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Technical efficiency of shrimp farms in Thailand under Good Agricultural Practice System

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Abstract

The main purpose of this study is to measure and investigate factors affecting technical inefficiency of white shrimp farms in Thailand. The data envelopment analysis (DEA) approach and farm-level cross-sectional survey data of shrimp farms in the Eastern Region in Thailand are used to estimate technical efficiency scores. Then, a Tobit regression is estimated and examined the effect of farm-specific socio-economic and management factors on farm efficiency. The empirical results suggest three important findings. First, the overall technical, pure technical and scale efficiency scores of some farms were considerably low. Second, there is confirmation that farm size and the differences in producers' experience in black tiger prawn production have influenced the overall technical and scale inefficiencies of shrimp farms while the difference in producers' participation in farm management training courses has different impacts on scale inefficiency in shrimp production in different farms. Finally, the empirical results also indicate that the difference in producers' education has different impacts on the overall technical, pure technical and scale inefficiencies in Thai shrimp production in different farms.

Keywords: Thai shrimp farms, data development analysis, technical inefficiency, Tobit regression, socio-economic and management factors

Introduction

Thailand is the world's major shrimp exporters. In 2008, Thailand's exports of shrimp totaled 335,372 tones, worth US$ 2.36 billion (Thai Frozen Foods Association, 2009). In addition, Thailand has been one of the world's largest producers of farm-raised shrimp in recent years (Josupeit, 2004). Therefore, the sustainability of the shrimp industry is extremely important to the country.

There are at least four causes for worry concerning the future development of shrimp production in Thailand. First, as indicated by Eureka Consulting (2005), the degradation of the environment is a primary problem for the Thai shrimp industry (i.e., the invasion and destruction of mangrove forests, degradation of land by increased salinity levels, water pollution from substandard farm management and improper use of chemical and antibiotic products). Second, a study of Eureka Consulting (2005) also indicates that, at the farm level, the key constraints are the availability of know-how on farming, inputs and disease problems. Third, Thai shrimp farms have continually improved production systems and kept up with fluctuating situations (i.e., unfavourable weather conditions, decreasing prices, increasing and stricter requirements from importing countries) as indicated by Leepaisomboon et al. (2009). Finally, Thai Good Agricultural Practice (GAP) system for shrimp farms has recently been imposed by the Thai government. Because of the above factors, economists and policy makers have raised the question of the technical efficiency of shrimp production in Thailand, especially at farm level.

The main purpose of this study is to measure and investigate factors affecting technical inefficiency of shrimp farms in Thailand. To estimate efficiency scores, the data envelopment analysis (DEA) approach is applied to farm-level cross-sectional survey data of white shrimp (Pacific Vannamei) farms in the Eastern Region of Thailand. Previous studies have investigated technical efficiency and its components 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 DEA in order to measure and explain technical efficiency and its components of white shrimp farms in Thailand. This enables more detailed understanding of the nature of technical efficiency in shrimp production in Thailand.

This paper is organised into five sections. Following this introduction, the analytical framework is described. Next, data and their sources are described. The last two sections cover the empirical findings of this study, and conclusions and policy implications.

Analytical Framework

Coelli et al. (2005), among many others, indicated that the DEA approach has two main advantages in estimating efficiency scores. First, it does not require the assumption of a functional form to specify the relationship between inputs and outputs. This implies that one can avoid unnecessary restrictions about functional form that can affect the analysis and distort efficiency measures, as mentioned in Fraser and Cordina (1999). Second, it does not require the distributional assumption of the inefficiency term.

According to Coelli et al. (2005), the constant returns to scale (CRS) DEA model is only appropriate when the firm is operating at an optimal scale. Some factors such as imperfect competition, constraints on finance, etc. may cause the firm to be not operating at an optimal level in practice. To allow for this possibility, Banker, Charnes and Cooper (1984) introduced the variable returns to scale (VRS) DEA model. Due to the consequence of the heavy intervention by the government in Thai agriculture, the farms may well have been prevented from operating at the optimal level in farm operation. Therefore, technical efficiency in this study is calculated using the variable returns to scale (VRS) DEA model. Following Fare, Grosskopf and Lovell (1985), Coelli et al. (2005) and Sharma, Leung and Zaleski (1999), the input-oriented VRS model is discussed below.

Let us assume there is data available on K inputs and M outputs in each of the N decision units (i.e., farms). Input and output vectors are represented by the vectors x_i and y_i, respectively for the i-th farm. The data for all farms may be denoted by the $K \times N$ input matrix (X) and $M \times N$ output matrix (Y). The envelopment form of the input-oriented VRS DEA model is specified as:

$$
\begin{aligned}
&\min_{\theta,\lambda} \theta, \\
&\text{st} \quad -y_i + Y\lambda \geq 0, \\
&\qquad \theta x_i - X\lambda \geq 0, \\
&\qquad N1'\lambda = 1 \\
&\qquad \lambda \geq 0, \qquad\qquad (1)
\end{aligned}
$$

where θ is the input technical efficiency (TE) score having a value $0 \leq \theta \leq 1$. If the θ value is equal to one, indicating the farm is on the frontier, the vector λ is a $N \times 1$ vector of weights which defines the linear combination of the peers of the i-th farm. Thus, the linear programming problem needs to be solved N times and a value of θ is provided for each farm in the sample.

