CHAPTER VI

TECHNICAL EFFICIENCIES OF RICE MILLS

In accordance with methodology mentioned in chapter 3, this chapter presents the empirical findings from Data Envelopment Analysis to determine technical efficiency. Then, this technical efficiency score was regressed in the second stage using a multiple regression to examine factors affecting technical inefficiency in rice mill systems in Thailand and Taiwan.

6.1 Data envelopment analysis (DEA)

6.1.1 Descriptive statistics of the variables

The data used for the calculation of technical efficiency include rice output and inputs; that is paddy, land, labor, and initial value of machine. The descriptive statistics i.e. minimum, maximum, standard deviation of the variables in the DEA model is present in Table 6.1 – Table 6.3.

Rice mills in Thailand have an average rice output of 10,680 ton per year, ranging from a minimum of 585 ton per year to a maximum of 112,320 ton per year (Table 6.1). Paddy used in mill operations averages 17,066.03 ton per year. The average land holding of a rice mill was found at 15.86 rais, ranging from 1 to 40 rais. Total labor used for rice mills averages about 24 people per mill. And the initial value of machines in Thai rice mills average 7,419,750 baht.

Table 6.1 Descriptive statistics for the sample of 36 rice mills in Thailand

Input/output variables	Minimum	Maximum	Mean	Standard Deviation
Output				
Rice (ton)	585	112,320	10,680.53	19,899.88
Inputs				
Paddy (ton)	900	172,800	17,066.03	30,903.73
Land (rai)	1	40	15.86	12.36
Labor (people)	4	67	24.64	17.82
Machine (baht)	320,000	35,000,000	7,419,750	8,336,434

On the other hand, average rice output of rice mills in Taiwan was 6,983.6 ton per year and range from 1,531 to 27,600 ton per year. Annual paddy used average 11,064.57 ton per year. The average land of the survey was 4.2 rais, (smaller than Thai rice mill). The average number of labor was approximately 13 people and the initial value of rice mill machine average at 17,542,000 baht.

Table 6.2 Descriptive statistics for the sample of 35 rice mills in Taiwan

Input/output variables	Minimum	Maximum	Mean	Standard Deviation
Output				
Rice (ton)	1,531	27,600	6,983.60	6,572.46
Inputs				
Paddy (ton)	2,296	54,000	11,064.57	11,279.72
Land (rai)	0.45	10	4.20	6.31
Labor (people)	5	38	12.86	6.97
Machine (baht)	4,128,000	79,500,000	17,542,000	13,758,232

When combining rice mills in Thailand and Taiwan, the data showed that there were wide variations in both the input used as paddy and expenditure on machine and rice output data (Table 6.3). That is, there are large variations in the levels at which inputs were being used. Also note that initial value on machine and paddy has a much larger proportionate variation maximum/minimum than land and labor. This may be a reflection of the increased capital intensification and automation in the rice mill industry. In addition, this shows that the size of Taiwan's rice mill is more uniform and use less land but higher investment.

Table 6.3 Descriptive statistics for the combined sample of 71 rice mills in Thailand and Taiwan

Input/output variables	Minimum	Maximum	Mean	Standard Deviation
Output				
Rice (ton)	585*	112,320*	8,853.87	14917.14
Inputs				
Paddy (ton)	900*	172,800*	14,101.93	23422.28
Land (rai)	0.45	40*	11.86	16.60
Labor (people)	4*	67*	18.83	14.75
Machine (baht)	320,000*	79,500,000	12,364,000	12,336,879.98

Note: * = extreme original from thai rice mills.

6.1.2 Data Envelopment Analysis result

DEA, three model specifications in equations 20 to 22 of chapter 3 were estimated. A summary of the efficiency scores for all rice mills is presented in Table 6.4. The constant returns to scale (CRS) assumption means that average productivity, denoted by output/ input ratio is not dependent on scale of production. However, the most general assumption that can be made in respect of returns to scale is that they are variable. This permits constant but also increasing and decreasing returns to scale for different scale sizes. To allow for this possibility, variable returns to scale (VRS) that measure technical efficiency can be decomposed into pure technical efficiency and scale efficiency (SE). The VRS rating is obtained when control for the scale size of the Decision Making Unit (DMU) and SE measures the impact of scale size on the productivity of a DMU. The technical efficiency score (in both CRS and VRS models) equal one implies full efficiency on the other hand if the score is less than one it indicated technical inefficiency. Similarly SE, if the score equals one then that is scale efficiency or if the score is less than one that is scale inefficiency. Furthermore, returns to scale are to do with how average productivity is affected by scale size and that is a property of the Pareto-efficient boundary. There is increasing returns to scale (IRS) hold at a production point then raising its output level however the percentage rise in output level will be lower than that of input level if decreasing returns to scale (DRS) and hold while inputs and outputs will change by the same percentage if CRS hold (see calculation method in page 24-25).

