Abstract

This study estimates the technical, allocative and economic efficiency obtained from the Data Envelopment Analysis (DEA) approach using farm level survey data in northern of Thailand. The objective of this study was to determine the efficiency of broiler farm in Chiang Mai province of Thailand. To explain some of these variations, the efficiency score were regressed on some human capital variable and farming system using a Tobit model. The results from the DEA approach show that most of broiler farms were bad operating practices that only 1 farm was efficiency score, based on Constant Return to Scale (CCR) model. But from the results of Variable Return to Scale (VAR) model, we found 3 farmers were efficient, meaning that they had an efficiency scores. The factors associated with economic efficiency of broiler were household size and experience of farmers, in case of Constant Return to Scale model. While in Variable Return to Scale model, age of farmers appears to be negatively and significantly at 10 percent significant level which indicates that younger farmers are more likely to be inefficiency than their older counterparts. Another variable, which seem to be relate to efficiency, is household size.

Keywords: DEA, Broiler, Farm, Northern, Thailand, Tobit , CCR, VAR

1. Introduction

Poultry provide an immense supply of food for the world’s population. In 2007, global poultry meat production is project at 86.77 million tons, 3 percent higher than last year. Poultry is expected in all regions; especially in Asia chicken meat output. It was the first place that surpassed North America and Europe continents; poultry meat production increased from 10 million tons in 1990 to 30.9 million tons in 2007 (See table 1).

However, condition and circumstances vary considerably between Asian countries. The situation considered here is in Thailand, small country by Asian standards but a globally significant exporter of poultry. Thailand is one of the world’s largest chicken meat producers. In 2007, it ranked 7 in Asian countries with production of 1,136 billion tons; it was produced 4.5 % of the total chicken meat producer in Asia behind Japan, Indonesia, Iran, India and China, respectively. Moreover, the growth of Thai poultry sector is largely attributed to the success achieved in the broiler industry.

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Table 1: Changing contribution of the continents to global poultry meat production between 1990 and 2007

<table>
<thead>
<tr>
<th>Continent</th>
<th>1990 Production (1,000 t)</th>
<th>1990 Share (%)</th>
<th>2007 Production (1,000 t)</th>
<th>2007 Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>1,991</td>
<td>4.9</td>
<td>3,610</td>
<td>4.2</td>
</tr>
<tr>
<td>Asia</td>
<td>10,018</td>
<td>24.4</td>
<td>30,852</td>
<td>35.5</td>
</tr>
<tr>
<td>Europe</td>
<td>11,759</td>
<td>28.7</td>
<td>13,297</td>
<td>15.3</td>
</tr>
<tr>
<td>North America</td>
<td>12,285</td>
<td>30.0</td>
<td>23,231</td>
<td>26.8</td>
</tr>
<tr>
<td>Latin America</td>
<td>4,465</td>
<td>10.9</td>
<td>14,759</td>
<td>17.0</td>
</tr>
<tr>
<td>Oceania</td>
<td>483</td>
<td>1.1</td>
<td>1,023</td>
<td>1.2</td>
</tr>
<tr>
<td>World</td>
<td>41,001</td>
<td>100.0</td>
<td>86,772</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Barbara and Hans-Wilhelm (2011)

From an economic perspective, broiler is the main sector production in the livestock sector, both for domestic consumption and export. While other sectors that also exhibited high growth performances were the swine and egg production. Furthermore, the main regional location of poultry activity is concentrated in the central region of Thailand and farms relatively larger scale of operation-more than 2000 birds on 2000. Northeastern region is the second larger scale in poultry production. While the North region is the third poultry activity but the size (larger scale) has been still small farm and the South region is the fourth to produce the broilers (See fig.1).

As is clear from figure 1, North region is difficulty leading producing meat in the countries. This implies that the several problems plaguing to industry, and make it difficult for existing farm to expand, especially small-scale producers. Therefore, to better understand the problem of agri-business, broiler production, Chiang Mai province, is chosen because it is the central economic growth both population and investment in North region of Thailand.
To improve broiler production in north region of Thailand, we used the Data Envelopment Analysis (DEA) approach to compute the efficiency of farms. Data Envelopment Analysis (DEA) is one of the most popular approaches used in the literature to appraise the performance of farms. Traditional DEA models usually deal with efficiency of input resources versus output products of associated decision-making units (DMUs) within cross sectional data (Tone et al, 2010).

