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EVALUATION TECHNICAL EFFICIENCY IN POTATO PRODUCTION OF VIETNAM USING STOCHASTIC FRONTIER ANALYSIS APPROACH

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Abstract

Potato (Solanumtuberosum L.) is considered as one of staple food in many countries in the world, including Vietnam. This study aims to analyze the technical efficiency and identify the factors affecting the technical efficiency of potato production in Vietnam by using a one-step translog production function model. Primary data were obtained from 139 potato producers in Bacgiang and Haiduong province in the 2016/2017 production year. The results indicated that the technical efficiency level was low, of 0.66 and 0.52 for Bacgiang and Haiduong province, respectively. Furthermore, the findings of the inefficient effects model revealed that experience had a significantly negative effect on technical inefficiency levels, while factors related to gender and age had a significant positive impact. Therefore, to enhance the technical efficiency of potato production, policy ideas should focus on improving the quality of potato seed, supporting farmers in accessing new technologies, enhancing training and sharing experience in farmer's group.

Keywords: potato production; technical efficiency; translog production function; Vietnam

1. Introduction

Potato is one of important crops that is widely planted in the world. Some studies shown that potato is ranked the third compared to other annual crops with approximately 327 million tonnes and nearly 19 million ha cultivated areas[1].As a statement of Mohammadi, et al. [1], potato also contains a high nutritional value such as vitamin C and B_6.The quantity of protein of potato is higher in compared to wheat and rice (54% and 78%, respectively)[2]. Thus, potato products are the best choice for people to replace other grains and it contributes to ensuring food security in developing countries in the world. In Vietnam, potato has grown since 19th century and it is considered as one of staple food which plays a vital role in developing agricultural economy of the Red River Delta region with the planted area accounts of 95% of the total[3-4].Potatois cultivated in the Red River Delta during months of the winter season (from

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September to December) after harvesting some early rice varieties and water source is available for irrigation. Current statistics indicated that the potato acreage for the 2017 production year was 20.480 ha with an average of 148.276 tonnes per ha [5]. However, Vietnamese trade statistics shows that the potato sector is not able to produce enough quantity to meet the growing demand. It is the reason why fresh potato which is imported by the Vietnamese market increased from 1.1 million USD in 2003 to 23.7 million USD in 2017 [4].

Important as it may be, potato production in Vietnam suffers from several challenges, out of which low unstable yield and quality are paramount. The storage techniques are mainly based on experience and traditional methods. As a result, the quality of the tuber seeds is low and the yield of potato is also affected. In addition, the crop is produced under traditional farming systems with low production resources, thus imposing inefficiency in the production process. Lack of education has been considered the most important challenge to improve productivity and efficiency levels of potato production in Vietnam.

Then, the major question is whether potato production is technically efficient enough to award maximum benefit without deteriorating the future productivity ability of land. The assessment of technical efficiency is far-reaching in addressing sources of inefficiency in the production process, thus ameliorating production without increasing input based. Due to the few research on analyzing technical efficiency in potato production in Vietnam, it is the reason why this study is necessary to do.

Stochastic frontier analysis (SFA) is a popular methodology in analyzing the efficiency of agricultural production due to its advantages compared to other methods. Recently, many authors employed SFA as a useful tool to evaluate the efficiencies with regard to optimal input resources in agricultural production, i.e., vegetable production [6-8], rice production [9-10], potato production [11-13].

Therefore, the main goals of this research were to analyze technical efficiency of potato production farms and to determines the factors influencing on technical efficiency levels at the same time providing suitable policies to develop potato sector in Vietnam.

2. Methodology

2.1. Data collection and data source

The data of input and output variables was collected in two provinces, namely Bacgiang and Haiduong. The primary data were taken from 139 producers in the period of 2016-2017 by using direct interviews technique. The questionnaires include two sections. In the first section, socioeconomic information of household was addressed, including name, gender, educational level, and experience in potato of household head. The second part was prepared to collect information about potato production of farmers, namely the quantity of seed, labor, planted area, and chemical fertilizer used, and the quantity of output such as yield and sale price. Variables were used in measuring the efficiency of potato farms are summarized in Table 1. The results showed that,

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on average, the output of potato farms ranged from 216.00 (kg/acre) to 1,445.59 (kg/acre), with a average of 793.40 (kg/acre). For the inputs, on average, producers employed 42.53 kg of seed, 17.60 kg of fertilizer and 26.79 grams of pesticide per acre in potato production. Farmers used approximately 13.58 man-days to produce potato in each acre, implying that labor plays a crucial role in potato production in Vietnam. In addition, on average, farmers had 8.29 years of experience in potato production. The average age of farm manager was 49.78 years old and 58% of the household head was female.

