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RESEARCH ARTICLE

IDENTIFICATION OF INFORMATION SOURCES INFLUENCING THE TECHNICAL INEFFICIENCY OF CROP FARMERS IN VIETNAM

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ABSTRACT

Vietnam is an agricultural country where rice and maize are the two most important cereal crops. Recently, the proportion of high-tech agricultural products has increased; however, output quality and quantity have not reached the expectations. There are many possible reasons, one of which is that farmers lack skill, experience, and knowledge to receive and generate information sources. This study estimated the technical efficiency levels and identified the information factors that influence the technical inefficiency of crop farmers in the northwest highland of Vietnam using farm-level data. The results show that there are significant opportunities to increase technical inefficiency and no farm has full technical efficiency. Agricultural information from printed materials and frequent watching of television were significantly and negatively related to technical inefficiency. This indicates that if farmers read more agricultural information from printed materials and watch television related to social life at appropriate times, the technical efficiency of crop farms would increase. Based on the results, some suggestion are proposed to optimize crop-farm technical efficiency and increase the effectiveness of using information sources.

INTRODUCTION

Over the past years, although Vietnam's economic and labor structure has changed, its rural population still accounts for 67.81% of the total and the main livelihood of rural dwellers is agricultural production. Rice and maize are the largest crops by planted area and comprise the biggest cereal crop production proportion (GSO, 2013). The National Assembly of Vietnam approved plans to grow gross domestic product (GDP) for the 2011—2015 period by on averages approximately 6.5—7% a year (National Assembly of Vietnam, 2011). In addition, poor households will be reduced in a fast and sustainable manner, by 2% a year on average and by 4% a year in districts and communities stricken by poverty and extreme difficulties. Furthermore, the proportion of high-tech products will account for around 30% of total industrial production by value with a technological innovation rate of 13% per year. However, GDP in 2011, 2012, and 2013 was 6.2%, 5.2%, and 5.4%, respectively; the poverty headcount ratio at the national poverty line was 17.2% of the population in 2012 (World Bank, 2015); and technology application remains low, especially in the agricultural field (Vietnam Trade Promotion Agency, 2014). One of the reasons for the low adoption technology is that farmers lack skill, experience, and knowledge to receive and generate information sources. Now a day, we cannot deny the important role of information in life activities. Information sources are needed for agriculture because of agriculture's importance for socio-economic development, especially in developing countries; food security and welfare issues; improving the quality and quantity of agricultural products; and reducing agricultural product costs (Kaaya, 1999). Adequate quality of information is the required condition to improve all areas of agriculture, especially in countries with increasingly larger markets (Milovanović, 2014). As the Vietnamese government has become aware of the importance of information and communication technology (ICT), it has put in place policies to promote ICT. These include Decision No. 1755/QD-TTg of September 22, 2010, which approved a national strategy for

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"Transforming Vietnam into an advanced ICT country"; Decision No. 698/QD-TTg of June 1, 2009, which approved general plan on information technology (IT) human resources development up to 2020; and Decision No. 1605/QĐ-TTg of August 27, 2010, which approved a national program of IT usage for government bodies for 2011—2015.

In particular, on July 12, 2011, the Prime Minister of Vietnam wrote an official letter No. 1138/TTg-QHQT allowing the Ministry of Information and Communications to establish and deploy the expanded project "Improved computer usage and public internet access ability in Vietnam" in 2011—2016 period. With a total value of 50.5 million USD, of which more than 33.6 million USD is funded by the Bill and Melinda Gates Foundation (BMGF) and Microsoft Corporation, this project aims to plug the digital gap between rural and urban areas, improve the livelihoods of people through the use of modern technology, and provide opportunities for people in rural areas to benefit from ICT services. The project has been deployed only in three provinces of Vietnam, namely, Thai Nguyen, Nghe An, and Tra Vinh. However, the status of information and communication use in Vietnam remain backward, especially in the agricultural sector and rural areas. Most ICT programs and projects are focused on urban areas and local officers. Compared to other regions and countries, progress has been very slow and there are many difficulties and challenges, especially for farmers in the highland area.