Table 6.4 Summary of the technical efficiency score for all rice mill in Thailand and Taiwan

No. of rice mill	Constant returns to scale model	Variable returns to scale model	Scale efficiency	Return to scale
1	0.804	0.832	0.965	drs
2	0.798	0.806	0.990	irs
3	0.944	0.988	0.956	irs
4	0.969	0.995	0.973	irs
5	0.929	0.938	0.990	irs
6	0.909	0.959	0.949	irs
7	0.901	1.000	0.901	irs
8	0.870	1.000	0.870	irs
9	0.866	0.923	0.938	irs
10	0.741	0.742	0.998	irs
11	0.861	1.000	0.861	irs
12	0.948	0.995	0.953	irs
13	0.861	0.875	0.984	drs
14	0.601	0.685	0.877	irs
15	0.776	0.789	0.983	drs
16	0.807	0.850	0.949	irs
17	0.796	0.805	0.989	irs
18	0.961	0.979	0.982	drs
19	1.000	1.000	1.000	crs
20	0.750	0.821	0.913	drs
21	0.963	0.805	0.947	irs
22	0.706	0.725	0.974	irs
23	1.000	1.000	1.000	crs
24	0.703	0.723	0.973	drs
25	0.728	0.742	0.982	drs
26	0.886	0.890	0.995	irs

Table 6.4 (Continue)

No. of rice mill	Constant returns to scale model	Variable returns to scale model	Scale efficiency	Returns to scale
27	0.842	0.847	0.994	irs
28	0.905	1.000	0.905	irs
29	0.814	0.818	0.995	drs
30	0.912	0.912	1.000	crs
31	0.635	0.640	0.993	irs
32	0.756	0.769	0.984	drs
33	1.000	1.000	1.000	crs
34	0.896	0.922	0.972	irs
35	0.769	0.843	0.945	drs
36	0.858	0.872	0.983	irs
37	1.000	1.000	1.000	crs
38	0.813	0.816	0.996	drs
39	0.625	0.695	0.899	irs
40	0.880	0.900	0.978	drs
41	1.000	1.000	1.000	crs
42	0.813	0.871	0.933	drs
43	0.843	0.886	0.951	drs
44	0.880	0.883	0.997	drs
45	0.825	0.868	0.950	drs
46	0.876	0.902	0.970	irs
47	0.868	1.000	0.868	irs
48	1.000	1.000	1.000	crs
49	0.914	0.935	0.977	irs
50	0.834	0.926	0.900	irs
51	0.836	0.863	0.968	drs
52	0.900	0.920	0.978	irs
53	0.850	0.852	0.998	irs
54	0.950	1.000	0.950	irs
55	0.929	0.958	0.970	irs
56	0.775	0.783	0.990	drs
57	0.946	1.000	0.946	irs
58	0.840	0.893	0.940	drs
59	0.850	0.858	0.991	drs
60	0.937	0.950	0.987	drs
61	0.832	1.000	0.832	irs

Table 6.4 (Continue)

No. of rice mill	Constant returns to scale model	Variable returns to scale model	Scale efficiency	Returns to scale
62	0.887	1.000	0.887	irs
63	0.948	1.000	0.948	irs
64	0.838	0.855	0.979	drs
65	1.000	1.000	1.000	crs
66	0.884	0.994	0.889	irs
67	0.845	0.846	0.998	drs
68	0.853	0.865	0.986	irs
69	0.906	1.000	0.906	irs
70	0.668	0.674	0.991	irs
71	0.846	0.860	0.983	drs

Sources: computed by DEAP Version 2.1 program

Note: crs = constant return to scale

drs = decreasing return to scale

ins = increasing return to scale

The results are summarized by the frequency in Table 6.5. The mean of total technical efficiency and pure technical efficiency of rice mills in Thailand is less than Taiwan. The average CRS measure of technical efficiency for rice mills in the samples for Thailand and Taiwan is 0.84 or 84 % and 0.87 or 87 %, respectively. While, the average VRS measure are 0.87 or 87 % in Thailand compared with 0.91 or 91 % in Taiwan.

