = 0.16 hectare)
Labour (x_2)	Man days	Amount of total labour use from family and hired labour per farm
Fertiliser (x_3)	Kilograms	Quantity of chemical fertiliser used per farm
Other inputs (x_4)	Baht	Total costs incurred for using pesticide, herbicides, chili varieties and all variable expenses per farm, except the above inputs (42 Baht = US$ 1)

Table 2

Variable definitions for inefficiency effects

Variables	Definitions
VARIETY	Dummy variable with a value of one if producer has used rainy season variety and zero otherwise
GAP	Dummy variable with a value of one if producer has applied GAP and zero otherwise
EXP	Producer’s years of cultivation experience
GENDER	Dummy variable with a value of one if producer is male and zero otherwise
SIZE	Dummy variable with a value of one if the planted area has been more than two rais and zero otherwise

Table 3

Summary statistics of data sample

Variables	Minimum	Maximum	Mean	Std. Deviation
Chili output	120.70	6666.66	1567.25	1224.62
Land	0.25	10.00	1.87	1.48
Labour	19.75	267.50	64.72	41.93
fertiliser	0.003	295.00	77.19	51.47
Other inputs	4240.25	54575.73	15106.54	8010.81
VARIETY	0	1	0.56	0.49
GAP	0	1	0.39	0.49
EXP	0	60	33.42	13.63
GENDER	0	1	0.43	0.49
SIZE	0	1	0.16	0.37

4. Empirical Results

The parameter estimates of the translog stochastic production frontier and the technical inefficiency effects model are reported in Table 4. Two-third of the estimated parameters are at least twice their corresponding standard errors. This indicates that the goodness of fit of the model is good.

Table 4

Maximum likelihood estimation results

Variables	Coefficients	Standard Errors
Stochastic frontier:		
Constant	-31.443	1.260
$\ln x_1$	2.856	1.154
$\ln x_2$	8.670	1.309
$\ln x_3$	0.556	0.963
$\ln x_4$	4.062	0.620
$\ln x_1 \times \ln x_1$	0.425	0.135
$\ln x_2 \times \ln x_2$	0.202	0.072
$\ln x_3 \times \ln x_3$	0.030	0.011
$\ln x_4 \times \ln x_4$	-0.004	0.065

$\ln x_1 \times \ln x_2$	0.874	0.161
$\ln x_1 \times \ln x_3$	-0.120	0.050
$\ln x_1 \times \ln x_4$	-0.571	0.155
$\ln x_2 \times \ln x_3$	-0.263	0.056
$\ln x_2 \times \ln x_4$	-0.980	0.117
$\ln x_3 \times \ln x_4$	0.046	0.110
Inefficiency model:		
Constant	1.890	0.272
VARIETY	-1.300	0.161
GAP	-0.594	0.133
EXP	-0.0001	0.005
GENDER	-0.038	0.125
SIZE	0.163	0.236
Variance parameters:		
$\sigma_s^2 = \sigma_u^2 + \sigma_v^2$	0.172	0.034
$\gamma = \sigma_u^2 / \sigma_s^2$	0.999	0.0000001
Log-Likelihood	-35.093	

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 chili farms. In the second test, the null hypothesis explored specifies that each chili 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 chili farms. The final test is to determine whether the variables included in the inefficiency effects model have no impact on the level of technical efficiency in Thai chili farms. This null hypothesis is also rejected confirming that the joint influence of the variables on technical inefficiency is statistically significant.

Table 5

Likelihood ratio tests (at 5% significance)

Null Hypothesis	λ	Critical Value	Results
1. H_0: $\beta_{kj} = 0$	41.52	18.31	Reject H_0
2. H_0: $\gamma = \delta_0 = ... = \delta_5 = 0$	115.16	14.07	Reject H_0
3. H_0: $\delta_1 = \delta_2 = ... = \delta_5 = 0$	98.59	11.07	Reject H_0

Following Coelli et al. (2005), the technical efficiency of *i*th farm is calculated and shown in Figure 1. The minimum estimated efficiency score is 0.02, the maximum score is 1.00 and the mean score is 0.45 with a standard deviation of 0.27. This indicates that there are possibilities to increase efficiency levels in Thai chili farms.

