Centre for ASEAN Studies

Centre for International Management
and Development Antwerp

ISSN-2031-065X

An efficiency analysis of fishery and rice processing firms in the Mekong Delta: a non-parametric approach

Quan Minh Nhut[1]

CAS Discussion paper No 75

May 2010

---

[1] PhD student, Can Thö University, Vietnam. Promotor: prof. dr. L. Cuyvers, Department of International Economics, International Management and Diplomacy, University of Antwerp, Belgium.

Abstract

This paper focuses on estimating firms' production efficiency in terms of technical, allocative, cost and scale efficiencies. We endeavour to single out factors influencing the efficiency. Cross-sectional data were collected in fishery and rice processing firms in the Mekong Delta in the year 2007. The empirical results indicate that the enterprises in both the fishery and rice processing sectors mostly attain high efficiencies in terms of technical, allocative, cost and scale efficiencies in comparison with the best performance enterprises of their own sector. Regarding sources of efficiency estimated by the truncated functions (the Tobit function), the results indicate that age, credit, education, type of firm and size of capital are the main factors influencing the efficiency of both the fishery and rice processing enterprises.

Keywords: technical efficiency, allocative efficiency, cost efficiency, scale efficiency, source of efficiency, fishery processing firm, rice processing firm, data envelopment analysis, tobit function.

1. Introduction

The Mekong Delta (MD) is known as a central region for the development of socio-economics with important contributions to the national economy development. The total number of enterprises in the MD is 12,757, accounting for about 14% of the total number of enterprises nationwide. However, most of them are likely small and medium scale enterprises in terms of labour force and capital resources (Statistical yearbook of the Mekong Delta, 2008). This may lead them to having some difficulties in their business activities and hence getting low efficiency of production. In addition, Vietnam has become an official member of the World Trade Organization (WTO) since 11 January, 2007. On the one hand, this may create big opportunities for enterprises with large consumption markets and investments. On the other hand, this may lead them to challenges with more risks of sharp competitions related to both prices and qualities of goods and services.

Because of such characteristics, the enterprises in the MD are facing opportunities and challenges - whether to get more opportunities or not? This definitely depends on their capacity and efficiency in their operation. An efficiency comparative analysis of the selected enterprises and determining factors influencing their efficiency, therefore, seem appropriate and useful.

2. Data collection

2.1 Secondary data

Secondary data include data on the characteristics of the enterprises in the MD in terms of the total number of enterprises; production scale with respect to labour, capital, fixed asset and long-term investment as well as turnover and profits; current situation and short and long term plans of production and development. Moreover, the data were collected from the trade departments and centers as well as from secondary sources such as statistical yearbooks, trade and economic journals and newspapers, official documents and reports and local authorities.

2.2 Primary data

The heads of the enterprises were personally interviewed by trained interviewers who are junior staff members of the School of Economics and Business Administration of Can Tho University (SEBA) under the supervision of the researcher.

Prior to official data collection, permissions to conduct the interview in the sample enterprises were secured by the municipal and local executives. Such permissions were necessary to establish relationship and cooperation with the respondents.

The surveys of two groups of enterprises correspond to two selected industry activities: fishery and rice processing. The surveys were carried out in eight provinces: Tien Giang, Tra Vinh, An Giang, Can Tho, Soc Trang, Ben Tre, Ca Mau and Kien Giang.

As it is impossible to study all the enterprises in the selected provinces, the samples were drawn to select enterprise representatives from a population which is specialized in fishery and rice processing in the year 2007. In each selected province, the selection of enterprises was done by a random sampling method. Through this sampling scheme, two groups of enterprises were randomly selected. Of these two groups, one consisted of 35 enterprises which specialized in fishery processing and the other included 65 enterprises which specialized in rice milling.

3. Methodology

3.1 Calculation of Scale Efficiency, using the Constant and Variable Returns to Scale - Data Envelopment Analysis (CRS and VRS-DEA Models)

Data envelopment analysis (DEA) is an approach to frontier estimation based on the mathematical programming method instead of the econometric method to measure the production efficiency of a firm. DEA was first proposed by Farrell (1957), then by Boles (1966), Shephard (1970), and Afriat (1972). However, the idea did not drawn much attention. This lasted until the publication of the comprehensive papers of Charnes, Cooper and Rhodes in 1978[2], in which the DEA model strongly focused on the input-oriented approach (i.e. a firm has more control on inputs than on outputs) and relied on the constant returns to scale (CRS) circumstance. This model is known as the CRS-DEA model.

In recent decades, many studies have decomposed the technical efficiency (TE) scores obtained from a CRS- DEA model into two components, one due to *"pure" technical efficiency* and one due to *scale efficiency* (SE). The TE reflects the ability of a firm to produce maximal output from a given set of inputs together with available production techniques and the best use of experience, infrastructure and policy supports, whereas a SE measure can be used to indicate the amount by which productivity can be increased by moving to the *technically optimal production scale* (TOPS).

