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THESIS

PROFIT EFFICIENCY OF HYBRID RICE PRODUCTION IN THE CENTRAL VIETNAM

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A Thesis Submitted in Partial Fulfillment of
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Thanks to its high yield, hybrid rice could contribute significantly to hunger eradication, poverty reduction, and national food security, especially in Central Vietnam where productive conditions are poor, and cultivated farmland is small and fragmented. The rate of hybrid rice adoption is declining in recent years, partly due to unattractive profit. The objectives of this study are to determine the profit efficiency of hybrid rice production and to identify determinants of profit inefficiency using farm-level data collected from 328 rice farmers in Central Vietnam in the winter-spring season of 2012/2013 by a three-stage stratified random sampling method.

Based on profit maximization assumption, a stochastic translog normalized profit frontier function was employed. The results showed that the average profit efficiency of farmers' hybrid rice production in Central Vietnam was 0.63, indicating the existence of inefficiency. The research also found that age, educational level, rice-cultivated area, irrigation, share of rice income, share of hybrid rice area, frequency of training attendance about hybrid rice production, experience of hybrid rice production, and the topography of farm are robust determinants of profit inefficiency of hybrid rice production among farmers.

To enhance households' profit efficiency from hybrid rice production in Central Vietnam, policies to improve educational level, increase training about hybrid rice production, improve irrigation system, and promote high-quality hybrid rice intensive production should be reinforced, especially in the upland areas.

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Student's signature Thesis Advisor's signature

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LIST OF ABBREVIATIONS

AC	=	Average cost
AE	=	Allocative efficiency
AVC	=	Average variable cost
CE	=	Cost efficiency
DEA	=	Data Envelopment Analysis
DMU	=	Decision-Maker Unit
EE	=	Economic efficiency
GDP	=	Gross Domestic Product
GSO	=	General Statistics Office
Ha	=	Hectare
IDRC	=	International Development Research Center
MARD	=	Ministry of Agriculture and Rural Development
OLS	=	Ordinary Least Squared
PE	=	Profit efficiency
RE	=	Revenue efficiency
SFA	=	Stochastic Frontier Analysis
Std. Dev.	=	Standard Deviation
TE	=	Technical efficiency
USD	=	United States Dollar
VIED	=	Vietnam International Education Development
VFA	=	Vietnam Food Association
SEARCA	=	Southeast Asian Regional Center for Graduate Study and Research in Agriculture

CHAPTER I

INTRODUCTION

Statement of the Problem

Agriculture is an important sector in Vietnam's economy, contributing to 19.67% of GDP (GSOa, 2012) and supporting jobs for about 47.4% of the population (GSOb, 2012). In the agricultural sector, rice is a staple crop, accounting for 87.39% of the total cultivation area and constituting 90.09% of the total grain outputs (43.66 million tons) (GSOc, 2012). Therefore, the rice sub-sector plays an important role in the nation's economy; it not only contributes to the eradication of hunger and reduction of poverty, ensuring national-food security, but it also earns foreign currency for the nation as well as creating jobs for laborers. With the advantages of natural conditions and with thanks to the government's supportive policies, applying the advanced science and technologies to production has led to an increase in the yield and the total production of rice annually (Table 1.1). In 2011, the total rice-planted area was 7.6 million ha[1] with an average yield of 5.5 tons/ha, and the total production reached 42.4 million tons (MARD, 2011)[2]. Vietnam has become the world's second largest country for rice exports in recent years with the total amount of rice exported reaching 7.1 million tons and worth (FOB[3]) 3.5 billion USD (VFA, 2011)[4].

Besides these achieved results, we cannot deny the challenges that rice farmers are facing such as soil degradation, water pollution, and the declines of rice-land area, the deteriorated quality of rice, as well as number of crops. These challenges are due to the negative impacts of the environment and urbanization associated with bad-practice treatments that only rely on exploiting the fertility of soil. This is especially true for the Central and Northern mountainous provinces of Vietnam where most of

[1] Hectare
[2] Ministry of Agriculture and Rural Development
[3] Free On Board
[4] Vietnam Food Association

the natural area is forestland and rivers, the rice cultivation area is limited, sloping, infertility, has bad water-store capacity, and is usually heavily affected by natural disasters such as typhoons, floods, landslides, drought, and salinity.

Table 1.1 Adoption and yield advantage of hybrid rice in Vietnam, 2000 - 2010

Year	Planted area (1,000 ha)			Average yield (tons/ha)		
	Total rice	Hybrid rice	The rate of hybrid rice adoption	Normal rice	Hybrid rice	Hybrid rice yield advantage (%)
2000	7,666.30	435.51	5.68	4.24	6.44	51.89
2001	7,492.70	480.00	6.41	4.29	6.48	51.05
2002	7,504.30	500.00	6.66	4.59	6.36	38.56
2003	7,452.20	600.00	8.05	4.64	6.26	34.91
2004	7,445.30	577.00	7.75	4.86	6.35	30.66
2005	7,329.20	553.00	7.55	4.89	6.50	32.92
2006	7,324.80	572.70	7.82	4.89	6.50	32.92
2007	7,192.50	620.00	8.62	4.99	6.50	30.26
2008	7,422.20	560.00	7.54	5.23	6.80	30.02
2009	7,437.20	709.82	9.54	5.24	6.82	30.15
2010	7,489.40	612.98	8.18	5.34	6.90	29.21

Source: GSO (2011) and Hai (2007)

In 1991, the Vietnamese government experimented and introduced hybrid rice varieties to plant in Northern Vietnam with an initial planted area of 100 ha. According to the statistic data of the Ministry of Agricultural and Rural Development (MARD), it showed that the yield of hybrid rice was higher than that of inbred rice varieties. Consequently, hybrid rice was widely adopted in Northern and Central Vietnam, and the planted area increased rapidly from 100 ha in 1991 to 709,820 ha in 2009 (Table 1.1) under the government's subsidy policies such as the subsidy policy of hybrid rice seed.

The record of hybrid rice in Vietnam over the period 2000 to 2010 indicated that hybrid rice had a yield advantage from 29.21% to 51.89% compared with inbred seeds (Table 1.1). According to the assessment from MARD (2011), hybrid rice is insects resistant and adapts to severe conditions of salinity, drought, and cold weather better than conventional varieties. The yield advantage of hybrid rice was also found in other major rice growing countries, which has a high adoption rate of hybrid rice. For example, in China hybrid rice has been adopted since 1979 and has brought an average yield of more than 20% compared with inbred varieties (Yuan, 2004). The Philippines from 2001 to 2007 recorded a yield advantage of hybrid rice, it found that the yield of hybrid rice was 33% more than that of inbred seeds; in Bangladesh it was 14%; and in Myanmar it was from 12 to 48% (Vien and Nga, 2009). In India, the study results found that the yield advantage of hybrid rice compared with inbred rice was from 24% to 36.4% (Xie, 2012). These indicate that hybrid rice predominates over inbred rice and the adoption of hybrid rice was necessary. However, the adoption rate of hybrid rice in Vietnam is still minimal and declining in recent years. In 2009, the total planted area of hybrid rice was 709,820 ha (9.54%) and only contributes to 11.05% of the total rice production (GSO, 2011). Meanwhile, in some other countries hybrid rice has been applied widely such as in China at 15.58 million ha (52.1%), in Bangladesh at 0.8 million ha (7%), in India at 1.63 million ha (3.9%), and in the USA the rate of hybrid rice adoption was at 15.9% (Xie, 2012). The reasons for this situation were because rice farmers depended on the seed supply sources, Vietnam has been having to import 70% of hybrid rice seed annually (from China and India). Secondly, the price of hybrid rice seeds is higher than that of inbred rice but the quality of imported seeds is not guaranteed (MARD, 2012). Thirdly, the quality of hybrid rice is lower than inbred rice, this results in its cheaper price. Finally, the severe natural conditions associated with poor-cultivation methods have a negative effect on the efficiency of hybrid rice.

The Central zone is one of the main large areas in Vietnam which is divided up based on terrain and climate conditions for agricultural production. While the Northern and Southern areas have the favorable conditions for the development of the agricultural sector, especially rice production with large deltas such as the Mekong River Delta in the South and the Red River Delta in the North. These are the main zones of rice production for export; in 2011, the planted-rice area of these two deltas accounts for 68% of Vietnam's total planted-rice area (GSO, 2011). By contrast, the Central zone has the unfavorable conditions for rice production; therefore, the rice production of this zone only meets local demand and the Northern Province's demand. The largest proportion of land area is made up of mountains and rivers. Rice land only makes up 4.8% of the total land area and accounts for 19% (1.45 million ha) of the whole country's total planted-rice area (GSO, 2011). Moreover, this zone is usually heavily affected by natural disasters such as typhoons, floods, erosion, drought, and landslides. These result in negative and direct effects on farmers' profits from rice production. In addition, within the population of 24.3 million people, there are many ethnic minorities that have bad cultivation methods. This have lead to adverse effects on stabilizing food security and sustainable development of the area, especially the remote and ethnic minority areas. Therefore, the application of hybrid rice for this zone is suitable and necessary. The initial results indicated that hybrid rice is adaptable a zone's cultivation conditions and is developing widely in some provinces such as Thanh Hoa, Nghe An, Quang Nam, Binh Dinh with the adoption rate of hybrid rice around 57-60%, 72-73%, 12-14%, 7-15%, respectively (MARD, 2012).

Nevertheless, regarding the economic aspect, the study of Vien and Nga (2009) conducted in the Red River Delta of Vietnam showed that the difference in profit between hybrid rice and inbred rice is minimal, the predominant profit from hybrid rice production that the farmers made is only 27.82 USD/ha and 15.27 USD/ha (approximately 3% more) in the spring and summer season, respectively. Meanwhile, another study conducted in India by IRRI found that the hybrid rice contributed to rice farmers profits with 12.8% and 34.5% higher profit than inbred varieties in East and North India, respectively (Xie, 2012). This raises questions whether farmers growing hybrid rice in Vietnam and the Central area achieved profit efficiency (profit maximization) or not? if not, What factors influence profit inefficiency and what needs to be done to solve these problems?

That is still an unanswered question. Until now, there is not any research analyzing profit efficiency of hybrid rice of farmers in Vietnam, particularly in the Central zone. There were some initial studies about hybrid rice but those only focused on analyzing economic impact. In addition, the use of the profit efficiency approach is minimal in Vietnam, especially at farm level. Studies only limited to analyzing technical efficiency or cost efficiency. Therefore, the application of profit efficiency analysis for hybrid rice is needed for policy implications and recommendations for hybrid rice farmers. Kolawole (2006) and Maudos *et al*. (2002a) indicated that technical efficiency considerations are an important improvement in production efficiency, but computing profit efficiency will lead to greater benefits for farmers and give more important information sources for policy makers than the partial vision offered by analyzing cost efficiency. Kumbhakar and Lovell (2003) also illustrated that a cost minimization objective is undoubtedly appropriate in some environments, but it can be argued that in other environments, it is not sufficiently stringent, because for many producers the ultimate objective is to maximize profit.

Objectives of the Study

This study is conducted with the following specific objectives:

1. To analyze the profit efficiency of hybrid rice production in Central Vietnam

2. To investigate the determinants of profit inefficiency of hybrid rice production in Central Vietnam

Expected Benefit of the Study

The results of this study could help rice households enhance profit as well as suggest proper policy recommendations to support hybrid rice farmers in Central Vietnam and help them perform more efficiently.

Scope of the Study

The Central Vietnam is separated into three sub-areas namely the North Central Coast, South Central Coast, and Central Highlands. Due to the limitation of the research budget, this study only focuses on sampling in the North Central Coast area in the winter-spring season of 2012/2013.

Outline of the Thesis

The thesis is organized as follows: chapter 1 introduces the statement of research problem, objectives, expected benefit of the study, and the scope of the study. Chapter 2 provides a literature review relating to the study issue including theoretical framework and the review of related studies, and the last section presents the hypotheses of the study. The chapter 3 describes the used methodology. Chapter 4 presents a descriptive analysis, empirical results and discussions. Conclusions and recommendations are shown in chapter 5.

CHAPTER II

LITERATURE REVIEW

This chapter is separated into the three main sections. The first section is the review of theoretical framework, which is related to economic efficiency, profit efficiency, the measurement method of efficiency, and the stochastic frontier analysis method. The second section is the review of related studies that is relevant to economic efficiency, profit efficiency of rice and hybrid rice production, and then the variables for this study are drawn. The last section presents the hypotheses of the study

Theoretical Framework

Efficiency Concepts

Efficiency begins with Farrell (1957), it can be defined as the ability to produce a given level of output at the lowest cost. The concept of efficiency has three components: technical, allocative, and economic efficiencies (Coelli, 1996).

Technical efficiency (TE), which reflects the ability of a firm to minimize input use in the production of a given output vector, or the ability to obtain maximum output from a given set of input vector (Kumbhakar and Lovell, 2003);

Allocative efficiency (AE), which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices;

Economic efficiency (EE), which reflects the ability of a firm simultaneously reaching both technical efficiency (TE = 1) and allocative efficiency (AE = 1), it is written as follows: $EE = TE * AE$. Therefore, technical and allocative efficiencies are together necessary conditions to obtain economic efficiency.