In the literature, some researches have studied technical efficiency (TE) and the factors that influence the TE of rice and coffee products in Vietnam, such as Rios and Shively (2005); Khai and Yabe (2011); Linh (2012); Bac *et al*. (2013). Nevertheless, none of them have studied both main cereal crops (rice and maize) and the impact of information sources on TE. Therefore, this study has two objectives. First, it estimates the TE of crop farmers in Son La province, Vietnam using stochastic frontier analysis (SFA). Second, we determine the information sources that influence technical inefficiency using farm-level data. The rest of the paper is organized as follows. Section 2 explains the methodology. Section 3 outlines the data used and the empirical model. The results and discussion are provided in Section 4. Lastly, Section 5 concludes and presents some recommendations.

MATERIALS AND METHODS

TE is the indicator reflecting the capacity of a farmer to achieve maximal output with a given set of inputs (Farell, 1957; Coelli *et al*., 2005). Stochastic frontier analysis (SFA) and Data envelopment analysis (DEA) are the two methods that are applied widely by many researches so far. Each method has different strengths and weaknesses. DEA is a deterministic and non-parametric method while SFA is a parametric method and can separate the effects of noise from technical inefficiency. This study is more interested in the SFA method. Following the work of Farell (1957), the stochastic production frontier was proposed by Aigner *et al*. (1977); Meeusen, W. and Van den Broeck (1977). It can be written as

$$Y_i = X_i\beta + \varepsilon_{i,} \qquad i = 1, \dots, N \tag{1}$$

where
Y_i is the scalar output of the i-th farm;
X_i is the vector of input quantities of the i-th farm;
β is a vector of parameters to be estimated; and
ε_i is a "composed" error term and can be represented as

$$\varepsilon_i = V_i - U_{i,} \tag{2}$$

where V_i is a two-sided random error ($V\sim N[0,\sigma_v^2]$) that captures the stochastic effects beyond farmers' control (e.g., measurement errors, disease outbreaks and weather). The term U_i is a non-negative random variable that represents the technical inefficiency of production (Coelli *et al*., 2005). The one-sided term U_i can follow some distribution as half-normal, truncated-normal, exponential, or gamma (Aigner *et al*., 1977; Meeusen, W. and Van den Broeck, 1977). This study assumes that U_i follows truncated-normal distribution with mean μ and variance ($U\sim N[\mu,\sigma_u^2]$), which is used widely in many research. It also assumes that U_i and V_i are independent of each other. The different frontier models are based on the different specification of technical inefficiency effects U_i. Some authors, like Bravo-Ureta, B and Pinheiro, A (1997); Khai and Yabe (2011), estimated stochastic frontiers to obtain farm-level efficiencies, then regressed these predicted efficiencies upon firm-specific factors, such as farmer characteristics, farm conditions, and production conditions, in an attempt to explain the different output between firms. However, Battese and Coelli (1995) revealed that these firm-specific factors might impact on efficiency if they were used directly in the estimation of the production frontier. This is inconsistent with the assumption of independence between inefficiency effects and noise in this two-stage estimation procedure. To overcome this problem, Battese and Coelli (1995) proposed a one-stage simultaneous estimation approach in which the technical inefficiency effects are stochastic and expressed as an explicit function of a vector of farm-specific variables. The technical inefficiency effects can be written as

$$\mu_i = Z_i\delta + \omega_i \tag{3}$$

where μ_i is the mean of technical inefficiency that can be estimated by one-stage simultaneous estimation. Z_i is a vector of variables that can influence the inefficiency of a farm. δ is a vector of unknown parameter to be estimated. ω_i is an error term (unobservable random variable).