To measure SE in DEA, a DEA model under the variable returns to scale (VRS) situation must be specified because SE is measured by the ratio of TE^{CRS} (TE under CRS) to TE^{VRS} (TE under VRS). This model was developed by several authors among which Banker, Charnes and Cooper in 1984[3]. The model of Banker et al. (1984) allows us to measure the efficiency of a firm which operates with VRS in both the input and output-oriented situation. This model is known as the VRS-DEA model. Many more papers such as Lovell et al. (1993), Battese and Coelli (1998) and Coelli et al. (2005) have been published since then.

According to C.A.K. Lovell et al. (1993), the evaluation of the efficiency of a decision making unit (DMU) is based on a comparison between observed and optimal values of its output and input. The comparison can take the form of *the ratio of observed to maximum potential output obtainable from the given input* or *the ratio of minimum potential to observed input required to produce the given output*. The former ratio corresponds with the *output oriented* approach while the latter is appropriate for the *input oriented* approach.

---

[2] Charnes, A., W.W. Cooper and E. Rhodes (1978), 'Measuring the Efficiency of Decision Making Units', European Journal of Operational Research, 2, 429-444.

[3] Banker, R.D., A. Charnes and W.W. Cooper (1984), 'Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis', Management Science, 30, 1078-1092.

The ratio is easy to calculate if the unit uses a single input to produce a single given output. However, it is no longer simple when the unit uses several inputs *{x_j, j = (1, 2,…, m)}* to produce a given output. In this case, the inputs must be aggregated, so that the efficiency remains the scalar *(say λ)*. Therefore, for a particular unit *p* $\{(p \in N, N = (1,2,\ldots,n)\}$ under input orientation, the ratio is written as follows:

$$\left(\frac{\sum_{j=1}^{m} \lambda_i x_{ji}}{\sum_{j=1}^{m} x_{jp}} \right), \qquad i = 1, 2,\ldots, n)$$

From an economic point of view, this ratio has to be minimized and forms the objective function for that unit. Generally, consider the situation with a sample of n decision making units (DMUs), {N=(1, 2,…, n)}, each of the DMUs produces s outputs {S=(1, 2,…, s)} by using m different inputs {M=(1, 2,…, m)}. According to Lovell (1993), Charnes et al. (1994) and Coelli et al. (1998 & 2005), the relative TE for the particular DMUp $(p \in N)$ under CRS and according to the input oriented approach the optimal weights (λ_i^*) are calculated by solving the following linear programming (LP) problem[4]:

$$\min_{\theta_p, \lambda} \left(\frac{\sum_{j=1}^{m} \lambda x_{ji}}{\sum_{j=1}^{m} x_{jp}} \right) = \theta_p$$

subject to: (1)

$$-q_{rp} + \sum_{i=1}^{n} \lambda q_{ri} \geq 0, \qquad r = 1,\ldots,s$$

$$\theta_p x_{jp} - \sum_{i=1}^{n} \lambda x_{ji} \geq 0, \qquad j = 1,\ldots,m$$

$$\lambda_i \geq 0, \qquad i = 1,2,\ldots,p,\ldots,n$$

[4] This model is called the CCR model or CRS-DEA model.

The LP problem (1) can be rewritten as the following full form :

$$
\left\{
\begin{array}{l}
\min\limits_{\theta_p,\lambda} \left(\dfrac{\sum_{j=1}^{m} \lambda x_{ji}}{\sum_{j=1}^{m} x_{jp}} \right) = \theta_p \\
\text{subject to:} \\
\left\{
\begin{array}{l}
-q_{1p} + (\lambda_1 q_{11} + \lambda_2 q_{12} + \ldots + \lambda_p q_{1p} + \ldots + \lambda_N q_{1N}) \geq 0 \\
-q_{2p} + (\lambda_1 q_{21} + \lambda_2 q_{22} + \ldots + \lambda_p q_{2p} + \ldots + \lambda_N q_{2N}) \geq 0 \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
-q_{Sp} + (\lambda_1 q_{S1} + \lambda_2 q_{S2} + \ldots + \lambda_p q_{Sp} + \ldots + \lambda_N q_{SN}) \geq 0
\end{array}
\right. \\
\left\{
\begin{array}{l}
\theta_p x_{1p} - (\lambda_1 x_{11} + \lambda_2 x_{12} + \ldots + \lambda_p x_{1p} + \ldots + \lambda_N x_{1N}) \geq 0 \\
\theta_p x_{2p} - (\lambda_1 x_{21} + \lambda_2 x_{22} + \ldots + \lambda_p x_{2p} + \ldots + \lambda_N x_{2N}) \geq 0 \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
\theta_p x_{Mp} - (\lambda_1 x_{M1} + \lambda_2 x_{M2} + \ldots + \lambda_p x_{Mp} + \ldots + \lambda_N x_{MN}) \geq 0
\end{array}
\right. \\
(\lambda_1, \lambda_2, \ldots, \lambda_p, \ldots, \lambda_N) \geq 0
\end{array}
\right.
\qquad (2)
$$

where: i = parameter presenting the number of DMUs (i = 1, 2,…, *p*,…, n);

j = parameter presenting the number of inputs (j = 1, 2,…, m);

r = parameter presenting the number of outputs (r = 1, 2,…, s);

