Technical Efficiency:
Study of Rice Farmers in Vietnam

by

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DEDICATION

To my Parents

CERTIFICATION PAGE

I hereby declare that this thesis *"Technical Efficiency: Study of Rice Farmers in Vietnam"* has been written by myself and referred no others than the sources cited.

PHAM Thi Huong

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LIST OF ABBREVIATIONS

CRS	Constant Return to Scale
DARDH	Department of Agriculture and Rural Development of Haiphong City
DEA	Data Envelopment Analysis
DSH	Department of Statistics of Haiphong city
FAO	Food and Agriculture Organization
GSOV	General Statistics Office of Vietnam
HH	Household
IRRI	International Rice Research Institute
OLS	Ordinary Least Squares
TE	Technical Efficiency
VHLSS	Vietnam Households Living Standard Survey
VND	Vietnamese Dong
VRS	Variable Return to Scale

ABSTRACT

Rice farmers in Vietnam are facing technical inefficient in rice production due to using an in-optimal combination of inputs as well as under the influence of socioeconomic characteristics of households. This study utilizes a stochastic frontier approach to estimate technical efficiency and its determinants among rice-farming households in Haiphong and Thai Binh, Vietnam. The Cobb-Douglas production function fits a cross-sectional data of 207 rice-farming households in Haiphong and Thai Binh withdrawn from Vietnamese Households Living Standards Survey 2012. The average technical efficiency in the whole sample is 0.756, suggesting that rice-farming households in Haiphong and Thai Binh produce at a lower level of technical efficiency compare to national and regional level. Farm’s location has the largest impact on the ability to capture potential output among rice-farming households. Whereas rice households located in Haiphong can achieve around 72.4% of their potential output, those in Thai Binh may produce at a higher level of technical efficiency of 76.9%. Besides the geographic characteristic of rice households, the irrigation, labor intensive and size of the household impact on household technical efficiency as well.

INTRODUCTION

As in many developing countries, rice farmers in Vietnam often are inefficiency in rice production due to using non-optimal input combination as well as under the influence of rice farm household characteristics. Therefore, the analysis of technical efficiency in rice production is necessary for policymakers, governors as well as rice farmers in designing and implementing policies.

In general, rice production in Vietnam is produced in two main regions, namely Mekong Delta and Red River Delta. Located in Red River Delta, Haiphong is the coastal city which is transferring the economic structure forward industrialization. However, a half rural labor force of Haiphong is working in rice production which accounts for 10% of total population. Rice production of Haiphong was 484,700 ton in 2014 and contributes to 7.17 % total rice production of Red River Delta (General Statistic of Vietnam [GSOV], 2015). By contrast, Thai Binh province is mainly based on an agricultural economy with the share of Agriculture, Forest and Fishery sector around 55.34% in 2011. Thai Binh is known as the foodstuff of Red River Delta with favorable soil and water especially for rice production. Rice farmers in Thai Binh also have been accumulated more experience in rice production compared to other areas nationwide. In 2014, rice production produced by Thai Binh's farmers was 1.061 million tons, contributed 15.72% to the rice production in Red River Delta (GSOV, 2015). The rice yield of rice farmers in Haiphong and Thai Binh is often higher than other areas in Red River Delta.

Even though Thai Binh and Haiphong is the two regions which have high rice productivity in Red River Delta, the difference in natural condition as well as economic structure results in different strategies for rice production development policies in each area. Besides that, the understanding of determinants of technical efficiency is important to policymakers in designing agriculture policy for each zone. For these reasons, this thesis aims to estimate the level of technical efficiency as well as investigate the determinants of technical efficiency among rice-farming households in Haiphong city and Thai Binh province. In order to achieve these objectives, author attempts to clarify the four following research questions: (1) *What are factor inputs of rice production among rice-farming households in Haiphong and Thai Binh?*; (2) *What is the level of technical efficiency among rice-farming households in Haiphong and Thai Binh?*; (3) *Is the difference in technical efficiency between rice-farming households which are located in Haiphong and those are in Thai Binh significant?;* (4) *What are factors which affect technical efficiency in rice-farming households in Haiphong and Thai Binh?*.

By using cross-sectional data at farm-level of 207 households withdrawn from Vietnamese Households Living Standard Survey (VHLSS) 2012, this study applies a stochastic frontier approach to estimate the production function which fits with the dataset, and from which predict technical efficiency. After that, the technical efficiency estimates enters the determinants regression in Tobit model to examine the influence of socioeconomics characteristics of rice-farming households on their performance.

In Vietnam, rice production is central to several studies in agriculture economics, especially studies of rice-farming households in Mekong Delta. Nonetheless, there are few studies about technical efficiency in rice production in Red River Delta - the second producing rice region - in general, and Haiphong & Thai Binh in particular. Moreover, in current reports of rice production in these two areas, rice productivity is usually measured by the ratio between output and single input such as yield whereas no study examined the gap between actual output to the potential output with a given combination of inputs. This thesis attempts to contribute to the gap in studies about Haiphong and Thai Binh by applying the sufficient measurement of technical efficiency for rice-farming households in these two regions.

The research background in Chapter 1 provides an overview of Vietnamese rice production as well as main features of Haiphong and Thai Binh. To understand the method of technical efficiency measurement, both theoretical literature and empirical studies about agriculture production and rice production will be taken into consideration in Chapter 2. Chapter 3 is where the empirical model will be constructed, the hypotheses are tested based on the dataset, and then the discussion and conclusion will be made as well. Eventually, the thesis is summarized in Chapter 4 including main findings, limitation, policies implementation and suggestion for future research.

CHAPTER 1

RESEARCH BACKGROUND

1.1. Nature of Rice Production in Vietnam

Agriculture still plays a significant role in Vietnamese economy, contributed 16.75% to Gross Domestic Product[1] and accounted for almost a half of labor force (World Bank, 2016). The Vietnamese government has implemented agriculture policies and emphasized rice crop as the most important staple. Since the "Doi Moi" reform in 1986, the change in land use rights corresponding with the promotion of using inputs such as high-yielding varieties, fertilizers, and pesticides had a particular impact on both production and productivity level in rice crop (Asian Development Bank, 2012). Since 1986, the rice production had increased remarkably from around 15 million tons to nearly 45 million tons in 2013 while the rice land area slightly varied around 5 million hectares during this period. Rice yield improved to almost 5 tons/hectare at a growth rate of 3.3% per year from 2.5 tons/hectare in 1986. Figure 1.1 displays the change in production, harvested area, yield, and exports of Vietnamese rice in the period from 1986 to 2013.

In term of rice trade, Vietnam had been a net rice importer until 1988. Since 1989, the volume of rice exports increased significantly with a

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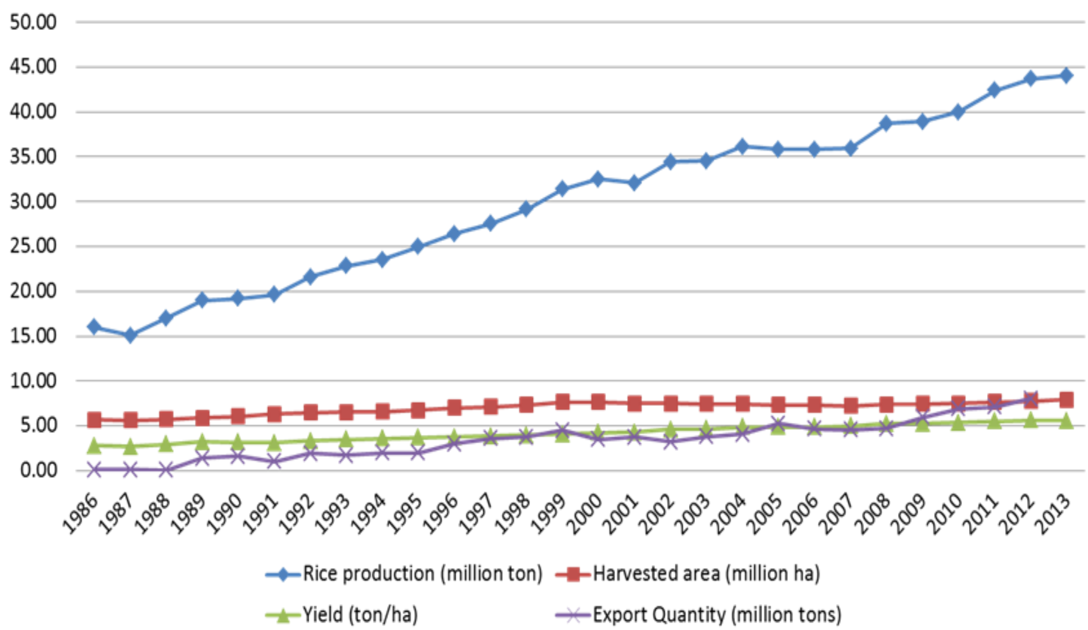
[1] Author calculated based on the statistic of General Statistics Office of Vietnam (2015).

growth rate of 7.8% per year and remarked Vietnam as one of the top rice exporters in the word *(IRRI, 2015)*. In 2012, the volume of Vietnamese rice exports surpassed those of Thailand and ranked first place among rice exporters. A year later, rice market experienced a remarkable change when the volume of Vietnamese rice exports surged to third place after Thailand and India.

Figure 1.1: Rice Production, Harvested Area, Yield and Export Quantity in Vietnam (1986-2013)



Source: FAO, World Rice Statistics (FAOSTAT), 2015

For rice distribution, most of the rice cultivated in Vietnam is in Red River Delta and Mekong Delta. About 15.02% of Vietnam's rice production produced in Red River Delta while nearly 56.13% in Mekong Delta[2] in 2014. These two main rice-growing regions contributed more than 70% to total rice production for the country. Besides that, rice is grown in other parts as the Northeast and the North-central coast as well (GSOV, 2015).

Consisted of 1 city and 12 provinces, Mekong Delta is the area which is blessed by nature with their fertile land and unlimited water source. The paddy land of this delta was 4,246,600 hectares in 2014 (GSOV, 2015). Rice farmers in Mekong Delta apply the direct-seeding method to reduce the labor costs. In a comparison, the total area of Red River Delta is 2,106,000 hectare with 1,122,800 hectare of rice production. The cultivating land in Red River Delta is often fragmented in small-scale as a result of a land allocation policy that equitably distributes land, accounting for varying soil quality (Dao & Lewis, 2013).

In Red River Delta, even though rice farmers face land fragment issue, the productivity of rice production is high as can be seen in Table 1.1. In 2011, the average yield in Red River Delta was 6.09 tons/ hectare and Thai Binh is the province achieved the highest yield nationwide at 6.59 tons/hectare (GSOV, 2015). While Thai Binh province has remained its first place in rice yield many years, rice farmers in Haiphong often produce at higher yield compare to other areas in Red River Delta.

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[2] Author calculated based on the data from Vietnamese General Statistic Office, 2014.

Table 1.1: Rice Yield in Selected Areas in Red River Delta

(2010 – 2014, tons/hectare)

	2010	*2011*	*2012*	*2013*	*2014*	*Average growth rate (%/year)*
Red River Delta	**5.92**	**6.09**	**6.04**	**5.89**	**6.02**	**0.42**
Haiphong	6	6.09	6.19	6.27	6.29	1.19
Thai Binh	6.66	6.59	6.51	6.51	6.56	-0.38
Hai Duong	5.94	6.17	6.19	5.88	5.93	-0.04
Nam Dinh	5.99	5.88	5.94	5.89	6.05	0.25
Hung Yen	6.28	6.45	6.46	6.22	6.21	-0.28

Source: GSOV, 2015

The average yield of rice production in Haiphong increased to 6.29 tons/hectare, a growth of 1.19% while the average yield of Thai Binh province decreased over this period by 0.1 tons/hectare. This decline caused by the reduction in both rice land area and rice production in Thai Binh in the period from 2010 to 2014.