However, following the work of Kumbhakar and Lovell (2003), the technical efficiency approach has a fairly weak standard, since no behavioral objective is imposed. He also indicated that the measurement of economic efficiency with a behavioral objective of cost minimization, revenue maximization or profit maximization is a more appropriate and exacting standard than the measurement of economic efficiency, which only exploits input and output quantity data without a behavioral objective being imposed. He introduced the definitions about cost, revenue, and profit efficiencies as follows:

Cost efficiency (CE) is defined as the ability of a firm to minimize cost given the input prices. It is economic efficiency with the behavioral objective of cost minimization imposed. The measurement of cost efficiency is given by the ratio of minimum cost to observed cost.

Revenue efficiency (RE) is defined as the ability of a firm to maximize revenue given the output prices. Revenue efficiency is also economic efficiency with the behavioral objective of revenue maximization imposed. The measurement of revenue efficiency is given by the ratio of actual revenue to maximum revenue.

Profit efficiency (PE) is defined as the ability of a firm to maximize profit given the prices of inputs and outputs and levels of fixed factors (Ali and Flinn, 1989). Thus, in order to obtain profit efficiency the firm needs to achieve technical efficiency and both input allocative efficiency and output allocative efficiency simultaneously. Profit efficiency is economic efficiency with the behavioral objective of profit maximization imposed. The measurement of profit efficiency is provided by ratio of actual profit to maximum profit.

Efficiency Measurement

Efficiency has been estimated using many different methods over the past four decades. The two principal methods are Data Envelopment Analysis-DEA (nonparametric approach or mathematical program) and Stochastic Frontiers Analysis-SFA (parametric approach or econometric method) (Coelli, 1996). The strengths and weakness of DEA and SFA are presented in the Table 2.1. In this study, the SFA method is employed to measure profit efficiency based on its advantages.

Table 2.1 The comparison of SFA and DEA methods

Item	Stochastic Frontier Analysis (SFA)	Data Envelopment Analysis (DEA)
Consistency	Both DEA and SFA methods are efficiency frontier analysis, and are similar in that they determine a frontier and inefficiency based on that frontier.	
Strengths	1. It does not assume that all firms are efficient in advance. 2. SFA makes accommodation for statistical noise such as random variables of weather, luck, machine breakdown and other events beyond the control of firms, and measures error. 3. It does not need to price information available. 4. It is capable to hypothesis test. 5. To estimate the best technical efficiencies of firm, rather than average technical efficiencies of firm.	1. It does not assume that all firms are efficient in advance. 2. It could handle with efficiency measurement of multiple inputs and multiple outputs. 3. It does not need to price information available. 4. It does not need to assume function type and distribution type. 5. While sample size is small, it is compared with relative efficiency.
Weakness	1. It needs to assume functional form and distribution type in advance.	1. It does not accommodation for statistical noise such as measure error.

Table 2.1 (Continued)

Item	Stochastic Frontier Analysis (SFA)	Data Envelopment Analysis (DEA)
	2. It needs enough samples to avoid lack of degree of freedom. 3. The assumed distribution type is sensitive to assessing efficiency scores.	2. It is not capable to hypothesis test. 3. When the newly added decision-maker unit (DMU) is an outlier, it could affect the efficiency measurement.
Application	It has applied to measure performance of profit organizations.	It has applied to assess performance of non-profit organizations or branches of firm.

Source: Lin and Tseng (2005)

According to Kumbhakar and Lovell (2003), profit efficiency analysis is based on the following assumptions. Firstly, producers face exogenously determined input prices and output prices and attempt to allocate inputs and outputs so as to maximize profit. Under this assumption, both inputs and outputs are determined endogenously. Therefore, when producers attempt to maximize profit, they have to decide not only how much of various inputs to use, but also how much of the various outputs to produce. In other words, the issue is not just one of finding the cost-minimizing input combination required to produce a given bundle of outputs, but also one of finding the revenue-maximizing output combination as well. Secondly, the markets of inputs and outputs are perfectly competitive (producers are price-takers in both input market and output market). A question to ask in a price-taking environment, profit-maximizing framework: Can inefficient producers survive? The answer is yes, they can but not for long. In a long-run competitive equilibrium context, profit is driven to zero and only efficient producers survive. However, in a short-run temporary equilibrium context inefficient producers can survive with some loss, even in a competitive environment, provided that the loss is less than the cost of their fixed inputs (AVC < MR=P < AC)[5]. Therefore, the estimation of profit efficiency in a price-taking environment is assumed to conduct in a short-run framework in which some inputs are exogenously determined and the appropriate standard against which to evaluate profit efficiency is the variable profit frontier. Finally, the profit function of farmers is assumed to be decreasing return to scale so that the condition of profit maximization is satisfied. Therefore, the production function of farmers must be a concave function.

The measurement of profit efficiency is expressed by a function as follows:

$$E_{\pi}(y, x, p, w) = (p^T y - w^T x)/\pi(p, w)\,, \text{provided}\,\pi(p, w) > 0. \qquad (1)$$

Where: E_{π} is profit efficiency, π is profit, *y* is a vector of outputs, *x* is a vector of inputs, *p* is a vector of output prices, *w* is a vector of input prices, *T* represents the actual cases.

The measurement of profit efficiency is provided by the ratio of actual profit to maximum profit, and obviously $0 \leq E_{\pi}(y, x, p, w) \leq 1$. However, this is the limitation of efficiency measurement method. The achieved results are greatly dependant on an extreme predominant performance of some farmers in the selected group. Specifically, if there are some farmers who perform so much better than the average performance of a group, then the estimated efficiency of group will be low.

In Figure 2.1, producer A faces the prices of output and input (p^A, w^A) and uses input vector x^A to produce output y^A. It is clear that producer A does not achieve profit efficiency because profit efficiency $E_{\pi}(y, x, p, w) = 1$ at point E where Iso-profit line tangents production possibility frontier, and $0 \leq E_{\pi}(y, x, p, w) < 1$ for all other feasible output-input combinations. In this case, it can be seen that increasing

[5] In short-run and input and output markets are perfectly competitive, a firm continues to produce when marginal revenue (MR=P) is less than average cost (AC) but still greater than average variable cost (AVC).

output-oriented technical efficiency by increasing output radically to ϕy^A will increase profit and profit efficiency for producer A, but he cannot achieve profit efficiency = 1, because he does not achieve output allocative efficiency.

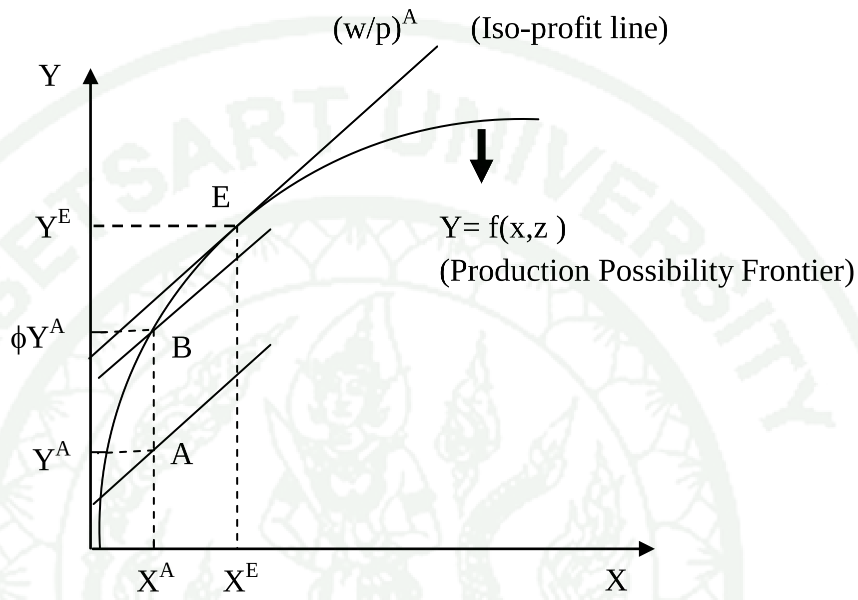

Figure 2.1 The Measurement of Profit Efficiency

Source: Adapted from Kumbhakar and Lovell (2003)

The Stochastic Frontier Analysis

The stochastic frontier production function was independently proposed by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977). The original specification involved a production function specified for cross-sectional data, which had two error components, one to account for random effects and another to account for technical inefficiency. This model can be expressed as follows:

$$Y_i = f(x_i;\beta)\cdot \exp(v_i)\cdot \exp(-u_i) \qquad i = 1, \ldots, n \qquad (2)$$

Where: Y_i is the production (or the logarithm of the production) of the *i*-th firm;

x_i is a vector of (transformations of the) input quantities of the *i*-th firm;

β is a vector of unknown parameters;

v_i are random variables which are assumed to be identical independently distributed $N(0, \sigma_v^2)$ and are assumed to capture the effects of statistical noise;

u_i are non-negative random variables which are assumed account for technical inefficiency in production and are often assumed to be iid as truncations at zero of the $N(0, \sigma_u^2)$ distribution.

$f(x_i; \beta)$ → deterministic kernel

$\exp(v_i)$ → effect on output of exogenous shocks

$\exp(-u_i)$ → inefficiency effects

$f(x_i; \beta) \cdot \exp(v_i)$ → stochastic frontier

$$
\begin{aligned}
TE &= Y_i / f(x_i; \beta) \cdot \exp(v_i) \\
&= f(x_i; \beta) \cdot \exp(v_i) \cdot \exp(-u_i) / f(x_i; \beta) \cdot \exp(v_i) \\
&= \exp(-u_i)
\end{aligned}
$$

Thus producers operate on or beneath their stochastic production frontier $[f(x;\beta).\exp\{v\}]$ according as $u = 0$ or $u > 0$. This original specification has been used in a vast number of empirical applications over the past two decades. The specification has been altered and extended in a number of ways. These extensions include the specification of more general distributional assumptions for the *u*, such as the truncated normal or two-parameter gamma distributions; the consideration of panel data and time-varying technical efficiencies; the extension of the methodology to cost function, profit function, and also to the estimation of systems of equations; and so on. A number of comprehensive reviews of this literature are available, such as Forsund *et al.* (1980), Schmidt (1986), Bauer (1990), Coelli (1996), and Greene (2008).

Stochastic profit frontier analysis

Profit efficiency is defined as profit gain from operating on the profit frontier, taking into consideration farm-specific prices and fixed factors or the ratio of actual profit to maximum profit. Thus, the standard against their performance is the profit frontier. The properties of profit function are imposed before estimating profit efficiency. In particular, (1) farmers' hybrid rice production function is assumed as continuous differentiable and concave. The profit function is (2) assumed convex and homogeneous of degree 1 in input and output prices for given fixed factor (Z); (3) non-decreasing in output price and non-increasing in input prices for given Z; and (4) non-decreasing, concave, and homogeneous of degree 1 in Z for given input and output prices (Kumbhakar and Lovell, 2003). Besides, (5) the input and output markets are also assumed as perfectly competitive (or rice farmers are price takers). The stochastic normalized profit[6] function of n farms is expressed as follows:

$$\pi_i = f(P_{ji}, Z_{ji}; \beta_j) \cdot \exp(v_i - u_i) \qquad i = 1, 2, 3 \ldots \ldots n \tag{3}$$

Where:

π_i is the normalized actual profit of the *i*-th farm;

P_{ji} is the vector of the *j*-th normalized input price[7] of the *i*-th farm;

Z_{ji} is the vector of the *j*-th quasi-fixed input factor of the *i*-th farm;

β_j is the unknown parameters that need be estimated

v_i are random variables which are assumed to be iid. $N(0, \sigma_v^2)$ and are assumed to capture the effects of statistical noise

u_i are non-negative random variables which are assumed to account for profit inefficiency and are assumed to be iid as truncations at zero of the $N(0, \sigma_u^2)$ distribution.

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[6] The normalized actual profit of the *i*-th farm is computed as gross revenue less variable cost, divided by the output price of the *i*-th farm.

[7] The *j*-th normalized input price of the *i*-th farm is computed as the *j*-th input price of the *i*-th farm divide the output price of the *i*-th farm.

And

$$u_i = \delta_0 + \sum \delta_h X_{hi} \qquad i = 1, 2, 3 \ldots \ldots n \qquad (4)$$

Where:

δ_0 and δ_h are unknown parameters that need to be estimated

X_{hi} is the vector of explanatory variables of the profit inefficiency of the *i*-th farm.

The profit efficiency of the *i*-th farm in the context of the stochastic profit frontier function is expressed as the ratio of predicted actual profit to the predicted maximum profit for a best-practiced rice farmer and this is represented as follows:

$$\text{Profit Efficiency } (\pi E_i) = \frac{\pi_i}{\pi_{max}} = \frac{f(P_{ji}, Z_{ji}; \beta_j) \cdot \exp(v_i - u_i)}{f(P_{ji}, Z_{ji}; \beta_j) \cdot \exp(v_i)} \qquad (5)$$

$$= \exp(-u_i)$$

$$= \exp(-\delta_0 - \sum \delta_h X_{hi})$$

πE_i takes the value between 0 and 1. If $u_i = 0$ the farm performs on the frontier, obtaining potential maximum profit given the prices it faces and the level of quasi-fixed factors. If $u_i > 0$, the farm is inefficient and losses profit.