$\sum_{j=1}^{m} \lambda x_{ji}$ is the minimum feasible/ potential input quantity {determined by a weighted combination (i.e. the λ_i) of input of all DMUi} that could be used to produce a given output level;

$\sum_{j=1}^{m} x_{jp}$ is the observed input quantity used by the DMUp to produce a given output level. Note that this observed input is fixed;

$\theta p = \dfrac{\sum_{j=1}^{m} \lambda x_{ji}}{\sum_{j=1}^{m} x_{jp}}$, is the ratio of the minimum feasible input to the observed input of DMUp required to produce a given output level. This ratio is considered as the efficiency score of DMUp and has a value $0 \leq \theta \leq 1$. The DMUp is more efficient corresponding to value of θ which is closer to the unity;

λ_i = an *N*x1 vector of weights which defines the linear combination of the DMU*i* and subsequently creating a *projected/ virtual point* of the DMU*p* lying on the frontier. This projected point is the fully efficient potential point produced by the radial contraction of the input vector with unchanged output level;

q_{rp} = amount of output *r* produced by the DMU*p*;

x_{jp} = amount of input *j* utilized by the DMU*p*;
q_{ri} is *(n x s)* matrix of *s* outputs of each DMU in the analyzed sample;
x_{ji} is *(n x m)* matrix of *m* inputs of each DMU in the analyzed sample.

The TE under CRS (TE^{CRS}) and the CRS-DEA model have been presented so far. The CRS is only appropriate when all units are operating at an optimal scale. In fact, there are several factors such as imperfect competition, constraints on finance, etc., which may cause some units for not operating at the optimal scale. To overcome this problem, a DEA model related to the VRS situation has been developed for estimation of the TE score under VRS (TE^{VRS}).

Technically, scale efficiency (SE) of a firm is measured by the ratio of the TE^{CRS} to the TE^{VRS}. Therefore, the TE^{VRS} must be calculated. To do this, a VRS production frontier must be defined for the envelopment of the observed data. In other words, a convex curve to the CRS production frontier must be constructed by the linear programming technique. This is done by simply adding the convexity constraint $\sum_{i=1}^{n}\lambda_i = 1$ to equation (1). This constraint makes sure that the technical inefficiency is only compared between similar firms (i.e., in this case, the projected point is defined by a convex combination of the peer firms on the frontier). This approach forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS and thus produces a VRS envelop/ frontier. The DEA approach for measurement the TE based on the VRS frontier is called the VRS-DEA model. Thanks to such characteristics, TE scores of farm households under the VRS frontier are greater than or equal to those under the CRS frontier.

Similarly, with regard to the situation with a sample of n firms, *{N=(1, 2,…, n)}*, each of the firms produces s outputs *{S=(1, 2,…, s)}* by using m different inputs *{M=(1, 2,…, m)}*. A linear programming (LP) problem based on the VRS and input-oriented approach to measure efficiency for the particular firm*p* $\left(p \in N\right)$ is specified as follows[5]:

$$\min_{\theta_p,\lambda} \left(\frac{\sum_{j=1}^{m}\lambda x_{ji}}{\sum_{j=1}^{m}x_{jp}} \right) = \theta_p$$

subject to: (3)

$$-q_{rp} + \sum_{i=1}^{n}\lambda q_{ri} \geq 0, \qquad r = 1,\ldots,s$$

$$\theta_p x_{jp} - \sum_{i=1}^{n}\lambda x_{ji} \geq 0, \qquad j = 1,\ldots,m$$

$$\sum_{i=1}^{n}\lambda_i = 1,$$

$$\lambda_i \geq 0, \qquad i = 1,2,\ldots,p,\ldots,n$$

[5] This model is called the BCC model or VRS-DEA model.

The LP problems (1, 2 and 3) can be solved by using a number of different computer programs. For simplicity, the DEAP[6] version 2.1 provided by Coelli (1998, 2005) is used in this study.

3.2 Calculation of Technical Efficiency, Allocative Efficiency and Cost Efficiency, using Constant Returns to Scale - Data Envelopment Analysis (CRS-DEA Model)

Productivity of a firm consists of not only the technical component as TE or of the component of operation scale like SE but also of other components such as effects of resource allocation (allocative efficiency-AE) and the use of productive costs (cost/economic efficiency - CE). The AE measure is used to evaluate the firm's ability to allocate and utilize a mix of inputs in the optimal way with given relative prices and production technology. The CE is calculated by the combination of TE and AE, and hence, may be used to estimate the possibility of the firm's cost savings when moving to the technically and allocatively efficient point with given input prices and technology.