1.2 Overview of Haiphong City and Thai Binh Province

Location and Population

Haiphong is a coastal city, located in the northeast of Red River Delta, Vietnam (see Appendix 1). Its total area is 152,338 hectares with the population was 1,946,013 people in 2014. Among those 1,036,900 people living in rural area, accounted for 52.38% of Haiphong's population. Respectively, population density was 1,274 person/km^2 in general and 970 person/km^2 in rural area. The proportion of labor force in Haiphong's population was 59.12%, equaling to 1,138,000 people. In which, urban labor and rural labor accounted for 44.6% and 55.6% correspondingly. The ratio of urban trained labor to urban labor force was 34% in urban area whereas the level of rural trained labor in Haiphong is higher than average level in the Red River Delta and nationwide, which was recorded correspondingly as 16%, 4.9% and 7.2% (GSOV, 2015; Department of Statistics of Haiphong city [DSH], 2014).

In comparison, Thai Binh province also located in the southern of Red River Delta. The total area of Thai Binh province is around 157,000 hectares, equals to 1.028 times of Haiphong's area. In 2014, the population is 1,788,800 people, less than Haiphong's population 157,313 people. Thai Binh had lower population density than Haiphong with 1139 person/km^2. The labor force accounted for almost 57% of total population, and 15% of them are trained labor. Similar to Haiphong, literacy in Thai Binh is around 98% (GSOV, 2015).

Economic Structure

The structure of Haiphong's economy experience an upward trend in the share of the Service sector and Industrial & Construction industry correspondingly as 53.62% and 38.35% in 2014, while Agriculture, Forestry and Fishery sector contributed only 8.03% to Haiphong's economy.

The Agriculture, Forestry and Fishery sector consists of three subsectors as Plantation, Livestock, and Aquaculture. According to Haiphong Statistics Office (2014), the total value of Plantation subsector in Haiphong's agriculture has increased significantly in recent years. From 2005 to 2010, the total production value of from crop plantation in Haiphong increased with the average growth rate of 1.9% per year, from 2,091.3 billion VND in 2005 to 4,920.6 billion VND in 2010. In next four years, the total production value from this subsector continued experiencing the upward trend with a lower average growth rate of 0.37% per year, resulting in a corresponding increase up to 5,875 billion VND in 2014.

The share of Plantation subsector in the total value of agriculture sector showed a downward trend, decreasing from 62.93% in 2005 to 54.16% in 2010 and to 48.86% in 2014. The proportion of the type of crop has remarkably changed through these years. Among them, the share of staple crops and fruit trees has decreased while the percentage of commercial plants and annual industrial crops tends to increase slightly (see Table 1.2).

Table 1.2: Share of Crops in Plantation Subsector, Haiphong (2014)

Share of Crops (%)	2005	2010	2014
Staple crops	53.5	50.6	48.2
Vegetable, bean, flower	23.4	22.9	24.1
Annual industrial crops	4.3	5.6	7.3
Fruit trees	13.1	10.8	11.4
Perennial industrial crops	0.3	0.2	0.3

Source: DSH, 2014

The Agriculture, Forestry and Fishery sector has contributed significantly to Thai Binh's economy. In 2000, this sector accounted for 54.1% of total production value and decreased to 34.96% in 2014. The proportion of Industry and Construction sector increased from 15% in 2000 to 30.98% in 2011 while Service sector only experienced a slight change through this period. In Agriculture, Forestry and Fishery sector, Plantation subsector still dominates others but with a decreasing trend. In 2007, the share of plantation subsectors was 62.96% and it reduced to 57.2% and 55.34% correspondingly in 2010 and 2011. However, the city government of Thai Binh province sets the target of reducing the proportion of the Agriculture, Forestry and Fishery sector to 20% in 2020 while expanding non-agriculture sectors. The Industrial & Construction sector and Service sector are planned to increase to 35% and 45% respectively in 2020.

Land

The agriculture area of Haiphong city has decreased in recent years. Its total agricultural land area in 2005, 2010 and 2014 was 86,591.86 hectares, 83,754.05 hectares, and 81,144 hectares. Overall, in the period from 2005 to 2014, the agriculture land area decreased 5,447.9 hectare with the average decreasing is 0.72% per year. The total rice land also was reduced from 48,568 hectares in 2005 to 46,057 hectares in 2010 and to 45,212 hectares in 2014 (DSH, 2014). The rice area in Haiphong experienced a downward trend due to the changing in using purpose in agricultural land. The growing area will be used for building infrastructure, or allocated for aquaculture activities or other crops which have higher profit efficiency. As known as an agriculture-based area, Thai Binh has 97,200 hectares agriculture land area, larger than Haiphong by 16,056 hectares (Huong, Sa, & Yen, 2014).

Labor

Haiphong's economy mainly is dominated by Industrial sector and Trade and Service sector which contributed to total production value of Haiphong economy in 2014 at 38.35% and 53.62%. However, Agriculture sector still plays important role since in 205,500 rural labors work in Agriculture sector, equals to 32.12% rural labor force and 10.3% of Haiphong's population. Those farmers concentrated in crop plantation and livestock (DSH, 2014).

Similarly, there is a significant proportion of Thai Binh's rural labor force working in Agriculture sector. In 2011, among 1,786,300 people of the workforce, 600,000 persons worked in Agriculture sector which equals to 33.58% of labor force and 33.54% total population in Thai Binh (Huong, Sa, & Yen, 2014).

Rice Production

In 2014, Haiphong had 77,118 hectares cultivated rice. This figure is reduced from 88,339 hectares in 2005 at an average decreasing rate of 1.5% per year. In term of yield, rice farmers in Haiphong seem to have the productivity advantage compare to the mean level of Red Delta River and some other neighboring cities/provinces. The rice yield in Haiphong had increased by nearly 1.2 tons/ha from 5.2 tons/ha in 2005 to 6.385 tons/ha in 2014. This yield level in 2014 was higher than average yield at 6.02 tons/ha of rice farmers in Red River Delta as well as in comparison to Hai Duong (5.93 tons/ha), Nam Dinh (6.05 tons/ha) and Hung Yen (6.21 tons/ha). Rice production in Haiphong city was 459,333 tons in 2005 and 484,716 tons in 2014. The average staple food per person was 250.6 kg in 2005 and 252.3 kg in 2014, ensured food security for Haiphong's residents. The share of quality rice varieties reached 47.96% in 2014, and the five top rice producing districts of Haiphong city are Tien Lang, Vinh Bao, Kien Thuy, An Lao, and Thuy Nguyen (DARDH, 2016).

In the period from 2010 to 2014, Haiphong built up 198 the concentrated production areas in 3,060 hectares, in which applied technical innovation of new rice varieties, machinery, etc. Rice farmers cultivated in these areas would obtain 1.8 to 3.5 times the economic efficiency compared to before. For example, one unit of capital in Fishery would bring an increase of 1.76% in the benefit for farmers in comparison with one spent for rice production (Department of Agriculture and Rural Development of Haiphong [DARDH], 2016).

However, in the consideration of efficiency in rice production, the target of Haiphong government to 2020 is to decrease total land area for rice production to 38,000 hectares, and 71.3% of which will be cultivated qualified rice. The land area is planned to fall 1,000 hectares per year from 2020 to 28,000 hectares in 2030 (DARDH, 2016). The predicted monthly staple food demand for Haiphong residents is predicted at 10.6kg rice/person and 9.2 kg rice/person in 2020 and 2030 correspondingly. With a smaller total rice land areas, the desire of having higher productivity is rising among rice farmer for food self-sufficiency.

As known as a great foodstuff production area in Red River Delta, Thai Binh has a favorable natural and ecological condition for rice production. Agriculture land in Thai Binh is abundant fertility with alluvial soil (Huong, Sa, & Yen, 2014). In 2014, rice production in Thai Binh accounted for 15.72% the total rice production in Red River Delta (GSOV, 2015).

CHAPTER 2

LITERATURE REVIEW

The understanding of technical efficiency would benefit both economists and policymakers. It is helpful to explain the economic development and the implementation of welfare policies (Sawaneh, Latif, & Abdullah, 2013). Especially in agricultural production, if policymakers know which factors determine the production ability of farmers, they would design appropriate supporting programs efficiently (Shapiro & Müller, 1977). Since then, this chapter reviews the method of measuring technical efficiency in theoretical perspective and empirical studies. Selected studies are conducted in rice production and other agricultural production as well.

2.1 Measurement of Technical Efficiency

In many studies, the term efficiency is used interchangeable with the term productivity. Productivity is measured by partial factor productivity index or total factor productivity (Sawaneh et al., 2013). Among which, partial factor productivity index is the ratio of output per each input used in production progress such as capital, labor, land and material. For rice production, the productivity of land is the output per unit land used or in other words, the rice yield. In comparison, the total factor productivity, defined by the Solow residual, is the proportion of output that is not explained by the combination of inputs using in the production (Comin, 2006). Consider an output with given factor inputs are labor and capital, even when the inputs are adjusted, the growth of output in a standard production function is still not fully captured by the growth of labor and capital (Dowling & Valenzuela, 2010, p13). Total factor productivity growth is decomposed into four components, including technical progress, changes in technical efficiency, changes in allocative efficiency, and scale effects (Kumbhakar & Lovell 2000; Dowling & Valenzuela, 2010). To our knowledge, total factor productivity, not partial productivity, is same as efficiency.

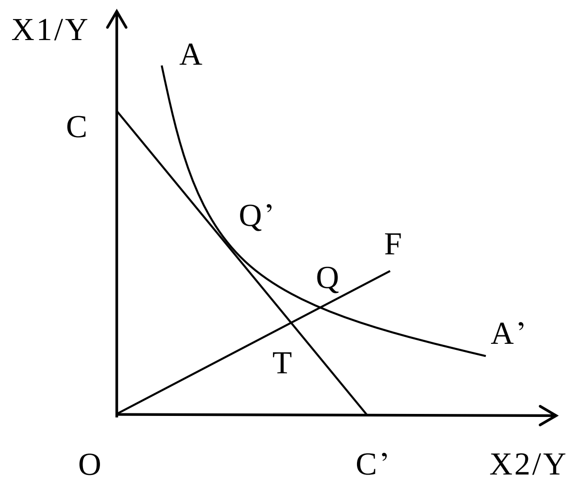
This study is only focusing on the difference in technical efficiency among rice farm households in a particular year. Therefore, the following is the literature about efficiency reviewed from chosen scholars in general and technical efficiency in particular.

Farrell (1957) defined the efficiency of a firm as the relative ratio of the actual productivity firm obtained to its maximum potential productivity. It measures the firm's success in producing as large as possible output from a given set of input. Efficiency, as known as *overall efficiency* or *economic efficiency*, of a firm, consists of two components, namely technical efficiency and allocative efficiency.

Technical efficiency is the ability of a firm to produce the maximum output from a given inputs combination (output-oriented measurement); or utilize the minimum amount of inputs to produce an output (input-oriented measurement) (Kumbhakar & Lovell, 2000). Then again, allocative efficiency is the ability of a firm to use input at an optimal proportion given corresponding price and technology. A firm is said economically efficient if it attains both technical and allocative efficiency.

Given a firm or farm which uses two-factor input X1, X2 to produce an output Y under a constant return to scale and given technology. Figure 2.1 illustrates the technical, allocative and economic efficiency of a firm by using the isoquant and cost constraint. In this, assumed that the isoquant AA' represents all the optimal combination of input X1 and X2 used to produce a unit of output. The points lie above the AA' as P, therefore, are said inefficient because it utilizes a higher level of input to produce the same amount of output. The inefficient technical level of this firm is measured by the ratio QF/OF and the technical efficiency (TE) presented by (1-QF/OF), or OQ/OF. If we have the information of market price of factor inputs, the ratio of their prices is the slope of the cost isoquant CC'. Then, RQ/OQ is the measurement of the allocative inefficiency of a firm, and its allocative efficiency (AE) is defined by OT/OQ.