Moreover, there are no studies to determine the efficiency of broiler production in Thailand, but there have focused on the major crop like rice, wheat etc, and none of them have dealt with broiler farming of Thailand. The study also differs from the previous research in Thailand into estimation and explanation of economic efficiency by including variables that relate to both personal aspects and aspects of the decision-making process of the farmer.

The objective of this study is to determine the efficiency of broiler farm. To explain some of these variations, the efficiency score were regressed on some human capital variable and farming system using a Tobit model.

2. Broiler Industry in Thailand

Chicken production as first promoted nationally by King Rama V who introduced at least three new breeds of chicken into Thailand around the turn of the 20th century (Rhode Island Red, White Leghorn, and Barred Plymouth Rock) (Thammabood, 1998). Prior to the 1950 the Thai poultry sector was comprised of smallholders raising birds for own consumption supplemented by local sale. The first move toward industrialization occurred in 1950s when the layer industry began at Kasetsart University in Bangkok (FAO, 2003). Nonetheless, specialization in broiler production did not begun unit the 1960s, developing along with urbanization and infrastructure development that was taking place rapidly in Thailand (Vijor NaRanong, 2007). During these early stages, there were 40-50 poultry wholesalers in Bangkok who purchased live chickens that had been collected by traders from across central and eastern Thailand (Poapongsakorn, 2005). In 1980, the growth of Thai poultry sector is largely attributed to the successes achieved in broiler industry; the sector has transformed itself into quite advanced industrial production under controlled evaporative (EVAP) housing systems, gaining a foothold in the highly competitive international market for chicken meat. The development of Thai poultry industry is likewise reflected in the growing importance of the contribution of the sector in the livestock economy. The share of poultry in livestock GDP steadily rose from 30% in 1980 to more than half (53%) by 2001-other sectors, cattle, buffalo, and swine, were declined (Achilles Costales, 2004).

Production and consumption of poultry have greatly increased over the past few decades. Per capita consumption of chicken meat rose from 2 lbs per year in 1970 to 22 lbs year in 1992 (Willis et al, 1992). As a result of decreasing prices and increasing incomes, chicken has become the most affordable and most popular source of meat in Thailand (Costales et al, 2005).

Export has been very significant for the broiler sector. Between 1994 and 2003, the total quantity of broiler export almost tripled, increased by 187%. This period also witnessed a significant structural change in export. Prior to 1994, almost all exports were frozen de-boned raw chicken, as Thailand’s competitive advantage stemmed from her low wage rates. The export of precooked chicken meat products began in the early 1990s and accounted for less than 10% of the total in 1994. It has been increasing sharply ever since (Viroj NaRanong, 2007).

However, High Pathogenic Avian Influenza (HPAI), H5N1 type, has hit Thailand periodically since January 2004. Domestic demand also decreased immediately. The shock affected poultry producers of all sizes. Economically, large producers sustained the biggest losses. The Thai broiler exporter association estimates that the industry lost 5-6 million Baht as a result of the outbreaks in 2004 alone (USDA, 2005).
Many small producers who rely on poultry as an important part of their livelihood were also adversely affected by the culling of their flock or loss of income from decreased demand. Since 2006, there are no reports of HPAI-related deaths or culls in broiler farms since the reoccurrence of the disease in July 2006. Since April 2007, the Thai broiler industry has successfully addressed many issues plaguing them in the past year. The factors driving this turnaround include increased productivity, reduced pressures from high stocks, and increased prices in both domestic and overseas markets. Reflecting growing domestic consumption and export demand. Thai broiler production is expected to increase by at least 8% in 2008.

3. Methodology

3.1 Data

The data used in this study were collected through broiler farmers in the north region, Chiang Mai province of Thailand. The farm accounting data for this empirical application was collected from 4 zones in Chiang Mai province. The survey carried out during the October to November, 2011. A sample of 52 broiler farms, which are located mainly in the Chiang Mai province was surveyed for the application of this analysis. This area was selected because broiler production and processing are important activity.

The questionnaire for the survey was constructed to ask for the detail about the poultry operation on the farms. In particular, questions were included to determine the number of broilers and the use of input, such as labor, feed and capital. Information was also obtained on some basic personal characteristics of the sample farmers.