The first thing to note about these results is that, under the CRS measure of technical efficiency 8.3 % of the sample rice mills in Thailand (3 out of 36 mills) and 11.4 % (4 out of 35 mills) of rice mills sample in Taiwan are identified as technically efficient, i.e. operating at best practice.

Table 6.5 Comparison of technical efficiency score of rice mill in Thailand and Taiwan

Range of efficiency score	Number of mills					
	CRS		VRS		SE	
	Thailand	Taiwan	Thailand	Taiwan	Thailand	Taiwan
Equal to 100%	3	4	7	11	4	4
>90 - < 100%	9	8	9	8	21	20
80 - < 90%	11	20	12	13	8	6
70 - <80%	11	1	6	1	3	4
60 - < 70%	2	2	2	2	0	1
Mean efficiency	0.841	0.871	0.874	0.910	0.963	0.958
Minimum efficiency	0.635	0.625	0.640	0.674	0.870	0.832
Maximum efficiency	1.00	1.00	1.00	1.00	1.00	1.00

Note: total number of observation = 71 mills including 36 mills in Thailand and 35 mills in Taiwan

The average level of technical inefficiency in Thailand and Taiwan is 0.16 or 16 % and 0.13 or 13 %, respectively (Table 6.5). This implies that, by adopting best practices, rice mills can, on average, reduce their inputs combination of land, labor, paddy, and expenditure on machine, by at least 16 % in Thailand and 13 % in Taiwan. However, to decrease the raw material of paddy in some cases could not be done, since the study analyzed the combined data in both countries and the higher percentage of head rice after processing in Taiwan has influence to enhance technical efficiency together extent than in Thai rice mills. The potential reduction in inputs from adopting best practices varies from mill to mill. The best practice or frontier firms cannot reduce their inputs. However the other 91.7% of rice mill in Thailand and 88.6% of rice mills in Taiwan can reduce their inputs according to the DEA results. They can do this by forming benchmarking partnerships with relevant best-practice firms and emulating the best practices of the latter.

As can be seen in Figure 6.1, the frequency distribution is skewed towards the right if referring to the technical efficiency score range as, from zero to one, with higher levels of technical efficiency. Nearly two-thirds of the observed mills achieved CRS technical efficiency scores of 80 % or more.

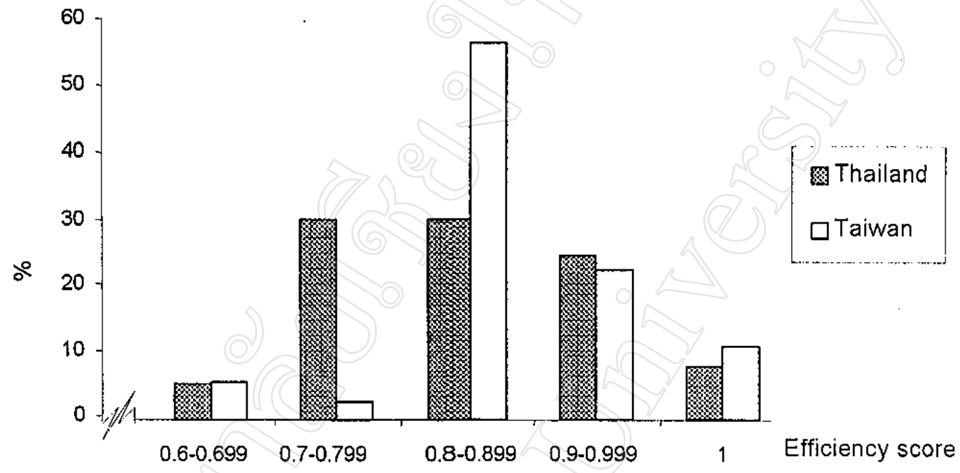

Figure 6.1 Comparison of distribution of CRS technical efficiency in Thailand and Taiwan

Since we have assumed constant returns to scale, the source of inefficiency referred to above may include inefficiencies due to scale as well as other sources of inefficiency such as inefficient processing management. Accordingly, the study has relaxed the assumption of constant returns to scale and obtained a variable returns to scale input measure of technical efficiency for each rice mill. These results are also summarized in Figure 6.2.