The stochastic frontier production (1) and technical inefficiency model (3) are estimated simultaneously using maximum likelihood method. We choose the widely applied computer program FRONTIER 4.1c (T.J. Coelli, 1996) for estimation. This program allows us to present the coefficients of variance parameters

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \tag{4}$$

$$\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2), \quad 0 \le \gamma \le 1 \tag{5}$$

where gamma parameter (γ) indicates the share of inefficiency in the overall residual variance and must lie between zero and one. If $\gamma = 0$, the deviations from the frontier are due to noise, and if $\gamma = 1$, all deviations are due to technical inefficiencies (Battese and Corra, 1977; Battese and Coelli, 1995).

DATA AND EMPIRICAL MODEL

Data

The data used in this study are based on a direct interview survey of 358 randomly selected crop-farm households in 12 villages of three districts in Son La province in the northwest highland of Vietnam. The data cover 2014. All the output and input variables are summaries of rice and maize crops. In the study area, maize products are used for both selling and self-consumption while rice products are mostly for self-consumption, therefore, using profit or income from the rice and maize product index does not display technical efficiency accurately. Therefore, the total gross income of rice and maize production is measured as output. The inputs chosen for the stochastic production frontier function are planted land, family and hired labor, seed, fertilizer (including organic, nitrogen-phosphorus-potassium, nitrogenous, and phosphate fertilizer), chemicals (including herbicide and pesticide) and other expenses (such as irrigation and transportation fees) (Hasnah *et al*., 2004; Khai and Yabe, 2011; Bac *et al*., 2013; Linh *et al*., 2015). Information is a vital resource for farmers. The information on generated technologies from research systems are important for farmer to apply to agricultural activities. Moreover, farmers need marketing information to make suitable decisions on how, when, and where to buy inputs or sell their products (Kaaya, 1999). In the literature, several studies have researched the importance and effects of information technology sources on agriculture, such as Ford and Babb (1989); Ortmann *et al*. (1993); Patrick *et al*. (1993); Foltz and Makus (1996); Kaaya (1999); Gloy *et al*. (2000); Gloy and Akridge (2000); Milovanović (2014). However, most of this research has taken place in the United States, as well as in such countries as Tanzania, and Serbia; none has occurred in Vietnam. Therefore, to our knowledge, this is the first study that evaluates the influence of information sources on technical inefficiency in Vietnam. Based on the literature and survey conditions, some information source variables are chosen and presented in Table 1 (Gloy *et al*., 2000; Boz and Akbay, 2005; Füsun Tatlıdil *et al*., 2008).

Table 1. Descriptive statistics of variables in the empirical model

Variable	Description	Mean	Std.Dev.	Min	Max
Y	Gross income (1,000 VND[a])	67,400.99	50,358.66	840	238,500
X1	Cultivated land (ha)	1.65	1.27	0.05	10.00
X2	Total amount of seed (1,000 VND)	10,953.42	7,750.732	192	40,220
X3	Total amount of fertilizer (1,000 VND)	1,947.28	1,481.87	80	9,630
X4	Total amount of chemicals (1,000 VND)	132.80	104.70	2.8	750
X5	Total labor, including family labor and hired labor (Man-days)	6,320.94	4,522.813	300	27,900
X6	Other expenses (1,000 VND)	319.01	1,129.62	0	10,400
Z1	Extension services. Takes 1 if farmers received information about extension services, 0= otherwise	0.22	0.41	0	1
Z2	CCPO. Takes 1 if farmers usually visit CCPO, 0= otherwise	0.29	0.46	0	1
Z3	Reading printed materials. Takes 1 if farmers read several times a month, 0= otherwise	0.25	0.43	0	1
Z4	Reading information. Take 1 if farmers read the agricultural information, 0= otherwise	0.24	0.43	0	1
Z5	Listening to the radio. Takes 1 if farmers listen at least 5 times per week, 0= otherwise	0.13	0.33	0	1
Z6	Listening information. Takes 1 if farmers usually listen the agricultural information, 0= otherwise	0.14	0.35	0	1
Z7	Watching TV. Takes 1 if farmers watch at least 5 times per week, 0= otherwise	0.89	0 .30	0	1
Z8	Watching information. Takes 1 if farmers usually watch agricultural programs, 0= otherwise	0.59	0.49	0	1
Z9	Takes 1 if farmers' cell-phones can access the internet, 0= otherwise	0.01	0.11	0	1
Z10	Takes 1 if the farmer has visited a good agricultural model, 0= otherwise	0.16	0.36	0	1
Z11	Takes 1 if the farmer has agricultural group membership, 0= otherwise	0.77	0.42	0	1