Table 1. Descriptive statistics of variables used in measuring technical efficiency of potato production

Variables	Mean	Minimum	Maximum	Std. Dev.
Output				
Yield of potato (Kg/acre)	793.40	216.00	1445.59	236.74
Inputs				
Seed (Kg/acre)	42.53	30.00	50.00	4.54
Labor (Man-days/acre)	13.58	8.00	23.00	2.63
Fertilizer (Kg/acre)	17.60	4.36	155.63	20.14
Pesticide (Gram/acre)	26.79	9.67	75.00	10.10
Characteristics of farms				
Gender (Dummy)	0.58	0.00	1.00	0.50
Age (Years)	49.78	29.00	66.00	8.23
Experiences (Years)	8.29	2.00	16.00	2.99

Note: In Vietnam, 1 acre =360m^2

2.2. Empirical Analysis Model

In this paper, SFA was employed to estimate the technical efficiency of potato producers due to its suitable characteristics with agricultural studies. The stochastic frontier analysis model is expressed by Equation (1):

$$Y_i = f(X_i, \beta) \exp(v_i - u_i) \quad (1)$$

where Y_i implies the yield of potato farm (kg/acre), X_i is the vector of inputs which farmer used in potato production, β describes the estimated unknown parameter, v_i is a two-side of independent and identically distributed (i.i.d) random error that related to natural factors beyond the control of producers, and u_i is one-sided of i.i.d random errors.

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The technical efficiency of potato farms was computed by using Equation (2) as follow:

$$TE_i = \frac{Y_i}{f(X_i, \beta)\ \exp\ (v_i)} = \exp(-u_i) \quad (2)$$

where TE_i is the technical efficiency of the i-th potato farm ($0 \leq TE_i \leq 1$).

Furthermore, the likelihood-ratio (LR) test was applied to choose the appropriate model to analyze the data. The value of the LR test was estimated by using Equation (3):

$$LR = -2\{\ln[L(H_0)] - \ln[L(H_1)]\} \quad (3)$$

where H_0 is the log-likelihood value of Cobb-Douglas function and H_1 denotes the log-likelihood value of translog production function. From the Equation (3), the estimated value of LR test was computed as LR = -2[-10.79-10.47] = 42.52. This result is higher than the value of critical value for the 10 degrees of freedom$\chi^2_{(10,\ 0.95)}$ = 18.307, implying that the translog model was more suitable with the data of this study. The translog production function is expressed as Equation (4):

$$\begin{aligned} LnY_i &= \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + 0.5\beta_{11}(LnX_1)^2 \\ &+0.5\beta_{11}(LnX_1)^2 + 0.5\beta_{22}(LnX_2)^2 + 0.5\beta_{33}(LnX_3)^2 + 0.5\beta_{44}(LnX_4)^2 \\ &+\beta_{12}LnX_1LnX_2 + \beta_{13}LnX_1LnX_3 + \beta_{14}LnX_1LnX_4 + \beta_{23}LnX_2LnX_3 \\ &+\beta_{24}LnX_2LnX_4 + \beta_{34}LnX_3LnX_4 + v_i - u_i \end{aligned} \quad (4)$$

where Ln is the natural logarithm, X_1 represents the quantity of seed (kg/acre), $X_2$is the number used (man-days), $X_3$is the quantity of fertilizer (kg/acre), and X_4 denotes the quantity of pesticide (gram/acre).

Technical Inefficiency effect model

In this study, the one-step estimation employed to define the factors affecting the technical efficiency of farms. The technical inefficiency effect model is expressed as Equation (5):

$$U_i = \delta_0 + \delta_1 Gender + \delta_2 Age + \delta_3 Experience + \varepsilon_i \quad (5)$$

where U_i describes the technical inefficiency level of potato farms. $\delta_0,\ldots,\delta_3$ are unknown estimated parameters. ε_i represents the random error.

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3. Results and Discussion

3.1. Estimation of translog production function

This study applied the FRONTIER 4.1 to estimate parameters for translog production function and compute the efficiency of potato farms. The estimated parameters of translog production function by using the maximum likelihood estimation (MLE) are presented in Table 2.

Table 2 shows that out of four inputs used, two inputs including seed and pesticide are significantly positive in the translog model. The coefficient of seed was the highest (3.9121) followed by the pesticide variable (2.3169), implying that the yield of potato would improve if the quality of the seed input increase. In addition, the γ value was 0.9990, meaning that 99.90 % of the deviation of potato output was due to the technical inefficiency of farms.