Figure 2.1: Technical, Allocative and Economic Efficiency



Source: Referred from Farrell (1957) and Battese (1992)

At point Q, the firm is said to perfect technically efficient since it uses minimum inputs to produce a unit of output; however, it is still not economically efficient. By contrast, at point Q', firm obtains both technical and allocative efficiency, in other words, firm has economic efficiency (EE) if it produces with the combination of X1 and X2 at point Q' as following:

TE = (1-QF)/OF = OQ/OF

AE = OT/OQ

EE = TE x AE = OQ/OF x OT/OQ = OT/OF

In order to measure technical efficiency, there are two methods widely used in previous studies, namely econometric approach and data envelopment analysis (DEA). The discussion of the strength and weakness of these methods was discussed by Hoang Linh (2007, 2012) and Khai & Yabe (2011).

The first method is the econometric approach which develops the stochastic production frontier model. This technique utilizes the statistical tests to choose the function form and estimates the coefficients in the model as well as provide the adequate estimation of two disturbance terms. According to Battese (1992), the stochastic production function for cross-sectional data is defined as follow:

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

where Y_i is maximum output the ith firm obtained by using inputs X_i and β is an unknown parameter. The component V_i ~ N $(0;\sigma_v{}^2)$ is the random error, assumed normally distributed and capturing the stochastic effects which are not under the control of firms for example climate, luck, machine performance, the method of collecting data, etc. Besides that, the component U_i is defined as inefficiency error, representing the loss of firm due to economic or technical inefficiency which is under firm's control. The U_i , independently distributed from V_i, is a one-sided component with either half-normal, exponential or gamma distribution (Aigner, Lovell, & Schmidt, 1977), implying that firm's output produced must lie on or below its frontier production curve. Despite the ability to separate the disturbance terms, this technique generates good estimating results only for production with a single output and multiple inputs (Khai

& Yabe, 2011). The stochastic frontier approach is applied widely in calculating technical efficiency in rice production since rice is the single-output and multiple-input production and rice farmers have to face the natural disaster which affects to rice production in general (Khai & Yabe, 2011). The technical efficiency is defined by $TE_i = \exp(-U_i)$.

While the econometric approach is a stochastic and parametric method, DEA is a deterministic and nonparametric approach. DEA is utilized to estimate the efficiency of technology and scale, being useful for production with multiple inputs and multiple outputs. Nonetheless, this technique does not have the ability to separate the influences of noise and inefficiency during the estimating of the technical score (Khai & Yabe, 2011).

The Tobit regression model has been applied widely in determining source of technical efficiency, formulated by:

$$TE_i = \alpha_0 + \sum_{j=1}^{k} \alpha_j Z_j + e_i$$

where Z_j (j=1, 2,..., k) was factor explanatory for the source of technical efficiency.

The Tobit[3] model, introduced by James Tobin (1958), is the model to explain the relation between a non-negative dependent variable and

[3] The name Tobit was phrased from the model's author name, "Tob" and add "it" due to the similar to Probit model (Amemiya, 1985, p360).

independent variables. Tobin proposed the "limited dependent variable" model to analyze the expenditure of household on durables goods using a regression model and particularly noticed that the dependent variable, expenditure, in his model cannot be negative. Since technical efficiency values are in the range from 0 to 1, to put in another way truncated to the left side of zero, choosing Tobit regression model is adequate estimation for technical efficiency determinants.

2.2 Empirical Studies

2.2.1 Agriculture Production

Besseah and Kim (2013) applied the stochastic frontier approach to examine the extent of productivity and investigate the source of technical efficiency among cocoa-producing households in Ghana. By using the Ghana Living Standards Survey with the consideration for six main regions of cocoa production, this study estimated Cobb-Douglas production function with four-factor inputs as capital, labor, land and material for a cocoa producing household. The empirical result showed that the average technical efficiency of Ghanaian cocoa households was 0.4782. Moreover, having a diversified crop, mechanization and hiring outsource labor helped to improve the technical efficiency level while the emigration, household size, and owning equipment had the negative impact on it. Based on the findings, the scholars recommended policy implementation such as encouraging hired labor among cocoa households, directing young labor to education or continuing the mass spray exercise for cocoa production, etc.

In the consideration of the land-scare situation in Vietnam, Dao & Lewis (2013) utilized DEA in estimating technical efficiency in the annual crop in the in the Northern Vietnam, represented by four provinces, namely Phu Tho, Yen Bai, Hung Yen and Thai Binh. A sample size of 432 farm households who cultivated rice, starchy crops, industrial plants or vegetables was withdrawn from VHLSS 2008. The Cobb-Douglass production model was utilized with the output was the total value of crops and factor input included land, seed, fertilizer, pesticide, equipment, other cost and family labor. Among these inputs, the labor input was represented by family labor variable, constructed by the number of household member involving in crop cultivation. This construction had not taken the hired outsource labor into consideration; therefore, the labor input of annual crop would not be fully explained. In the findings, the mean of technical efficiency estimated was 0.83 and the technical score of farmers who cultivated market-oriented product such as industrial crops have greater technical efficiency than those focusing on rice and maize. Although Dao & Lewis (2013) had not investigated the source of technical efficiency estimates yet, the scholars discussed the important of crop diversification and emphasized the combination of rice and cash crops in the market-oriented context should be focused on making agriculture policies for agriculture productions in Vietnam.

The stochastic frontier approach was utilized in the study of Abebe (2014) to investigate the relation between off-farm income and technical efficiency in smallholders in Ethiopia. By using the Ethiopian Rural Household Survey conducted by the International Food Policy Research Institute selected for four main regions in Ethiopia, this study tested model specification with Cobb-Douglas production function was fitted better with the dataset. In addition, the result showed an average level of technical efficiency at 0.53 in agriculture production among smallholders in Ethiopia. The determinants were found in positive association with the technical efficiency were the household size, schooling year and gender of household leader, extension service, the practice of soil conservation as well as off-farm income. Among which, the role of off-farm income was emphasized in contributing to the investment for modern inputs in agriculture production. The spillover effect of off-farm income possibly improved the farm production in Ethiopia (Abebe, 2014).

Based on a primary dataset of 400 farm households, Chiona, Kalinda, & Tembo (2014) examined the level and determining factors of technical efficiency among maize producers in Zambia. This study applied stochastic frontier approach and estimated the average technical efficiency among the maize farmers at 0.5. The level of technical efficiency was in a range from 0.02 to 0.84, suggesting the opportunity for maize producers in Zambia to increase the actual output with current using inputs. Among these farmers, around 46% of them produced at 50% of their potential output while 28% of them captured less than 30% or higher than 70% of the potential output. Chiona et al. (2014) addressed that using hybrid seed, access to credit, extension service as well as the age of household head positively influence the technical efficiency of maize producers whereas off-farm income resulted in the diminishing of technical efficiency. The maize farmers would withdraw the managerial factor from farming activities and put more concentration in non-farm activities, thus, the lower technical efficiency they obtained in maize production. This finding was opposite with Abebe (2014) where the higher off-farm income leads to higher technical efficiency in farm production. However, this negative impact is not uncommon since Abdulai & Huffman (2000) in the study of rice farmers in northern Ghana indicated that farmers who have more sources of incomes besides crop plantations tend to be occupied by non-farm activities and pay less attention to the important of agricultural practice.

2.2.2 Rice Production

Since rice is one of the main crops in developing countries, efficiency in general and technical efficiency in rice production has been focused on in many studies. For example, DEA was applied in the research of Dhugana, Nuthall, & Nartea (2004) for 75 farm households in rice production in Nepal, addressing that the average level of economic, technical and allocative inefficiency are 0.34, 0.13 and 0.24 among those farmers. This study utilized Tobit regression model in explaining the source of TE. The finding is the level of inefficiency was highly associated with farm households' demographic, education and attitude toward risk. Dhugana et al. (2004) addressed that elderly male family leaders tended to be more efficient in rice production. The role of gender reflected via the physical features of male labor with stronger ability and more skills in organizing and managing production process; whereas the higher age allowed household heads accumulated more farming experience in choosing appropriate rice variety, factor inputs or method of production. Education of family leaders also positively resulted in their decision-making process via acknowledging the change in natural environment or combining element inputs efficiently.

Based on the panel data at the farm level, Koirala, Mishra, & Mohanty (2013) attempted to explain the determinants of technical efficiency of Philippine rice farmers. This research collected data from the Loop Survey of the International Rice Research Institute from 2007 to 2012. The frontier production was formulated in Cobb-Douglass form with the output was the total value of rice production and several inputs, including land, cost of seed, fuel, fertilizer, pesticide, labor, operation, property rental, irrigation, planting season. The technical score was estimated at 0.548 in average via fixed-effect model, ranging from 46% to 74%. These efficiency estimates were negatively influenced by land rent cost and price of fuel as well as fertilizers while rice production had a positive impact on the level of technical efficiency. This study examined the source of technical efficiency from direct inputs and output of rice production in quantity as well as a dummy variable for planting season effects. Other farmers characteristic for example demography, education, finance were not investigated in this research.

The study of Balde, Kobayashi, Nohmi, Esham, & Tolno (2014) estimated the technical efficiency level as well as its determinants for mangrove rice production in the Guinea. By applying the stochastic frontier model for the primary cross-sectional data collected from 69 farmers in 2013, this study estimated the technical score in mangrove rice in the Guinean coastal area with a mean value of 0.23. In the frontier Cobb-Douglas production function, the dependent variable was the output of mangrove rice production while the independent input variables are fertilizer and pesticide cost, hired labor cost, depreciation cost of farm tools, seed quantity, active family labors per family size and farm area for rice. However, the empirical result showed that only the depreciation on the tools and farm area directly contributed to the rice production of farmers. In term of explaining the source of technical efficiency, the farmers with older age and farming experience, large household size, and access to off-farm income and remittance tended to affect positively on technical score. In the contrast, the level of education, seed use, access to credit and extend service provided by the government had a negative impact on efficiency in producing mangrove rice in Guinea. Even though this study discussed related government policies which would be able to enhance the level of technical efficiency, its findings from empirical results should not be generalized due to the limitation of using small sample size (Balde et al., 2014, p192).

Based on the primary data set of 815 rice-farming households in Can Tho, Vietnam, Dung (2015) estimated the economic efficiency of those farms by using the stochastic frontier profit function as well as investigated the source of technical efficiency by applying Tobit regression model. The empirical result indicated that rice-farming households in Can Tho obtained an average level of economic efficiency at 55.8%. The level of economic efficiency was significantly influenced by the intrinsic factors including farm size, the method of selling rice, crop pattern, location and so on. In addition, the external factors as access market information, the possibility of getting informed in using inputs also positively associated with rice-farming household's economic efficiency.

Not only using these two approaches separately, several studies combined SFA and DEA, for example, Wadud and White (2000). This research examined the effects of rice-farming characteristics, environment, and irrigation scheme to the inefficiency in rice production in Bangladesh at farm-level. Based on the sample of 150 rice-farming households, Wadud and White (2000) estimated average technical score at 0.79 in the stochastic frontier model and 0.789, 0.858 in constant return-to-scale (CRS) DEA and variable-return-to-scale (VRS) DEA respectively. The rice farmers were concluded slightly experiencing decreasing returns to scale under the stochastic frontier approach. The elasticity of land, irrigation, labor, and pesticide positively associated with rice output whereas fertilizers showed a negative impact on the production at the elasticity of 0.0392. In comparison, under DEA approach, the decreasing returns to scale of rice farmers were increasing, implying that the rice farmers in the sample were operating at non-optimal scale. For the source of technical inefficiency, the regression results were entirely different between two approaches. Rice farmers who had more years of schooling tend to be more inefficient in stochastic frontier and CRS DEA model while this factor had positive coefficient with efficiency in VRS DEA model. The land fragment had a negative associated with technical inefficiency under parametric method and did not significantly affect to farm ability in catching up maximum potential output under both CRS and VRS DEA. However, the using of fuel in operating irrigation as well as the soil degradation showed positive associations with technical inefficiency. The findings from this research raised the question about the various results between two approaches and suggested more investigations on these aspects.

2.3 Constraints in Increasing Rice Production

Rice is the main crop in many developing countries as well as occupies the overwhelming importance in the global food system. Moreover, rice observes more than half of the farm labor force in many countries. It is not only for food security but also a tool for poverty alleviation since most of poorest farmers involve rice production.