Note: 1 USD = 21,125.00 VND (March 2014)
Source: Own survey, 2014

Table 1 shows that total gross income of rice and maize products in 2013 was 67.4 million VND. Total rice and maize cultivated land was 1.65 ha of which most is maize. Because maize and rice are cultivated mostly on highland and sloping land, these crops demand much more seed, labor, and fertilizer. All cultivation is based strongly on human power, and thus, the total amount of chemicals and other expenses are less than other inputs. In the survey, 22% of farmers received extension services. Farmers may not have the time or inclination to read printed materials and listen to the radio. Only 25% and 13% of respondents read printed materials every month and listen to the radio at least five times per week, respectively. Of this total, only one fourth and one sixth were interested in reading and listening to agricultural information, respectively. On the other hand, 89% of respondents said they usually watched television at least five times per week and 60% of them usually watched agricultural programs. Most farmers owned cell-phones but only 1% had tried to access the internet through their smart-phones. In addition, 77% respondents were members of at least one farm group and only a small proportion of farmers had visited good agricultural models.

Empirical model

There are several production functions in econometric estimation, such as the Cobb-Douglas function, translog function, and constant elasticity of substitution (CES). Based on Hanley and Spash (1993), Khai and Yabe (2011) proposed that the Cobb-Douglas functional form is suitable if the model has three or more independent variables. Our study has six independent variables, and therefore, the Cobb-Douglas production function is chosen; it can be written as

$$lnY_i = \beta_0 + \sum_{j=1}^{6} \beta_{ji} lnX_{ji} + V_i - U_i \quad (5)$$

where Y_i is the output of i farmer, X_{ji} are the j input variables presented in Table 1, and β_{ji} are parameters to be estimated.

The inefficiency model is estimated from

$$\mu_i = \delta_0 + \sum_{k=1}^{11} \delta_{ki} Z_{ki} + \omega_i \quad (6)$$

where μ_i represents the mean technical inefficiency effects. Z represents various information source variables presented in Table 1.

Hypotheses tests

It is noted that several tests are needed to test the presence of inefficiency in the model and whether the efficiency parameters are significantly different from zero (Coelli and Battese, 1996). Therefore, the following hypotheses tests are of interest:

$H_{01}: \mu = 0$, the null hypothesis specifies that the inefficiency effects are half-normal distribution;

$H_{02}: \gamma = \delta_0 = \cdots \delta_{11} = 0$, the null hypothesis specifies that the inefficiency effects are not present;

$H_{03}: \gamma = 0$, the null hypothesis specifies that the inefficiency effects are not stochastic; and

$H_{04}: \delta_1 = \cdots \delta_{11} = 0$, the null hypothesis specifies that the coefficients of the variables in the model for the inefficiency effects are zero.

Since the model is estimated using maximum likelihood, these null hypotheses can be tested using the general likelihood-ratio statistic, λ, given by

$$\lambda = -2[L(H_0) - L(H_1)] \tag{7}$$

where $L(H_0)$ and $L(H_1)$ present the value of the likelihood function under the null (H_0) and alternative (H_1), respectively. The critical values for each of these tests are derived from Kodde and Palm (1986), as they are adjusted Chi-square (χ_J^2) values to take into account the mixed nature of the likelihood ratio test (Coelli and Battese, 1996), where J is the number of restrictions under H_0 .

RESULTS AND DISCUSSION

Parameter estimates

The maximum likelihood estimates (MLE) of the parameters of the stochastic frontier production function and the inefficiency model are estimated simultaneously and reported in Table 2.