Because the VRS DEA is more flexible and envelops the data in a tighter way than the CRS DEA, the VRS TE score is equal to or greater than the CRS or 'overall' TE score. The relationship can be used to measure scale efficiency (SE) of the i-th farm as:

$$SE_i = \frac{TE_{i,CRS}}{TE_{i,VRS}} \qquad (2)$$

where SE = 1 implies scale efficiency or CRS and SE < 1 indicates scale inefficiency. However, scale inefficiency can be due to the existence of either increasing or decreasing returns to scale. This may be determined by calculating an additional DEA problem with non-increasing returns to scale (NIRS) imposed. This can be conducted by changing the DEA model in equation (1) by replacing the $N1'\lambda = 1$ restriction with $N1'\lambda \leq 1$. The NIRS DEA model is specified as:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ \text{st} \quad & -y_i + Y\lambda \geq 0, \\ & \theta x_i - X\lambda \geq 0, \\ & N1'\lambda \leq 1 \\ & \lambda \geq 0, \end{aligned} \tag{3}$$

If the NIRS TE score is unequal to the VRS TE score, it indicates that increasing returns to scale exist for that farm. If they are equal, then decreasing returns to scale apply. Note that efficiency scores in this study are estimated using the computer program, **DEAP** Version 2.1 described in Coelli (1996).

In order to examine the effects of the government policy and farm-specific factors on farm efficiency, a regression model is estimated where the level of inefficiency from DEA is expressed as a function of these factors. However, as indicated in Dhungana, Nuthall and Nartea (2000), the inefficiency scores from DEA are limited to values between 0 and 1. That is, farms which achieved Pareto efficiency always have an inefficiency score of 0. Thus, the dependent variable in the regression equation cannot be expected to have a normal distribution. This suggests that the ordinary least squares regression is not appropriate. Because of this, Tobit estimation, as mentioned in Long (1997), is used in this study.

Data

The data used in this study is based on a direct interview survey of 80 randomly selected shrimp farms in the Eastern Region of Thailand. The farms selected were owner operated and had faced similar technologies and economic and marketing environment for inputs and outputs. One output and five inputs are used in the empirical application of this study. The five inputs groups are seed, concentrated feed, land, labour and “other inputs”.

Several farm-specific factors are analysed to assess their influence on productive efficiency. The farm area variable is intended to examine the impact of farm size on the technical inefficiency and its components of the shrimp farms in Thailand. The producer’s education is defined in terms of years of schooling, while GAP experience is derived from a producer’s years of GAP participation. In addition, a dummy variable (1 for participating in farm management training courses, 0 for otherwise) introduced as proxy for participating in shrimp farm management training courses of producers is used, while a dummy variable introduced as proxy for sideline works is employed to investigate the effects of differences in types of producers’ sideline works in different farms on the technical inefficiencies. In addition, the sample shrimp farms also differ in terms of water system which is represented by a dummy variable (1 for the existence of water circulation, 0 for otherwise). Finally, a dummy variable (1 for producer’s experience in black tiger prawn production, 0 for otherwise) introduced as proxy for experience in black tiger prawn production is used to investigate the impacts of the experience on the technical inefficiency and its components of the shrimp farms in Thailand.

Empirical Results

The empirical results indicate that there are significant possibilities to increase efficiency levels in Thai shrimp farms. The producers who have higher education achieved higher levels of overall technical, pure technical and scale efficiencies and a larger farm is likely to be technically more efficient compared to a smaller one. In addition, the producers who experienced in tiger prawn production are likely to achieve higher levels of overall technical and scale efficiencies while there is confirmation that the producers who received farm management training courses achieved higher levels of scale efficiencies.

Conclusions and Policy Implications

This study applied the DEA approach to measure farm-specific technical inefficiency using the 2008 farm-level cross-sectional survey data of Thai shrimp farms. Then, a Tobit regression is estimated and examined the effect of farm-specific socio-economic and management factors on farm efficiency.

There is confirmation that farm size, the differences in producer's education, experience in black tiger production and participation in the training courses have influenced the technical inefficiency of shrimp farms.

The results indicate advantages in producers' higher education and participation in the training courses and larger farms in Thai shrimp production. Therefore, the development policies of the above areas should be used to increase the technical efficiencies of these inefficient farms in Thailand.

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