The variance of the random errors σ_v^2, and that of the profit inefficiency effect and overall variance of the model, σ^2 are related, thus: $\sigma^2 = \sigma_v^2 + \sigma_u^2$ measures the total variation of profit from the frontier which can be attributed to profit inefficiency (Battese and Corra, 1977). Battese and Coelli (1993) provided log likelihood function after replacing σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and thus estimating gamma (γ) as: $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$. The parameter γ represents the share of inefficiency in the overall residual variance with values in interval 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in the favor of OLS estimation.

The estimate for all parameters of the stochastic profit frontier function and the inefficiency model are simultaneously obtained using the program FRONTIER 4.1c (Coelli, 1996). A two-stage estimation method is used in obtaining the final maximum likelihood estimation.

Review of Related Studies

Profit efficiency of rice production using stochastic frontier analysis

There are many studies related to the efficiency analysis of rice production conducted in many countries. However, considerable efforts have been directed at examining productive efficiency of farmers that is exclusively focused on technical efficiency. Little attention has been given to measuring the profit efficiency of farmers even when the prices of output and input are known in an attempt to examine the allocative efficiency of farmers. In Vietnam, most of the studies only focused on analyzing technical efficiency (Linh, 2012).

Based on the previous studies results, Maudos *et al.* (2002) indicates that computing profit efficiency constitutes a more important source of information for policy makers than the partial vision offered by analyzing cost efficiency. Kolawole (2006) also showed that the physical productivity considerations (Technical efficiency) are an important improvement in production efficiency, but profit efficiency will lead to greater benefits to agricultural producer. The studies related to profit efficiency of rice production were conducted by Adesina and Djato (1996), Abdulai and Huffman (1998), Rahman (2003), and Kolawole (2006). Based on the review of these studies associated with the real situation of hybrid rice production in Vietnam, variables are used for models in this study as follows:

Variables for profit efficiency model

The previous studies on profit efficiency of rice production in some countries indicated that seeds, fertilizer, labor, and pesticide are the main inputs in farmers' rice production. Therefore, their prices and farm size were used as independent variables to measure profit efficiency of rice production such as the studies of Adesina and Djato (1996) in Côte d'Ivoire, Abdulai and Huffman (1998) in Northern Ghana, Rahman (2003) in Bangladesh, Kolawole (2006) in Nigeria, and Linh (2012) in Vietnam.

Determinants of profit inefficiency model

The factors that affect the profit efficiency of hybrid rice production can be separated into the following categories:

Farmer characteristics:

The educational level of the household head is the most important factor that influences the profit efficiency of rice production. The studies indicated that the higher educational level the head of household has, the more efficiently they perform. This means that in the profit inefficiency model, the sign of education will be expected as a negative value, this was found by Adesina and Djato (1996), Ali *et al.* (1996), Abdulai and Huffman (1998), Kolawole (2006), Khai (2011), Tan *et al*. (2010), Galawat and Yabe (2012), and Hoang and Yabe (2012).

The age of the household head is also a factor that influences the profit inefficiency of rice production. However, the impact of age on rice production is still unclear. The results of Kolawole (2006) research on determinants of profit efficiency among small scale rice farmers in Nigeria, Galawat and Yabe (2012) research on profit efficiency in rice production in Brunei Darussalam, and Tan *et al*. (2010) impacts of land fragmentation on rice producers' technical efficiency in South-East

China found that the age of the household head negatively influences inefficiency. By contrast, the studies of Ali *et al.* (1996) in Pakistan, Abdulai and Huffman (1998) in Northern Ghana, Srisompun and Isvilanonda (2012) in Thailand, and Khai (2011), Linh (2012), and Hoang and Yabe (2012) in Vietnam indicated that age has a positive relationship with inefficiency in household's rice production.

The farming experience of the household head is also one of the significant factors that affect the profit inefficiency of rice production. Similar to education, the household head who has high experience in growing rice is expected to perform less inefficiently than other households do. This was found in the studies of Rahman (2003), Kolawole (2006), and Galawat and Yabe (2012).

Household size is one of the important factors that influences profit inefficiency of rice production. The previous studies showed that a big family has higher profit efficiency than a small family (Kolawole, 2006). In this study, it is hypothesized that household size negatively influences profit inefficiency.

Farm characteristics:

Farm size is a very important factor that affects the profit inefficiency of rice production. Adesina and Djato (1996), and Galawat and Yabe (2012) found that farm size has a positive effect on profit inefficiency. By contrast, Ali *et al.* (1996) research on cost efficiency of rice production in Pakistan and Abdulai and Huffman (1998) research on profit inefficiency of rice farmers in Northern Ghana indicated that the relationship between farm size and the profit inefficiency was negative. However, in this study, farm size is defined as the rice-cultivated area of a household, and it is expected to have a negative effect on profit inefficiency.

Irrigation is very important for rice production; it is especially true to Central Vietnam where terrain is sloped and there is a low capacity for water storage. The rice fields that are stably irrigated will get more productivity than other fields, and the profit efficiency will be higher; this negative relationship between irrigation and inefficiency in farmers' rice production was found in the studies of Rahman (2011) in the resource use efficiency under self-selectivity of Bangladeshi rice producers, and Khai (2011) and Hoang and Yabe (2012) research conducted in technical efficiency analysis of rice production in Vietnam and impact of environmental factors on profit efficiency of rice production in Vietnam's Red River Delta, respectively. In this study, the irrigation variable is hypothesized as having a negative relationship with profit inefficiency.

The topography of the farm is also a very important factor affecting the profit inefficiency of rice production (Adesina and Djato, 1996). In this study, topography of the farm variable is a dummy variable to compare the profit inefficiency between the upland households and the lowland households, and it is hypothesized that the lowland households operate less inefficiently than the upland households.

Other variables related to profit inefficiency:

The type of seed is one of the key factors that decide the profit efficiency of rice production. In Vietnam, there are two groups of hybrid rice seeds, two-line hybrid rice seeds and three-line hybrid rice seeds. Three-line hybrid rice seeds are assessed higher than two-line seeds in yield, resistance to insects, pesticides, and quality of rice (cooking characteristics). Therefore, in this study, the type of seed is a dummy variable, and it is hypothesized that three-line hybrid rice seeds have less profit inefficiency than the two-line hybrid rice seeds.

The share of rice income in household's total income also influences the profit inefficiency of rice production. Rahman (2003) used the non-farm income variable and found that they had positive relationship. This means that farm income (the share of rice income) has a negative relationship with profit inefficiency. Based on the socio-economic conditions of the study site, the share of rice income is expected to have a negative effect on profit inefficiency of hybrid rice production.

Besides, other variables are hypothesized to have effects on profit inefficiency of farmers' hybrid rice production. These variables comprise of the share of rice for sale, the share of hybrid rice area, the frequency of training attendance about hybrid rice production, the source of the seeds, the hybrid rice production experience of the household head, and the number of family labors for hybrid rice production.

Hypotheses

The hypotheses of this research are as follows:

1. Farmers growing hybrid rice in Central Vietnam have different profit efficiency. In other words, there is the existence of profit inefficiency among hybrid rice farmers. This hypothesis can be tested by the Likelihood Ratio (LR)[8] test.

$H_0: \gamma = 0$ the profit inefficiency is not present (Null hypothesis)

$H_1: \gamma > 0$ there profit inefficiency is present among hybrid rice farmers (Alternative hypothesis)

2. Profit inefficiency of farmers' hybrid rice production in Central Vietnam is affected by farmer characteristics, farm characteristics, and other related socio-economic variables. This hypothesis can be tested by T-test[9]

$H_0: \beta_i = 0$ the used variables do not influence on the profit inefficiency of farmers' hybrid rice production (Null hypothesis)

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[8] LR = -2(LLF_0 – LLF_1), where LLF_1 is value of Log Likelihood achieved by estimating unrestricted model and LLF_0 is value of Log Likelihood achieved by estimating restricted model. Reject H_0 (γ=0) if LR > χ_R^2 table value, where R = number of restrictions.

[9] Finding t-ratio = (parameter estimate)/(standard error). Reject H_o (β_i=0) if t-ratio > t_α two-tail critical value (*t* distribution table)

H$_1$: $\beta_i \neq 0$ the used variables influence on the profit inefficiency of farmers' hybrid rice production (Alternative hypothesis)

CHAPTER III

METHODOLOGY

This chapter describes the method used in this study and are divided into three sections. The first section presents the analytical framework of the study. The second section describes the sampling procedure and data collection. The data analysis is provided in the last section.

Analytical Framework

The analytical framework is developed based on objectives of the study and the literature review. The main objectives of this study focuses on analyzing profit efficiency and assessing the effect of factors on the profit inefficiency of hybrid rice production, hence, the stochastic frontier analysis method with profit function approach will be employed in this study. Moreover, stochastic the frontier analysis method is a parameter approach, which will give us the research results more accurately and reliably than non-parameter approaches. Besides, the descriptive statistics method is also applied to describe natural conditions, socio-economic conditions, farmer characteristics, farm characteristics, and the situations of rice and hybrid rice production of surveyed households. To be sure that the study results have significance, the review method of literature and expert method are used in this research to verify and reduce random errors during the period of conducting research.

The data for this study comes from primary data collected through household interviews by the stratified random sampling method to seek the information about farmer characteristics, farm characteristics, input and output quantities as well as their prices, and other variables relevant to the profit inefficiency of hybrid rice production of households. The analytical framework is presented in Figure 3.1.

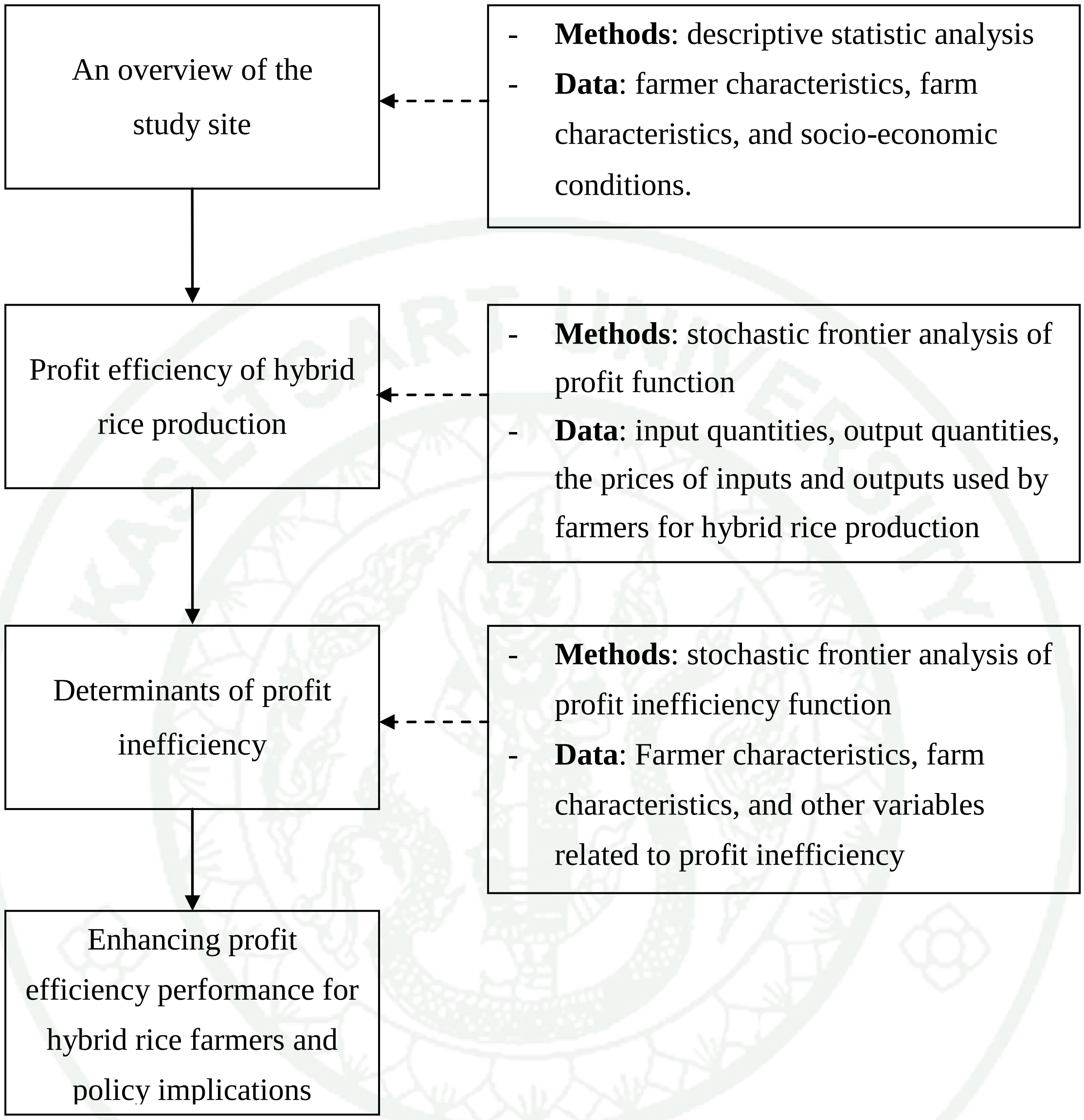

Figure 3.1 Analytical framework

Sampling Procedure

Based on the attributes of the research objectives and objects, the stratified sampling method is employed in this study. In stratified sampling the population of N units is first divided into subpopulations of N_1, N_2, …, N_i units, respectively. These subpopulations are non-overlapping, and together they comprise of the entire population. The subpopulations are called strata and the sample is drawn independently in different strata; the sample size within the strata are denoted by n_1, n_2, …,n_i, respectively (Groves *et al.*, 2004). In this study, the simple random sample is taken in each stratum as follows:

In the first stage, the study site is stratified based on the adoption rate of hybrid rice. The differences in the adoption rate of hybrid rice between provinces may be due to the difference in its profit explained by factors used in the models (farmer characteristics, farm characteristics, and other related variables). Therefore, the stratification based on the adoption rate of hybrid rice will increase the precision of sample and the significance level of the study result. The study site is stratified into two stratums comprising of major and minor zones based on the average adoption rate of hybrid rice in the whole country (around 10%). The major zone, which has more than 10% of the adoption rate of hybrid rice, has two provinces namely Thanh Hoa and Nghe An. The minor zone is the rest of provinces, which have an adoption rate of hybrid rice of less than 10% (Table 3.1).