The total technical efficiency can be decomposed into pure technical efficiency and scale efficiency. The VRS measure of technical efficiency of 19.4 % and 31.4 % (of the sample of rice mills in Thailand and Taiwan) are identified as technically efficient and operating at best practice. The average VRS measure of technical efficiency for mills in Thailand is 0.87 and 0.91 in Taiwan (Table 6.5). This means that 3 % and 4% of the difference between VRS technical inefficiency and

CRS technical inefficiency identified above are due to rice mills operating at non-optimal scale. The skew to the right of the frequency distribution of pure technical efficiency, Figure 6.2, is now more pronounced with nearly 80% and 90% of the sample of rice mills in Thailand and Taiwan, achieving technical efficiency of 80 % or more.

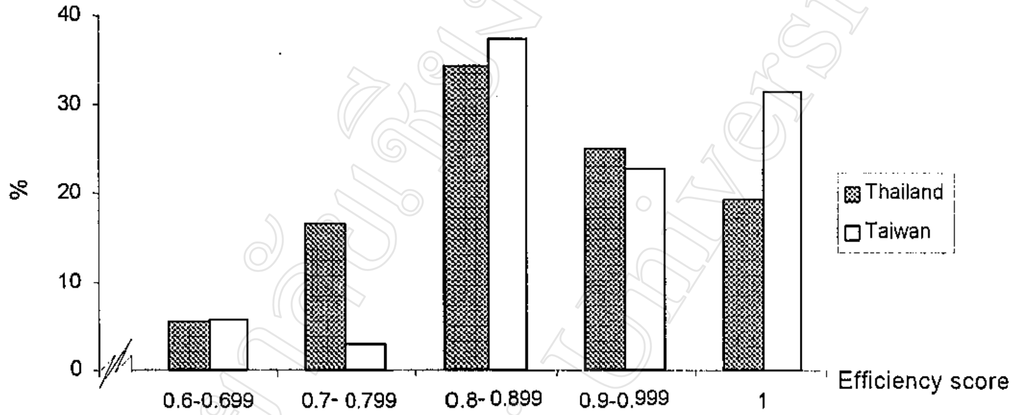

Figure 6.2 Comparison of distribution of VRS technical efficiency in Thailand and Taiwan

As indicated earlier, the scale efficiency of the rice mills can be measured by the ratio of the constant returns to scale and the variable returns to scale input measures of technical efficiency. A ratio of unity implies that the rice mill is operating at optimal scale. A ratio of below unity implies that the rice mill is experiencing technical inefficiency because it is not operating at its optimal scale.

When technical efficiencies obtained with CRS and VRS models are equal then the operator is running under constant returns to scale (Coelli *et al.*, 1998). The results for scale efficiency are presented in Figure 6.3. These results suggest that 11.1 and 11.4 % of the rice mills in Thailand and Taiwan are operating at their own optimal scale (constant returns to scale). Since, rice mill scale efficiency in Thailand is a little higher about 96.3 % than 95.8% in Taiwan. Hence, inefficiency due to scale accounts for approximately 4 percentage points of the average technical inefficiency of 16 and 13 % in Thailand and Taiwan. According to the results, therefore, over 80 % of the rice mills in the sample are experiencing some technical inefficiency due to their size.