The results of the inefficiency effects model indicated that all variables related to the characteristic of the household head had a significant effect on the technical inefficiency of potato farms. The gender of household head was a positive impact on technical inefficiency at 1 % of significance level, meaning that women labor play an important role in agricultural production as well as in improving the efficiency of potato production in Vietnam. The role of gender in agricultural production was also studied by Shrestha, et al. [14]. The coefficient of the age of farmers positively affects the technical inefficiency of potato farms at 5 %, indicating that older farmer tends to be more inefficient in comparison with young counterparts. The correlation between age and technical efficiency in potato production was showed by Abedullah, et al. [10], Khai and Yabe [15], Mengui, et al. [16], Linh [17] and Adhikari, et al. [18]. The negatively estimated coefficient of experience showed that experience in the production of farmers plays a vital role in reducing technical inefficiency. Farmers with more years in potato production tend to get higher efficiency because they have better skills in farming management and accessing new technologies. This result is also consistent with the statement of Nyagaka, et al. [12].

Table 2: Maximum likelihood estimates of translog production function model

Variables	Coefficients	Std. Err.	t-Ratio
Constant (β_0)	-0.0338	1.0749	-0.0314
LnX_1 (β_1)	3.9121***	0.9650	4.0539
LnX_2 (β_2)	-2.2723	1.4259	-1.5935
LnX_3 (β_3)	0.0467	0.8902	0.0525
LnX_4 (β_4)	2.3169***	0.8587	2.6981
$(LnX_1)^2/2$ (β_{11})	-1.2945**	0.5711	-2.2668
$(LnX_2)^2/2$ (β_{22})	-0.1983	0.5574	-0.3557

$(LnX_3)^2/2$ (β_{33})	-0.2795***	0.0953	-2.9319
$(LnX_4)^2/2$ (β_{44})	-0.2922*	0.1770	-1.6509
LnX_1 LnX_2 (β_{12})	0.6106	0.4528	1.3485
LnX_1 LnX_3 (β_{13})	0.1315	0.2287	0.5751
LnX_1 LnX_4 (β_{14})	-0.6126**	0.2941	-2.0833
LnX_2 LnX_3 (β_{23})	-0.0366	0.1578	-0.2322
LnX_2 LnX_4 (β_{24})	0.2703	0.2766	0.9772
LnX_3 LnX_4 (β_{34})	0.1476	0.1170	1.2620
Inefficiency Effects Model			
Constant	0.4705***	0.1416	3.3235
Gender (1=Female, 0=Male)	0.1311***	0.0499	2.6291
Age (Years)	0.0063**	0.0026	2.4074
Experience (Years)	-0.0479***	0.0090	-5.3148
σ^2	0.0437***	0.0061	7.2139
γ	0.9990***	0.0003	32.5754
Log-Likelihood	33.9696		

3.2. Technical efficiency estimation of potato farms in Vietnam

The distribution of the technical efficiency of potato farms was expressed in Table 3. The results revealed that on average, the technical efficiency of potato farms was low with 0.66 and 0.52 in Bacgiang and Haiduong province, respectively. These findings imply that producers could increase the output of potato by 48% and 34%, respectively, without increasing the number of current inputs.

In addition, the mean technical efficiency was found to be higher in Bacgiang province compared to Haiduong province. In Bacgiang province, the efficient scores varied from 0.36 to 1.00 while the technical efficiency levels of farmers in Haiduong province ranged from 0.20 to 0.70.

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Table 3: The technical efficiency distribution of potato farms

TE levels	Bacgiang province (*n=114*)		Haiduong province (*n=25*)	
	No. of farms	**Percentage**	**No. of farms**	**Percentage**
≤ 0.50	18.00	15.79	11.00	44.00
0.51-0.60	19.00	16.67	9.00	36.00
0.61-0.70	32.00	28.07	4.00	16.00
0.71-0.80	27.00	23.68	1.00	4.00
0.81-0.90	11.00	9.65	0.00	0.00
> 0.90	7.00	6.14	0.00	0.00
Mean	0.66		0.52	
Min	0.36		0.20	
Max	1.00		0.70	

4. Conclusions

This study applied the translog production function model to analyze the technical efficiency of potato farms in two provinces of Vietnam. The cross-sectional data obtained from 139 households in two provinces, namely Bacgiang and Haiduong. The technical efficiency score of farms in Bacgiang province ranged from 0.36 to 1.00 with an average of 0.66 while farms in Haiduong province obtained lower technical efficiency level, with a mean of 0.52. Moreover, the results of inefficient effects model indicated that gender and age of household head positively affected the technical inefficiency of potato farms while the experience of farmers in potato production was found to be a negative effect. This suggests that policymakers should pay attention to programs like organizing training courses, sharing experience, and improving the role of extension system as well as women's association which can help farmers with less experience in enhancing their efficiency. In addition, the quality of seed had the highest effect on the output of potato, meaning that agricultural researches should focus on improving the seed with better characteristics to increase the yield of potato.

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