In the case of available information on input prices, the TE, AE and CE can be measured by using the CRS Input-oriented DEA Model. Consider the situation with n observations of firms, each of the firms produces s outputs using m different inputs. The LP problem must run n times, one for each firm. For the particular firm $p\,(p \in N)$, the DEA model is specified[7].

$$\min_{\left\{\lambda, x_{jp}^{*}\right\}} \left\{ w_{jp}^{'} x_{jp}^{*} \right\}$$

subject to: (4)

$$-q_{rp} + \sum_{i=1}^{n} \lambda q_{ri} \geq 0, \qquad r = 1,\ldots,s$$

$$x_{jp}^{*} - \sum_{i=1}^{n} \lambda x_{ji} \geq 0, \qquad j = 1,\ldots,m$$

$$\lambda_i \geq 0, \qquad i = 1,2,\ldots,p,\ldots,n$$

where x_{jp}^{*} is the input vector j utilized by the firm p with respect to production cost minimization, x_{jp}^{*} is calculated from the LP, w_{jp} is the input price vector j paid by the firm p, and all notation used is as previously defined in the LP problem (1).

The LP problem (4) can be analogously explained as the LP problem (1) except that the problem (4) must have the optimal values for λ and x_{ij} (i.e., λ^{*} and x_{ij}^{*}) in order to be able to obtain the efficiency of the firm p with respect to production cost minimization.

Similarly, the LP problem (4) can be solved by using specific computer programs. For simplicity, the DEAP version 2.1 is used.

---

[6] See "A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program", Coelli (1996).

[7] Coelli et al. (2005).

3.3 Calculation of Sources of Efficiency, using the Tobit Function

In this section, we would like to know how the environment factors have impact on the TE, AE and CE of the selected enterprises. Remember that, however, scores of these efficiencies have values between zero and one. Therefore, the dependent variable attains values between 0 and 1. In other words, the dependent variable can be considered as a truncated variable between 0 and 1. Thus, the Tobit regression method should be used to estimate the impact of environment factors on the efficiencies (McCarty and Yaisawarng, 1993, Coelli et al., 2005).

To estimate these impacts, we use eleven variables in the model such as Sex, Age, Credit, Land ownership, Education, Ratio of Female labour to Total labour, Experience, Scale of firm, Type of firm, Training and Size of capital. The Tobit function is written as follows:

$$\text{Efficiency} = \beta_1(\text{Sex}) + \beta_2\ln(\text{Age}) + \beta_3(\text{Credit}) + \beta_4(\text{Land ownership}) + \beta_5\ln(\text{Education}) + \beta_6\ln(\text{Fe\_labour/Total}) + \beta_7\text{Ln}(\text{Experience}) + \beta_8(\text{Scale of firm}) + \beta_9\text{Ln}(\text{Type of firm}) + \beta_{10}\text{Ln}(\text{Training}) + \beta_{11}\text{Ln}(\text{Size of capital}) \quad (5)$$

where:

Efficiency	= Technical Efficiency/ Allocative Efficiency/ Cost Efficiency of enterprises calculated in the DEA methods;
Sex	= dummy variable for gender, 1 if the enterprise head is male, or 0 if the enterprise head is female;
Age	= the age of the enterprise head;
Credit	= dummy variable for bank loan, which equals one if the enterprise has a bank loan and zero otherwise;
Land_Ownership	= dummy variable for land ownership, which equals one if at least a part of the area used for production is on a tenancy arrangement and zero otherwise;
Education	= years of formal schooling of the enterprise head;
Fe_Labour/T_Labour	= the proportion of female labour, measured as the number of female labourers divided by the total labourers in production process;
Experience	= the number of years in operation;
Scale of firm	= dummy variable for type of enterprise, which equals one if the enterprise is small and medium size and zero if large;
Type of firm	= 1 = foreign and private, 2 = state own enterprise (SOE);
Training	= the number of days to be trained;
Size of capital	= total value of the enterprise.

4. Results and discussion

4.1 Technical, allocative and cost efficiencies

4.1.1 Data for calculation of household efficiency, using the DEA model

To measure the TE, AE and CE of the selected enterprises in the MD, two separate data sets - one from 30 fishery processing enterprises and the other from 56[8] rice processing enterprises - were used.

The variables of output quantities, input quantities and prices – used in the Constant Returns to Scale Input-Orientated DEA Model to calculate the TE, AE and CE using DEAP Version 2.1 – are depicted as in Table 1.