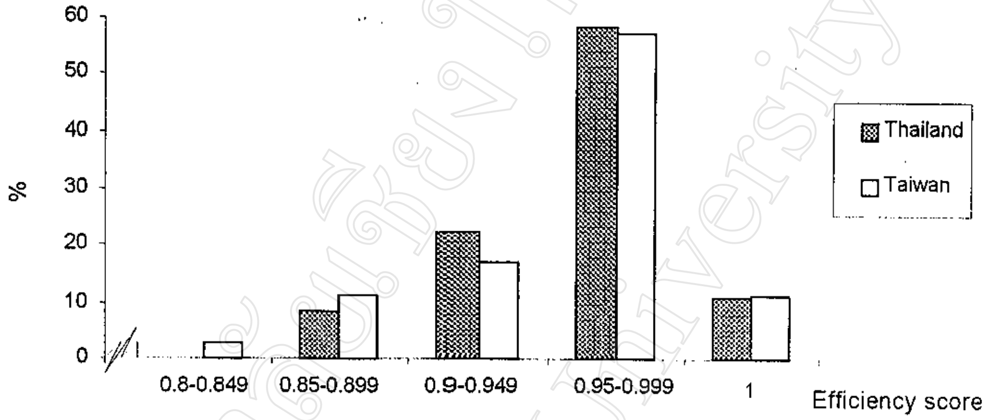

Figure 6.3 Comparison of distribution of scale efficiency in Thailand and Taiwan

As indicated above, the existence of sub-optimal scale is identified by the equality or the inequality of the variable returns to scale and the non-increasing returns to scale input measures of technical efficiency respectively. According to the results of this, summarized in Figure 6.4, 61.1 % and 48.57 % of rice mills in Thailand and Taiwan are operating above of their optimum scale. Moreover, 27.8 % and 40 % are operating below their optimum. This implies that increasing returns to scale and decreasing returns to scale rice mills should be increasing or downsizing the combination of inputs in the optimal scale, respectively. Of the rest, approximately 11 % of both Thailand and Taiwanese rice mills are operating in their own optimum scale for each rice mill. It means these rice mills could increase their technical efficiency by continuing to increase their capacity.

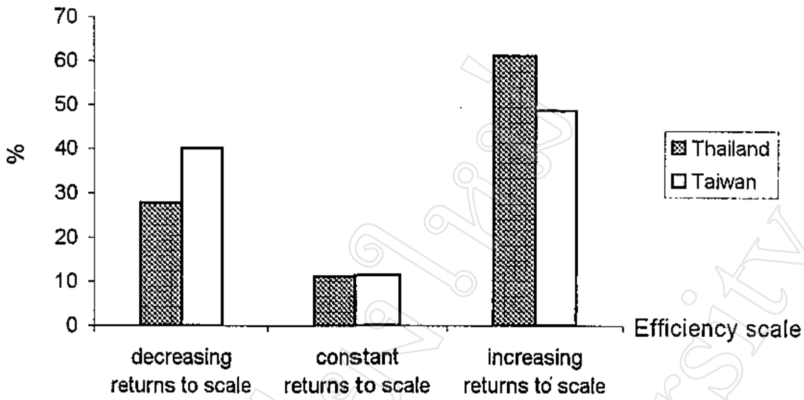

Figure 6.4. Comparison of the scale efficiency of rice mills industry in Thailand and Taiwan

6.1.3 Use of DEA results to study inefficiency on individual rice mill

Throughout the DEA modeling approach for efficiency analysis, it is possible to achieve two types of results. First, it is possible to identify the adjustments that can be made in the use of inputs on inefficient mills by comparing then with their 'peer' mills. Second, the factors that can be manipulated to minimize the excessive use of inputs and hence reduce the costs of production can be established.

For example, by using the result of the VRS DEA model (Appendix A) to work out what is required by inefficient rice mills to become efficient. Taking the rice mill Decision Making Unit (DMU) 1, with efficiency scores of 0.804 and 0.832 under the CRS and VRS assumptions, respectively. For rice mill, the firms 19 (lambda weight = 0.020), 41 ((lambda weight = 0.159) and 65 ((lambda weight = 0.820) are referents when VRS are assumed.

The production practices of the DMU-1 and its referents are compared in Table 6.6 The use of input by the DMU-1 is excessive. The above comparison would suggest strategies for the DMU-1 to rationalize the use of its inputs. The lambda values obtained from the DEA solution for this rice mill provide a composite DMU, which would produce the equivalent level of output, however by using lesser levels of input.

A composite DMU result shows that DMU-1 should reduce land and labor to 1.4 rais and approximately 12 men, respectively. In addition, rice mill should increase their machine utility such as expand time in operation, to raise technical efficiency. Nevertheless, paddy could not be decrease from 12,480 tons to 10,388.4 tons as it is restricted by the cracking percentage of milled rice in Thailand.