3.2 Method of Analysis

In this study input-oriented measures were chosen to reflect local reality, where a decrease in scarce resources (input) use is relevant. Let us suppose that there are \( k = 1, \ldots, K \) Decision Making Units (DMUs), which in the context of our empirical application are broiler farmers. Each DMU produces \( m = 1, \ldots, M \) output using inputs that are both under and beyond a farmer control. Let us further assume that there are data available on \( K \) inputs and \( M \) outputs for each of \( N \) exploitations. The \( K \times N \) input matrix \( X \) and the \( M \times N \) output matrix \( Y \) represent the data for all the farms. An intuitive way to introduce the DEA is via the ratio form. For each farm we would like to obtain a measure of the ratio of all output over all inputs. According to Charnes et al (1978), the optimal weights are obtained by solving following mathematical programming problem (1):

\[
\begin{align*}
\text{Max}_{u,v} \left( u^\prime y_i / v^\prime x_i \right) \\
\text{st} \quad u^\prime y_i / v^\prime x_i \leq 1 & \quad j_i = 1,2, \ldots, N \\
u, v \geq 0
\end{align*}
\]

where, \( u \) is an \( M \times 1 \) vector of output weights and \( v \) is a \( K \times 1 \) of input weights. The efficiency measure for the \( i \)-th DMU is maximized, subject to the constraints that all efficiency measures must be less than or equal to one. To avoid this, Charnes et al (1978) proposed the use of a CRS (constant return to scale) equivalent Duality Linear Program which is defined as the following:

\[
\begin{align*}
\text{Min} \quad & \theta \\
\text{Subject to} \quad -y_i + Y\lambda \geq 0 \\
\theta x_i - X\lambda & \geq 0
\end{align*}
\]
where, $\theta$ is a scalar and $\lambda$ is a vector of constants $x_i$ and $y_i$ are column vectors with the input and output data for the $i$-th farm. $X$ is a K by N matrix and $Y$ is a M by N matrix with respectively all input and output data for all input and output data for all N farms in the sample. The value $\theta$ is a score always lying between zero and one, with a value of one indicating that the farm lies on the frontier and is efficient. An implicit assumption of the model described above is that returns to scale are constant and thus farms are operating at an optimal scale (Fraser and Cordina, 1999). A BCC (Banker et al, 1984) DEA model computes however for a Variable Return to Scale (VAR) by adding the convexity constraint: $N \lambda = 1$, to the CCR model (1) above. Without this convexity constraint, the DEA model will describe a CRS situation.

Furthermore, based on the technical and allocative efficiency the economic efficiency can be determined as $EE = AE \cdot TE$. Allocative efficiency itself is calculated in two steps. First a cost minimizing vector of input quantities given the input prices is determined using the model from program 3:

$$
\begin{align*}
\text{Min}_{x_i^*, \lambda} \quad & w' x_i^* \\
\text{Subject to} \quad & -y_i + Y \lambda \geq 0 \\
& x_i^* - X \lambda \geq 0 \\
& N \lambda = 1 \\
& \lambda \geq 0
\end{align*}
$$

(3)

where $w_i$ is a vector of input prices for the $i$-th farm and $x_i^*$ (which is calculated by using linear programming) is the cost-minimizing vector of input quantities for the $i$-th farm, given the input prices $w_i$ and the output level $y_i$. The other symbols are defined the same as eq. 1. The economic efficiency (EE) of the $i$-th farm is calculated as the ratio of the minimum cost to the observed cost (eq.2).

$$
EE = \frac{w' x_i^*}{w' x_i}
$$

(4)

After efficiency measurement, the research identifies the factors that influence the farm technical, allocative and scale efficiency using a Tobit analysis. The factors used in this study consist mainly of farm’s human capital variables. Human capital variables includes farmer’s age, farmer’s education background or schooling (number of years), total number of family members (family size), experience, and access to credit.

In this research, Tobit analysis has been used because the dependent variable, efficiency, is a censored variable with an upper limit of one (Lockheed et al, 1981). This Tobit model is employed using DEA method to estimate the factors associated with efficiency with the help of Limdep statistical tool. The dependent variable in this model is the initial $IE_i$ calculated by DEA.

$$
IE_i = \alpha_0 + \alpha_1 \text{Age} + \alpha_2 \text{EDU} + \alpha_3 \text{EXP} + \alpha_4 \text{HH} + \alpha_5 \text{Credit} + \epsilon
$$

(5)

where;

$IE_i$ is the technical, allocative and economic efficiency of poultry farms
Age is the age of the farmer in year
Edu is the education of the farmers (years)
Exp is the experience of poultry farming (year)
HH is the family member in number
Credit is access to credit (dummy variable; it the credit access = 1, and otherwise = 0)
$\epsilon$ is the error term.
4. Empirical Results

4.1 Correlation between input sources and output in broiler production

Data in Table 2 indicated the correlation between inputs and output used in the broiler production in the studies area, Chiang Mai province. The value of correlation co-efficiency could vary from minus one to plus one. A plus or positive indicated a perfect positive correlation.