In the second stage, the study site continues to be stratified based on the existence of the center for F1 seed production. Because in the provinces which have a seed production center, they will be ensured with seed resources and the quality of seeds. Moreover, these seeds may adapt better with the local climate conditions and the price of seeds is also cheaper than other provinces. Therefore, these things may affect the profit efficiency of hybrid rice production of farmers. According to the plan of MARD (2011), the study site has one province to produce hybrid rice seeds namely Thanh Hoa province. The group without a center for hybrid rice seed production is the rest of the provinces (5 provinces). Then, three provinces are randomly selected in three stratum including Thanh Hoa, Nghe An, and Thua Thien Hue. While, Thanh Hoa has the seed production center and the high adoption rate of hybrid rice, Nghe An represents the high adoption rate of hybrid rice without a seed production center, and Thua Thien Hue represents the low adoption rate of hybrid rice and without a seed production center.

Table 3.1 Major and minor hybrid rice zones of the Central Vietnam 2011

	Agricultural land		**Planted-paddy area**		**Adoption rate of hybrid rice (%)**
	1,000 ha	**Percentage (%)**	**1,000 ha**	**Percentage (%)**	
Total	7348.40	28.83	1229.20	16.07	n/a
Major zone					
Thanh Hoa	847.70	11.54	257.10	20.92	60.00
Nghe An	1231.10	16.75	186.00	15.13	73.00
Minor zone					
Ha Tinh	471.50	6.42	99.10	8.06	4.60
Quang Binh	713.00	9.70	52.80	4.30	6.00
Quang Tri	378.70	5.15	48.50	3.95	4.00
Thua Thien Hue	376.60	5.12	53.50	4.35	1.00

Source: GSO (2011)

The final stage, from the selected provinces in the second stage, four districts are randomly drawn up to be surveyed. These consist of Tinh Gia district of Thanh Hoa Province; Quynh Luu district and Dien Chau district of Nghe An province; and A Luoi district of Thua Thien Hue province. The simple random sampling is then applied in each stratum, and the sample size of 328 households is calculated based on the sampling technique of James *et al*. (2001) with a confident level of 99%.

Table 3.2 Stages of sampling procedure

Stage 1 Intensity of hybrid rice area	Stage 2 The seed production center exists	Stage 3 Sample districts	Sample size	Sample proportion
Major hybrid rice provinces	Exists: Thanh Hoa	Tinh Gia	70	21.33
	None: Nghe An	Quynh Luu	120	36.59
		Dien Chau	100	30.49
Minor hybrid rice provinces	Exists: -	-	-	-
	None: Thua Thien Hue	A Luoi	38	11.59
	Total		**328**	**100**

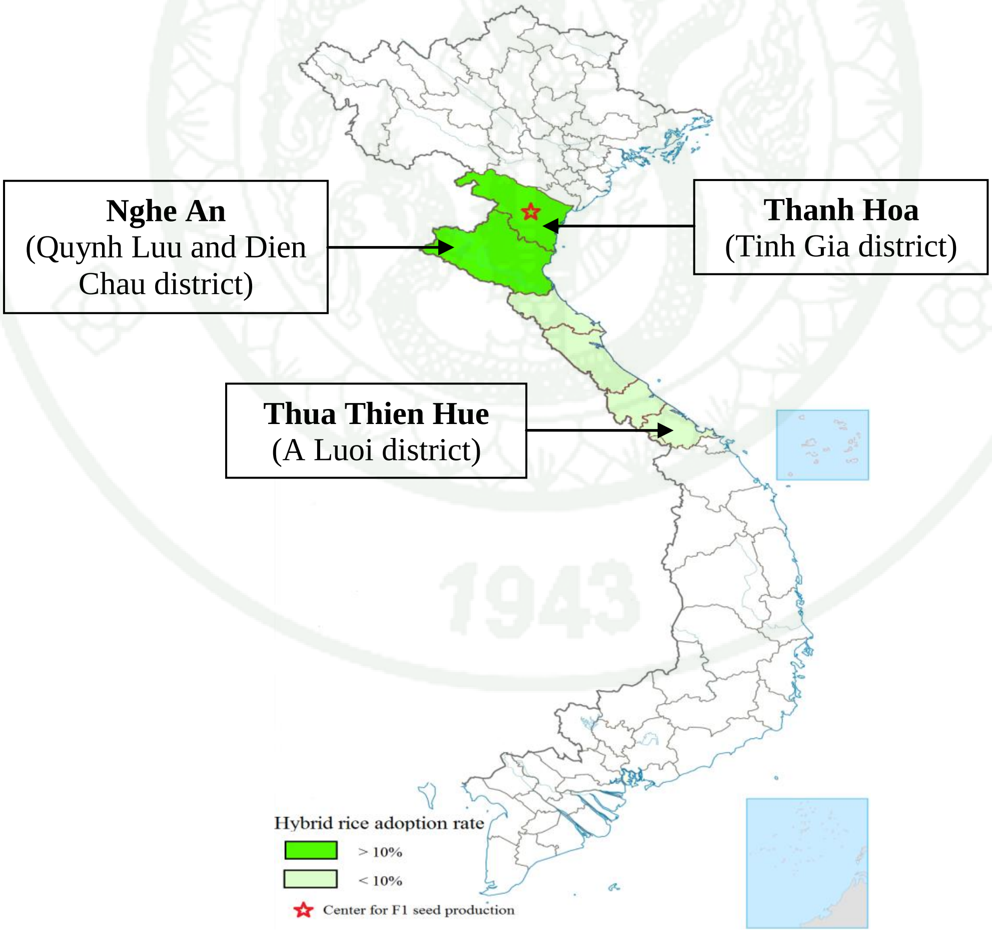

Figure 3.2 Map of study site

Data Collection

The primary data for analyzing profit efficiency and the determinants of profit inefficiency of hybrid rice production was collected through personal interviews using a questionnaire to seek information about farmer characteristics, farm characteristics, and data about quantities as well as the prices of inputs and outputs for hybrid rice production of rice households in Central Vietnam. The data was collected in winter-spring crop season of 2012/2013.

Data Analysis

The data analysis is organized into two stages. The first stage is a statistic description analysis about farmer characteristics, farm characteristics, and hybrid rice production of surveyed farmers. The second stage measures the profit efficiency and the determinants of profit inefficiency of hybrid rice by SFA method. The definition and the unit of measurement of variables used in the models is presented in Table 3.3 and Table 3.4, respectively.

Table 3.3 Variables and their definition used in the profit efficiency model

(Unit: per crop)

Variables		Definition
π	=	The normalized actual profit of hybrid rice production
P_{Seed}	=	The normalized price of seed
$P_{Fertilizer}$	=	The normalized price of fertilizer
P_{Labor}	=	The normalized price of labor
$P_{Pesticide}$	=	The normalized price of pesticide
FSIZ	=	The rice-cultivated area of the household

The value of these variables is computed as follows:

The normalized actual profit of hybrid rice production (π) of the *i*-th farm is computed as gross revenue less variable cost, then divided by the rice price of the *i*-th farm.

The normalized price of seeds (P_{Seed}) of the *i*-th farm is computed as the price of seeds divided by the price of rice.

The normalized price of fertilizer ($P_{Fertilizer}$) of the *i*-th farm, because farmers simultaneously use some kinds of fertilizers; therefore, the normalized price of fertilizer is computed as (price of the *j*-th fertilizer * quantity of the *j*-th fertilizer)/(total quantity of fertilizer used by the *i*-th farm), and then divided by the price of rice.

The normalized price of labor (P_{Labor}) of the *i*-th farm is computed as the price of labor divided by the price of rice.

The normalized price of pesticide ($P_{Pesticide}$) of the *i*-th farm is similar to fertilizer, farmers simultaneously use some kinds of pesticides. Therefore, the normalized price of pesticide is computed as (price of the *k*-th pesticide * the number of the *k*-th pesticide packets)/(the total packets of pesticide used by the *i*-th farm), and then divided by the price of rice.

When the actual profit and input prices are normalized by the price of rice, it means that the homogeneous condition of degree 1 in inputs and output price was imposed in the model. These values included the rice-cultivated area are taken logarithm before estimation of the model using program Frontier 4.1c. However, using translog functional form cannot consider negative profit. Therefore, farmers who have the negative actual profit are eliminated from the sample.

Table 3.4 Definition, unit and expected sign of variables used in the inefficiency model

Variables	Definition	Unit	Expected sign
AGE	Age of the household head	Year	+
HHS	Household size	Person	-
EDU	Educational level of the household head	Year	-
FEX	Farming experience of the household head	Year	-
FSIZ	Rice-cultivated area of the household	Hectare	-
IRR	Irrigation	Percentage (%)	-
RIN	Share of rice income in household's total income	Percentage (%)	-
RIS	Share of rice for sale	Percentage (%)	-
HRA	Share of hybrid rice area	Percentage (%)	-
TRA	Frequency of training attendance about hybrid rice production	Number	-
HEX	Hybrid rice production experience of the household head	Year	-
FLA	Number of family labors for hybrid rice production	Person	-
D1	Topography of the farm (dummy variable)	1=lowland, 0=otherwise	-
D2	Type of seed (dummy variable)	1=3 lines, 0=otherwise	-
D3	Source of seed (dummy variable)	1=domestic, 0=otherwise	-

Empirical Model

This study uses cross-sectional data and applies model 2 of Battese and Coelli (1995) Specification (Coelli, 1996) with translog function form (Griffin *et al.,* 1987) to analyze profit efficiency and investigate the determinants of profit inefficiency of hybrid rice production of farmers. A number of empirical studies have estimated stochastic frontiers and predicted firm-level efficiencies using these estimated functions. The translog function is a flexible functional form that needs fewer assumptions than Cobb-Douglas function form. However, it is more complicated and difficult to interpret the results.

The stochastic translog normalized profit frontier function of n farm is written as follows:

$$\ln\pi_i = \beta_0 + \sum_{j=1}^{4}\beta_j \ln P_{ji} + \alpha_1 \ln FSIZ + \frac{1}{2}\sum_{j=1}^{4}\sum_{k=1}^{4}\beta_{jk}\ln P_{ji}\ln P_{ki} + \frac{1}{2}\alpha_{11}(\ln FSIZ)^2 + \sum_{j=1}^{4}\gamma_{j1}\ln P_{ji}\ln FSIZ + (v_i - u_i) \qquad i = 1,2 \ldots . n \qquad (6)$$

Where:

π_i represents normalized actual profit of the *i*-th farm;

P_{ji} represents the *j*-th normalized variable input price of the *i*-th farm including price of seed, fertilizer, labor, and pesticide;

FSIZ represents the quasi-fixed input, that is the rice-cultivated area of the *i*-th farm.

$\beta, \alpha,$ and γ are unknown parameters that need to be estimated

v_i are random variables which are assumed to be iid. $N(0, \sigma_v^2)$ and are assumed to capture the effects of statistical noise

u_i are non-negative random variables which are assumed account for profit inefficiency and are assumed to be iid as truncations at zero of the $N(0, \sigma_u^2)$ distribution.

And the profit inefficiency equation

$$u_i = \delta_0 + \delta_1 AGE_i + \delta_2 HHS_i + \delta_3 EDU_i + \delta_4 FEX_i + \delta_5 FSIZ_i + \delta_6 IRR_i + \delta_7 RIN_i + \delta_8 RIS_i + \delta_9 HRA_i + \delta_{10} TRA_i + \delta_{11} HEX_i + \delta_{12} FLA_{2i} + \delta_{13} D_{1i} + \delta_{14} D_{2i} + \delta_{15} D_{3i} \qquad i = 1, 2, 3 \ldots n \qquad (7)$$

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter comprises of two parts: the descriptive analysis and empirical results and discussions. The first part describes the general status of rice farmers in the study site such as farmer characteristics, farm characteristics, and farmers' hybrid rice production. The second part presents the estimation results of profit efficiency and inefficiency models associated with discussions as well as the comparison together with the tests of statistical hypotheses.