Table 6.6 Input use levels of the DMU-1 and its referents DMU in the VRS case

Variable in DEA model	Input used level	Input level of the referent units			Composite DMU
	DMU-1	DMU-19	DMU-41	DMU-65	
Lambda values		0.020	0.159	0.820	
Output					
Rice (ton)	7,488	36,000	25,900	3,200	7,488
Inputs					
Paddy (ton)	12,480	60,000	36,909	4,000	10388.4
Land (rai)	14	33	1.35	0.62	1.4
Labor (people)	26	28	22	8	11.2
Machine (bath)	10,000,000	10,000,000	29,688,000	4,128,000	8,324,059.8

The results found in the previous section are the difference in technical efficiency that exists among rice mills in Thailand and Taiwan in different categories. The interesting issue to investigate is, "what are the factors that influence the difference in technical efficiency level?" The next section is presented with the purpose of answering this question.

6.2 Factor affecting technical inefficiency in rice mill industry

To assess the sources of measured efficiencies, this study uses a Tobit regression model as efficiency scores are truncated (Zheng et al., 1998). Therefore, firm specific estimates of pure efficiency are used as a dependent variable and as information on potential explanatory variables defined in Chapter 3, as Eq. (28) followed below:

$$\text{PTE}_i = \alpha + \beta_1 Year_i + \beta_2 Capa_i + \beta_3 Exp_i + \beta_4 Edu_i + \beta_5 Energy_i + \beta_6 Type_i + \varepsilon_i$$

The estimated used the Tobit procedure in the LIMDEP software package. The outcomes are presented in table 6.7. Technical efficiency measures are regressed on number of years established, degree to full capacity of operation, experience, education level of entrepreneurs, energy source in mill operation and dummy variable of business type (i.e. private rice mill and cooperatives rice mill) of each rice mill.

At level of significance, the results showed that experience and educational level have a significant effect on the efficiency level in both Thailand and Taiwan. The value of the estimated coefficient is positive, indicating that greater specialization in production is associated with higher relative efficiency. It can be concluded that management is probably most important to explain the relative technical efficiency. Even the word management here is not describing unique activity, but rather a complicated one, which comprises many activities within rice mills. This starts with the importance of education and the information of the millers. It was found during the field survey that the millers who were well educated were usually more advanced in managing their organization. In addition, work experience in milling or related fields, including formal training, has contributed to management skill. It was found that most of the millers who are successful in business usually have over ten years of working experience.

In Taiwan, further, the year established has an important impact on the efficiency level, but in contrast, in Thailand it is at 0.10 significant level. Due to in Taiwan, the average age of the rice mill is older than in Thailand and restriction to new entrepreneurs to enter into business. Some of rice mills have transferred into the third generation. Thus, a positive relationship between the age of the firm and technical efficiency can be expected due to learning-by-doing effects in Taiwan.

Additionally, the type of business is found to be related significantly in a positive way with technical efficiency at $\alpha = 0.05$ in Thailand and 0.10 significant level in Taiwan. This is due to commercial rice mills trying to operate at full capacity for maximum profit however cooperative rice mills were setup to help members against the uncertain value of paddy when they purchased it. Therefore, private rice mills could reach higher technical efficiency than cooperative rice mills.

Table 6.7 Tobit regression analysis testing pure technical inefficiency of rice mills in Thailand and Taiwan

Variable	Thailand		Taiwan	
	coefficient	p-value	coefficient	p-value
Constant	0.8313	.0000	0.8868	.0000
Year of establish	-0.0427	.2307	0.0391	.0938
Capacity	-0.00065	.7942	-0.00014	.9415
Experience	0.0164	.0000	0.0882	.0004
Education	0.1409	.0000	0.1500	.0000
Energy source	0.0129	.6981	0.0280	.1900
Type of business	0.2134	.0477	0.1485	.0981
Log likelihood	12.6402		10.3133	-
Number of observation	36		35	-

The other variable, capacity and source of energy, are not found to have a significant association with technical efficiency as measured for the sampled mills. It can be denoted that capacity and source of energy may appropriated with their own mill business.

CHAPTER VII

CONCLUSIONS AND RECOMENDATIONS

As the results of the study, this chapter deals with conclusion and recommendation as well suggestion for further, researchable, issues related to the present study

7.1 Conclusions

Rice is an important economic crop of Thailand. It is not only a major source of farmers' income, but also a main source of agricultural export earning and employment. Taiwan is an industrial country, however, rice is still a staple food in Taiwan's economy. In both Thailand and Taiwan, the rice-milling industry is important as an economic intermediate, that converts paddy into milled rice, which is traded in domestic and international rice markets.

