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Analyzing The Technical Efficiency And Allocative Efficiency Of Farmers Growing Lotus Root In Soc Trang Province, Vietnam

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Abstract

The study focuses on analyzing economic efficiency, technical efficiency (TE), allocative efficiency (AE) and profit (CE) in household lotus root cultivation in Soc Trang province, Vietnam. Along with that, Stata software is applied to estimate production efficiency. Research results show that lotus growing households have an average yield of 8.29 tons/ha; average profit reached 49,357,143 VND/ha; the average revenue/cost ratio is 174%; profit/cost ratio is 73% and profit/sales ratio is 42%. This is a quite encouraging result, showing that compared to other crops, lotus root has higher economic efficiency. In addition, the article also analyzes the limitations and causes of the limitations affecting the production efficiency of lotus growers in the province such as the ineffective use of fertilizers and pesticides, causing waste of time. fee. Farmers have not been trained in technical processes, so they have not applied technical learning to production to increase productivity and reduce costs. Harvesting is still quite manual, which is labor intensive and reduces the quality of tubers after harvest. From there, provide solutions as well as recommendations to local authorities and lotus growing households to increase productivity and reduce costs in order to improve the efficiency of lotus root production of lotus growers.

Keywords: allocative efficiency, cost efficiency, data envelopment analysis, technical efficiency, lotus roots.

1. Introduction

The Mekong Delta is the country's largest reservoir of rice, with the entire region's winter rice cultivation area reaching 171.2 thousand hectares, with more than 24 million tons of rice annually, accounting for more than 50% of the country's rice production. It accounts for more than 90% of exports. At the same time, it provides employment and income for more than 1.5 million agricultural households. In the past, agriculture has driven crop restructuring in the face of unpredictable climate change, drought and salinity that repeatedly impact agricultural production conditions. In order to increase agricultural production, households reduced the area planted with rice and replaced it with other crops such as fruit trees and tubers. Lotus root in particular is a common plant grown in his two provinces of the Mekong Delta, Soc Trang and Dong Thap.

In recent years, many scholars have also conducted research on economic efficiency and technological efficiency in the agricultural sector of the Mekong such as Nguyen Huu Dang (2017), Tran Thi Ai Dong, Quan Minh Nhut and Thach Thi Kim Khanh (2017), Cao Tien Si (2018), Ho Que Hau (2019), Phan Thi Xuan Hue (2019), Ngo Thanh Trac, Son Thi Thanh Nga and Duong Ngoc Thanh (2019). These studies focus on analysis of factors affecting farmers' production efficiency of crops such as rice, corn, chilli, onion and dragon fruit. More and more attention is being focused on improving the efficiency of agricultural production. However, there are few studies on lotus root production efficiency.

In Soc Trang province, many production models are applied towards the application of science and technology suitable for the production situation. Lotus root in particular is one of the production models that has many advantages in terms of labor and soil in this area. Lotus root has historically been a popular product among consumers, and production and consumption of this product occurs all year round. However, there are still many problems in the production and consumption of lotus root products. As the demand for lotus root grows, farmers are more interested in investment, production and business activities. Find out the factors that affect production efficiency and propose solutions to improve lotus root cultivation efficiency for farmers in Soc Trang province. The following article focuses on analyzing the technical efficiency and allocation efficiency of lotus growing households and proposes solutions to improve production efficiency.

2. Related Literature and Methodogy

Performance measurement began with work by (Farrell, 1957). Furthermore, it builds on the concept of efficiency previously described in the work by (Debreu, 1951) and (Koopmans, 1951). Farrell (1957) proposed that efficiency has two components. Technical efficiency (TE) reflects a firm's ability to produce maximum output given a set of inputs and efficiencies. Allocative efficiency (AE) or cost effectiveness reflects a firm's ability to use its inputs in optimal proportions at a given price level and production technology. The combination of these two types of efficiency forms the concept of economy or overall efficiency.

In this study, technical efficiency is the application of technological measures to improve the productivity of agricultural production, and allocative efficiency is the optimization of inputs to increase farmers' profits. Farmers in production. Productivity expresses the relationship between benefits and costs. In other words, the more useful a unit is per cost, the more efficient it is.