The necessary of understanding about limiting factors, as known as constraint, has emphasized by many institution and scholars. A constraint is any factor that holds yield below the biologically determined maximum potential. *"As defined by plant physiologists, the yield potential is the maximum capacity of the rice plant to produce output given the nature of the cropland, moisture conditions, temperature level and availability of solar energy"* (Barker, 1985). The researchers have investigated the limiting factors in rice production based on their background, and rice productivity is influenced significantly by technical constraint and socioeconomics constraint.

The first limiting factor is technical feature of rice factor inputs. According to Barker (1985), the typical parameters that restrict the rice production over the world are temperature, water, and soil. The favorable temperature range for rice plant is from 20^0C to 34^0C. Areas which have temperature out of this range tend to lose their productivity. For water, it is important to supply an appropriate amount and at the correct time for rice plants since the excessive water causes the decrease in rice yield. Being an essential element of rice production, soil provides nutrients for rice plants. Farmers attempt to enhance soil fertility by using both chemical and organic fertilizers for their rice land. In flooding areas as well as salinity soil areas, the rice yield can be increased by using the salt-tolerant varieties.

Most frequently discussed among economists, the socioeconomic constraint refers to the factors that prevent farmers implementing technology in rice production. Some farmers adopt technology more rapidly than others and this fact might cause by the difference in their socioeconomic characteristics. According to Barker (1985), the common causal factors are age, education, farming experience in years, extension contacts, size of family and the contact with group which promotes agriculture process. Besides that, tenure and type of irrigation are also frequently discussed among scholars. Based on his review, education is the most frequented factor was investigated and usually showed the positive relation with rice farm's efficiency as can be seen in Dung (2015). Similarly, irrigation and extension contact positively associated with adoption to modern rice varieties. However, age did not show the consistent result of his reviewed studies.

Even though education and irrigation often have positive impact on the ability of rice farmers to using technology efficiently, there no one can make the strong generalization that which factor constraints the technology adaptation. This is necessary to acknowledge these factors based on the situation in each research area in order to explain the performance of rice farmers as well as recommend agricultural policies.

2.4 Conclusion

The primary purpose of studies in agriculture production and rice, in particular, is to enhance the production ability of farmers. Scholars attempted to estimate the level of efficiency and technical efficiency in both individual production and multiple productions with technical efficiency is defined as the ratio of actual output to maximum potential output.

In order to pursue this aim, stochastic frontier and DEA method are two main methods applied in measuring technical efficiency. Stochastic frontier approach permits generating the coefficient for factor input and is able to separate random noise and inefficient error. However, it requires an appropriate assumption of production function and distribution of inefficient term. By contrast, even though DEA allows to measure technical and scale efficiency, all the deviations from the frontier are considered inefficiency without distinguishing between random noise and inefficient error.

Within the reviewed literature, farmers in developing countries often produce at a lower level of their maximum potential output. The productive inefficiency is addressed in association with both intrinsic factors as inputs and external factors as demography, geography, educational characteristic of households as well as other determinants. Besides that, agriculture production also significantly is influenced by natural condition and the implementing of government policies.

The understanding about which factors associate with technical efficiency in agricultural production and rice in particular support policies makers in designed supporting programs for farmers toward improving their production.

CHAPTER 3

TECHNICAL EFFICIENCY IN RICE PRODUCTION IN HAIPHONG CITY AND THAI BINH PROVINCE, VIETNAM

3.1 Introduction

Vietnamese farmers historically and practically are closed to rice crop. Being successful in self-sufficient supply for domestic rice consumption in 1988, Vietnam started exporting rice in 1989 and has remained its position among top rice exporters in the world recently.

In the empirical perspective, Vietnamese researchers have accessed and applied stochastic frontier approach and DEA either in studies of technical efficiency in rice production. Several studies in English or Vietnamese, at national, industrial or regional have been conducted with the effort of understanding nature of rice productivity in Vietnam. In order to review the main argument and discussion among the researchers about the technical efficiency of rice production in Vietnam, chosen empirical studies will be briefly summarized and discussed in the subsection of *Literature review*. Consequently, their findings in using appropriate production function with reasonable factor inputs, the method of data collection as well as the explanation for technical efficiency remarkably support the later researchers in designing empirical model in subsequent studies. These studies have attempted to investigate comprehensively rice production in Vietnam and suggest possible policies to enhance rice farmers' ability in capture their potential output.

Following previous researchers, author gives an effort to build up empirical model in explaining rice production as well as determinants of technical efficiency among rice-farming households in Haiphong city and Thai Binh province, which have high rice yields in Red River Delta. The findings address some common factors which affect to household technical efficiency and give evidence for other factor compared to the previous study as well. This Chapter 3, therefore, consists of the following contents. The *Empirical Model* is presented with the consideration of trans-log form or Cobb-Douglas form of production function as well as the determinant regression model in rice production. The *Data* subsection describes data collection process whereas the *Variable Construction* subsection provides the definition and the way all variables are constructed in this study. The findings are discussed in *Empirical Result and Discussion* subsection. Last but not least, the *Conclusion* is made based on the empirical results.

3.2. Literature Review

Technical Efficiency in Vietnam

The important of studying about technical efficiency in rice production has been rising by several scholars recently.

By using stochastic frontier approach, Hien, Kawaguchi, & Suzuki (2003) estimated technical efficiency in rice production for a sample of 120 rice-farming households in Mekong Delta River. The mean of the technical score calculated for Winter-Spring, Spring-Summer and Summer-Autumn season was 0.8623, 0.7955 and 0.8024 correspondingly. Chemical fertilizer and pesticide cost negatively associated with the rice yield while fertilizer and machinery cost had positive impacts on rice yield. Moreover, rice-farming households with larger land size, variety diversification, and being able to access credit and apply new cultivating technology would produce more efficiently than others.

In 2004, Kompas used the stochastic production frontier for the regional data panel to estimate technical efficiency rice industry in Vietnam. He found that the level of technical efficiency of rice production in Vietnam was 0.65 in 1999 nationwide and 0.78 for main areas, which are Red River Delta and Mekong River Delta. The empirical result showed that the farm size, proportion of used tractor and the major land areas indicator positively affected by the level of technical efficiency (Kompas, 2004).

Emphasized role of human capital and using stochastic frontier production function, Song (2005) addressed that rice farmers in the province of Hanoi produced at 70 – 80% of their frontier production in the year 2003 and 2004 and the average level of technical inefficient among those farmers are 14% in two years. In this study, data was collected by field survey from 449 rice farmers in Dong Anh and Gia Lam districts where rice are most cultivated among districts in Hanoi. Whereas labor had the largest influence on the rice productivity, the education and the acknowledgment from agriculture technical training of the household head remarkably associated with the ability to capture higher level of technical score since the household head was the decision maker in production process. The education attainment and acknowledgment of the household members, non-decision makers, did not show any significant effect on technical efficiency. Song (2005) concluded that, by improving quality of rice cultivation process, Hanoi potentially might increase its rice production by 20,300 tons for total 33,000 hectares rice land in 2004 without increasing any inputs.

Based on a field survey, Chi and Yamada (2005) investigated the technical inefficiency of rice production in Thoi Lai Commune, Co Do District, Can Tho City, Vietnam within the good adaptation of row-seeder, a labor-saving technology, in the intensive rice farm. This study compared the efficiency between row seeder practiced farmers and row seeder non-practiced farmers by utilizing frontier production function and cross-sectional data. The findings are even though adaptation to new technology could not fill all the gap between actual output and potential output, the yield loosed due to inefficient effects was lower than practicing traditional method and farmers who applied row seeding technology obtained the higher rice income and both non-farm and off-farm income compared to those who practiced broadcasting. In addition, technology adoption improved the rice yield and save inputs including fertilizer quantity, seeds as well as labor. Another key finding to remember is that the education of the household leader is the most significant factor affecting the level of technical inefficiency in Thoi Lai Commune since farmers have higher education would be able to acknowledge and apply technology in cultivation better. However, besides learning new knowledge in implementing new machinery, the farmers also should be trained how to use inputs effectively and understand how variety technologies applied interrelate in rice production process.

Acknowledge that Kompas (2004) gave the initial experience for measuring efficient score for rice industry in Vietnam, Hoang Linh (2007, 2012) nonetheless argued that using regional data in measuring technical efficiency might not useful in providing information about efficiency score and source of technical efficiency at rice-farming household level. Therefore, Hoang Linh (2007) for the first time attempted to calculate technical efficiency in rice production at farm level nationwide by using the Vietnamese Households Living Standard Survey (VHLSS) 2004[4]. The technical efficiency level of rice production was estimated for a sample of 595 farms randomly selected from 4300 rice-farming households in VHLSS 2004. Furthermore, this study utilized both stochastic frontier

[4] Since then, the statistic of VHLSS has been widely utilized in several studies about technical efficiency in rice production in Vietnam.

approach and data envelopment analysis (DEA) approach with bootstrap method to compare the result of efficiency estimations obtained, providing in-depth understanding about measuring methods for technical efficiency in rice production in Vietnam[5]. The level of technical efficiency was estimated at 0.785 under the variables return to scales for input-oriented DEA and 0.634 from stochastic frontier approach. These methods together suggested that regional indicator, land holding, land size and education, especially primary education positively influence efficiency in rice production while non-farm ratio has no significant effect on households' performance. Another point to mention is that this study used the fertilizer costs instead of fertilizer quantity because of unavailable information in surveys.

Based on dataset of VHLSS 2006, Khai and Yabe (2011) determined the technical efficiency of rice production in Vietnam using stochastic frontier analysis method in Cobb-Douglas production function. This study applied stochastic production function for 3733 rice–farming households in rural and urban areas nationwide with the assumption of *"no big differences in land and technology used by the rice farmers across the country"* (Khai and Yabe, 2011, p140). In this, labor input was defined by the family labor allocated for rice production, calculated by multiplying the total family labor for farming with the proportion of rice value to the farm obtained. The finding is that technical efficiency was 0.816 for observed rice-farming households. That is to say, labor intensive, irrigation, live improvement as well as education at level of secondary school notably helped rice farmers drawn from VHLSS 2006 in increase technical efficiency level. Nonetheless, agriculture policies have negatively affected the capacity in capturing the potential rice value. It was explained that the government agricultural policies targeted in poor households who might produce rice less efficiently than others or the policies' impacts were not strong enough in supporting targeted farmers (Khai &Yabe, 2011).

Hung (2011) attempted to use household fixed-effects method to examine agriculture productivity ability for farmers in two provinces, Ha Tay and Yen Bai, Vietnam. The mean of technical efficiency estimated for farms in Ha Tay was 0.48 and 0.49 for farms in Yen Bai. Whereas the age and education of the household head did not show any notable influence in farmers' production ability, the participation of farmers in agricultural training section as well as the number of plot farmers has positively impact on farmers' performance.

In order to compare the technical and economic efficiency in rice production in Mekong Delta River, Thong (2011) applied frontier stochastic production and profit function in Cobb-Douglas form for the primary data at farm-level. A sample of 447 rice-farming households was randomly selected from four provinces namely Hau Giang, Can Tho, Vinh Long and Long An in Winter-Spring season of period 2008-2009. The empirical result showed that the average yield of rice-farming households in the sample was 7.2 tons/hectare and the average profit was around 20 million VND/hectare. The level of technical and economic efficiency was 0.85 and 0.72 which resulting in a corresponding loss of 1.2 tons/hectare and 3.2 million VND/hectare. The inefficiencies caused by the using non-optimal input combination and the ability in adapt new technology of rice farmers. Thong (2011) additionally addressed that the participation of rice farmers in technical training program could help to improve technically and economically rice production of rice-farming households in four selected provinces.

Using the panel data at farm-level in four years, Dang (2012) analyzed the change in technical efficiency in rice-farming households in Mekong Delta. This study applied frontier production Cobb-Douglas function for a sample of 155 rice-farming households in four provinces. The average technical efficiency estimated was 0.8896 however the level of technical efficiency experienced a downward trend from 0.892 in 2008 to 0.887 in 2011. Dang (2012) addressed that access to credit, technical training as well as participating in professional associations positively influenced household technical efficiency.