A correlation of zero means there is no relationship between the two variables. The highest correlation value found was between feed and chick cost as 0.86, indicating that, as the value of bird or feed cost increases, the value of the feed cost or bird increases.

Table 2: Correlation between input sources and output in broiler production

<table>
<thead>
<tr>
<th>Variables</th>
<th>Chick</th>
<th>Labor</th>
<th>Feed</th>
<th>Fixed costs</th>
<th>Variables cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chick</td>
<td>1.00</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Labor</td>
<td>0.69</td>
<td>1.00</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Feed</td>
<td>0.86</td>
<td>0.72</td>
<td>1.00</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fixed costs</td>
<td>0</td>
<td>0</td>
<td>0.29</td>
<td>1.00</td>
<td>0</td>
</tr>
<tr>
<td>Variable costs</td>
<td>0.68</td>
<td>0.50</td>
<td>0.69</td>
<td>0.25</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Source: Author calculated

4.2 Technical Efficiency, Allocative Efficiency, and Efficiency score of farm base on CRS and VAR model

In this study, we used CRS and VAR modes to evaluate technical, allocative, and economic efficiency of broiler farms. The results of CRS and VAR models were shown in Figure 2. Based on CRS results, this study showed only 1 farmer was relatively efficiency in TE, AE, and EE and the remaining 51 farms were inefficient (i.e. their efficiency score were below 1). But from the results of VAR model, we found 3 farmers (out of total 52 farmers) were efficient, meaning that they had an efficiency score of 1, in TE, AE, EE, respectively. Other farmers that had efficiency score less than one, were inefficiency in input used.
The average values of TE, AE, and EE were summarized in Table 3. The average values of TE, AE, and EE were found to be 0.62, 0.63, and 0.38, respectively. The efficiency farmers obviously followed bad operating practices. However, among the efficient farmers, some farms showed better operating practices than others. Therefore, discrimination is required to be made among the efficiency farmers while seeking the best operating practices. These efficient farms could be selected by inefficiency DMUs as best practice DMUs, making them a composite DMU instead of using a single DMU as a benchmark (Heidari Md. et al., 2011).

Table 3: Summary statistical of efficiency estimates of farm based on CRS and VAR model

<table>
<thead>
<tr>
<th>Efficiency index (%)</th>
<th>Data Envelopment Analysis</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CRS</td>
<td>TE</td>
<td>AE</td>
<td>EE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VAR</td>
<td>TE</td>
<td>AE</td>
<td>EE</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.62</td>
<td>0.63</td>
<td>0.38</td>
<td>0.69</td>
<td>0.62</td>
</tr>
<tr>
<td>Maximum</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.44</td>
<td>0.23</td>
<td>0.15</td>
<td>0.54</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Source: Field survey, 2011
4.3 Tobit regression analysis of factors associated with inefficiency

The Tobit regression model was used to estimated factors associated with economic efficiency of broiler as illustrated in Equation (5). The maximum likelihood estimation of determinants of efficiency of broiler farms was presented in Table 4. From the result household was positively and significant related to farm’s technical, allocative and scale efficiency in case of CRS. This finding supports the view that the members of firm/farm could decrease their costs for produce the broiler.

The experience of farmers was significant and positive at 90 % (technical efficiency). A possible way explanation was that experienced farmers have more knowledge on their resource & practices, which enables them to resource utilization more efficiency. The implication was that farmers with more years of experience tend to be more efficient in broiler production. Continues practices of an occupation for long period presumably make a person more experienced and more productive in practice. This agreed with Adeoti (2004) who reported the years of experience reduce farmers’ inefficiency.

