

Cost And Scale Efficiency Of Rice Farmers In Soc Trang Province, Vietnam

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Abstract

Through the application of a non-parametric method, the research focused on measuring cost efficiency based on estimating technical efficiency and allocative efficiency in resources of rice farmers in Soc Trang Province, Vietnam. Moreover, the research centered on its values through the estimated and compared scale efficiency in the production of farmers. Research data was collected from 240 rice farmers who have been cultivating rice in My Tu and Thanh Tri districts, Soc Trang Province. The Data Envelopment Analysis (DEA) was used to estimate the effective component of rice farmers. The results showed that rice farmers achieved relatively high scale efficiency whereas the cost efficiency only was an average proportion.

Keywords: cost and scale efficiency, rice farmers, Soc Trang

PROBLEM STATEMENT

Soc Trang Province has long been regarded as the “cradle” of fragrant rice in the Mekong Delta. As of 2024, the entire province of Soc Trang has approximately 330,000 hectares of rice fields, with specialty rice varieties accounting for nearly 50%. This achievement is the result of investments in researching and transferring advanced scientific technologies to rice crops. In recent years, Soc Trang has implemented over 20 research topics and projects on the selection and rejuvenation of rice varieties. Notably, there are programs for breeding fragrant rice varieties like the ST line. As a result, several brands such as ST rice have gained initial trust from both domestic and international customers. To date, 21 specialty fragrant rice varieties under the ST brand have been carefully selected, including ST1, ST3, ST5, ST8, ST10, and ST20. Especially, ST20 is

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IJEBIR, Volume 04 Issue 06, 2025



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especially known for its long rice grains, soft and sticky texture, with the aroma of pandan and green rice. It is considered the flagship fragrant rice variety, outstanding not only in Soc Trang but throughout Vietnam, with yields ranging from 6.5 to 7 tons per hectare and meeting export standards.

Despite these positive aspects, the rice industry in Soc Trang still faces significant challenges, such as a portion of farmers practicing rice production independently with small-scale production relying on traditional experiences; the use of outdated rice varieties leading to a reduction in the quality of commercial rice; the application of advanced technical models is not standardized, resulting in suboptimal investment efficiency. Particularly, the quality of the relationship between farmers and rice-consuming businesses remains limited (Nguyen & Mai, 2021; Hoang et al., 2022). These issues may cause risks in the production and consumption of rice, affecting the farmers' production efficiency (Mai et al., 2022). Therefore, the question arises: Have rice farmers in Soc Trang achieved efficiency in production? This study is conducted to answer this question and proposes recommendations to enhance the production efficiency of rice farmers in Soc Trang Province.

RESEARCH METHODOLOGY

Research data

In this study, the Data Envelopment Analysis (DEA), with indexes such as cost efficiency (CE) and scale efficiency (SE), is employed to evaluate the production efficiency of rice farmers. Data for the study was collected from 240 rice farmers in the districts of My Tu and Thanh Tri (in Soc Trang Province), using a stratified random sampling method.

Table 1: The number of households divided by administrative area

Survey area		Number of households	%
District	Town		
My Tu	Nguyen Huu Nghia	57	23.75
	My Tu	75	31.25
Thanh Tri	Phu Loc	45	18.75
	Tuan Tuc	63	26.25
Total		240	100.00



To measure cost efficiency (CE) and scale efficiency (SE), this study utilizes output, input, and input price variables in three seasons: Winter-Spring, Summer-Autumn, and Autumn-Winter, as presented in the table below:

Table 2: Variables used in CE and SE estimation

Variable	Unit	Winter-Spring	Summer-Autumn	Autumn-Winter
		Mean	Mean	Mean
Quantity	Kg/ha	805.7	620.1	550.9
Inputs				
Seed	Kg/ha	18.9	20.7	22.1
URE fertilizer	Kg/ha	15.6	16.6	14.5
DAP fertilizer	Kg/ha	7.1	7.9	7.1
KALI fertilizer	Kg/ha	4.1	4.4	5.1
NPK fertilizer	Kg/ha	13.0	13.9	12.3
Herbicide	Liter/ha	103.9	99.2	80.1
Pesticide	Liter /ha	177.3	198.3	192.2
Growth stimulant	Liter /ha	40.0	33.1	48.1
Fuel	Liter /ha	2.1	1.7	1.8
Labor	Workday/ha	1.1	1.4	1.6
Equipment	Hour/ha	2.8	2.5	2.5
Input price				
Seed	1.000 VND/kg	9.9	9.2	8.3
URE fertilizer	1.000 VND/kg	10.2	10.4	10.4
DAP fertilizer	1.000 VND/kg	15.4	14.9	14.3
KALI fertilizer	1.000 VND/kg	14.3	14.4	14.7
NPK fertilizer	1.000 VND/kg	14.2	14.3	14.3
Herbicide	1.000 VND/liter	1.5	1.7	1.9
Pesticide	1.000 VND/ liter	1.4	1.4	1.3
Growth stimulant	1.000 VND/ liter	2.6	3.4	2.1
Fuel	1.000 VND/ liter	21.1	20.5	21.6
Labor	1.000VND/workday	202.1	187.6	231.1
Equipment	1.000 VND/hour	171.7	176.8	151.3

Estimation model

The cost efficiency (CE) estimation model:

According to Coelli et al. (2005), cost efficiency can be measured using the Constant Returns to Scale Input-Oriented DEA Model (CRS-DEA Model). In the multi-input multi-output case, as in this analysis, assuming N decision-making units (DMUs), each



DMU produces S products using M different input variables. In this scenario, to estimate the CE of each DMU, a set of linear equations must be established and solved for each DMU (Coelli, 1996). This can be accomplished using the CRS Input-Oriented DEA model, formulated as follows:

Minimize $[\lambda_i x_i^* w_i x_i^*]$

with conditions:

$$\left\| \begin{array}{l} \sum_{i=1}^N \lambda_i x_{ji} - x_{ji}^* \leq 0, \forall j \\ \sum_{i=1}^N \lambda_i y_{ki} - y_{ki} \geq 0, \forall k \\ \lambda_i \geq 0, \forall i \end{array} \right\| \quad (1)$$

In which: w_i = vector of the production factor unit price for the i^{th} DMU,
 x_i^* = vector of the number of input factors in the direction of minimizing production cost for the i^{th} DMU determined by model (1),
 i = 1 to N (the number of DMUs),
 k = 1 to S (the number of products),
 j = 1 to M (the number of input variables),
 y_{ki} = amount of product k produced by i^{th} DMU,
 x_{ji} = amount of input j used by i^{th} DMU,
 λ_i = dual variables.

The estimation of CE in the model (1) can be performed by various computer programs. However, for convenience, the authors use the DEAP version 2.1 program for CE estimation in this study.

The scale efficiency (SE) estimation model

In recent decades, many studies have decomposed the technical efficiency (TE) achieved from constant returns to scale (CRS) into two components: the first part is pure technical inefficiency, and the second is scale inefficiency. Therefore, measuring scale efficiency (SE) can be used to determine the extent to which productivity can be improved by adjusting the production scale to an optimal scale.

To measure SE using the DEA method, we need to estimate an additional production margin: the Constant Returns to Scale (CRS-DEA). Then, measuring SE can



be done for each household by comparing the TE achieved from CRS-DEA with the TE achieved from the Variable Returns to Scale (VRS-DEA). If there is a difference in TE between CRS-DEA and VRS-DEA, we can conclude that there is inefficiency in scale (Scale Inefficiency = 1 – Scale Efficiency).

According to Coelli et al. (2005), SE can be measured using the Variable Returns to Scale Input-Oriented DEA Model (VRS-DEA Model). In the multi-input multi-output case, as in this analysis, assuming N decision-making units (DMUs), each DMU produces S products using M different input variables. In this scenario, to estimate the SE of each DMU, a set of linear equations must be established and solved for each DMU. This can be accomplished using the VRS-DEA model, formulated as follows:

$$\begin{aligned} & \text{Minimize } \left\|_{\theta_p, \lambda} \{\theta_p\} \right\| \\ & \text{with conditions: } \left\{ \begin{array}{l} \sum_{i=1}^N \lambda_i x_{ji} - \theta x_{jp} \leq 0, \forall j \\ \sum_{i=1}^N \lambda_i y_{ki} - y_{kp} \geq 0, \forall k \\ N1' \lambda_i = 1 \\ \lambda_i \geq 0, \forall i \end{array} \right\} \quad (2) \end{aligned}$$

In which:

- θ_p = efficiency value,
- i = 1 to N (the number of DMUs),
- k = 1 to S (the number of products),
- j = 1 to M (the number of input variables),
- y_{ki} = amount of product k produced by i^{th} DMU,
- x_{ji} = amount of input j used by i^{th} DMU,
- $N1$ = Nx1 vector 1,
- λ_i = dual variables.