Discussion from the Previous Studies

To summary from above-chosen papers, rice farmers in Red River Delta and Mekong Delta had an average technical score of 0.78 in 1999 (Kompas, 2004). This level seems to increase and is proved in more recent studies whereas rice farmers in Red River Delta would produce at 80.1% of their maximum potential output, those in Mekong Delta reached at higher proportion of their maximum potential output, around 83.1% (Hoang Linh, 2007). Furthermore, Vietnamese rice farmers had average of technical score at 0.816 nationwide (Khai &Yabe, 2011) since Red River Delta and Mekong are the two the most important rice cultivation regions in Vietnam, rice farmers in these two regions seems to be more efficient in producing rice compared to other areas. Research on the annual crop also gave some ideas related to rice production in the relation with other plants (Dao & Lewis, 2013).

For dataset, these studies used different sample size at regional level and household level. Data was collected from field survey as in the researches of Chi & Yamada (2005), Song (2005), Hung (2011), and Thong (2011). On the other hand, 3 out of 9 reviewed studies based on the VHLSS, which provides a particular section where scholars would find revenue and cost of households in rice production. Moreover, the VHLSS included the farm households' background information is useful in investigating what make the different performance among these farm households as well as conducting the research with larger sample size.

These studies applied stochastic frontier and DEA approaches; nonetheless, most of the scholars utilized the stochastic frontier production to separate statistical noise and technical inefficient term. Cross-sectional data also mainly used in the estimation might due to the availability of data. They further used the Cobb-Douglas function with the reason suggested as rice production is the multiple input and single output production (Khai & Yabe, 2011). In addition, Cobb-Douglas function is also convenient in testing return to scale (Hoang Linh, 2007) due to the elimination of interact relation among input variables. However, the test of model specification was not mentioned in these studies.

The definition and construction of dependent and independent variables in rice production function are varied among these studies. The dependent variable was defined as rice output, measured by either quantity or value of rice production. The independent input variables would range from six to nine inputs, consisting of seed, pesticide, fertilizer, machinery service, hired labor, family labor for rice, land area, small tool and energy and other expenditure. In term of labor factor input, the scholars constructed variable in a number of family members for rice production, expenditure on hired labor or total days per year of household labor spent for cultivating rice. However, these measurements of labor input are not taken the contribution of both family labor and hired labor together into consideration due to the informative limitation from VHLSS. The scholars might also want to examine the impact of hired labor and family labor separately. As a result, there is no research converted both hired labor and family labor together in the same unit as a measurement of labor input when using dataset from VHLSS.

Determinants of technical efficiency in rice production

For rice production Determinants of technical efficiency have been widely discussed in these studies, considering about demography, geography, and quality of inputs of rice farm households. These factors affect to the managerial skill and technical implementation in production process.

In *demographic*, the household head is usually concerned as the representative of the rice-farming household since he/she is the decision maker in production process. Provided that, the age of household head were concerned in the positive relation with technical efficiency level farm obtained (Abdulai & Huffman, 2000; Dhugana et al., 2004). A higher age allows rice farmers accumulated more farming experience especially in rice cultivation including choosing cultivating method, rice variety, fertilizers and pesticide which is particularly based on the farming season. However, it does not always mean that elderly farmers are more efficient in rice production as the neutral relation between age of household head and technical efficiency in studies of Chi & Yamada (2005) and Khai & Yabe (2011).

Besides that, the gender of household head might affect production process. The male leaders tend to be more efficiency than female in rice production due to their physical features. They are stronger and familiar with multiple farming tasks in large area, showing better managerial skill in production process (Abdulai & Huffman, 2000; Dhugana et al., 2004). Related to the supply of labor, the larger the size of household is, the more labor probably are allocated for rice production. Therefore, household size is expected to associate positively with the level of technical efficiency.

For geography, the location of rice farmers shows the association with the regional indicator was significant result in the level of technical efficiency among rice farmers (Kompas, 2004; Hoang Linh, 2012). Rice farmers in main rice region such as Red River Delta and Mekong Delta achieved higher level of technical efficiency (0.801 and 0.831 correspondingly) while those on the south central coast produced rice less efficiently (0.715). Farm's location leads to the difference in their performance in rice production due to the variance of land input among regions (Hoang Linh, 2012) or difference in cultivating skill among rice farmers.

In general, *Education* represents the quality of labor input which significantly affects the efficiency of rice farm households in rice production. It can be measured by the schooling years or level of qualification of household head, average years in school of family members or education level of labor. Based on 18 studies in 13 countries for individual production and multiple productions, Lockheed, Jamison, & Lau (1980) studied about the relation of education and small-farm production with the distinguish of modernizing agriculture and traditional farming. Modernizing agriculture is defined as including availability of new crop varieties, innovative planting methods approach, loss control, and capital inputs such as pesticides, fertilizers, and tractors or machines. Lockheed et al. (1980) concluded that the effects of education were much more likely to be positive in modernizing agricultural environments than the traditional one. They also estimated an increase in the mean of agriculture output for four years of education under modernizing conditions was 9.5%, compared with 1.3% under traditional conditions. Moreover, take the representative of household head, education directly affected the decision-making process of those in rice production. It results in the ability of quick access and reaction to the change in natural environment as well as using inputs efficiently of farm households (Abdulai & Huffman, 2000; Dhugana et al., 2004; Song, 2005). Chi & Yamada (2005) also found the positive impact from the schooling years of household heads on the level of technical efficiency among farmers in Thoi Lai Commune, Vietnam, confirming for the contribution of education to rice farming practice. Khai & Yabe (2011) addressed that level of education is an essential factor which influences the capacity of Vietnamese rice farmers in capturing their potential output. In which, rice farmers who had secondary education level or above tended to produce rice more efficiently than those who had not been to school or only finished primary education.

The participating in agricultural technical training, crop diversification and land size also resulted in a higher level of technical efficiency for rice farmers (Hung, 2011; Dao & Lewis, 2013). The proportion of using tractor and labor intensive are also significant to technical efficiency (Kompas, 2004; Hoang Linh, 2007).

Life improvement statistically positively influenced technical efficiency in rice production (Khai & Yabe, 2011). However, Life improvement variable might be seen as a not explicit variable since the way it was constructed in the survey and how its content might be considered as the consequence rather than determinant. In the VHLSS, farmers are asked whether they experience an improving in life condition or not compared to five previous years, and the producers will answer in Yes or No. It is not clear to understand how difference the living standard of households was by this measurement, and life improvement somehow would be the consequence of having high technical efficiency in rice production since farmers produce rice efficiently would get higher income from rice, therefore, experience a better-living standard. For these reasons, the explanatory variable which reflects households' life improvement will not be included in the technical efficient determinants model in this paper.

3.3 Empirical Model

This study approaches rice production via four input factors consisting capital, labor, material and land, denoted as K, L, M, N respectively. Even though previous studies mainly utilized several inputs for rice productions, four-input-factor KLMN model is also widely used for agricultural production including rice (Lockheed et al., 1980).

For a typical rice-farming household, the log-linear Cobb-Douglas production form is as follow:

$$lnY_i = \beta_0 + \beta_j \sum_{i=j} lnX_j + (v_i - u_i) \tag{3.1}$$

where Y_i represents total rice value of the ith rice-farming household (i=1,2,…,n); lnY_i, lnX_i is the natural log of rice value and input X_i respectively; β_o, β_j are parameters to be estimated; i, j are input indicators. The two-sided error component v_i is statistical noise assumed distributed independently and identically (Aigner et al., 1977), capturing the effects outside of rice-farming households' control but specified. In the household survey, the bias caused by the method of data collection, data measurement is not under the influence of rice households presented by v_i. The component u_i is the one-sided, random and non-negative inefficiency error, representing the loss of technical efficiency due to unobserved effects. The distribution of component u_i can be half-normal, exponential or truncated (Aigner et al., 1977; Kumbhakar, Wang, & Horncastle, 2015). In this study, the u_i is assumed exponentially distributed due to the inefficiency of half-normal and truncated-normal distribution in using maximum likelihood estimation for the dataset. In practice, the capacity of rice farms to reach the maximum potential output would be affected by their social-economic characteristics, location, household structure, and inputs quality features considered as unobserved influences. This inefficiency error reveals the gap between the actual output and maximum potential output of rice-farming families, utilizing in predicting technical efficiency (TE) of these households.

$$TE_i = \exp(-u_i) \tag{3.2}$$

In other words, technical efficiency is defined as the ratio between actual output and maximum potential output of rice households.

The output elasticity of output Y_i (e_i) respects to input X_i is measured from equation (3.1) as the coefficient of input X_i, that is

$$e_i = \beta_i$$

In other words, 1% changing in input X_i results in e_i% change in the output Y_i, *ceteris paribus*.

Then, the return to scale (RTS) in rice production can be formulated by

$$\text{RTS} = \sum_i e_i, \qquad i = K, L, M \text{ and } N \tag{3.3}$$

These efficiency approximations then enter the second stage of regression analysis to investigate the determinants of technical efficiency with Tobit regression function model specified for the ith Vietnamese rice households as follows.

$$TE_i = \omega_0 + \omega_1 * D_i + \sum_{j=2}^{k} \omega_j D_i W_i^* + \sum_{j=k+2}^{l} \omega_j W_i + \rho_i \tag{3.4}$$

where TE_i is the technical efficiency of ith household, D_i is the dummy variable for farm's location; W_i (i=1,...,k) are explanatory variables affected Vietnamese rice households' efficiency, W_i^* is the factors which interact with regional variable, ω_0, ω_1, ω_j are unknown parameter to be estimated; k, l are the numbers of parameters, and ρ_i is the random statistics noise. The maximum likelihood estimation is conducted by using software **STATA 12**.

3.4 Data

Vietnamese Household Living Standards Survey (VHLSS) has been carried out by the General Statistical Office of Vietnam (GSOV) since 1998 in every two years to gather information through commune and household level questionnaires. The household survey is organized into nine sections comprising *Basic demography*, *Employment and labor force participation*, *Education*, *Income*, *Expenditure*, and other sections[6]. Moreover, since rice is the main crop in Vietnam its information gradually is gathered by General Statistics Office of Vietnam. VHLSS 2012 is the most recent published data[7], containing related information of farm households in rice production in section 4B of this survey.

This study uses the cross-sectional data at farm-level in 2012 for rice selected from Haiphong city and Thai Binh province. Data utilized in this study would be drawn from the VHLSS 2012. The households,which located in Haiphong city and Thai Binh province, are coded in VHLSS. In this study, a rice-farming household is defined as one has rice production by utilizing either self-employment or outsourced labor. Since then, the households did not cultivate rice in 2012 were dropped to obtain 665 observations which later were unified into 209 farm households. 2 farm households which did not use the capital for their rice production were excluded; eventually the sample consists of 207 farm households. Among them, 70 farms are located in Haiphong city, accounted for 33.82% of the whole sample while 137 farms were listed from Thai Binh province.

[6] The other sections included in VHLSS are *Health*, *Housing*, *Fixed assets and durable goods*, and the *Participation in poverty reduction programs*.

[7] According to GSOV, the VHLSS 2014 statistics will be released in June, 2016.

3.5 Variable Construction

The 207 rice-farming households in the sample were specified by the household identification number *(id)*. Based on this *id*, all variables were categorized and merged from the VHLSS 2012 database respectively. The monetary values are measured in thousand VND.

3.5.1 Stochastic Frontier Production Function Model

In order to construct the dependent variable of output (Y), the value of rice output is comprised total value of plain rice, sticky rice and specialty rice a farm obtained in 2012. In VHLSS 2012, the rice outputs were recorded in either quantity (in kilograms) or value (in thousand VND) for such three types of rice. Due to the fact that plain rice is majorly cultivated in Vietnam, the information of plain rice output was recorded in main season separately whereas the data for output of sticky rice and specialty rice were noted over one year with less quantity produced. According to Handbook of VHLSS 2012, the rice production values were given by rice farmer according to their trade in the market or self-evaluation. If the farmers self-consume their production, the local market price at the harvested time was applied in the calculation. This measurement resulted in the variability of rice value among rice households due to the difference in price of rice based on their location, traded market, and interview time as well. On the other hand, the values of rice output would reflect how farm household benefited from their rice production in term of income. For these reasons, this research will utilize rice value instead of rice quantity as a dependent variable in the stochastic frontier production function. The monetary value of plain, sticky as well as specialty rice has been aggregated together to attain a single value of total income from rice for each observed households.