Descriptive Statistics

Demographic Characteristics

The summary statistics of demographic characteristics of 328 surveyed rice farmers is shown in Table 4.1. The gender of household decision-makers is almost equally distributed between male (49.39%) and female (50.61%). The average age of surveyed rice farmers is at 50.10 years and the average educational level (year of schooling) is 7.34 years with the lowest level at zero and the highest level at 12 years. The survey indicates that the educational level depends on socio-economic conditions and their age. It is observed that the older they are, the lower their educational level is.

The farming experience and the hybrid rice production experience are more or less influenced by age. The average years of farming experience and the hybrid rice production experience are 24.33 years and 8.05 years, respectively. Hybrid rice is quite new to this area, and it requires farmers to know how to grow it before cultivating. However, the frequency of training attendance about hybrid rice production of farmers is low, only 1.69 times per farmer, and the percentage of participants is only 61.89% of the total sampling farmers.

Table 4.1 Summary statistics of demographic characteristics of rice farmers

Variable	Mean	Min	Max	Frequency	Percent
Number of observations	-	-	-	328	100.0
Gender					
Male	-	-	-	162	49.39
Female	-	-	-	166	50.61
Age of the household head (year)	50.10	20.00	80.00	-	-
Educational level of the household head (year)	7.34	0.00	12.00	-	-
Farming experience of the household head (year)	24.33	3.00	54.00	-	-
Hybrid rice production experience of the household head (year)	8.05	1.00	15.00	-	-
Frequency of training attendance about hybrid rice production (No.)					
No	-	-	-	125	38.11
Yes	-	-	-	203	61.89
Household size (person)	4.40	1.00	10.00	-	-
Number of family laborers for hybrid rice production (person)	2.19	1.00	5.00	-	-
Household’s total income (USD)	3,397.4	476.2	11,904.8	-	-
Share of rice income (%)	35.66	5.18	96.00	-	-
Share of rice for sale (%)	22.85	0.00	90.00	-	-

With household size, it is found that the average amount of people per household is around 4 people, while the average number of laborers per household is high around 3 people and number of dependent people per household is about 1 person. The survey results also show that the number of household's laborers for rice production is around 2 people, this implies that rice production activity plays an important role in supporting jobs for rural laborers in Central Vietnam.

With household's total income, the total average income of farmers is 3,397.4 USD/year or 772.14 USD/person/year, while income from rice makes up 35.66%. This shows that the average income per capita of rice farmers in the study site is very low, and rice production significantly contributes to a household's total income.

The share of rice for sale is approximately 23% of the household's total rice production. It reveals that the main aim of rice production activity in the Central region is self-sufficient (household's consumption). This is explained by household's small rice-cultivated area (0.27 ha/household) and large household size (4 people/household). The self-sufficient characteristic may lead to inefficiency in hybrid rice production of farmers, because they may not consider the market elements carefully when they make decisions.

It can be concluded that the socio-economic conditions of rice farmers in Central Vietnam may not be favorable for rice farming. This may lead to the inefficiency in their hybrid rice production.

Farm Characteristics

The summary statistics of farm characteristics is presented in the upper part of Table 4.2. The most remarkable point of this part is the rice-cultivated area of the household; the rice-cultivation area in Central Vietnam is quite small, with an average size at 0.27 ha per household or 0.06 ha per person (divided by an average household size of 4.4 persons). Although the rice-cultivated area is small, it is divided into many small fields. This fragmented situation has existed in Vietnam, especially in the Central region for the last two decades. The fragmentation of land results in negative and direct effects on the application of mechanization, productive efficiency, and profit efficiency.

The irrigation system is supplied with an average rate of 85.34% of the total rice-cultivated area, the minimum rate is 50% and the highest rate is 100%. This implies that although most of land in the Central region is upland and sloping, the irrigation was one of the primary concerns.

The average share of hybrid rice area is 32.62%, this result is suitable for the adoption rate of the study site. However, the survey shows that most of farmers only grow hybrid rice in the winter-spring season. In the total surveyed samples, the percentage of farmers living in the uplands is 56.40% and 43.60% for the lowlands.

The quality of seeds plays an important role in hybrid rice productivity. Currently, hybrid rice varieties are divided into two groups based on the traits including two-line seeds and three-line seeds. The three-line seeds dominate the two-line seeds in the quality of rice such as taste, soft, yield and tolerance to insects. Thus, the price of three-line rice seeds is higher than that of the two-line seeds. Based on the survey results, the adoption rate of the three-line seed is only 30.18%, and 69.82% for the two-line seed.

The source of seeds is a large constraint in Vietnam. The survey result shows that the sources of hybrid rice seed come from two main sources, domestic and imported (China and India). While the imported sources account for 89.02% and only 10.98% is the domestic source. In recent years, the quality of imported varieties are not guaranteed and cause the heavy loss for rice farmers. It is becoming a debatable issue whether the promotion of hybrid rice should be adopted or not, even as Vietnam has to import about 75% of seed demand. This is a big issue, and it should be clearly considered when building the development strategy for hybrid rice.

Table 4.2 Summary statistics of farm characteristics and investment in rice production

Variable	Mean	Min	Max	Frequency	Percent
Farm characteristics					
Rice-cultivated area of the household (Ha)	0.27	0.05	2.00	-	-
Irrigation (%)	85.34	50.00	100.00	-	-
Share of hybrid rice area (%)	32.62	8.33	50.00	-	-
Year of adoption (year)	2002	1997	2011	-	-
Topography of the farm					
Lowland	-	-	-	143	43.60
Upland	-	-	-	184	56.40
Type of seed					
2 lines	-	-	-	228	69.82
3 lines	-	-	-	99	30.18
Source of seed					
Vietnam	-	-	-	36	10.98
Import	-	-	-	291	89.02
Investment in production (USD)					
Loan	377.18	0.00	6,190.48	-	-
Cattle	1,235.19	0.00	14,285.71	-	-
Pig	59.48	0.00	952.38	-	-
Plough machine	52.05	0.00	4,761.90	-	-
Water pump machine	4.79	0.00	142.86	-	-
Rice grind machine	15.53	0.00	1,666.67	-	-
Pesticide gun machine	1.05	0.00	23.81	-	-

The investment in production is presented in the lower part of Table 4.2. In general, the level of mechanization in rice production of rice farmers in the Central region is minimal. It can be seen from the table that the farmers' investment in machines for their rice production is low. This is partial due to small scale and the fragmentation of cultivation area.

Hybrid Rice Production

Table 4.3 illustrates the summary of hybrid rice production in three parts. The upper part shows inputs and the input prices of hybrid rice production. Rice farmers use about 29.60 kg of seed, 761.98 kg of fertilizer, 82.44 packets of pesticide, and 108.40 man-day of labor per hectare. With the average prices of seed, fertilizer, pesticide, and labor are 4.49 USD/kg, 0.36 USD/kg, 0.30 USD/packet[10], and 7.24 USD/man-day, respectively. The total average cost that farmers invested in hybrid rice production is 1,390.74 USD/ha.

The output quantity and price of rice is presented in Table 4.3. The most remarkable point is yield. It is clear from the table that the average yield of hybrid rice is around 6.2 tons/ha, and the lowest yield is 3.2 tons/ha; it is low compared to the highest yield of 8.0 tons/ha. The price of hybrid rice fluctuates significantly between 0.24 USD/kg and 0.43 USD/kg, and the average price is 0.32 USD/kg. The differences in yield and the fluctuation of output price result in the significant difference in total revenue; the average revenue that rice farmers achieve is around 2,011.76 USD/ha with the lowest value at 1,142.86 USD/ha and the highest value is 3,076.19 USD/ha. This causes a noticeable difference in the profit of hybrid rice production that is clearly shown in the lower part. The average profit of hybrid rice cultivation is 621.02 USD/ha, with a large fluctuation range between 3.81 USD/ha and 1,677.14 USD/ha. This indicates that there is a difference in productive efficiency in hybrid rice production among farmers.

[10] 1 packet = 15 gramme

Table 4.3 Summary of input, output, and profit

(Unit: per crop)

Variable	Unit	Mean	Std. Dev.	Min	Max
Input quantity and price					
Seed	Kg/ha	29.60	8.60	16.00	60.00
Fertilizer	Kg/ha	761.98	172.34	160.00	1,580.00
Pesticide	Packet/ha	82.44	44.56	20.00	300.00
Labor	Man-day/ha	108.40	15.80	80.00	170.00
Price of seed	USD/kg	4.49	1.28	1.43	7.14
Price of fertilizer	USD/kg	0.36	0.04	0.17	0.60
Price of pesticide	USD/packet	0.30	0.14	0.12	0.71
Price of labor	USD/man-day	7.24	0.51	4.59	8.57
Total cost	USD/ha	1,390.74	139.92	998.10	1,813.33
Output quantity and price					
Yield	Kg/ha	6,220.40	781.80	3,200.00	8,000.00
Price of rice	USD/kg	0.32	0.04	0.24	0.43
Total revenue	USD/ha	2,011.76	359.65	1,142.86	3,076.19
Net profit	USD/ha	621.02	364.39	3.81	1,677.14

Empirical Results and Discussions

Profit Efficiency

The parameters of the stochastic translog normalized profit frontier function in equation (6) and the parameters of inefficiency model in equation (7) are estimated by the maximum-likelihood method using FRONTIER 4.1c (Coelli, 1996). The results are shown in the Table 4.4 and Table 4.7, respectively.

Table 4.4 Parameter estimates of stochastic translog normalized profit frontier function

Variable	Coefficient estimates	T-statistics
Constant	- 5.6832	- 0.82
$\ln P_{Seed}$	0.8214	0.48
$\ln P_{Fertilizer}$	- 3.6661	- 1.09
$\ln P_{Labor}$	5.3549	0.98
$\ln P_{Pesticide}$	- 2.8745***	- 2.86
ln FSIZ	3.3787***	2.93
$1/2(\ln P_{Seed})^2$	0.2674	0.92
$1/2(\ln P_{Fertilizer})^2$	0.0420	0.03
$1/2(\ln P_{Labor})^2$	- 0.8609	- 0.38
$1/2(\ln P_{Pesticide})^2$	0.1210	0.74
$1/2(\ln FSIZ)^2$	- 0.0345	- 0.34
$\ln P_{Seed}$ x $\ln P_{Fertilizer}$	0.5279	1.01
$\ln P_{Seed}$ x $\ln P_{Labor}$	- 0.6022	- 0.94
$\ln P_{Seed}$ x $\ln P_{Pesticide}$	- 0.1342	- 0.92
$\ln P_{Fertilizer}$ x $\ln P_{Labor}$	0.3885	0.28
$\ln P_{Fertilizer}$ x $\ln P_{Pesticide}$	- 0.1208	- 0.34
$\ln P_{Labor}$ x $\ln P_{Pesticide}$	0.9741**	2.70
$\ln P_{Seed}$ x ln FSIZ	0.2265*	1.90
$\ln P_{Fertilizer}$ x ln FSIZ	0.4106	1.21
$\ln P_{Labor}$ x ln FSIZ	- 1.2648***	- 3.13
$\ln P_{Pesticide}$ x ln FSIZ	0.1024	1.16
Variance Parameters		
$\sigma^2 = \sigma_v^2 + \sigma_u^2$	2.5267***	8.70

Table 4.4 (Continued)

Variable	Coefficient estimates	T-statistics
$\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$	0.9892***	327.22
Log-likelihood	- 209.9237	
N	328	

Note: ***, ** and * are statistically significant at 1%, 5% and 10%, respectively.
P denotes as the normalized price for the named inputs

The lower part of Table 4.4 shows the results of testing the hypothesis on the existence of inefficiency effects. The estimation value of γ is equal to 0.9892 (close to 1), and is significantly different from zero (statistically significant at 1%). Therefore, H_0 ($\gamma = 0$) is rejected and H_1 ($\gamma > 0$) is accepted; it can be concluded that there is the existence of inefficiency in hybrid rice production among farmers in Central Vietnam. This result is similar to the results of Rahman (2003) in Bangladeshi, Galawat and Yabe (2012) in Brunei Darussalam, and Kolawole (2006) in Nigeria.

The frequency distribution of profit efficiency of hybrid rice production is illustrated in Table 4.5 and Figure 4.1. The average profit efficiency is 0.63, it implies that farmers can increase their profit of hybrid rice by 0.37 through the improvement of technical, allocative and scale efficiencies. One of the remarkable points of this table is the distribution of profit efficiency in a wide range from 0.01 to 0.95. The high percentage of farmers operating greater than 0.9 of profit inefficiency level accounts for about 9.15%; however, 49.09% of rice farmers achieved profit efficiency level greater than 0.7. This result is similar to the result of Kolawole (2006) in Nigeria where the average profit efficiency was 0.6; however, it is quite low compared to the results from Ghana, Bangladeshi, and Brunei Darussalam. For examples, Abdulai and Huffman (1998) reported the average profit efficiency of rice farmers in Northern Ghana was 0.73, Rahman (2003) reported the average profit efficiency of high yielding varieties of farmers in Bangladeshi was 0.77, Galawat and Yabe (2012) reported the average profit efficiency of farmers' rice production in Brunei Darussalam was 0.81.