Production efficiency is determined by the relationship between the results obtained and the costs (human resources, material resources, etc.) expended to achieve the results.

The Cobb-Douglas function is most commonly used in agricultural production. It has been shown that "the logarithms of the output Y and the input Xi are usually linearly related". This production function is usually written as: $Q = AL^{\alpha} K^{\beta}$. In which:

Q is the output

A, α, β are positive constants

L is labor

K is the capital used.

Production function: Represents the relationship between input and output elements. Combining specific inputs to maximize output $Y = f(x_1, x_2, \dots x_m)$

In which: Y is the level of output (product).

Factors of production x1, x2, …xm. ($x \geq 0$).

The limit of the production function consists of a level of output (y) resulting from a level of input (x) used (Shephard, 2012)

- Random marginal production function

Technical efficiency is estimated by the random marginal production function Aigner, Aigner, Lovell, & Schmidt (1977), Meeusen & van Den Broeck (1977) through the discovery of (G.E. Battese and T.J. Coelli, 1992). The random marginal production function has the form:

$Y_i = f(x_i; \beta) \exp(V_i - U_i)$

In which:

- Yi: household productivity or output; Xi: input element i; β: Estimated coefficient; Vi: statistical error; Ui: the Technical inefficiency is considered to be greater than or equal to 0.

u = 0 if household production and business activity are at the production front. This means that the maximum level of productivity or production is achieved based on available production factors and technology.

If household productive activity is below the marginal production line (frontier), i.e. u > 0, i.e. Productivity real output (Yi) is lower than productivity, maximum output (Y*) and efficiency The number between Y* and Yi is the part of the technical inefficiency, and the larger the difference, the lower the technical efficiency (Coelli, Rao, O'Donnell, & Battese, 2005),(Fare, Grosskopf, & Lovell, 1994).

- Technical efficiency (TE): The ratio of actual productivity or performance to maximum productivity or output. TE is calculated as follows:

$TE_i = Y_i / Y_i^* = f(x_i; \beta)\exp(V_i - U_i) / f(x_i; \beta)\exp(V_i) = \exp(-U_i)$

The marginal production function that can be estimated by the Cobb-Douglas model has the form: $\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + ... + \beta n \ln Xn + V_i - U_i$

In the regression model above, the important βk values indicate the direction and impact of input Xi on household productivity.

- Non-Technical Efficiency (TIE): It is a combination of socioeconomic factors to achieve maximum performance. Ui in the equation is the Technical Inefficiency Function (TIE-Technical Inefficiency Function) used to describe the factors that influence technical inefficiency. Technical inefficiencies take the form of:

$TIE = U_i = \delta_0 + \delta_1 Z_1 + \ldots + \delta n Zn$

In which: TIEi is the technical inefficiency factor. Zi (i = 1,2,...,6) are factors affecting technical inefficiency.

Sample size: Formula for calculating sample size by population: $n = \frac{p(1\text{-}p)}{MOE^2} Z^2_{\propto/2}$

In there

n: Sample size;

p: Rate of occurrence of elements in the sampling unit exactly as the sampling target (0 < P < 1);

Z: The lookup value of the normal distribution Z corresponding to the confidence level; MOE: Small sample tolerance

(1) Data volatility V= p(1 – p), in the worst case the data volatility is at its maximum

$$V = p(1 - P) \to \max \to V' = 1 - 2p = 0 \to p = 0{,}5$$

(2) Choose the confidence level at 90%, so the maximum error is α=10%. Look up the normal distribution table with 90% confidence is $Z_{\alpha/2}$ = 1.645

(3) allowable error with small sample size is 10%

Combining (1), (2), (3) we have: $n = \frac{0{,}25 \times (1{,}648^2)}{0{,}1^2} \approx$ 68 observations

Random stratification method was applied to survey 68 lotus growing households. Respondents can be either the head of the household or the main direct participant in the household so that they can provide comprehensive information on the household's production and trade indicators.