Table 1: The Input and Output Variables used in CRS-DEA Model

(Average values of the selected enterprises)

Items	Variables	Fishery processing enterprises	Rice processing enterprises
Outputs			
Output (ton)	y	12,652	13,278
Inputs			
Area for production (m^2)	x_1	5,689	1,901
Machine (quantity)	x_2	6	2
Labour (person)	x_3	855	27
Electricity (kw)	x_4	4,453,425	482,354
Water for production (m^3)	x_5	615,997	-
Input raw material (ton)	x_6	28,024	16,300
Input prices			
Hired area (1000VND/m^2)	w_1	11.09	11.00
Depreciation of machine (1000VND/year)	w_2	517,671	50,080
Wage (1000VND/person/month)	w_3	1,856	1,485
Electricity (1000VND/kw)	w_4	0.85	0.90
Water (1000VND/m^3)	w_5	4.50	-
Material (1000VND/ton)	w_6	37,086	3,658

Source: Own estimates from the data surveyed in 2008.

A linear programming problem must be solved for each enterprise in each of the two selected industries. Thus, the CRS input-oriented DEA model for the enterprise p is used.

In the case of the rice processing industry, there are data on 1 output and 5 inputs of 56 enterprises (Table 1), Model (4) is written as follows:

[8] The author first interviewed 65 rice milling enterprises and 35 fishery processing enterprises, but some observations were eliminated because of their ineligibility for analyses. Subsequently, there were 56 and 30 involved in rice and fishery processing were used, respectively.

min

$$(w_{11}x^*_{11}+ w_{12}x^*_{12} +...+ w_{1p}x^*_{1p}+...+ w_{1\,56}x^*_{1\,56})$$
$$(w_{21}x^*_{21}+ w_{22}x^*_{22} +...+ w_{2p}x^*_{2p}+...+ w_{2\,56}x^*_{2\,56})$$
$$\dots\dots\dots\dots\dots\dots\dots\dots\dots$$
$$(w_{51}x^*_{51}+ w_{52}x^*_{52} +...+ w_{5p}x^*_{5p}+...+ w_{5\,56}x^*_{5\,56})$$

subject to:

$$\begin{aligned}
&- y_{1p} + (\lambda_{11}y_{11} + \lambda_{12}y_{12} +...+ \lambda_{1p}y_{1p} +...+ \lambda_{1\,56}y_{1\,56}) \geq 0 \\
&x^*_{1p} - (\lambda_{11}x_{11} + \lambda_{12}x_{12} +...+ \lambda_{1p}x_{1p} +...+ \lambda_{1\,56}x_{1\,56}) \geq 0 \\
&x^*_{2p} - (\lambda_{21}x_{21} + \lambda_{22}x_{22} +...+ \lambda_{2p}x_{2p} +...+ \lambda_{2\,56}x_{2\,56}) \geq 0 \\
&\dots\dots\dots\dots\dots\dots\dots\dots\dots \\
&x^*_{5p} - (\lambda_{51}x_{51} + \lambda_{52}x_{52} +...+ \lambda_{5p}x_{5p} +...+ \lambda_{5\,56}x_{5\,56}) \geq 0 \\
&(\lambda_1, \lambda_2,..., \lambda_p,..., \lambda_{56}) \geq 0
\end{aligned} \tag{6}$$

In the case of the fishery processing industry – there are data on the 1 output and 6 inputs of 30 enterprises (Table 1) – the model used to measure the TE, AE and CE is similar to Model (6).

4.1.2 Empirical results

With regard to the TE, the mean TE scores are less than 1 for both types of enterprises. However, their variations are not the same. The TE scores of fishery processing enterprises range between 0.436 and 1.000 with the mean and standard deviation being 0.806 and 0.173, respectively, while the better range of 0.778-1.00 along with the mean (0.892) and standard deviation (0.079) are found for the rice processing enterprises (Table 2). Most farmers in both sectors obtain high TE scores that range between 0.60 and 1.00. In which, about 30 and 18 percent of enterprises which are fully efficient enterprises corresponding to the fishery and rice processing sectors.

In Table 2, we can recognize that most rice processing enterprises are rather efficient in making optimal decisions for the allocation of the input mix and vice versa for the fishery processing enterprises. The AE scores range around from 0.812 and 1.00 together with the mean AE score is 0.927 for the rice processing enterprises and the corresponding values of the AE's range and mean are 0.353 – 1.000 and 0.652 for the fishery processing enterprises.

Related to the CE, a much wider spread of CE scores with values between 0.32 and 1.00 for the fishery processing enterprises, the results indicate that there are *cost inefficiencies* in their operation corresponding to values ranging from 0.00 to 0.68. Making reference to Table 2, the mean CE scores are found to be 0.51 and 0.83 respectively for the fishery and rice processing enterprises. This implies that if the enterprise with average efficiency in the sample of fishery sector is to achieve the cost efficiency level of the fully efficient counterpart, then the average enterprise can receive a cost saving of 49 % (i.e., 1-[0.51/1.00]). The same calculation for the lowest efficiency one suggests a gain in cost efficiency of 68 % (i.e., 1-[0.32/1.00]). Similarly, the average enterprise and the most inefficiency one in the sample of rice processing sector can realize a cost saving of 17 and 35 %, respectively (i.e., 1-[0.83/1.00] and 1-[0.65/1.00]).