Table 4: Tobit regression analysis of factors associated with inefficiency

<table>
<thead>
<tr>
<th>Factors</th>
<th>TE</th>
<th>AE</th>
<th>EE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant return to scale</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.642**</td>
<td>0.522**</td>
<td>0.397***</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0037</td>
<td>-0.0046</td>
<td>-0.0052</td>
</tr>
<tr>
<td>Education</td>
<td>-0.0051</td>
<td>0.0090</td>
<td>0.0055</td>
</tr>
<tr>
<td>Household</td>
<td>0.031*</td>
<td>0.0503***</td>
<td>0.0293*</td>
</tr>
<tr>
<td>Experience</td>
<td>0.0048*</td>
<td>0.0038</td>
<td>0.0042</td>
</tr>
<tr>
<td>Access to Credit</td>
<td>0.0100</td>
<td>-0.030</td>
<td>-0.001</td>
</tr>
<tr>
<td><strong>Variable return to scale</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.8943***</td>
<td>0.4494*</td>
<td>0.545**</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0094**</td>
<td>-0.0016</td>
<td>-0.0046</td>
</tr>
<tr>
<td>Education</td>
<td>-0.005</td>
<td>0.009</td>
<td>0.0085</td>
</tr>
<tr>
<td>Household</td>
<td>0.374</td>
<td>0.0451*</td>
<td>0.0241</td>
</tr>
<tr>
<td>Experience</td>
<td>0.0047</td>
<td>0.009</td>
<td>0.0013</td>
</tr>
<tr>
<td>Access to Credit</td>
<td>0.0725</td>
<td>-0.038</td>
<td>-0.0025</td>
</tr>
</tbody>
</table>

Source: Field survey, 2011

Note: * significant at 5 % level, ** significant at 10 % level, and *** significant at 1% level.

In case of VRS, age was negatively and significantly related to farm’s technical efficiency. According to these results, age of farmers appeared to be negatively and significantly at 10 percent significant level which indicated that younger farmers were more likely to be inefficiency than their older counterparts. Another variable, which seem to be relate to efficiency, was household size. It was positive and statistically significant in allocative efficiency but insignificant in technical and scale of economic.

5. Discussion

Poultry production has been a good business for many Thailand farmers. In the study area, the total bird population in 52 farms was more than 5,000 birds. This shows that broiler production was medium-scale in the study area. This result agreed with FAO (2003) that poultry farmers of Thailand were in the categories...
of medium and large-scale. Looking at the efficiency score, the results were not surprising as it has been shown that DEA scores computed with the CRS assumption were less than or equal to the corresponding VRS efficiency scores. This agreed with Khalid and Francis (2003) that technical, allocative and economic efficiency were significantly higher with VRS than CRS.

For the relative to output performance studies, the results revealed substantial production efficiency for the sample of broiler farmers in Chiang Mai province of Thailand and hence considerable potential for enhancing profitability by reducing the production costs by improving the efficiency. Analysis of various farms showed that household or family size has positive and significant effect on technical efficiency level, CRS. The positive and significant sign of the coefficients were in line with the finding of Yusuf and Malono (2007). They point out that household size had significant impact on the farmers’ efficiency.

6. Conclusion

In this study technical, allocative and economic efficiency of broiler farms in Thailand have been estimated by using the Data Envelopment Analysis (DEA) approach and the variation in economic efficiency was explained using various farm-specific human capital variables. Assessment of efficiency implies considerable amount of technical, allocative and economic efficiency among the sample farms. The results showed that under constant return to scale (CRS) and variable returns to scale (VAR) specification, technical, allocative and economic efficiencies were bad operating practices that only 1 farm was efficiency score, based on Constant Return to Scale (CCR) model. But from the results of Variable Return to Scale (VAR) model, we found 3 farmers were efficient, meaning that they have an efficiency score.

Evaluating factors associated with efficiency suggest that farmer’s household, and experience, were most statistically significant factors associated with technical efficiency in CRS specification. These mean that the members of farm could decrease their costs and more years of experience tend to be more efficient in broiler production. Thus the results of the study gave information to policy makers and extension services on how to better aim efforts to improve broiler farm efficiency.

To summarize, this paper could be considered as applying a more advanced approach of identifying the efficiency drivers. It exhibits a DEA approach which was combined with Tobit analysis to obtain estimates of efficiency score. Therefore, this analysis contributes to knowledge about the efficiency sources of Thailand broiler production farms. Policy makers and managers can use these results with increasing confidence in order to develop ways to improve performance of separate farms and of the whole industry.

7. Acknowledgement

The authors are grateful to thank Dr. Narin Throngvitaya for assistance and for providing the data. Provincial Livestock Office in Chiang Mai province of Thailand is also gratefully acknowledged for providing the data on Chiang Mai province. Moreover, the authors would like to thank all broiler farmers who contributed to this survey.

References