The production input factors are Capital (K), Labor (L), Material (M) and Land (N).

Capital (K) is measured by the total expenditure of rice-farming households on durable equipment. From VHLSS2012 statistics, K is formulated as the total monetary value the rice farms spent on the *hiring of assets, machines, vehicles and mechanical work; hiring of transport as well as hiring of plough cattle* in the year 2012.

The labor input (L) is the total time employment involving to rice production spent in a year. In general, there is two type of labor involving rice cultivation in Haiphong and Thai Binh, namely *family labor*[8] (as known as *self-employment*) and *hired labor*. *Family labor* is the person who is self-employed in rice cultivation, considering it as the most or the second time-consuming job. *Hired labor* is defined as an individual who is employed by a household and earns a wage to do rice cultivating tasks[9], for instance, growing rice, spreading pesticides, harvesting rice, etc. In this

[8] The term "family labor" is preferred from Hoang Linh (2007, p7).
[9] The information of job status is available in Section 4A of the VHLSS 2012.

study, the author could not find the evidence of a high correlated relation between rice value a household created and the number of their family member labor (see Appendix 2) as argued in the literature review. The labor input now is calculated as follow:

$$L_i = F_i + H_i$$

where L_i is the total amount of time for rice production per year of the *ith* rice-farming household, F_i and H_i are the total amount of time per year spent on rice production by family labor and hired labor, respectively.

For F_i, the survey provides the total working day per year and the average hour per day in last 30 days a household labor spends on rice production. To solve the problem of difference in interview time, an assumption is imposed as the family member spends a half amount of time in a working day for rice cultivation in the non-main season compared to in the primary season.

Therefore,

$$F_i = \begin{cases} \sum h * d \quad ; & if\ data\ is\ recorded\ in\ main\ season \\ \sum h * d * 2 \quad ; & if\ data\ is\ recorded\ in\ non-main\ season \end{cases}$$

where h represents the average hour spent on rice cultivation in last 30 days recorded and d is the number of days per year dedicated to rice cultivation.

For H_i, the amount hired labor working for household's rice production is converted from family's expenditure on hiring these labor in a year. Assumed that the hired labor works in same hours for every working week, the total amount of time hired labor spent on rice cultivation per year of ith rice-farming household is calculated as follows.

$$H_i = \frac{Total\ expenditure\ on\ hiring\ labor\ in\ 2012}{Wage\ per\ hour\ for\ hired\ labor\ in\ rice\ production} = \frac{HHep}{\frac{w}{t*4}}$$

where w is the average wage per month of employment who works in Agriculture, Forestry and Aquaculture industry in 2012, t is the average working hours per week of agricultural labor in Red River Delta in 2012. In Labor and Employment Survey 2012 (GSOV, 2012), w and t are 44.7 hours and 2,543,000 VND respectively.

This method of variable construction for labor input is to avoid the exclusion of observations from the estimation of production due to labor input equals to 0. Furthermore, the change in rice value would be explained more accurately by the fluctuation in labor input[10].

The third input, Material (M) is the total monetary value of costs on materials in 2012 consisting buying seeding and seedling plus expenditure on chemical fertilizer, self-supplied and outsourced organic fertilizer,

[10] This measurement gave higher correlation between labor input and rice value as seen in Appendix 2.

pesticide, and herbicide as well as payment for energy, fuel, and inner-field irrigation.

Lastly, Land (N) reveals the total land size in square meters (m^2) a rice-farming household allocated for rice cultivation in 2012. It is the collective of households' farm plots recorded in the survey.

In agriculture production, the inputs usually positively associated with the level of outputs (Abebe, 2014), implying that farm household using more inputs would produce more output. Therefore, this study is expected to find the positive associations between K, L, M, N, and the rice value in the stochastic frontier production function.

3.5.2 Tobit Regression Model

In order to determine the source of technical efficiency in rice cultivating practice of households, several household-specific socioeconomics as well as quality variables have been used for Tobit regression model. These variables were grouped into demography, geography (location), diversification, and quality of input factors.

In demography, the age of household head is assumed representing for the household age and the education of household head is considered in years of schooling. The household size is the total number of members in a rice-farming household. Dummy variables were designed to take full account effects of demography to a household performance, including gender and education level of household head. A household is assigned as

1 if the household head is male, 0 otherwise. The education level of the household leader would interact with the years of schooling; nonetheless, it would reveal exactly which level of education the family leader already completed. Household has leader finished primary school, secondary school, high school and higher education is assigned as 1, 2, 3, 4, accordingly, and as 0 for no school.

Related to the geographic impact as the central of this study, a dummy variable created equals to 0 if rice-farming households are located in Haiphong city, and equals to 1 for those in Thai Binh province. The variable of crop diversification is defined as the number of crops consisting of rice, staple food, industrial plants or fruit trees cultivated by households in 2012. This variable is to reveal the impact of having diversified crop whether it would lead to increase the rice value household obtained or not in the referred to the previous work of Hoang Linh (2012), Dao & Lewis (2013), and Besseah and Kim (2014).

Moreover, the quality of input factors will be indicated by other variables as well. The mechanization feature is represented by the ratio of capital to rice land size since capital of rice farm households in dataset was mainly spent on hiring equipment for rice production (row-seeding machine, harvesting machine, tractor, plough, sprayer, etc.) while only small amount of capital is allocated for buying fixed asset or maintenance. The ratio of labor input per unit land indicates the labor intensive farming in term of labor input for rice production. Since irrigation has been concerned as an important determinant of technical efficiency in rice production (Khai & Yabe, 2011), household applied inner-field irrigation in 2012 is assigned as 1, and 0 otherwise. Table 3.1 displays the definition and statistic of the variables utilized in the estimation of production function as well as investigating technical efficiency determinants of rice-farming households in Haiphong and Thai Binh, Vietnam.

Table 3.1: Summary of Variables in Empirical Model

Variables	Explanation	Mean
Rice value (Y)	The total value of plain, sticky and specialty rice in 2012	13516.76 *(8103.66)*
Capital (K)	Total expenditure on hiring of assets, machines, vehicles and mechanical work; hiring of transport as well as hiring of plough cattle in 2012	1621.05 *(1089.37)*
Labor (L)	Total working hour that family labor and hired labor spent on rice production in 2012	1712.28 *(1620.13)*
Material (M)	Total expenditure on materials for rice production in 2012	3246.98 (1958.*36)*
Land (N)	Total land size allocated for rice production in m^2	1713.81 (1007.*93)*
HH Size (HHsize)	Number of family member	3.367 (1.2*47)*
Age of HH Head (Age)	Age of HH head in year	52.435 *(11.776)*
Gender (Gen)	Gender of HH head Male=1, Female=0	168
School attendance (Schl)	Number of schooling year of HH head	8.440 *(2.530)*
Education level (Edulv)	No education = 0 Completing Primary education = 1 Secondary school education =2 High school education = 3 Higher education = 4	16 36 112 22 20
Location (Reg)	The regional dummy Haiphong=0, Thai Binh=1	 70 127
Diversification (Diver)	Number of crops including rice, staple food, industrial plants and fruit trees.	2.019 *(0.876)*
Mechanization (K/N)	Capital to land size ratio	0.959 *(0.332)*

Labor intensive (L/N)	The input labor to land size ratio	0.704 *(0.732)*
Irrigation (Irrg)	The dummy var. for inner-field irrigation Yes=1, No=0	181

The standard error is in the parentheses.
Y, K, and M are measured in thousand VND.

3.5.3 Descriptive Statistics

As shown in Table 3.1, the average size of rice households is 3 people and its maximum size is 6 people. The average age of rice household heads is 52 years while it ranges from 27 to 85 years. Rice farm households are led by male are 168 out of 207, accounting for 81.16% of the whole sample.

For variables reflected labor quality, literacy and education level of rice household heads are concerned. In this sample, nearly 98% of rice households have at least one member have attended school. The average school years of rice household heads are 8 with a range of 0 to 12, representing a large variability among rice households in Haiphong and Thai Binh. Nonetheless, in term of education level, there are 16 household heads, equal to almost 7.7%, grouped in No education level since they have not completed the primary education yet. Around 54.15% of rice household heads finished Secondary education while only 9.7% of them have the completion of vocal training or higher education for example university and college. Even though there exists the correlation of 0.8093 at 5% level of significant between the number of school years and level of education completion, using terms of education level might not useful for those who were in the transition stage of education level. The average year of schooling is quite similar among rice farms in two areas. Household head in Haiphong has been to school for almost 8 years while Thai Binh's farm leaders had 9 years of schooling. Rice farmers in Hai Phong seem to have lower level of education compared to those in labor city when the total proportion of those who qualified in Primary, Secondary, and High school education are 77.14% and 84.67% in Haiphong and Thai Binh correspondingly.

For crop diversification, in the sample typically 2 crops are cultivated in the year 2012, and the rice farmers in Haiphong city are corresponding with this mean whereas those in Thai Binh mainly have rice monoculture. 28.57% of Haiphong's households only cultivate rice and 11.43% of those have 4 crops. In comparison, there is 34.31% of Thai Binh's households growing rice without other crops while only 1.46% of those cultivate four types of crop per year. The significant statistical differences in means of schooling years, level of education and number of crops imply that there might exist the relation between rice farms' location and these characteristics.

By contrast, there are no significant differences among factor inputs and output based on region. In general, rice farm households in the sample obtain an average value from rice production of 15,255,890 VND in the year 2012, using 1,621,000 VND capital, 1,712 hours of labor, 3,246,976 VND materials, and 0.1713 square meter land. In term of capital and labor intensive, a typical rice farm in this study spends 9,587,000 VND and 11,657 hours for 1 hectare land in 2012. Whereas rice farmers in Haiphong expend more than those in Thai Binh an amount of 318,000 VND on hiring equipment for production process, they use less labor input by 2184 hours per year for 1 hectare of rice cultivation. Furthermore, nearly 87% of rice farmers in the whole sample have access to inner-field irrigation.

3.6 Empirical Result and Discussion

3.6.1 Analysis of Rice-Farming Households Production Function

The maximum likelihood estimation is used since the distributional assumption in stochastic frontier production leads to the inefficiency of the OLS estimator (Kumbhakar et al., 2015, p.59).

Table 3.2 displays the coefficient estimates in Cobb-Douglas stochastic production function[11]. All of the parameter estimates in Cobb-Douglas model statistically differ from zero at 1% level of significant. The estimated $\lambda = \sigma_u/\sigma_v = 2.09\text{E} + 08$ is extremely vast; therefore, the null

[11] The estimation of trans-log model showed all the coefficients statistically significantly. However, the elasticity of output respect to both Capital and Material were estimated to be negative, made the estimation meaningless. This might suggest that the regression was suffered from the multicolineriality (Kamp, 2004). As mentioned in this chapter, some previous studies applied Cobb-Douglas form for production function in rice crop since it excludes the interacting relation among factor input (Khai & Yabe, 2011). The dataset utilized in this thesis showed very high correlation between Material and Land (0.8571) (see Appendix 4); therefore, the trans-log model regression was suffered from the multicollinearity.

hypothesis of no effect from inefficiency technology was rejected at 0.01 level of significant by the maximum likelihood ratio test, implying that farmers in Haiphong and Thai Binh are facing technical inefficiency in rice production.