Table 4.5 The frequency distribution of farm specific profit efficiency

Profit Efficiency Index	Observation	Percentage
< 0.1	30	9.15
≥ 0.1 and < 0.2	8	2.44
≥ 0.2 and < 0.3	9	2.74
≥ 0.3 and < 0.4	16	4.88
≥ 0.4 and < 0.5	17	5.18
≥ 0.5 and < 0.6	40	12.20
≥ 0.6 and < 0.7	47	14.33
≥ 0.7 and < 0.8	52	15.85
≥ 0.8 and < 0.9	76	23.17
≥ 0.9 and < 1.0	33	10.06
= 1.0	0	0.00
Summary of profit efficiency		
Mean	0.63	
Std. Dev.	0.26	
Min	0.01	
Max	0.95	

The inefficiency among farmers is partially explained by socio-economic factor variables used in the inefficiency model presented in the next section. The remaining part can be due to the negative effect of natural conditions that is only observed but cannot be measured in this study.

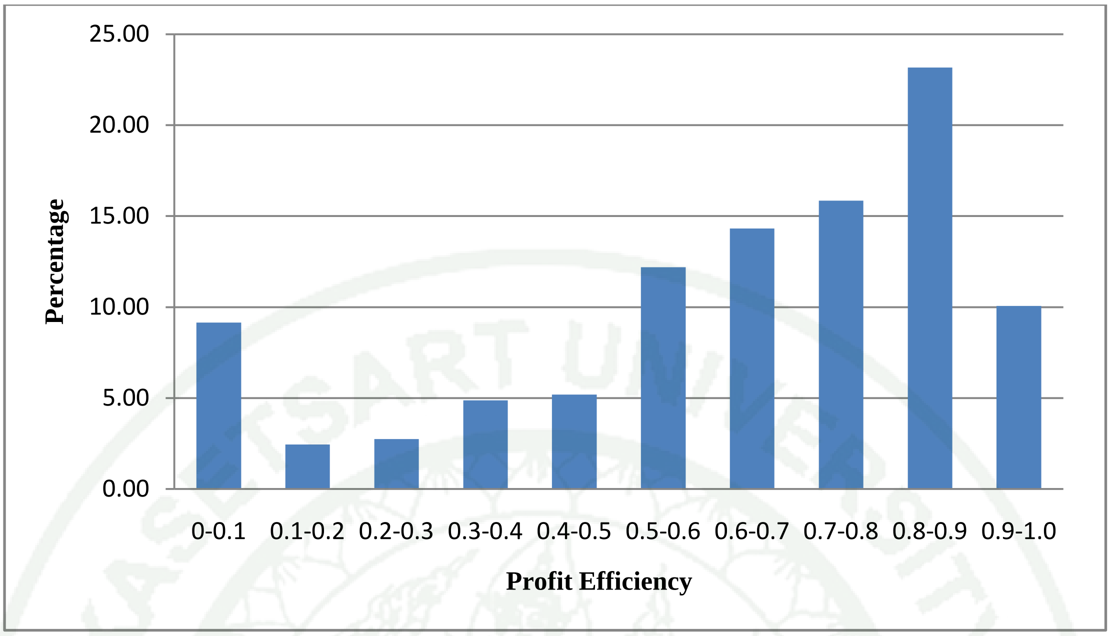

Figure 4.1 The density distribution of profit efficiency

Table 4.6 shows the comparison of farmer and farm characteristics by profit efficiency groups including low profit efficiency group (Low-PE group) and high profit efficiency group (High-PE group) that were divided based on the median value of profit efficiency at 0.68. The results show that the mean values of irrigation, the share of rice income in household's total income, the frequency of training attendance about hybrid rice production, and the hybrid rice production experience of the household head in high profit efficiency group are higher than those of the low profit efficiency group with a statistically significant level of 1%, respectively. The same results were found in the farming experience of the household head, the rice-cultivated area, and the share of hybrid rice area with the statistically significant level of 5%, 10%, and 10%, respectively. This implies that these variables more or less positively affect profit efficiency of farmers' hybrid rice production. While there is not any evidence about the difference in the average value of the age of the household head, household size, the educational level of the household head, the share of rice for sale, and the number of family laborers for hybrid rice production between the two groups.

Table 4.6 Comparison of farmer and farm characteristics by profit efficiency level

Factors	Mean value		T-statistics
	Low-PE	High-PE	
Profit efficiency (mean)	0.41	0.83	
Age of the household head (year)	49.78	50.41	- 0.52
Household size (person)	4.52	4.28	1.30
Educational level of the household head (year)	7.14	7.54	- 1.49
Farming experience of the household head (year)	23.25	25.36	- 2.18**
Rice-cultivated area of the household (ha)	5.124	5.84	- 1.88*
Irrigation (%)	82.25	88.27	- 4.84***
Share of rice income in household's total income (%)	31.83	39.78	- 3.81***
Share of rice for sale (%)	21.69	23.96	- 0.78
Share of hybrid rice area (%)	31.41	33.78	- 1.70*
Frequency of training attendance about hybrid rice production (number)	1.21	2.14	- 5.23***
Hybrid rice production experience of the household head (year)	7.19	8.88	- 5.23***
Number of family labors for hybrid rice production (person)	2.24	2.14	1.12

Note: ***, ** and * are statistically significant at 1%, 5% and 10%, respectively.

Determinants of Profit Inefficiency

The parameter estimates of the explanatory variables for the profit inefficiency and their t-ratio are shown in the Table 4.7. As mentioned above, the explanatory variables are hypothesized having a negative effect on the profit inefficiency of farmers' hybrid rice production except for the age of the household head. The estimation result illustrates that almost all of explanatory variables have the expected sign except for the rice-cultivated area and the share of rice for sale, which have positive signs. The impact and significant level of these variables is clearly explained as follows:

Constant value is 11.4725 and significantly different from zero. It can be concluded that there is the impact of other factors on the profit inefficiency of farmers' hybrid rice production that were not used in the model yet.

The age of the household head, it was found that the age of the household head has a positive effect on profit inefficiency, as expected. This result is similar to finding in the studies of Ali *et al.* (1996) in Pakistan, Abdulai and Huffman (1998) in Northern Ghana, and Linh (2012) in Vietnam. This indicates that the older the household head is, the more inefficiency they perform. The coefficient estimate is 0.0779 and significantly different from zero implying that if the age of the household head increases by one year, the profit inefficiency will also increase by around 0.0779%.

Household size, the coefficient estimate of household size has an expected sign but it is not significantly different from zero. It can be concluded that there is not any evidence of the relationship between household size and their profit inefficiency of hybrid rice production. This finding is consistent with the findings of Ali *et al.* (1996) and Kolawole (2006).

The educational level of the household head is one of the most important factors affecting the profit inefficiency of hybrid rice production. It is expected that with a high education level, rice farmers can reduce their profit inefficiency. The estimation result shows that the coefficient of the educational level is - 0.2288 and it is significantly different from zero. This can be concluded that the educational level of the household head has a negative effect on profit inefficiency, specifically if the educational level of the household head increases by one year of schooling, the profit inefficiency will decrease by 0.2288%. This result is in line with the results of Ali *et* *al.* (1996), Abdulai and Huffman (1998), Kolawole (2006), and Galawat and Yabe (2012).

Table 4.7 Parameter estimates of profit inefficiency model

Variable	**Coefficient estimates**	**T-statistics**
Constant	11.4725***	6.38
Age of the household head (year)	0.0779***	3.05
Household size (person)	- 0.0689	- 0.62
Educational level of the household head (year)	- 0.2288***	- 3.72
Farming experience of the household head (year)	- 0.0044	- 0.14
Rice-cultivated area of the household (ha)	0.1761**	2.39
Irrigation (%)	- 0.0674***	- 3.82
Share of rice income in household’s total income (%)	- 0.0705***	- 5.98
Share of rice for sale (%)	0.0254**	2.66
Share of hybrid rice area (%)	- 0.0528***	- 3.71
Frequency of training attendance about hybrid rice production (number)	- 0.5371***	- 4.08
Hybrid rice production experience of the household head (year)	- 0.6877***	- 8.79
Number of family labors for hybrid rice production (person)	- 0.5081**	- 2.14
D1_Topography of the farm (1 = Lowland, 0 = otherwise)	- 2.6933***	- 5.51
D2_Type of seed (1=3 lines, 0=2 lines)	- 0.6186	- 1.19
D3_Source of seed (1=Domestic, 0=otherwise)	- 0.9432	- 1.09

Note: ***, ** and * are statistically significant at 1%, 5% and 10%, respectively.

The farming experience of the household head is expected to negatively influence the profit inefficiency of hybrid rice production. The estimation result shows that the farming experience of the household head has the expected sign (δ_4 = -0.0044) but it is not significantly different from zero. Therefore, it can be concluded that there is not any evidence about the effect of farming experience on their profit inefficiency. This finding is consistent with the findings of Kolawole (2006) and Galawat and Yabe (2012).

The rice-cultivated area of the household, this research found that the rice-cultivated area has a positive sign, not as expected, but the result is significantly different from zero with its coefficient at 0.1761. It can be concluded that the rice-cultivated area has a positive effect on profit inefficiency, and the profit inefficiency will increase by 0.1761%, if the rice-cultivated area increases by one hectare. A similar result was found in the study of Galawat and Yabe (2012) in Brunei Darussalam.

Irrigation, it is one of the most important factors in rice production, and it is also expected to contribute to the reduction of profit inefficiency of hybrid rice production. The coefficient estimate of irrigation is - 0.0674, as expected and it is significantly difference from zero. It can be concluded that irrigation negatively affects the profit inefficiency, specifically if irrigation increases by one percent, the profit inefficiency will reduce by approximately 0.0674% with statistically significant at 1%. This result is similar to the finding of Galawat and Yabe (2012).

The share of rice income in the household's total income, it is hoped that the higher the share of rice income in the household's total income is, the less the profit inefficiency is. The result shows that the coefficient estimate of the share of rice income has the expected sign with – 0.0705 and it is significantly different from zero. It can be concluded that the share of rice income is negatively related to profit inefficiency, specifically if the share of rice income increases by one percent, the profit inefficiency of hybrid rice production will be reduced by about 0.0705%.

The share of rice for sale, it was found that the relationship between share of rice for sale and the profit inefficiency is a positive sign, not as expected; however, it is significantly different from zero at 5%. It can be concluded that the profit inefficiency of hybrid rice production is positively affected by the share of rice for sale; in particular, the profit inefficiency will increase by 0.0254% if the share of rice for sale increases by one percent.

The share of hybrid rice area, this research found that the coefficient estimate of the share of the hybrid rice area is - 0.0528, as an expected sign and it is significantly different from zero. It can be concluded that the share of the hybrid rice area negatively affects on the profit inefficiency. It also indicates that if the share of the hybrid rice area increases by 1%, the profit inefficiency will decrease by about 0.0528% with statistically significant at 1%. This finding implies that in order to enhance the profit efficiency of hybrid rice farming, farmers should increase the share of hybrid rice area instead of the local rice varieties.

The frequency of training attendance about hybrid rice production of the household head, it is expected to negatively affect their profit inefficiency of hybrid rice production. The result shows that its coefficient estimate has the expected sign, and it is significantly different from zero. It can be concluded that the frequency of training attendance about hybrid rice production of the household head has a negative effect on their profit inefficiency of hybrid rice production. It was found that if farmers attend training courses just one more time, the profit inefficiency will decrease by 0.5371% which is statistically significant at 1%. This result is consistent with the results of Ali *et al.* (1996), Rahman (2003), and Galawat and Yabe (2012). This finding reveals that increasing the frequency of training attendance about hybrid rice production plays an important role in improving their profit inefficiency.

The hybrid rice production experience of the household head is one of the most remarkable and important factors influencing the profit inefficiency of farmers' hybrid rice production. It is expected to have a negative effect on profit inefficiency.

The result shows that its coefficient estimate is equal to - 0.6877, this is expected and is significantly different from zero. It can be concluded that experience of hybrid rice production of the household head negatively affects their profit inefficiency; in particular, the profit inefficiency will decrease by 0.6877% if the farmers' experience of hybrid rice production increases by one year (statistically significant at 1%). This result is in line with the findings of Rahman (2003). It can be suggested that the programs of visiting and learning experience from well-performed farmers about hybrid rice production are necessary and practical to increase farmers' profit efficiency.

The number of family laborers for hybrid rice production, it was found that the number of family laborers for hybrid rice production has a negative effect on profit inefficiency. Its coefficient estimate is equal to - 0.5081 implying that if the number of family laborers for rice production increases one laborer, the profit inefficiency will decrease by 0.5081% which is statistically significant at 5%.

The topography, the result shows that farmers in the lowland perform around 2.6933% less inefficiently than those in upland area. The type of seed, in this study, the type of hybrid rice is categorized into two groups based on number of hybrid lines namely two-line hybrid rice group and three-line hybrid rice group. While the three-line hybrid rice group has higher quality than the two-line hybrid rice group. The coefficient estimate of the type of seed shows a negative sign, as expected; however, it is not significantly different from zero. Therefore, it can be concluded that there is no difference in profit inefficiency between the three-line hybrid rice group and the two-line hybrid rice group.

The source of seed, as mentioned above, around 75% of hybrid-rice seed demand in Vietnam is imported from China and India. In recent years, the quality of imported seeds has been not guaranteed, this resulted in the noticeable damages to profit for hybrid rice farmers. The result shows that the coefficient estimate of the source of seed has the expected sign, but it is not significantly different from zero. It can be concluded that there is no difference in profit inefficiency between the domestic seed source and the import-seed source.