Table 2: Production efficiency in industry of the selected enterprises

Items	Fishery processing enterprises		Rice processing enterprises	
	Freq.	Percent	Freq.	Percent
TE scores				
1.00	9	0.30	10	0.18
8.00 – 0.99	6	0.20	37	0.66
0.60 – 0.79	13	0.43	9	0.16
0.40 – 0.59	2	0.07	0	0
< 0.40	0	0	0	0
Mean TE	0.806		0.892	
Range	0.436-1.000		0.778-1.000	
Standard deviation	0.173		0.079	
AE scores				
1.00	1	0.03	4	0.07
8.00 – 0.99	7	0.23	52	0.93
0.60 – 0.79	9	0.30	0	0
0.40 – 0.59	11	0.37	0	0
< 0.40	2	0.07	0	0
Mean AE	0.652		0.927	
Range	0.353-1.000		0.812-1.000	
Standard deviation	0.192		0.053	
CE scores				
1.00	1	0.03	4	0.07
8.00 – 0.99	0	0	29	0.52
0.60 – 0.79	7	0.23	23	0.41
0.40 – 0.59	16	0.53	0	0
< 0.40	6	0.20	0	0
Mean CE	0.510		0.830	
Range	0.317-1.000		0.645-1.000	
Standard deviation	0.150		0.110	

Source: Estimated from the surveyed data, using the DEAP software.

4.2 Scale efficiency

The estimated mean SE scores for the two selected industries are illustrated in Table 3. These scores are 0.904 for the milled rice industry and 0.851 for the fishery industry.

These results indicate that enterprises in both sectors are confronted with scale inefficiency. However, the amounts of inefficiencies seem to be small, hence, they are rather efficient with respect to scales of operation. The results presented in Table 3 show that the mean scale inefficiency score (1–scale efficiency score) is not so much with the values of 0.149 and 0.096 corresponding to 66.7% and 82.1% of farm households operating under either the IRS or DRS situations for the fishery and rice processing enterprises, respectively.

Table 3: Enterprise scale efficiency of the two selected industries in the Mekong Delta in Vietnam in the year 2007

Parameters	Scale efficiency			
	Fishery processing enterprises		Rice processing Enterprises	
	Freq.	Percent	Freq.	Percent
Number of firms in IRS	17	56.7	46	82.1
Number of firms in DRS	3	10.0	0	0.0
Number of firms in CRS	10	33.3	10	17.9
Number of firms	30	100.0	56	100.0
Mean SE	*0.851*		*0.904*	
Min	*0.436*		*0.778*	
Max	*1.000*		*1.000*	
SD	*0.176*		*0.090*	

Source: Measured from the surveyed data, using the DEAP software.
Notes: IRS = increasing returns to scale, DRS = decreasing returns to scale, CRS = constant returns to scale, SD = standard deviation.

4.3 Sources of Efficiency

4.3.1 For the fishery processing enterprises

The estimates of the Tobit functions are presented in Table 4. We see that five variables are found to be statistically significant as follows:

Age is the main characteristic of the enterprise head that was included to estimate the effect of age of the enterprise head on the efficiency. We expect that the enterprises will get higher efficiency in production. If the heads are not too old, the expected sign of this variable is negative. From the results in Table 4, we can see that this variable is positive and statistically significant in the TE model only. This is somewhat strange. The positive sign of its coefficient means that the TE probably tends to increase with an increase in age of the farmers. However, the surveyed data show that the average age of the enterprise heads in both sectors is about 43 years old. At this age, farmers seem to be not very old. They can enjoy a relatively good health and have enough experience. Such statistics can be used to interpret for the positive relationship between TE and age in this case.

Credit is a dummy variable that was used to measure the impact of bank loans on the efficiency of the enterprises in their production. The availability of credits will reduce the constraints of production in order to get the inputs on time and hence support to increase the efficiency. However, the credit variable in the study is not statistically significant in the TE model. This variable is significant in both the AE model and the CE model with a negative sign of the coefficients. The results suggest that the availability of credit is not an important factor in attaining higher levels of TE, AE and CE. Therefore, credit simply helps the enterprises to borrow more capital from a bank for their production, but does not promote application of new technologies to get higher efficiencies.

Education, the number of formal school years of the enterprise head was included in the model. The higher education the enterprise heads have, the higher efficiency they get. Therefore, the expected sign of this variable is positive. From the results in Table 4, we can see that this variable is positive and statistically significant only in the AE model.