The signs of the coefficients of the stochastic frontier are as expected, except the negative of land for cultivation and chemical variables. The negative sign of land for cultivation, which is significant at 5% level, may be due to the fact that most cultivated land is fragmented and located in the highland. Thus, the more cultivated land is, the lower is productivity efficiency. Hung *et al*. (2007) indicated that land fragmentation is very common in the north of Vietnam. In addition, they found that land fragmentation increased family labor use and other expenses and had negative influence on crop productivity (Hung *et al*., 2007). This also explains our results when the coefficients of seed, fertilizer, and labor are positive and highly significant at the 1% level. The insignificance of the coefficients of chemicals and other expenses indicate that they are not important factors and rarely used by farmers. Chemical prices are quite high and famers know that chemicals are very harmful. Farmers use mostly human power; transportation is mostly by human and animal and lower levels of technology are applied. Thus, other expenses are very small and do not effect crop productivity.

Hypothesis testing

Generalized likelihood tests are conducted to test the null hypothesis that the technical inefficiency effects are absent or that they have simpler normal distribution. The results are shown in Table 3. The first null hypothesis (H_{01}) that the inefficiency effects are half-normal distribution is rejected at the 10% level of significance, indicating that our assumption of truncated-normal distribution is adequate. The second null hypothesis (H_{02}), which specifies that the inefficiency effects are absent from the model, is rejected. The third null hypothesis (H_{03}), which specifies that the inefficiency effects are not stochastic, is strongly rejected at the 1% level. Thus, it can be said that the inefficiency effects are both stochastic and present. The γ- parameter associated with the variance in the stochastic frontier is 0.64 and significant at the 1% level. This can explained as 64% of the variation of gross income from maize and rice being due to technical inefficiency. The last null hypothesis (H_{04}), in which the coefficients of the variables in the model for the inefficiency effects are zero or have no effect, is rejected. This suggests that even the individual effects of 1 or more of 11 explanatory variables of the inefficiencies of production may not be statically significant but, in general, the joint effects of all variables are significant.

Technical efficiency estimates

The distribution of technical efficiency (TE) is shown in Figure 1. We can see that most crop farms have TE of higher than 0.7 but no farm is fully technically efficient. The mean TE of crop farmers is estimated to be 0.751 with the range from 0.332 to 0.967. This indicates that farmers could improve TE by 24.9% with a given set of inputs and technology at that time. This mean value is smaller than the finding of Khai and Yabe (2011) and Bac *et al*. (2013). However, Khai and Yabe (2011) estimated TE for rice production of farmers in all Vietnam using The Vietnam Household Living Standard Survey 2005-2006 and Bac *et al*. (2013) estimated TE for two rice seasons in the northern highland of Vietnam while our study calculates crop production, including rice and maize throughout the year.

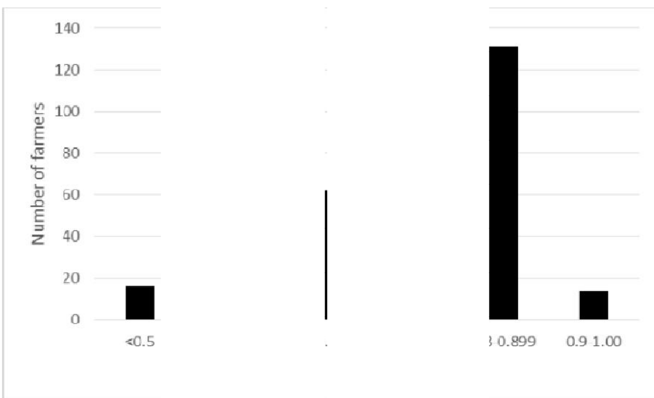

Figure 1. Distribution of technical efficiency

Table 2. Parameter estimates of stochastic production frontier and technical inefficiency models