The results show that age, educational level, rice-cultivated area, irrigation, share of rice income, share of the hybrid rice area, frequency of training attendance about hybrid rice production, hybrid rice production experience, and topography are determinants of profit inefficiency in farmers' hybrid rice production in Central Vietnam.

Profit-loss Estimation

Table 4.8 shows the estimation of the profit-loss, actual profit, and potential profit of farmers' hybrid rice production.

Table 4.8 The estimation of farmers' profit-loss in hybrid rice production

Item	Mean	Min	Max	Std. Dev.
Profit efficiency (score)	0.63	0.01	0.95	0.26
Actual profit (USD/ha)	621.02	3.81	1,677.14	364.39
Profit-loss[11] (USD/ha)	325.46	43.06	1,885.71	247.87
Potential profit[12] (USD/ha)	946.48	380.95	2,277.17	319.71

It can be seen clearly that with the average actual profit of hybrid rice production that farmers achieved is 621.02 USD/ha and the average profit efficiency is only 0.63, then rice farmers incur profit-loss of around 325.46 USD/ha. This indicates that the average potential profit of hybrid rice that farmers could reach by the improvement of technical, allocative, and scale efficiencies is about 946.48

[11] Profit-loss = Actual profit * (1-Profit efficiency)/Profit efficiency

[12] The average potential profit is computed by formula: the potential average profit = actual profit + profit-loss.

USD/ha. This is a significant amount of income for rice farmers in Central Vietnam. Therefore, the policies to enhance profit efficiency of hybrid rice are necessary and practical to eradicate poverty and increase rice farmers' income.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This research employs a stochastic translog normalized profit frontier function to examine the profit efficiency of farmers' hybrid rice production in Central Vietnam and investigate the determinants of profit inefficiency using the farm-level data. The primary data is conducted from 328 rice farmers in season crop 2012/2013 by three-stage stratified random sampling method. The estimated results show that the average profit efficiency of farmers' hybrid rice production is not efficient, about 0.63 with a wide variation among farmers (minimum of 0.01 and maximum of 0.95), and the average actual profit that farmers earned is around 621.02 USD/ha. This implies that 0.37 of profit is lost (corresponding to about 325.46 USD/ha) due to the combination of technical, allocative, and scale inefficiencies. It is clear that the improvement of profit inefficiency will significantly contribute to not only ensuring food security issues but also to alleviating poverty and increasing household's income in this region.

The findings from investigating the determinants of profit inefficiency show that age of the household head, educational level of the household head, rice-cultivated area of the household, irrigation, share of rice income in household's total income, share of hybrid rice area, frequency of training attendance about hybrid rice production, hybrid rice production experience of the household head, and topography of the farm are the robust determinants of profit inefficiency of hybrid rice production among farmers in Central Vietnam. In particular, the older the household head is less efficient than the younger ones. By contrast, profit inefficiency can be reduced if the educational level of the household head increases. Similar to the educational level variable, the increase in irrigation, share of rice income, share of hybrid rice area, frequency of training attendance about hybrid rice production, and hybrid rice production experience, respectively are ways to reduce the profit inefficiency. The research also found that the rice farmers in the lowlands operate less inefficiently by 2.72% than their peers in the upland do.

Recommendations

The policy implications are drawn based on the findings to help farmers enhance the profit efficiency in hybrid rice production and use their input sources more efficiently. In addition, these findings provide proper policy implications to support farmers growing hybrid rice in Central Vietnam. The policy implications are as follows:

For hybrid rice farmers, they should incessantly learn and enhance their experience of hybrid rice production by actively attending the training courses as well as learning experience about hybrid rice production from well-performed farmers in their area. This will help them use the inputs and response to the market prices more efficiently. In addition, increasing the share of the hybrid rice area is suggested for hybrid rice farmers as a way to reduce profit inefficiency. Furthermore, although this research did not find any significant evidence about the difference in profit inefficiency between the three-line hybrid rice seeds and the two-line hybrid rice seeds, it is recommended that rice farmers should select and apply the new high-quality hybrid rice varieties that dominate over the old hybrid rice varieties.

For the Vietnamese government, they should have policies to improve socio-economic conditions for this area by enhancing educational levels and improving irrigation systems, especially in the uplands. In addition, the government should also have policies to promote the adoption of high-quality hybrid rice varieties such as the three-line hybrid rice seeds. Last but not least, the supportive policies should increase the frequency of training courses about hybrid rice production and organize a program of field trips and learning experience from well-performed farmers to increase the profit efficiency of hybrid rice production.

Further Study

Estimating the elasticity of input demand and output supply as well as taking into account multiple outputs that are jointly produced in farms are suggested for further studies to have more policy implications to help hybrid rice farmers increase their profit efficiency. In addition, although market variables were surveyed and tested in this research, there was not significant impact on farmers' profit inefficiency because the rice market system in this study site is not dynamic. By contrast, in the Mekong River Delta and Red River Delta, the rice market system is very dynamic and it may influence rice farmers' profit efficiency. Therefore, market variables should be added in the models, if research is conducted in these two regions about profit efficiency of farmers' rice production. One of the limitations in this study is the elimination of farmers who have negative profits due to the specification of profit efficiency model. It is suggested that function forms of profit function may be change to include those with negative profit. Furthermore, cost efficiency or revenue efficiency or both may be considered when a significant number of samples experience the loss.

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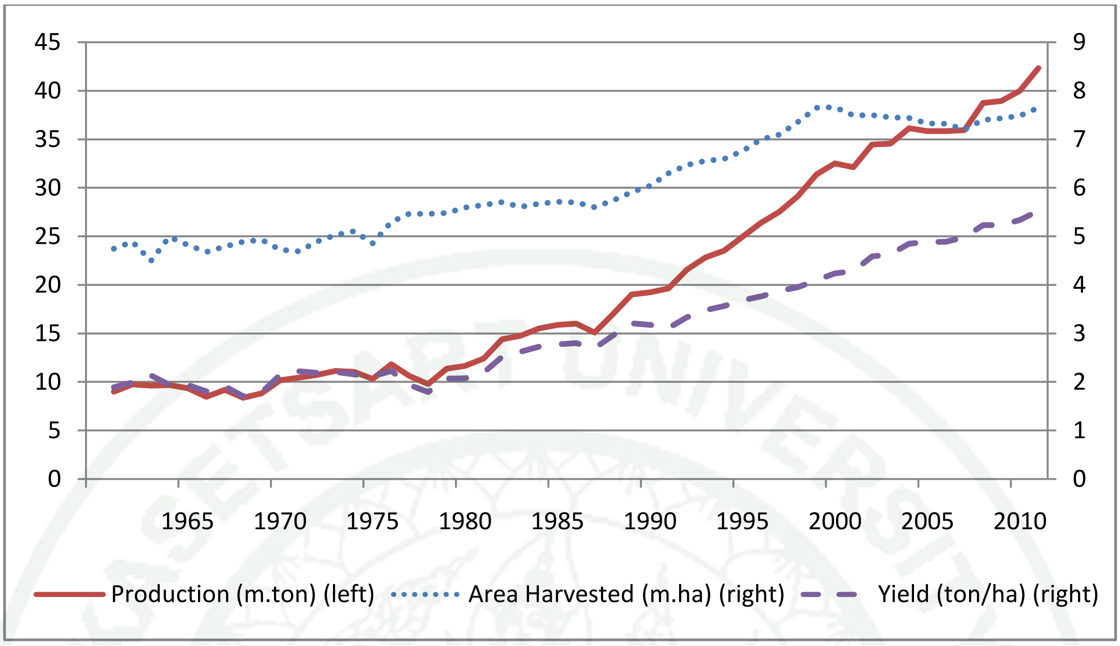
APPENDICES

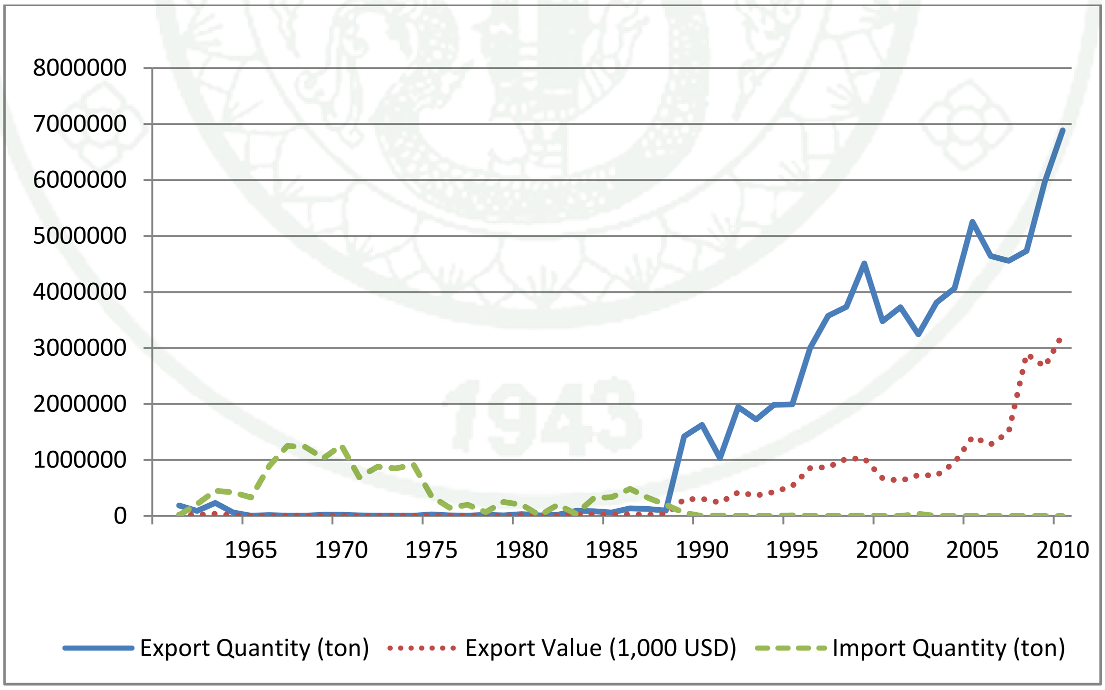
Appendix A

Rice and Hybrid Rice Production in Vietnam



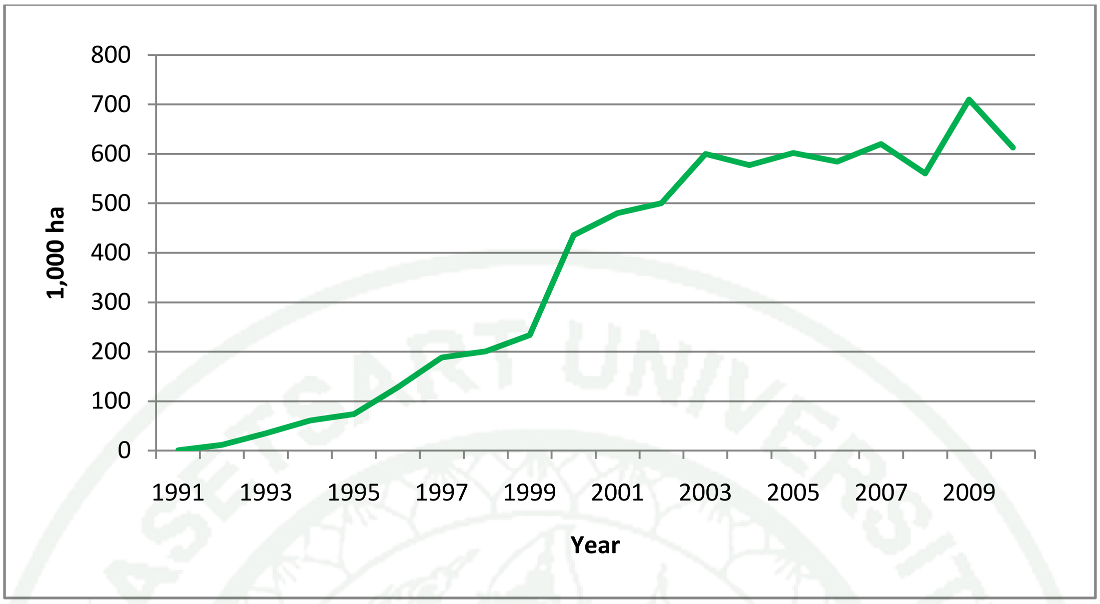
Appendix Figure A1 The rice production of Vietnam from 1961 to 2011

Source: FAOSTAT (2011)