Type of firm, this was used to explain the impact of the different types of capital ownership on the effects of the enterprises. The different holders are different in terms of regulation and decision and may affect the enterprises' efficiency. The results in Table 4 show that this variable is statistically significant in all the TE, AE and CE models.

Size of capital was included in the model for testing whether the productive efficiency is changed with different levels of investment. Normally, the more capital the enterprises invest, the more productivity they obtain. In this study, for both the TE and AE models, this variable is not statistically significant.

4.3.2 For the rice processing enterprises

Most variables, except land ownership and the experience variable, appear to be statistically significant as follows:

Sex is a dummy variable that was used to estimate the impact of gender on the efficiency of the enterprises; as the result, this is statistically significant in the TE model only. Age is a positive and statistically significant variable in the TE and CE models. Credit, a dummy variable that was used to measure the effect of bank loans on the efficiency of the firms, is found to be a significant variable in the TE model. Education, the number of formal school years of the firm head, from the results in Table 4, is positive and statistically significant in the TE model. Fe_Labour/Total Labour was an included variable of the efficiency model - this variable is also statistically significant in the CE model. Finally, we recognize that the scale of the firm, the type of firm and the size of the capital stock are statistically significant in all the TE, AE and CE models.

Table 4: The truncated estimates for the sources of efficiency

Variables	TE		AE		CE	
	Coef.	**z**	**Coef.**	**z**	**Coef.**	**z**
Fishery processing enterprises						
SEX	0.0719	0.8700	-0.1179	-1.0770	-0.0435	-0.5660
AGE	0.0118	3.6360	-0.0049	-0.9680	0.0038	1.0670
CREDIT	-0.0100	-0.1680	-0.2118	-2.2490	-0.1508	-2.2780
LAND OWNERSHIP	0.0253	0.4040	0.0296	0.3540	0.0191	0.3240
EDUCATION	-0.0130	-1.1170	0.0424	2.7550	0.0061	0.5630
FE_LABOUR/TOTAL	0.0702	0.9790	0.0626	0.5560	0.0065	0.0820
EXPERIENCE	-0.0020	-0.4890	0.0004	0.0640	-0.0006	-0.1380
SCALE_OF_FIRM	0.0590	1.0010	0.0409	0.5220	0.0217	0.3940
TYPE_OF_FIRM	0.1692	2.6390	0.2064	2.3790	0.1649	2.7040
TRAINING	0.0000	0.0110	0.0011	0.4850	0.0010	0.6120
SIZE_OF_CAPITAL	0.0000	0.5720	0.0000	1.0330	0.0000	2.8430
Log-Likelihood func.	19.0384		10.7611		10.7611	
Rice processing enterprises						
SEX	0.0664	2.3120	0.0099	0.4400	0.0257	1.0340
AGE	0.0038	2.6540	0.0016	1.4690	0.0029	2.4140
CREDIT	0.0770	2.3860	0.0258	1.0210	0.0468	1.6700
LAND OWNERSHIP	0.0140	0.4280	0.0047	0.1810	0.0410	1.4360
EDUCATION	0.0094	2.2500	0.0028	0.8390	0.0021	0.5570
FE_LABOUR/TOTAL	0.1160	0.6680	-0.0091	-0.0640	-0.3369	-2.1530
EXPERIENCE	0.0019	0.5990	0.0006	0.2470	-0.0013	-0.4380
SCALE_OF_FIRM	0.3218	5.3450	0.2602	5.4470	0.2409	4.5460
TYPE_OF_FIRM	0.0922	2.5770	0.2682	7.7790	0.2087	5.4580
SIZE_OF_CAPITAL	0.0000	4.3850	0.0000	4.8750	0.0000	5.0890
Log-Likelihood func.	60.9049		75.1363		69.3336	

Source: Calculated from the surveyed data.

5. Conclusions

This study uses data envelopment analysis and estimates truncated functions for the enterprises which specialized either in rice processing or in fishery processing in the Mekong Delta.

Productivity depends on several factors, some of which can be controlled but the others cannot. In other words, productivity varies from differences in production technology, differences in location of production and differences in the efficiency of the production process. A main part of the study is trying to estimate technical, allocative, cost and scale efficiencies of the enterprises specialized in rice processing and fishery processing in the Mekong Delta and identify the determinants of those efficiencies. As a part of the methodology used in the study, the constant and variable returns to scale input-oriented Data Envelopment Analysis models (the CRS & VRS-DEA models) were used to estimate. In this study, the results from the analyses indicate that the enterprises in both the two sectors mostly attain high efficiencies in comparison with the best performance enterprises of their own sector.

Another important part of this study is to examine the sources of the enterprises' production efficiency. To do this, the relationships between the technical, allocative and cost efficiencies and various attributes of the selected enterprises were estimated by using the truncated functions (Tobit function). The results show that age, credit, education, type of firm and size of capital are the main factors influencing the efficiencies of both the fishery and rice processing enterprises.