RESEARCH RESULTS AND DISCUSSION

Cost efficiency (CE)

Using the DEAP program version 2.1 to estimate the cost efficiency (CE) of rice-producing households in Soc Trang Province, the results are presented in Table 3.



Table 3: Cost efficiency of rice-producing households

Efficiency value	Winter-Spring		Summer-Autumn		Autumn-Winter	
	Number of households	%	Number of households	%	Number of households	%
1.000	2	0.8	1	0.4	1	0.7
0.900 – 0.999	8	3.3	6	2.5	3	2.2
0.800 – 0.899	30	12.5	12	5.0	7	5.1
0.700 – 0.799	44	18.3	27	11.3	12	8.8
0.600 – 0.699	71	29.6	66	27.5	39	28.7
0.500 – 0.599	63	26.3	79	32.9	39	28.7
0.400 – 0.499	22	9.2	35	14.6	28	20.6
< 0.400	0	0.0	14	5.8	7	5.1
Total	240	100	240	100	136	100
Mean	0.66		0.601		0.594	
Range	0.44 – 1.00		0.22 – 1.00		0.30 – 1.00	

Cost efficiency, also known as the overall economic efficiency of rice-producing households, is calculated based on the synthesis of technical efficiency and resource allocation efficiency in production. The calculated result in Table 3 shows that the cost efficiency of rice-producing households in Soc Trang Province is quite low and widely dispersed. The average CE value is 0.66 with a corresponding range of 0.44 to 1.00 in the Winter-Spring season, 0.60 with a range of 0.22 to 1.00 in the Summer-Autumn season, and 0.69 with a range of 0.30 to 1.00 in the Autumn-Winter

season. This indicates a significant variation in cost efficiency among rice-producing households, which may be explained by differences in the adoption of technological advancements and financial resources among these households.

The result in Table 3 also indicates that few rice-producing households in Soc Trang Province achieve optimal cost efficiency (2 households in Winter-Spring, 1 household in Summer-Autumn, and 1 household in Autumn-Winter). This suggests that the majority of rice-producing households do not use optimal input quantities. The average investment cost for input factors of a rice-producing household is higher compared to the investment cost for the most cost-efficient household, approximately 50% higher. The main reason for cost inefficiency is the wastage of input factors during production, coupled with an inadequate coordination of input factors according to prices. The result further indicates that if a household



with an average level of cost efficiency achieves the highest level of efficiency, that household could save an amount of 0.4 monetary units (1,000 - [0.60/1,000]). Similarly, a household with the lowest level of efficiency could save an amount of 0.78 monetary units (1 - [0.22/1.00]).

Scale efficiency (SE)

The analysis result in Table 4 indicates that the average scale efficiency of rice-producing households in Soc Trang Province is quite high, with average scale efficiency values in the three seasons: Winter-Spring, Summer-Autumn, and Autumn-Winter being 0.91, 0.91, and 0.87, respectively. This suggests that rice-producing households in the research area have efficient production scales.

Table 4: Scale efficiency of the rice-producing house in Soc Trang Province

Scale efficiency	Winter-Spring		Summer-Autumn		Autumn-Winter	
	Number of households	%	Number of households	%	Number of households	%
Total number of rice-producing households	240	100.0	240	100.0	136	100.0
Households with IRS	173	72.1	204	85.0	110	80.9
Households with DRS	26	10.8	9	3.8	6	4.4
Households with CRS	41	17.1	27	11.2	20	14.7
Mean SE	0.91		0.91		0.87	
Min	0.54		0.59		0.58	
Max	1.00		1.00		1.00	

Note: IRS = increasing returns to scale, DRS = decreasing returns to scale, CRS = constant returns to scale