This study is based on cross-sectional data obtained from field surveys in year 2000. Stratified and purposive sampling technique was applied to select 36 commercial rice mills in Thailand and 35 in Taiwan, respectively. Descriptive statistics, data envelopment analysis and Tobit regression were used as the principle methods for data analysis.

Firstly, the study focused mainly on comparing rice marketing and production management processes of rice millers in Thailand and Taiwan. The statistics of rice-mills indicate that the average age of rice mills in Taiwan is older than Thailand. More than half of the sampled mills were individual proprietors in both Thailand and Taiwan. Approximately 40 % of rice mills in Thailand are less than 10 year sold, 60 % of rice mills in Taiwan are more than 20 years. As for the educational level of the rice mill owners, 45.7 % of the respondents in Taiwan had a high school or vocational school degree, and 17.1 % graduated from university. However, millers in Thailand have higher education level, 33.3 % had bachelor's degree and 5.6 % finished graduate school.

As for the technique of production, in Thailand it can be classified into three types with respect to the source of power used, including diesel engines, steam engines and electric motors. On the other hand, in Taiwan, only electric motors and automatic machines were used in the rice mills.

Sources of paddy in operations, during first crop season, Thai private rice mills purchased 55.9 % of the paddy from farmer following by assemblers who took 42.6 %. In Taiwan, farmers, assemblers and other rice mills were the main sources of paddy, which accounted for 61%, 23.5% and 10.9 %, respectively. For cooperatives in Thailand, they bought paddy from their members (76.7 %) subsequent by farmers (21.6 %). In additions, farmer association in Taiwan used paddy in mill operations from members (56 %) followed by farmers (38 %).

When off-season, assemblers were a big source of paddy accounting for 53.8 % in Thailand. Rice mills in Taiwan, however, purchased paddy from other rice mills (44.1 %) and assemblers (33.3 %). In Thailand, 85 % of paddy from members was sold to cooperatives; comparatively, in Taiwan only 63.3 % of paddy from members was sold to farmer association.

Based on surveyed data in 2000, the investment cost of warehouse, machinery, and other equipments in Taiwan's rice mills was higher than in Thailand. The other expenses including paddy, credit, labor, packaging and other expenditure in Thailand was greater than Taiwan because there is larger volume in rice mill processing.

The average land area used by rice mills in Thailand is 18.6 rais, which is greater than that in Taiwan, at only 4.9 rais. In addition, labor count per mill in Thailand is also greater than Taiwan. Approximately, 15 permanent labors and 9 temporary labors worked in Thai rice mills compared to 8 permanent labors and 4 temporary labors in Taiwanese rice mills. These gave proof that Thailand is land and labor intensive while Taiwan is capital intensive in the rice mill business.

The major product produced in Thailand is 100-kg packaged product, which accounts for 47.2 % and were sold to commission agents, exporters and wholesalers. That is followed by 50-kg packaged product accounting for 38% sold to wholesalers in local or other regions, and to some retailers. Though most rice in Taiwan is for domestic consumption the 30-kg packaged product was most common and accounted for 46.2 % of what wholesalers and retailers bought. The 4.5 and 5 kg packaged product accounted for 14.5 %, and was sold to retailers and supermarkets.

Regarding the concerns of millers in the rice mill business, Thailand's rice millers ranked incidence of high competitiveness as their first priority followed by quality of paddy. On the other hand, high rate of energy expense and insufficient paddy are the problems of Taiwan rice millers.

The second purpose of this study is to present the empirical result that would answer the technical efficiency level for the rice milling industry and for each particular individual sample rice mill in Thailand and Taiwan. To estimate technical efficiency level, data envelopment analysis was used to estimate total technical efficiency, pure technical efficiency and scale efficiency of each input variable: paddy, land, labor and expenditure for machines in the input oriented DEA models.