3. Results

3.1 Density, scale and area of lotus planting

The household with the smallest lotus growing area is 0.5 ha and the household with the largest lotus growing area is 120 ha, the average value of lotus growing area of the 68 surveyed households is 20.8 ha, respectively 916.0 kg seeds/ha

Table 1. Area and density of lotus varieties

Indicators	**Unit**	**Minimum**	**Maximum**	**Average**
Land area	ha	0.5	120	20.8
Number of kilograms of seed/hecta	kg	800	1,050	916

Source: Survey data in 2022

3.2. Production cost of lotus farmers

For the production of lotus root, it includes: costs of seeds, land preparation, labor (planting, weeding, harvesting...), fertilizers, plant quarantine drugs and other costs for the production process

Table 2. Farmer's cost of growing lotus root
ĐVT: VND/ha

Cost items	**Minimum**	**Maximum**	**Average**	**Percentage (%)**
Cost of seedlings	5,000,000	9,000,000	7.071.420	10.5
Labor cost	5,000,000	9,000,000	8.642.850	12.8
Machine cost	2,000,000	4,000,000	2.428.570	3.6
Fertilizer cost	7,000,000	8,000,000	7.428.570	11.0
Cost of pesticides	31,000,000	33,550,000	31,285,710	46.3
Other costs	10,000,000	12,000,000	10,714,280	15.9
Total	60,000,000	75,550,000	67,571,430	100.0

Source: Survey data in 2022

The results in Table 2 show that the average cost of lotus farmers is about 67,571,430 VND/ha. In which, the average cost of seed is 7,071,420 VND/ha, accounting for 10.5% of the total production cost of lotus farmers. Lotus seeds are purchased by farmers mainly from producing households with prices ranging from 6,000 VND/kg to 7,000 VND/kg.

The cost of plant protection drugs accounted for the highest proportion with 46.3% of the total cost of producing 1 ha of lotus root; followed by labor cost, accounting for 12.8%; Fertilizer cost accounted for 11.0%; Machine cost is 3.69% and the remaining 15% is other cost.

The survey shows that all households use pesticides to protect lotus from harmful pests. Activities of using pesticides are strictly followed according to recommendations, ensuring safe production and consumption.

3.3 Income of lotus growing households

Table 3. Financial performance of lotus farmers

Indicators	**Unit**	**Minimum**	**Maximum**	**Average**
Productivity	Kg/ha	700	10.000	829
Price	VND/kg	12,000	15,000	14,200
Revenue	VND/kg	84,400,000	150,000,000	117,714,280
Expense	VND/kg	60,000,000	75,500,000	67,571,430
Profit	VND/kg	24,000,000	74,500,000	50,142,850
Revenue/Cost	%	140	199	174
Profit/Revenue	%	29	50	43
Profit/Cost	%	40	99	74

Source: Survey data in 2022

Table 3 shows that the average yield is from 700 kg/ha to 10,000 kg/ha, with an average of 829 kg/ha of lotus root/ha. Compared with the productivity of some lotus growing areas such as Hung Yen, Hai Duong, Nam Dinh and Hue provinces of Vietnam, the average yield of lotus tubers is from 400 kg/ha to 500 kg/ha (according to statistics from the Fruit and Vegetable Research Institute, 2019). As a result, the lotus root yield of lotus growers in Soc Trang province is higher than the national average.

The average profit/ha of lotus growing households is VND 50,142,850/ha. However, the profit difference between lotus growing households is quite large, the lowest is 24,000,000 VND/ha and the highest is 75,500,000 VND/ha. The cause of this difference is due to factors affecting the production process, of which the most important factor is the care technique. Good production techniques can reduce costs and help lotus plants produce more bulbs. In addition, the weather factor also greatly affects the profit because bad weather, pests and diseases, households have to spend money on pesticides and care.

3.4 Technical efficiency analysis

Table 4. Descriptive statistics for marginal product function variables

Indicators	**Unit**	**Minimum**	**Maximum**	**Average**
Acreage	ha	0.5	120	20.8
Amount of seeds	Kg/ha	800	1,050	916.2
Amount of nitrogen fertilizer	Kg/ha	30	35	33.7
Amount of phosphate fertilizer	Kg/ha	30	36	33.8
Amount of Potassium Fertilizer	Kg/ha	10	35	29.8
Labors	VND/ha	5,000,000	9,000,000	8,642,850
Cost of pesticides	VND/ha	31,000,000	33,500,000	31,285,740

Source: Survey data in 2022

Table 4 shows that the average land area for each household to produce lotus root is 20.8 ha, the average amount of seed used is quite high, about 916.2 kg/ha, the average for 1 ha of land for growing lotus root. Farmers have to spend 31,285,740 VND for medicine.