In the Winter-Spring season, households in the region experiencing increasing returns to scale (IRS) account for 71.1%. This indicates that farmers can enhance production efficiency by expanding their investment scale. Additionally, about 10.8% of households need to decrease returns to scale to improve production efficiency (DRS). On the other hand, approximately 17.1% of households in the region operate at optimal scale efficiency or, in other words, constant returns to scale (CRS). For the Summer-Autumn season, the scale efficiency index of households does not differ significantly from



the Winter-Spring season. However, in the Summer-Autumn season, the number of households that need to increase returns to scale (IRS) is 85%, those have constant returns to scale (CRS) constitute 11.2%, and only 3.8% of households need to reduce their scale of investment in rice production. The scale efficiency value in the Autumn-Winter season does not vary much compared to the previous two seasons. Although the average scale efficiency value in the Autumn-Winter season is slightly lower, the number of households with constant returns to scale (CRS) or achieving optimal resource use is 14.7%, higher than in the Summer-Autumn season. The number of households that need to decrease returns to scale (DRS) to achieve optimal resource use is 4.4%, which is lower than in the Winter-Spring season but higher than in the Summer-Autumn season. The number of households in the region that need to increase returns to scale (IRS) exceeds 81%. The analysis results suggest that rice-producing households that need to increase returns to scale can add more input factors to the available rice field area, coupled with a rational allocation of inputs at reasonable prices to increase productivity and output, thereby enhancing production efficiency. For those households experiencing a decrease returns to scale (DRS), they can reduce their scale of investment (reduce fertilizer, pesticide spraying, labor hiring, etc.) to achieve optimal production efficiency.

Suggestions for adjusting rice-producing inputs

Based on the results of cost efficiency (CE) and scale efficiency (SE), it is evident that although rice-producing households in Soc Trang Province achieve high scale efficiency (SE), cost efficiency (CE) remains at an average level. Therefore, farmers need to adjust input quantities reasonably to improve cost efficiency and enhance production efficiency. According to the analysis results using DEAP version 2.1 software, a directional model (projected value) is established, indicating the potential cost savings that households can achieve by using input factors reasonably while ensuring constant output levels. Rice-producing households can refer to the result presented in Table 5.

Table 5: Input resource allocation based on actual surveys and proposed results from the DEA model for rice farmers

Inputs	Winter-Spring		Summer-Autumn		Autumn-Winter	
	Reality	Proposed from DEA model	Reality	Proposed from DEA model	Reality	Proposed from DEA model
Seed (kg/ha)	18.93	16.08	20.73	17.24	22.13	18.34
URE fertilizer (kg/ha)	15.63	12.60	16.58	12.72	14.50	11.97

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DAP fertilizer (kg/ha)	7.10	5.62	7.90	6.05	7.05	5.81
KALI fertilizer (kg/ha)	4.11	3.25	4.37	3.31	5.12	4.25
NPK fertilizer (kg/ha)	12.99	10.56	13.91	11.2	12.27	10.22
Herbicide (liter/ha)	103.88	85.17	99.17	80.38	80.09	67.02
Pesticide (liter/ha)	177.27	144.63	198.34	160.76	192.23	160.85
Growth stimulant (liter/ha)	40.00	32.62	33.06	26.76	48.06	40.21
Fuel (liter/ha)	2.14	1.54	1.69	1.08	1.83	1.33
Labor (workday/ha)	1.14	0.90	1.39	1.06	1.61	1.25
Equipment (hour/ha)	2.84	2.19	2.47	1.75	2.53	1.84

CONCLUSION

Applying the Data Envelopment Analysis (DEA) method, the research results show that in cases where scale does not affect production efficiency, rice-producing households in Soc Trang Province achieve average cost efficiency. However, the study also reveals that the majority of rice-producing households achieve scale efficiency in all three seasons: Winter-Spring, Summer-Autumn, and Autumn-Winter. Based on the research results, several recommendations are proposed as follows: (i) For rice-producing households: Adjust input quantities in the production process reasonably; Learn and apply new technical advancements to rice fields; Expand production scale with new models such as production linkages and large-scale sample fields. (ii) For the Agriculture sector in Soc Trang Province: Transfer technical advancements to rice-producing households through various forms such as training, on-site seminars, and experience exchange programs; Encourage farmers to participate in advanced production models such as VietGAP and Global GAP; Expand large-scale sample field models into larger field models.

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