The results showed that the average of total technical efficiency and pure technical efficiency of rice mill in Thailand is less than Taiwan. The average CRS measure of technical efficiency is 84 % in Thailand and 87 % in Taiwan. The averages VRS measures are 87 % in Thailand, compared to 91 % in Taiwan. This shows that efficiency of rice mills in Taiwan are clustered at the higher level than the rice mills in Thailand

When technical efficiencies obtained with CRS and VRS models are equal then the operator is running under constant returns to scale. Scale efficiency results illustrated that 11.1 % and 11.4 % of the rice mills in Thailand and Taiwan are operating at their optimal scale. Rice mill scale efficiency indices are about 96.3 % and 95.8% in Thailand and Taiwan, respectively. This implies that even if Taiwan has higher technical efficiency but the appropriate scale efficiencies of rice mill in both countries are almost identical. In addition, it can be mentioned that rice mills in

Thailand and Taiwan, at least from the sample firms, are producing at an increasing return to scale. Therefore, these rice mills could increase their technical efficiency by continuing to increase their size.

The DEA results for each rice mill are also available to determine whether an individual rice mill can increase its technical efficiency by increasing or decreasing its inputs or whether it is already operating at optimal scale. The adjustments that can be made in the use of inputs by inefficient firms can be found by comparing them with their 'peer' firms. The composite of inputs on each decision making unit (DMU) was suggested how minimizing the use of excessive inputs could produce unchanged output.

Finally, this study attempts to identify factors inducing technical inefficiency of rice mills in both Thailand and Taiwan. The use of Tobit regression model to regress total technical efficiency on explanatory variables, defined as the number of years established, capacity of operation, experience, education level of rice miller, source of power, and dummy variable on type of business. The outcome from the analysis indicated that experience and educational level of rice miller was correlated significantly (and positively at α = 0.05) with the technical efficiency of rice mill in both Thailand and Taiwan. Moreover, the age of the rice mill has an important impact on the efficiency level in Taiwan but not in Thailand. Finally, commercial rice mills have more technical efficiencies than cooperatives rice mills in Thailand and Taiwan at level α= 0.05 and α= 0.10, respectively.

7.2 Recommendation

The important issue that would be recommended here is the degree of capital and labor intensity between rice mill establishments in Thailand and Taiwan. This is important, because which kind of rice mill should be promoted depends, at least in part, on how efficiently firms utilize resources. Even if Taiwan has higher technical efficiency, Thai rice mills have more appropriate scale efficiency on their sizes than rice mills in Taiwan. Taiwan has a higher technical efficiency that comes from the use of high technology and large amount of capital investment.

The mechanisms for technological acquisition for rice mill production in Thailand are wide ranging. At one end, hardware was imported, modern machines obtain better quality output. At the other extreme, only locally produced traditional technology was used. In between there are cases where copied versions of foreign machines are used concurrently with conventional machinery. Trails and errors were also a major means of acquisition. Technological diffusion is through informal personal contacts, factory visits and sub-contracting of common machinery producers that was caused Thailand's rice mills to have their own ways to improve their technical efficiency.

The findings suggest that provision of training on rice technology in Thailand which is a combination of knowledge concerning the physiochemical properties of rice and corresponding milling or processing technology in a few selected vocational schools in the heart of the rice land. This is to institutionalize what has been firm knowledge or firm heritage to allow accelerated technical improvements.

The other is provision of fund for research on rice milling technology and for an interested interaction between educational institutes and the industry. In such maner, it is expected that academic expertise and practical technical experience will be pooled to produce better rice mill production system.

Furthermore, it is more appropriate Thailand, which has an abundant labor resource, to employ labor-intensive techniques in production, it is nevertheless necessary to consider if this leads to slower growth of output as compared to the capital intensive route. If the intensive use of capital leads to higher efficiency of production and enables entrepreneurs to reap a higher rate of return, which in turn leads to higher rate of investment, the choice of intensive industry may eventually lead to a higher rate of growth of output in Thailand. Nevertheless, the choice of capital-intensive also relies on scale of production. Small scale rice mills may be more efficient in the case of Scale Efficiency if they use labor intensive techniques. This can be seen from the fact in the Thai rice milling industry smaller scale rice mills are more labor intensive.

7.3 Suggestions for further study

Due to the shortcomings of this study and other interesting points, the followings are suggested for further study:

1. To further improve the study on technical efficiency, a pooled time series with cross sectional data should be employed.

2. Price efficiency should be accounted in investigating technical efficiency in order to assess the allocative efficiency of one particular industry. The technical efficiency itself cannot explain the utilization of existing resources when the price factor is not taken into consideration. The study in the allocative efficiency would provide empirical work that can give more implication to the real phenomena.

3. In order to have a more precise picture about technical efficiency, all the inputs should be quantified by physical unit instead of value unit.