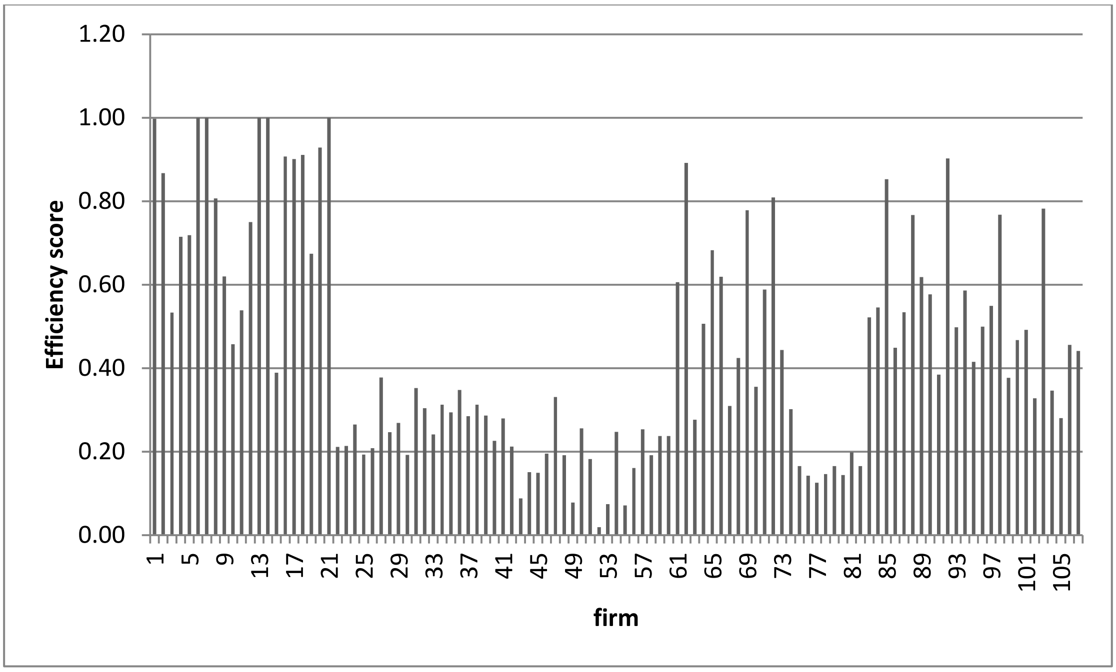

Figure 1. Predicted technical efficiency

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 three important findings. First, the estimated coefficient of the variety variable is negative. This implies that producer has used rainy season variety achieved higher levels of technical efficiency. In other words, producers who have used the rainy season variety are likely to get higher levels of technical efficiency in their farm management. Second, the empirical results indicate that GAP has a negative effect on technical inefficiency. This suggests that farmers who applied GAP are more technically efficient than those who did not. Finally, there is no confirmation that the differences in farm experience, gender and farm size have influenced the technical inefficiency of chili farms. This implies that the considerable variability of farm experience, gender and farm size does not have different impacts on technical efficiency in Thai chili production in different farms.

5. Conclusions

This study applies a stochastic frontier production function approach to measure farm-specific technical inefficiency using the 2013 farm-level cross-sectional survey data of Thai chili farms in a single estimation technique applying the maximum likelihood estimation method.

The empirical results indicate that there are possibilities to increase efficiency levels in Thai chili farms. Producers who used rainy season variety and applied GAP achieved higher levels of technical efficiency. In addition, there is no confirmation that the differences in farm experience, gender and farm size have influenced the technical inefficiency of chili farms. However, the results must be viewed with caution due to the small sample of the data set.

The results indicate advantages in applying rainy season variety and GAP in Thai chili farms. Therefore, development policies of the above areas should be used to increase the technical efficiencies of these inefficient farms in Thailand. That is, the policies on training on GAP to increase famers' knowledge and suggesting the farmers to use the rainy season variety in Thai chili farms are recommended to increase technical efficiency in chili production in Thailand.

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