Variables	Parameter	Coefficient	Standard error
Stochastic production frontier			
Constant	β_0	2.53***	0.96
Log(land)	β_1	-0.45**	0.22
Log (seed)	β_2	0.35***	0.05
Log (fertilizer)	β_3	0.21***	0.04
Log (chemical)	β_4	-0.03	0.04
Log (labor)	β_5	0.87***	0.20
Log (other)	β_6	5.48E-06	0.01
Technical inefficiency model			
Constant	δ_0	0.37*	0.20
Extension services	δ_1	-0.04	0.11
CCPO	δ_2	0.02	0.11
Reading printed material	δ_3	0.23	0.16
Reading information	δ_4	-0.32*	0.19
Listening to the radio	δ_5	-0.39	0.27
Listening information	δ_6	0.39	0.26
Watching television	δ_7	-0.29*	0.16
Watching information	δ_8	-0.18	0.11
Cell phone can access internet	δ_9	-2.82	3.43
Visited good agricultural model	δ_{10}	0.09	0.14
Agricultural group membership	δ_{11}	0.05	0.12
Variance parameters			
Sigma squared	σ^2	0.21***	0.05
Gama	γ	0.64***	0.12
Log-Likelihood		-137.701	

*Note:****, **, and * => Significance at the 1%, 5%, and 10% levels, respectively.

Table 3. Results of hypothesis tests

Null hypothesis	Test statistic	d.f.	Critical value (χ^2)	Decision
$\boldsymbol{H_{01}: \mu = 0}$	2.126	1	1.642	Reject H_0
$\boldsymbol{H_{02}: \gamma = \delta_0 = \cdots \delta_{11} = 0}$	21.598	13	19.216	Reject H_0
$\boldsymbol{H_{03}: \gamma = 0}$	25.448	1	6.635	Reject H_0
$\boldsymbol{H_{04}: \delta_1 = \cdots \delta_{11} = 0}$	18.932	11	16.67	Reject H_0

Sources: Own survey, 2014

Factors influencing technical inefficiency

The most interesting finding of this study is the determination of information technology sources that affect the technical inefficiency of crop farmers. The estimation of an inefficiency model was performed simultaneously with the stochastic frontier model and the results are also presented in Table 2. The results show that the estimated coefficients of reading agricultural information through printed material and frequent watching of television are negatively significant with technical inefficiency. In other words, they had positive relationships with TE of crop farms. This indicates the importance of information from printed materials and television for improving farmers' perceptions, knowledge, and increasing crop efficiency.

Agricultural extension services in Vietnam are run by the Ministry of Agriculture and Rural Development. These services extend from the government to villages. They are expected to have a significantly negative impact on decreasing technical inefficiency, but the results indicate that they do not significantly influence even the negative sign with technical inefficiency. This is inconsistent with the finding of Linh *et al*. (2015). They found that extension services were positively significant with the TE of maize crops but not rice crops. However, this research uses the sum of both rice and maize crops. The Commune Cultural Post Office (CCPO) is an important and significant program of the Vietnamese government to support information and improve knowledge for citizens, especially in difficult and remote areas. Another study used it to evaluate the economic returns to farmers of participating in the CCPO (Linh *et al*., 2014). The results indicated that despite its many investments so far, the CCPO has many disadvantages and it does not affect the economic return of farmers (Linh *et al*., 2014). This is confirmed by our result that the CCPO is not statically significant on TE. Even the coefficient of frequent reading of printed materials by farmers was not significant, although the agricultural information that farmers read is negatively significant with technical inefficiency. This proves the importance of the information that influences TE. Printed materials can be read by own buying, borrowing, or going to the CCPO. However, the extent of reading printed materials was found to be far less in the study area. These printed materials are quite out of date and are not sufficient. This is in line with the results of Boz and Akbay (2005), who studied factors influencing the adoption of maize in Turkey.