Table 3.2: Maximum Likelihood Estimation for Cobb-Douglas Stochastic Frontier Production Function; Dependent Variable: Log of Rice value

Variables	Coefficient estimates
Log(Capital)	0.122*
Log(Labor)	0.040*
Log(Material)	0.347*
Log(Land)	0.483*
Intercept	2.227*
sigma v	1.46E-09
sigma u	0.305
sigma2	0.093
lambda	2.09E+08
Log likelihood	*38.644*
No. Obs.	*207*

***, **:** *The coefficient estimates are significant at 1% level of significant.*

All the factor input shows positive associations with rice value and the coefficients are interpreted directly as the elasticity of output. Among four inputs KLMN, the size of rice land area has the largest impact on rice value. *Ceteris paribus*, 1% increase in land size will lead to increase 0.483% in rice value for rice-farming households.

As the input which has the second largest impact on rice value, Material input shows the positive association with the rice value. If rice farmers increase their material input by 1 %, their value of rice output will increase by 0.347 %.

Capital input shows positive influence on rice value produced by farmers in Haiphong and Thai Binh. It means adding 1% of expenditure on hiring equipment for rice production causes 0.122% increase in rice value rice-farming households obtained. Mechanization would lead to higher level of rice output since by hiring more equipment rice farmers would produce in a larger area and harvest more production. Supporting that, Khai & Yabe (2011) found 1% increase in expenditure on machinery services would increase rice value by 0.0057%.

Labor input is positively associated with the value of rice output. Since labor is essential factor input for agriculture production, rice is not an exemption. An addition to total hours for rice production leads to an increase in the value of rice output by around 0.04% for rice farmers in Haiphong and Thai Binh. It is similar to the number of family labor and expenditure on hiring outsourced labor in positively contributing to rice output production with the elasticity of 0.0392 and 0.0057 correspondingly (Khai & Yabe, 2011).

The return to scale is the total of rice value elasticity respect to four inputs KLMN, suggested by

$$\text{RTS} = \sum_{i} e_i = 0.122 + 0.040 + 0.347 + 0.482 = 0.991$$

The null hypothesis of existing constant return to scale (RTS=1) is rejected at 1% level of significant by The Wald test with chi-square statistics is 7.5e+08. Since the sum of estimated coefficients in Cobb-Douglas function equals to 0.991 which is smaller than 1, there exists the decreasing return to scale among rice-farming households in Haiphong and Thai Binh. This result implies that rice-farming households in Haiphong and Thai Binh increase by one the size of all the four-factor input will cause a less percent increase in the rice value (0.991). By contrast, Khai & Yabe (2011) found the possibility of increasing return to scale among Vietnamese rice farmer with the RTS=1.035 at 5% significance level.

Technical Efficiency Distribution

The estimated frontier rice value, then, is utilized to predict the level of technical efficiency. Table 3.3 presents the summary of technical efficiency estimates for rice-farming households in Haiphong and Thai Binh.

Table 3.3: Distribution of Technical Efficiency Estimates

Technical efficiency	Number of households	Proportion (%) Sample	Haiphong*	Thai Binh**
<=0.5	7	3.38	7.14	1.46
>0.5 - <=0.6	11	5.31	7.14	4.38
>0.6 - <=0.7	58	28.02	28.57	27.74
>0.7 - <=0.8	53	25.60	28.57	24.09
>0.8 - <=0.9	52	25.12	15.71	29.93
>0.9 - <=1	26	12.56	12.86	12.41
Total	***207***	***100.00***	***100.00***	***100.00***
Mean TE	0.756 *(0.136)*		0.724 *(0.159)*	0.769 *(0.120)*
Minimum TE	0.072		0.072	0.442
Maximum TE	1		1	1

*, **: *The proportions were calculated in total 70 and 137 households in corresponding areas. The standard deviations are in the parentheses.*

In average, rice farmers in Haiphong and Thai Binh produce at 75.6% their maximum feasible output in rice production. The wide range of technical efficiency lever is from 0.072 to 1, suggesting that still have potential for rice farmers in these two local regions improve their performance. Rice farmers in the sample seem to be less efficient in rice production in term of technology since their level of technical efficiency in 2012 is lower than the average level of 0.801 farmers in Red River Delta (Hoang Linh, 2007) where these two areas located. They also catch up a lower proportion of frontier output than the national average level of 0.816 which was concluded by Khai & Yabe (2011). The one-sample t-test confirmed this prediction at 1 % level of significant. However, the variation of technical efficiency of the rice farmers in Haiphong and Thai Binh is wider than rice farm in the sample of Khai & Yabe (2011) which only ranged from 0.165 to 0.816.

In the sample, only 3.38% of rice-farming households has an average level of technical efficiency lower than or equal to 0.5. While 33.33% of rice farmers have the technical score ranging from 0.5 to 0.7, the majority of 63.29% rice farmers obtain the technical score between 0.7 and 1. Moreover, 5 rice farmers in the sample reached their maximum production. Among them, 2 households are located in Haiphong and the other 3 households are in Thai Binh.

Related to demography, the households that are led by female produce more efficiency than those with male leaders at the corresponding levels of 0.765 and 0.751 of technical efficiency. In this sample, a rice-farming household with more members tends to be more productive in producing rice. Households with the maximum size of 6 members catch up 78.00% of their potential output while others had a lower level of technical efficiency. Accounted for almost 31.4% of the whole sample, rice-farming households with 4 members achieve technical efficiency level at 76.70%. However, the least technical efficiency farm households are the ones which have the family size of 3 members. These households only produce at 73.60% of their potential output with given input combinations.

In term of education, the majority of rice-farming households are ones that have the household head with 9 years of schooling. These farms produce at 75.60% of their potential output. What's more, the household heads also mainly completed the secondary education and their farm operations at 75.50% level of technical efficiency.

In related to diversification, there is no clear tendency that rice-farming household with more crops achieved a higher level of technical efficiency. Farm households which only cultivate rice have technical efficiency of 75.90%. At the same time, farm households who grow 3 types of crops a year have a higher technical score at 76.60% in average. However, this slight difference should be examined again in order to conclude about crop diversification impact on technical efficiency of rice-farming households.

Considering about rice-farming household's location, the average technical score rice farmers in Haiphong city obtained is nearly 72.40% while those in Thai Binh produce at higher level of technical efficiency at 76.90%. The two-sample t-test with equal variances rejects the null hypothesis of there is no difference between these two mean of technical score at 0.01 significance level, confirming that rice farmers in Haiphong are less efficient in using technology compare to those in Thai Binh.

Among perfect technical efficiency rice-farming households, the average rice value obtained in 2012 was 17.604 million VND by using 1.294 million VND of capital, 3.436 million VND of material and nearly 1879 labor hours on 0.17 hectares rice land. As can be seen in Appendix 5, the potential outputs were obtained by perfect technical efficient rice-farming households in Haiphong that operate their rice production at around 0.2 hectare whereas those households in Thai Binh have smaller land size at 0.14 hectare. The capital and labor intensive ratios are quite different among these farmers. An entire technical efficient rice-farming household in Haiphong spent 8.98 million VND per hectare for hiring equipment and allocated 10,150 hours per year for one hectare while in Thai Binh, the average amount of capital and labor per hectare in a year were 6.53 million VND and 11,990 hours respectively.

In next part, the study is investigating the sources of the efficiency in rice production which would explain the difference between the capacities of capturing maximum output by farm households in the sample.

3.6.2 Determinants of Technical Efficiency

For the factor determinants, five models are designed to catch up the effect of an individual factor as well as the interaction among explanatory variables. The chi-square statistics of five models are all significant at 5% level of significant, suggesting that the all the independent variables in all five model appropriately jointly explain the dependent variable. Table 3.4

displays the coefficient estimates by maximum likelihood estimator for technical efficiency determinants.

Model 1 is the baseline model and designed with nine variables. Among which, education of the household head is represented by schooling years. The result came out that size of households, its location, labor intensive and irrigation significantly influence technical efficiency whereas age, gender and education of household head, the number of crops, and capital to land ratio statistically does not effect on technical efficiency. In Model 2, the level of education of household head replaces the number of schooling years in representing the quality of labor. However, this replacement does not show any significant relation between education of household head and level of technical efficiency rice-farming households obtained.

Table 3.4: Parameter Estimates of Technical Efficiency Determinants; Dependent Variable: Technical Efficiency

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Size	0.017**	0.017**	0.019**	0.018**	0.018**
	(0.008)	*(0.008)*	*(0.008)*	*(0.008)*	*(0.08)*
Gender	-0.29	-0.27	-0.031	-0.028	-0.030
	(0.026)	*(0.026)*	*(0.026)*	*(0.026)*	*(0.026)*
Age	0.0002	0.00007	-9.26e-0.6	-9.26e-0.6	0.0002
	(0.0009)	*(0.0009)*	*(0.0009)*	*(0.0009)*	*(0.0009)*
School attendance	0.001		0.008		0.001
	(0.004)		*(0.006)*		*(0.004)*
Region	0.055**	0.056*	0.150**	0.088**	0.033
	(0.021)	*(0.021)*	*(0.068)*	*(0.044)*	*(0.049)*
Diversification	0.007	0.007	0.008	0.007	0.0007
	(0.011)	*(0.011)*	*(0.011)*	*(0.011)*	*(0.017)*
Mechanization	0.028	0.028	0.033	0.032	0.028
	(0.029)	*(0.028)*	*(0.029)*	*(0.029)*	*(0.029)*
Labor intensive	-0.018**	-0.018**	-0.019**	-0.019**	-0.018**
	(0.008)	*(0.008)*	*(0.008)*	*(0.008)*	*(0.008)*
Irrigation	0.056**	0.056**	0.056**	0.057**	0.056**
	(0.027)	*(0.027)*	*(0.027)*	*(0.027)*	*(0.027)*
Education Level		0.0006		0.011	
		(0.010)		*(0.015)*	
School*Region			-0.011		
			(0.008)		
Education Level*Region				-0.017	
				(0.020)	
Diversification*Region					0.011
					(0.022)
Intercept	0.056*	0.608*	0.546*	0.591*	0.607*
	(0.082)	*(0.073)*	*(0.088)*	*(0.076)*	*(0.085)*
LR Chi-square	18.50**	18.40**	20.67**	19.10**	18.75**
Log likelihood	115.493	115.493	116.573	115.790	115.61
	0.132	0.132	0.131	0.132	0.132
Sigma	*(0.007)*	*(0.007)*	*(0.007)*	*(0.007)*	*(0.007)*
Observation	207	207	207	207	207

, **, *: The coefficient is significant at 1%, 5%, and 10% significance level. The standard error is in the parentheses.*

For the demography, the size of household is significantly and positively 5% significance level in all five models. An additional individual of a family will gain 0.017 (Model 1) units technical score for rice-farming households, *ceteris paribus*. Since rice production in Vietnam still depends on labor, family labor is the valuable input for producing process. In the sample, each rice-farming household has average 2 family labor involving rice production. Moreover, a farm household with more members tends to generate more off-farm income which can be used to pay the loan or hire equipment for rice production process (Abebe, 2014).

Irrigation is the factor which highly associated with rice yield (Barker, 1985). In all five models, having modern irrigation for rice land area shows a consistent and positive impact on technical efficiency at 5% level of significant. When we keep all other factors constant, irrigated rice land area produces 0.056 units of technical score (Model 1). This result is in line with finding from Khai & Yabe (2011) where having modern irrigation contributes to technical efficiency by 0.084 units. In practice, irrigation is one mechanized step in rice production (Barker, 1985). Haiphong and Thai Binh is two areas which almost have modern irrigation in rice production. 95% of rice land area in Haiphong is irrigated while the ratio of mechanization in land preparation and transportation are 100% and 90% respectively (DARDH, 2015). For rice farmers in Thai Binh, land preparation and post-harvested threshing are completely mechanized while

90% of rice land areas are applied modern irrigation (Department of Agriculture and Rural Development of Thai Binh province, 2015).

For geographic characteristic of households, there exists the difference in technical efficiency of rice-farming households related to their location as expected. The coefficient of households' location is statistically different from zero at 1% of significance level in Model 2, while it is significant at 5% level of significant in Model 1, 3 and 4. *Ceteris paribus*, there is an increase by 0.055 (Model 1) units of technical efficiency if rice-farming household is located in Thai Binh province. In comparison with other causal factors, farm location often has more impact on technical efficiency since its coefficient is higher than others'. Even in Model 3, rice-farming households located in Thai Binh province have 0.150 units of technical efficiency more than those in Haiphong city. Similarly, Kompas (2004) and Hoang Linh (2007) also confirmed the impact of location on rice farm technical efficiency in their study. However, the null hypothesis of the coefficient of area's effect is different from zero cannot be rejected in Model 5 at 5% level of significant.