The household labor cost that farmers spend to produce lotus root per crop is on average 8,642,850 VND/ha. Estimating the stochastic marginal product function model by the MLE maximal estimation method using Frontier 4.1 software, we have the following results:

Table 5. Estimation results of marginal production functions and technical inefficiencies

Codes	**Variables**	**Coefficient**	**Standard deviation**	**T value**
Marginal production function				
	Constant	3.94^{***}	0.99	3.96
Ln X_1	Area (ha/household)	0.93^{***}	0.07	2.75
Ln X_2	Amount of seed (kg/ha)	0.12^{ns}	0.67	0.18

Ln X_3	Amount of nitrogen fertilizer (kg/ha)	-0.22^{ns}	0.92	-0.23
Ln X_4	Amount of phosphate fertilizer (kg/ha)	-0.67^{ns}	0.93	-0.72
Ln X_5	Amount of potassium fertilizer (kg/ha)	0.22^{*}	0.06	1.84
Ln X_6	Labor (1,000 VND/ha)	-0.04^{**}	0.09	-2.14
Ln X_7	Cost of pesticides (1,000 VND/ha)	-0.05^{***}	0.06	-8.59
Technical inefficiency function				
	Constant	0.96^{***}	0.98	9.80
Z_1	Education (Number of years of schooling)	-0.09^{**}	0.89	-2.01
Z_2	Experience (Years)	-0.02^{**}	0.24	-2.09
Z_3	Credit (1= yes, 0= other)	-0.15^{***}	0.91	2.68
Z_4	Training (1= yes, 0= other)	0.02^{ns}	0.96	0.03
Z_5	Family Labor (Person)	-0.00^{ns}	0.51	-0.01
Z_6	Join a professional association/organization (1= yes, 0= other)	0.14^{ns}	0.44	0.32
σ^2		0.03^{*}	0.01	2.62
γ		0.96^{*}	0.95	1.01
Average technical efficiency		85.15%		

Source: Data analysis results in 2022 using Frontier 4.1 software

Note: *, ** and *** represent the estimated parameters, respectively, that are statistically significant at the 10%, 5% and 1% levels, respectively, ns: not statistically significant.

Survey results were analyzed by Frontier software to estimate technical efficiency (marginal production function) and factors affecting technical (non-productive technical function) with the following results:

+ The gamma coefficient (γ) equal to 0.96 shows that socio-economic variables have an impact on technical efficiency, farmers not only affect input factors but also have an impact on technical efficiency, household agriculture. Socioeconomic variables are also known as technical inefficiencies.

+ The average technical efficiency of surveyed households is 85.15%, that is, with current resources combined with suitable production models, the household's productivity increases by 14.85%.

+ The results in Table 5 show that input factors such as area, amount of potassium fertilizer, drugs cost can increase the yield of lotus root of farmers.

- Area (X_1): The coefficient of $\beta 1$ of $\ln X_1$ is 0.93 and this variable is statistically significant at 1%, showing that when the area increases by 1%, the yield increases by 0.93%, in the other factors remain unchanged.

- Amount of potassium fertilizer (X_5): The $\beta 5$ coefficient of $\ln X_5$ is 0.22 which is statistically significant at 10%, showing that when increasing the amount of potassium fertilizer 1%, the model yield increases by 0.22%. Lotus has a high demand for potassium during flowering and tuber formation, so applying the right amount of potassium fertilizer at the right dose will improve the yield of lotus growers.

- Labor (X_6): The coefficient of this variable is statistically significant at 5% and negative, which shows that when we increase one working day, productivity decreases by 0.04%. The survey shows that most of the work of lotus growers is hired labor, which will reduce production efficiency because households use a lot of hired labor.

In addition, the results of technical inefficiency function estimation show that the factors of education, experience and credit are statistically significant at 1%, 5% and 10%, respectively, with negative signs. This means that they have a positive relationship with technical performance.