Radio and television are extensively used in the study area, but the main purpose of utilizing these mass media is for news and entertainment, and the programs on television or radio lack agricultural information. Out of 9,071 communes in the whole country, there were 7,380 communes with loudspeaker systems linked to villages in 2011 (GSO, 2012). This system is built to spread information and knowledge for residents. Thus, the number of radios that farmers owned in the research area is 0.06%. However, the loudspeaker system was used mostly twice per day (morning and evening), and each time was for only around 30 minutes. In addition, the information is used to spread government policy and is not related entirely to agriculture and farm life. The results show that 91.1% of households in the study area have their own television and some families have more than one television. In this area, the television program is transmitted using analog signals. Most television programs are for entertainment and a few programs or channels are for farmers, like VTV1, VTV2, and VTV5. Most respondent stated that television programs did not supply sufficient agricultural information, and this may explain why the coefficient of agricultural information watching is not statistically significant. When cell-phones are used widely in Vietnam, the numbers of people who used fixed phones decreases gradually. In the study area, 99% farmers have cell-phones but all of them stated that they use it only to communicate with each other for social life and not for agriculture. Now a day, the power of computers and the internet for information transmission and daily life is known widely. However, in the study area, no respondents used or owned computers, although some accessed the internet through their cell-phones. However, smart-phones, which can access the internet, are priced highly. Farmers do not have experience in and are not trained to use the internet. The two carriers that have good networks for remote areas are Viettel and Vinaphone. However, 3G is expensive and its speed is slow. The survey results indicate that 1% of respondents can use the internet though their cell-phones but do so for entertainment and not for agricultural purposes.

A good way for farmers to obtain information and improve farm efficiency is to visit a good farm model. Of the 358 respondents, only 16% had visited good agricultural models and all of them stated that this was very helpful; in addition, 298 farmers stated they wanted to visit good agricultural models for free at least once. While there are some agricultural groups to help farmers with agricultural activities, such as farmers' groups, women's groups, credit groups, and veteran groups, they do not perform as expected. According to the field survey, 275 households (77%) are members of groups but 264 (96%) said their group was ineffective and should improve to become more appropriate to farmers' lives. This explains why membership of a farm group does not necessarily help farmers.

CONCLUSION AND RECOMMENDATIONS

The purpose of this research was to estimate technical efficiency (TE) levels and identify the information factors that influence the technical inefficiency of crop farmers in the northwest highland of Vietnam. We chose 358 respondents randomly based on a multi-stage procedure. The stochastic frontier production function and the inefficiency model were estimated simultaneously using maximum likelihood estimates (MLE). Several tests were undertaken to test the null hypothesis that technical inefficiency effects are absent or that they have simpler normal distribution. The results show that there is significant room for technical inefficiency and no farm is fully technically efficient. Because of land fragmentation and highland location, labor, seed, and fertilizer are the most important factors for enhancing TE of these crop farms. This study found some interesting results with regard to information sources that have impacted on technical inefficiency. Agricultural information from printed materials and frequent watching of television were two negatively significant factors for technical inefficiency. This indicates that if farmers read more agricultural information from printed materials and watched television related to social life at appropriate times, the TE of crop farms would increase. Some factors were found to be statistically insignificant but as they are important information sources, we need to find good reasons and explanations.

Based on this research finding, some implications are suggested. First, management of annual crop production and cultivation methods for farmers needs to continue. Second, improving co-operation in cultivation, crop diversity, and optimal land use would optimize farm production. Third, the effectiveness of the Commune Cultural Post Office (CCPO), extension services, and group support should be checked and strengthened. Fourth, the quantity and quality of printed materials for farmers through the CCPO, extension service system, farm group system, or local government should be increased. Fifth, the number of programs and appropriate information for farmers through radio and television should be increased; there should be a focus on teaching and spreading information about agricultural activities, such as livestock, cultivation, and fishing. Sixth, training programs should be developed and extended for farmers in remote area to improve their experience and knowledge to access and use computers and the internet. Lastly, there should be more funds available for farmers to visit good agricultural models to help them develop agricultural information and business networks.

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