The quality of labor measured by the years of school of household head and level of their education does not show a consistent impact on household technical efficiency. The schooling years' coefficient is not significantly different from zero in Model 1, 3 and 5 at 5% significance level. It is predicted that schooling year would have relation with rice-farming household's location. Therefore, the interacting variable between schooling year and area's effect is created and added to Model 3. However, the coefficient of this interaction term also is not significantly different from zero at 5% significance level. Even though Chi & Yamada (2005) could not find evident of impact from the education of household head on technical efficiency, Hung (2005) and Khai & Yabe (2011) statistically proved the positive relation between education and household technical efficiency. Besides that, even though the interacted term between area's effect and level of household head's education as well as the number of crops are generated, these terms are not significant at 5% significance level in Model 4 and 5. It suggests that diversification and level of education have no impact on rice-farming households in the sample as well. These results emphasize that education and crop diversification would not be the causal factors which explain the difference in technical efficiency among rice-farming households in two areas.

Another index for input is Labor intensive which negatively associates with household technical efficiency in all five models at 5% level of significant. An increase in the ratio of labor to land results in a decrease of technical efficiency by 0.018 units, *ceteris paribus*. This finding is opposite with Khai & Yabe (2011) where the labor intensive was found in positive relation with technical efficiency in rice production. The negative influence reflects the inefficient of labor in rice production. In Haiphong, the city government has launched the policy of changing using purpose of rice land areas which results in the decrease of rice land areas. However, the rural labor that used to work in rice production has not been observed in other agricultural activities as well as other sectors due to lack of skills. Therefore, the surplus labor in rice production may cause the technical efficiency in rice production (gsneu.edu.vn, 2011).

3.7 Conclusion

This study has tried to investigate the relation of household's location on technical efficiency of rice-farming households in Haiphong and Thai Binh province. Based on cross-sectional data at farm-level, this study utilized the stochastic frontier approach to estimate the household technical efficiency as well as investigate its determinants. The Cobb-Douglas form is the appropriate production form for this dataset. Four factor inputs KLMN positively associate with rice value at 1% level of significant. Among them, Land has the largest influence on rice value, followed by Material, Capital, and Labor. The Wald test confirmed that there is no constant return to scale and exists possibility of decreasing return to scale among rice-farming households in Haiphong and Thai Binh.

The Cobb-Douglas form of the stochastic frontier production function with the assumption of exponential distribution confirmed the existence of inefficient error term. The household technical efficiency is estimated in the range from 0.072 to 1 with an average mean of 0.756, suggesting that rice-farming households in Haiphong and Thai Binh produce at 75.60% of their potential output. These estimates are in line with other previous studies about technical efficiency in rice production in Vietnam and indicate that rice-farming households in Haiphong and Thai Binh capture the lower level of technical efficiency compare to national and regional level. Between two areas, rice farmers in Haiphong have the technical efficiency of 0.724 while those in Thai Binh obtain higher level at 0.769. The one-sample t-test confirmed the difference of two mean technical efficiencies between two areas, implying that rice farmers in Haiphong is are less technically efficient than those in Thai Binh.

The demographic, geographic, educational, crop diversified, and input's quality variables are generated to cover the socioeconomics characteristic of rice-farming households in the sample. Maximum likelihood estimator is applied in Tobit regression model to examine impacts of these factors. The estimation result shows that *size* of households, households' *location* (area's effect) as well as having inner-field *irrigation* positively associate with household technical efficiency. Among them, households' location is the most significant influent factor to household technical efficiency, indicating that rice-farming households located in Thai Binh province gain more technical efficiency in rice production than those in Haiphong. However, this study has not found any relation between schooling years or level of education of the household heads and the household technical efficiency in rice production. The number of crops does not show any significant influence on rice farmers' performance as well. Moreover, the interacted term between location and schooling year, the level of education or the crop diversification similarly is not significant in the estimation, suggesting that the education level of households head and diversified crop may be not the explanatory factors for the difference in the technical efficiency between two areas.

In general, the technical efficiency of rice-farming households in Haiphong city varies from 0.072 to 1 while the minimum technical efficiency of rice farmers in Thai Binh is 0.442. It implies that even though rice-farming household in Haiphong would produce at high productivity, they still are less efficient in using technology than rice-farming households in Thai Binh – the agriculture-based area. The tendency of reducing the rice land area in Haiphong and transferring land use purpose toward higher economic efficient activities need further empirical studies as the reference for the decision-making process. The support policies in training for rural labor after changing using purpose of land rice also should be noticed by the city governments. The author hopes that further studies will continue to investigate the impacting factors of technical efficiency in Haiphong and Thai Binh province in the future.

CHAPTER 4

CONCLUSION

This thesis is set out to explore the concept of technical efficiency and has identified in the context of Vietnam the nature of rice production, then narrowed down to the case of Haiphong city and Thai Binh province. It is to examine the level of technical efficiency in rice production among rice-farming households in Haiphong and Thai Binh, Vietnam in the consideration of households' characteristics as well as the production scale of rice-farming families with the identified factor inputs including Capital, Labor, Material, and Land. Besides this thesis also has sought to find out whether rice-farming households located in the two areas achieved the different percentage of their potential rice values or not.

The chosen theoretical and empirical works on technical efficiency in agriculture production, especially in rice production in Vietnamese context provided a broad research background about the determinants of technical efficiency of the Vietnamese main staple crop. Following the literature review, this study sought to answer these four questions: (1) *What are the factor inputs of rice production among rice-farming households in Haiphong and Thai Binh?*; (2) *What is the level of technical efficiency among rice-farming households in Haiphong and Thai Binh?;* (3) *Is the* *difference in technical efficiency between rice-farming households which are located in Haiphong and those are in Thai Binh significant?*; (4) *What are factors which affect technical efficiency in rice-farming households in Haiphong and Thai Binh?*.

The main empirical findings are summarized within the respective practical chapter (*Chapter 3: Technical Efficiency in Rice Production in Haiphong City and Thai Binh Province, Vietnam*). This section will synthesize the finding in order to answer the four research questions.

Firstly, what are the factor inputs of rice production among rice-farming households in Haiphong and Thai Binh? For the factor inputs of rice production, Capital, Labor, Material, and Land were represented for all essential inputs with the corresponding elasticity to output 0.122%, 0.04%, 0.347% and 0.483%. Capital, defined as the expenditure on hiring assets, machines or transportations, reveals the replacement of equipment for labor powers. Labor seems to be a less productive input might due to the labor surplus in Haiphong and Thai Binh. Otherwise, the rice output of rice-farming households in Haiphong and Thai Binh predominantly depend on the use of land area and materials. Having larger land size for rice results in utilizing more seeding, seedling, fertilizers, pesticides, and so on, this leads to generate more rice value output.

Secondly, what is the level of technical efficiency among rice-farming households in Haiphong and Thai Binh? The level of technical efficiency of rice-farming households in Haiphong and Thai Binh is lower than the average level of rice farmers in Red River Delta. These farmers only produced at 75.6% of their potential output, suggesting that there is the possibility for rice farmers in these two areas to increase their productivity.

Thirdly, is the difference in technical efficiency between rice-farming households which are located in Haiphong and those are in Thai Binh significant? The rice farmers in Hai Phong city are less technically efficient than those in Thai Binh. The estimated technical efficiency level for rice farmers in Hai Phong and Thai Binh are 0.724 and 0.764, respectively. This difference raised the question of the role of location in farmers' efficiency.

Fourthly, what are factors which affect technical efficiency in rice-farming households in Haiphong and Thai Binh? The rice production is predicted under influence of rice-farming households' characteristics. The determinant's regression confirmed the effect of rice-farming households' location in their technical efficiency. Besides that, size of household associates with the level of technical efficiency via the ability of increasing family labor for rice production. Moreover, having inner-field irrigation also has positive influence on the rice value output. Even though Hung (2005) and Khai & Yabe (2011) emphasized the role of education in increasing technical efficiency of rice farmers, the regression, nonetheless, did not show the relationship between the household head's education level associated with the technical efficiency these households achieved.

This study attempts to contribute for the understanding about technical efficiency at farm-level in rice production in the context of Haiphong city and Thai Binh province. It is also expected to provide a useful econometric platform for policymakers in Haiphong and Thai Binh not only in rice production but also other agricultural productions as well.

Limitation of the Study

Despite the efforts of the author, this study would not exhaust the topic due to two following limitations. Firstly, the data utilized in this study is the national living standards survey data at farm-level which contained information about rice production; however, the number of rice-farming households in Haiphong and Thai Binh listed in VHLSS 2012 is quite small. Therefore, the sampled rice-farming households might not be representative of rice-farming households in Haiphong and Thai Binh.

In term of practice, since rice producing in Thai Binh is operated with higher and more comprehensive technology compare to in Haiphong city, policymakers in Thai Binh province emphasized the role of household head's education via enhancing technology adaptation ability of rice farmers which positively contributes to a higher level of technical efficiency. However, the descriptive statistic, as well as estimation of

Tobit regression model has not confirmed the expected result. The reason for it may be due to the small sample size of this study.

Policy Implication and Recommendation for Future Research

The agriculture policies in Haiphong and Thai Binh are toward mechanizing process. By increase the percentage of applying agricultural equipment in each stage of rice cultivation process, it is expected to increase the rice value output of rice farmers in both areas. Especially, supporting inner-field irrigation for farmers are also should be considered. In the consideration of economic efficiency of rice production, the policy of decreasing the rice land area which perform less productive and transform the using purpose into growing industrial plants or aquaculture while still ensure food security for local residents.

Moreover, the difference in the performance of rice farmers in Haiphong city and Thai Binh province still need more discussion. To design achievable policies, there is need for more case studies for the education background, training opportunity as well as the experience in rice production of rice-farming households in both city and commune level. By learning from Thai Binh case, the government city of Haiphong would apply feasible policies in rice production to raise their productivity in the future.

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APPENDICES

Appendix 1: Map of Red River Delta, Vietnam

Source: http://www.askviet.com/Map_of_Vietnam/

Appendix 2: Rice Cultivating Season in Red Delta River

	Season	Month	
		Growing	**Harvesting**
Main season	Winter-Spring	February, March	May, June
	Autumn-Winter	July, August	October, November
Non-main season	-	January, April	September, December

Source: Handbook of VHLSS 2012, page 72

Appendix 3: Correlation Matrix in Labor Input Construction

	Rice value	Family labor in person	Hired labor in monetary value	Labor
Rice value	1			
Family labor in person	0.135	1		
Hired labor in value	0.337*	-0.0898	1	
Labor	0.359**	0.2947*	0.0148	1

**: The correlation is significant at 5 % of significance level.*

Appendix 4: Correlation Matrix in Cobb-Douglas Model

	Rice value	Capital	Labor	Material	Land
Rice value	1				
Capital	0.8171*				
Labor	0.3591*	0.3435*	1		
Material	0.8817*	0.7996*	0.3671*	1	
Land	0.8587*	0.7955*	0.3161*	0.8571*	1

**: The correlation is significant at 5 % of significance level.*

Appendix 5: Summary Statistics of Sample and Perfect Technical Efficiency Rice-farming Households

	Sample	Perfect TE		
		5 rice HHs	Haiphong	Thai Binh
Rice value	13516.76	17604	21733	14851.33
Capital	1621.05	1294	2070	776.67
Labor	1712.28	1878.817	3001.615	1130.29
Material	3246.98	3436.4	3460	3421
Land	1713.81	1682.4	2106	1400
HH size	4	4	4	4
School	9	10	9	10
Age	52	54	49	57
Diversification	2	2	2	2
K/N	0.959	0.75	0.898	0.653
L/N	0.704	1.125	1.015	1.199