Accordingly, the more educated farmers are, the easier it is to absorb advanced science and technology, resulting in higher production efficiency than other farmers. In addition, farmers with experience in taking care of lotus roots will accumulate higher technical efficiency, contributing to higher yields.

Access to credit helps to remove financial difficulties of households, facilitates households to invest in machinery and equipment for production, and quickly responds to inputs such as fertilizers and drugs. Agro-pharmaceuticals serve the production process, thereby helping farmers to increase production efficiency.

Table 6. The distribution of household efficiency

Efficiency level (%)	**Number of households**	**Percentage (%)**
<60	07	10.29
61-80	12	17.65
81-90	26	38.24
>90	23	33.82
Tổng	68	100.00
Average	85.15	
Maximum	98.11	
Minimum	65.08	

Source: Survey data in 2022

Table 6 shows that there is a difference in technical efficiency among lotus root producing households. In which, 10.29% of households achieved technical efficiency below 60% and up to 17.65% of households achieved technical efficiency from 61% to 80%.

Some farmers have low technical efficiency, possibly due to inefficient use of inputs or the impact of other factors (climate, pests,...). The estimated values are shown below:

Table 7. The distribution of lost productivity

Level of inefficiency (%)	**Actual productivity (kg/ha)**	**Productivity can reach (kg/ha)**	**Productivity is lost (kg/ha)**
0-10	973	1,320	347
10-20	868	1,280	412
20-30	736	1,030	294
30-40	700	1,046	346
Average	**874**	**1,250**	**376**

Source: Survey data in 2022

Table 7 shows that the actual average yield achieved by the farmer household is 874 kg/ha, if the technical inefficiency is maximized, the average yield that the farmer household can achieve is 1250 kg/ha. ha.

Yield loss due to inefficiencies was 347 kg/ha. For households with a level of technical inefficiency from 0 to 10%, the average yield loss was 347 quintals/ha.

The higher the level of household inefficiency, the greater the loss of output. Specifically, at the level of technical inefficiency from 10% to 20%, the average yield loss per household is 412 kg/ha, while at the level of technical inefficiency over 30% to 40%, the energy Fertilizer yield can be up to 294 kg/ha. ha. This shows that there are big differences in farming techniques and input use efficiency among farmer households. Therefore, it is necessary to train and disseminate synchronous techniques to farmers to improve productivity for lotus growers.

4. Conclusion

The model of growing lotus for its roots is one of the new economic models to help farmers improve their income, which has been popular in recent years due to its higher efficiency than growing rice and some other crops.

However, with fragmented production methods, the use of labor and pesticides is not effective. In addition, the application of science and technology, machinery and equipment to production is still limited. This affects product yield and growth efficiency of lotus root. Therefore, in order to improve the efficiency of the lotus root production model, it is necessary to focus on improving the following activities:

Firstly, regularly open technical training courses for farmers, encourage lotus growing households to improve the application of science and technology in production. In addition, the relevant professional bodies should pay more attention to the breeding of high yielding varieties, resistant to pests and diseases. Second, reduce costs to improve production efficiency.

- Effective use of fertilizers and pesticides:

The results of the marginal production function model show that the amount of nitrogen fertilizer used is directly proportional to the production efficiency. However, the use of too much fertilizer will also have an adverse effect on the soil, increasing production costs, and making plants susceptible to pests and diseases. Therefore, it is necessary to propagate and apply fertilizer techniques as recommended by the “five good” standard (good fertilizer, good fertilizer, good canopy, good object, good weather - season, good fertilization).

Third, it is necessary to support production capital so that farmers can invest in science and technology and production materials in a timely manner. In addition, capital can help farmers cover costs such as hiring workers, buying pesticides and fertilizers to help them produce the right crop.

At the same time, it is necessary to have solutions to help farmers improve their knowledge and skills to control financial resources, balance revenues and expenditures, and get rid of the vicious cycle of lack - debt - debt repayment - lack.

It is necessary to develop training content suitable to the actual situation; diversify forms of technical training such as agricultural extension clubs, establish many agricultural extension consulting points, promote professional associations/organizations to propagate and mobilize members to participate in training courses, apply scientific and technical advances to production.

For local authorities and relevant professional agencies, a solution is needed to breed new varieties with high yielding characteristics, resistance to pests and diseases, and adaptation to climate change.

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