REFERENCES

- (2008). *Statistical yearbook of the Mekong Delta*. General Statistical Office of Vietnam.
- Afriat, S.N. (1972). Efficiency Estimation of Production Functions, International Economic Review, 13, 568-598.
- Banker, R.D., Charnes, A., and Cooper, W.W. (1984). *Some Models for Estimating Technical and Scale Inefficienies in Data Envelopment Analysis*. Management Science, 30, 1078-1092.
- Battese, G.E., and Coelli, T.J. (1995). *A model for technical inefficiency effects*. Economics, Volume 20, 325-332.
- Battese, G.E., and Coelli, T.J. (1998). *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic Publishers.
- Boles, J.N. (1966). *Efficiency Squared – Efficiency Computation of Efficiency Indexes*. Proceedings of the 39th Annual Meeting of the Western Farm Economics Association, pp. 137-142.
- Bravo-Ureta, B.E., and Evenson, R.E. (1994). *Efficiency in agricultural production: the case of peasant farmers in eastern Paraguay*. Agricultural Economics, Volume 10, Issue 1, January 1994, pages 27-37.
- Bravo-Ureta, B.E., Pinheiro, A.E. (1997). *Technical, Economic, and Allocative Efficiency in peasant farming: evidence from the Dominican Republic*. The Developing Economics, XXXV-1 (March 1997): 48-67.
- Charnes, A., Cooper, W.W., and Rhodes, E. (1978). *Measuring the Efficiency of Decision Making Units*. European Journal of Operational Research, 2, 429-444.
- Charnes, A. and Cooper, W. (1994). *Data Envelopment Analysis: Theory, Methodology and Applications*. Kluwer Academic Publishers, 23-47.
- Coelli T.J. (1996). *A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program*. Center for Efficiency and Productivity Analysis, University of New England, Australia.
- Coelli, T.J. et al. (1998). *A multi-stage Methodology for the Solution of Orientated DEA Models*. Operational Research Letters, 23, 143-149.
- Coelli T.J., Rao, D.S.P., O'Donnell C.J., Battese, G.E. (2005). *An Introduction to Efficiency and Productivity Analysis. Second Edition*. Kluwer Academic Publishers, Chapters 8, 9 and 10.
- Farrell, M.J. (1957). *The Measurement of Productive Efficiency*. Journal of the Royal Statistical Society, Series A, CXX, Part 3, 253-290.
- Lovell, C.A.K., Fried, H.O. and Schmidt, S.S. (1993). *The Measurement of Productive Efficiency: Techniques and Applications*. Oxford University Press, 121-149.
- McCarty, T.A. and Yaisawarng, S. (1993). *Technical Efficiency in New Jersey School District*. In Fried, H.O., Lovell, C.A.K., and Schmidt, S.S. (Eds.). The Measurement of Productive Efficiency: Techniques and Applications. Oxford University Press, New York, 271-287.
- Muller, J. (1974). *On Sources of Measured Technical Efficiency: The Impact of Information*. American Journal of Agricultural Economics, Vol. 56, 730-738.
- Quan, M.N. (2006). *Technical Efficiency analysis of the household with the continuous rice and crop rotation pattern in Cho Moi district, An Giang province in the year 2005*. Scientific research journal of Can Tho University, Volume 6.
- Quan, M.N. (2007). *Profitability and Scale Efficiency analysis of the household with the continuous rice and crop rotation pattern in Cho Moi district, An Giang province in the year 2005*. Scientific research journal of Can Tho University, Volume 7.
- Quan, M.N. (2007). *Allocation and cost efficiency analysis of selected farming patterns within and outside boundary irrigated systems in Tri Ton and Cho Moi district, An Giang province (Mekong River Delta, Vietnam)*. Center for ASEAN Studies, University Antwerp, Antwerp.
- Seyoum E.T., Battese, G.E., and Fleming, E.M. (1998). *Technical Efficiency and Productivity of Maize Producers in Eastern Ethiopia: A Study of Farmers within and outside the Sasakawa-Global 2000 Project*. Agricultural Economics.
- Sharma, R.K.. Leung, P. and Zaleski, H.M. (1997). *Productive Efficiency of the Swine Industry in Hawaii: Stochastic Frontier vs. Data Envelopment Analysis*. Journal of Productivity Analysis, Volume 8, 447-459.
- Shephard, R.W. (1970). *Theory of Cost and Production Functions*. Princeton University Press, Princeton.
- Srinivas Talluri, Silberman (2000). *Data Envelopment Analysis: Models and Extensions*.
- Tham, M., and Fleming, E. (2004). *An Analysis od Scope Economies and Specialization Efficiencies among Thai Shrimp and Rice Smallholders*. University of New England, Australia.

- Wadud, A., and White, B. (2000). *Farm Household efficiency in Bangladesh: a comparison of stochastic frontier and DEA methods*. Applied Economics, volume 32, 1665-16673.