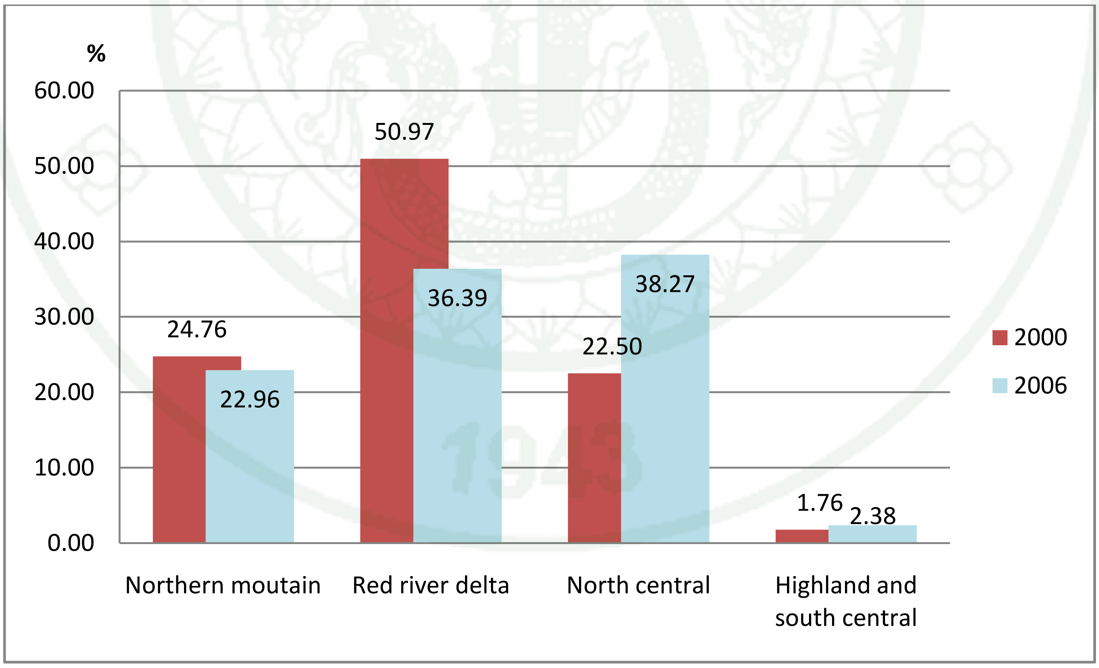
Appendix Figure A2 The rice export and import of Vietnam from 1961 to 2010

Source: FAOSTAT (2011)



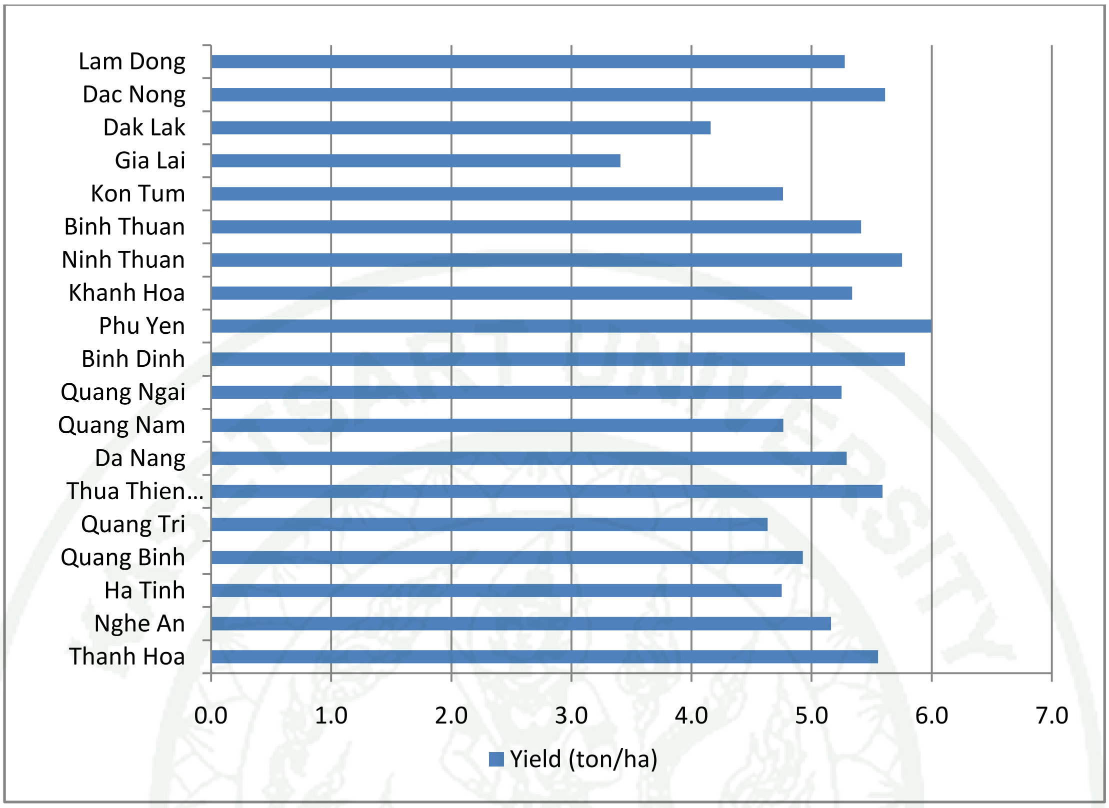
Appendix Figure A3 The planted area of hybrid rice in Vietnam from 1991 to 2010

Source: MARD (2007) and GSO (2011)



Appendix Figure A4 The adoption of hybrid rice in Vietnam by areas between 2000 and 2006

Source: Hai (2006)



Appendix Figure A5 The rice yield of provinces in the Central Vietnam 2011

Source: GSO (2011)

Appendix B

Table for Determining Minimum Returned Sample Size for a Given Population Size for Continuous Data

Appendix Table B1 Minimum returned sample size for a given population size for continuous data

Population size	Sample size (margin of error = 0.03)		
	alpha= .10 **t = 1.65**	**alpha= .05** **t = 1.96**	**alpha= .01** **t = 2.58**
100	46	55	68
200	59	75	102
300	65	85	123
400	69	92	137
500	72	96	147
600	73	100	155
700	75	102	161
800	76	104	166
900	76	105	170
1,000	77	106	173
1,500	79	110	183
2,000	83	112	189
4,000	83	119	198
6,000	83	119	209
8,000	83	119	209
10,000	83	119	209

Source: James *et al.* (2001)

Appendix C

Questionnaire

QUESTIONNAIRE OF HOUSEHOLD'S RICE PRODUCTION

(Rice households in the Central Vietnam in 2013)

Interviewer:…………………. …Date of interview:……… ……………Code:….……

I. GENERAL INFORMATION

1. Full name of interviewee:........................2. Age:……3. Gender: ☐ Male ☐ Female

4. Name of the head of the household:……………………….5. Age:…………………

6. Gender: ☐ Male ☐ Female 7. Ethnic:…..............8. Education……..

9. Specialty: ☐ Primary ☐ Intermediate ☐ College ☐ University ☐ Graduate

10. Job (Main):………………………………...Sideline:…………………….…..…….

11. Address: Village:…………………………..Commune:…………………………......

Districts:…………………………...Province:…………………., Vietnam

12. Type of household: ☐ Poor ☐ Average ☐ Rich

13. Please He/She indicates household members

Code	Description	Persons
1	Total number of household members	
2	Number of member who are working (15-60 years old)	
3	Number of children below 15 years old	
4	Number of member older than 60 years	
5	Disability/ chronic illness	

14. How many people participate to household's rice production?:……………………

15. Area of land types controlled by household

Land type	Area (m^2)	Source of land (*)
1. Settle and garden land		
2. Agricultural-cultivation land		
2.1. Water-rice land		
- *Winter-spring rice land*		
- *Summer-autumn rice land*		
2.2. Mountainous rice land		

3. Forest land		
4. Aquaculture land		
5. Other lands ……..		

Note: (*) 1= Reclaimed; 2= Certification of own land; 3=Renting; 4=Putting out to lease

16. Household's Capital and Tools for production

16.1. Household's capital borrowing

Source	Amount (1.000vnd)	Year	Period (month)	Rate (%/month)	Purpose (*)	Debt (1.000vnd)
1. Bank						
- AgriBank						
- Social policy Bank						
2. Interest Fund						
3. NGOs						
4. Friends						
5. Individual						
6. Others						

Note (*): (1) Planting short-day industrial trees; (2) Planting long-day industrial trees; (3) Raising cattle and poultry; (4) Rice production; (5) Business; (6) Buy tools, (7) Expenditure, (8) Others…

16.2 Household's tools for production

Item	Unit	Amount	Buying value (1.000vnd)	Used time (month)	Present value (1.000vnd)	Note
1. Cattle for production	No					
2. Cattle for reproductive	No					
3. Pig	No					
4. Seeding facilities	M^2					
5. Lake	Ha					
6. Plough machine	No					
7. Light lorry	No					

8. Water pump machine	No					
9. Rice grinder machine	No					
10. Pesticide gun	No					
11. Small tools	No					
12. Others ……	No					

II. RICE PRODUCTION

When have you adopted hybrid rice?.....................

How many crops do you grow hybrid rice per year?..............(crops)

2.1. Winter-Spring season

Hybrid rice area: ....(Sao); How many percentage is area irrigated?..................(%)

Usually used seeds: 2 lines................................ Source:……………………………..

3 lines:……………………..Source:……………………………

How far is it from your home to rice field?...............................(Km)

Sao = 500 m2

Item	Unit	Amount		Price	Distance
		Available	Buy	(1.000vnd)	(Km)
2.1.1.Initial cost					
-Reclaim	Labor				
-Land hire	Sao				
-Others					
2.1.2. Investment cost					
-Seeds	Kg				
-Organic fertilizer	Kg				
-Nitrogen fertilizer	Kg				
-Potassium fertilizer	Kg				
-Phosphate fertilizer	Kg				
-NPK fertilizer	Kg				
-Pesticide cost	Packet				

-Herbicide cost	Packet				
-Labor costs	Labor				
+Plough	Labor				
+Transplanting	Labor				
+Weeding	Labor				
+Harvest	Labor				
-Irrigation cost	Sao				
-Machine use	Hour				
-Other costs					
2.1.3. Output					
- Main products	Kg				
- Sideline products	Kg				

2.2. Summer-Autumn season

Hybrid rice area: ....(Sao); How many percentage is area irrigated?...................(%)

Usually used seeds: 2 lines................................ Source:……………………………...

3 lines:………………………..Source:………………………………

How far is it from your home to rice field?................................(Km)

Sao = 500 m2

Item	Unit	Amount		Price	Distance
		Available	Buy	(1.000vnd)	(Km)
2.2.1.Initial cost					
-Reclaim	Labor				
-Land hire	Sao				
-Others					
2.2.2. Investment cost					
-Seeds	Kg				
-Organic fertilizer	Kg				
-Nitrogen fertilizer	Kg				

-Potassium fertilizer	Kg				
-Phosphate fertilizer	Kg				
-NPK fertilizer	Kg				
-Pesticide cost	Packet				
-Herbicide cost	Packet				
-Labor costs	Labor				
+Plough	Labor				
+Transplanting	Labor				
+Weeding	Labor				
+Harvest	Labor				
-Irrigation cost	Sao				
-Machine use	Hour				
-Other costs					
2.2.3. Output					
- Main products	Kg				
- Sideline products	Kg				

III. RICE CONSUMPTION

3.1. The proportion of rice in household's total income 2012

Item	Amount	Percentage (%)
Total income		100
1. Cultivation		
- *Rice*		
2. Raising		
3. Aquaculture		
4. Business		
5. Service		
6. Salary		
7. Other		

3.2. Rice consumption and sale

	Percentage (%)
3.2.1. Type of rice consumption	100
Use for family	
Use for seeding	
Pay for input costs	
Sell	
3.2.2. Sell location	100
At field	
At home	
Agent	
Market	
Other	
3.2.3. Consumption object	100
Retail	
Processing company	
Other…………………………………………………………	

3.3. The expenditure of household

Item	Total expenditure (1,000 VND)	Note
Food		
Foodstuff		
Production tools		
Electricity		
Education		
Clothes		
Medical		
Funeral		
Wedding		

Others		
Total		

3.4. Please He/She indicates the status of family's equipment?

Item	Unit	Quantity	Value (1000vnd)	Note
1. Television	Number			
2. Phone	Number			
3. Fridge	Number			
4. Radio cassette	Number			
5. Motorcycle	Number			
6. Bicycle	Number			
7. Table and Chair	Number			
8. Bed and wardrobe	Number			
9. Others …………	Number			

IV. OPEN QUESTIONS

4.1. How many years have you grown rice (experience)?....................................(years)

4.2. How many years have you grown hybrid rice?...(years)

4.3. What kind of information channel do you know about hybrid rice seeds?

☐ TV ☐ Radio ☐ Friend (relatives) ☐ Newspaper

☐ Magazine ☐ Seed company ☐ Localgovernment ☐ Others…………

4.4. How many time do you participate in training about hybrid rice production?......... and who is organizer?

☐ Local government ☐ Seed dealer ☐ Seed company ☐ Other……………………

4.5. How far is it from you home to the nearest input market?.............................. (Km)

4.6. How far is it from you home to the nearest output market?.............................(Km)

4.7. How many input and output markets is near your home?..........................(markets)

4.8. Do you access to credit for hybrid rice production? ☐ Yes ☐ No

THANK YOU FOR YOUR TIME!

BIOGRAPHICAL DATA

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SCHOLARSHIPS:	- The scholarships to pursue M.Sc. (Agricultural and Resource Economics) from Vietnamese government (322 scholarship) under the management of Bureau of Vietnam International Education Development (VIED), Ministry of Education and Training - A partial scholarship from International Development Research Center (IDRC) of Canada under the management of Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), Los Baños, Laguna, Philippines (IDRC-SEARCA scholarship).