경제학 박사학위논문

미얀마 쌀 농가의 생산효율성 계측 및 효율성 요인 분석

전남대학교 대학원

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YU YU TUN

2013년 8월

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이 논문을 경제학 박사학위 논문으로 제출함

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Doctoral Dissertation

Measuring Production Efficiency and Identifying its Determinants in Myanmar Rice Farming

Department of Agricultural Economics
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August 2013

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A dissertation submitted in partial fulfillment of the requirements for the Doctor of Philosophy in Economics.

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Measuring Production Efficiency and Identifying its Determinants in Myanmar Rice Farming

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(ABSTRACT)

Rice farming in Myanmar is not only significant in the area of food security but also in rural employment, economy, biodiversity, cultural and traditional conservation. Therefore, improving the production efficiency in the rice industry has the same meaning of developing the Myanmar agricultural sector and the nation itself. The purpose of this study is to obtain a better understanding the current rice production conditions, production efficiency, and to find the ways to overcome the constraints faced by the farmers. This study focuses to measure the rice production efficiency of sample farmers by using non-parametric and parametric approaches, then to identifying the factors affecting the efficiency.

Data contains 195 sample farmers accounted for their summer paddy and monsoon paddy growing during 2012 in one of the major rice growing region Bogalay township in the Irrawaddy Delta region in

Myanmar. For non-parametric approach, data envelopment analysis and for parametric approach, stochastic frontier analysis with traslog production functional form are used. And then, comparing the efficiency and determinants factors on efficiency are carried out by using the variable return to scale results for both analysis. The average technical efficiency values are 63% with constant return to scale, and 69% with variable return to scale for non-parametric approach and 78% with variable return to scale for parametric approach, respectively.

Thereafter, the identifying determinant factors which influence the efficiency of the sample farmers are also discussed. The determinant variables included the age of the farm household or decision maker, the education level, off-farm income dummy variable, labor ratio, and the number of mechanical tools use in rice farming. Among these variables, education variables, labor ratio and mechanical tools are significantly related to the efficiency indexes in DEA while only education variables and mechanical tools are significantly associated in SFA. As a conclusion, in order to improve the rice production efficiency in Myanmar, it is essential to upgrade the basic infrastructure needs such as systematic education training programmes and application of the modernized mechanical tools in rice production. However, the efficient mechanical utilization in rice industry is accompanied with systematic land reclamation and consolidation.

Conversion table used in this study

Item	Basket	Pound	Kg
		2.205	1
Paddy	1	46	20.86
Milled rice	1	75	34.01
1 metric ton		2240	1000

1 hectare (ha)	2.471 acres
1 acre (ac)	0.405 hectare

Chapter1. Introduction

As all know, efficient production in agriculture is the basic foundation for all round development of a country. For Myanmar, rice is a major crop and it is essential for the basic development of agriculture sector through to improve the production efficiency. So this study is carried out to know and understand the production efficiency and the current situations of rice farms in Myanmar. In this chapter, the background of the study, objectives, problem statement and a brief outlines of the study are presented.

A. Background of the Study

Efficiency study is an important area of economic analysis and there are many applications of efficiency measures to evaluate the performance of decision making units in the last decades (Ajibefun, 2008). The production efficiency of a firm occurs when the economy is utilizing all of its resources efficiently. Measurement of technical efficiency is very useful to evaluate the relative performance of production units within the firms, to measure the causes of inefficiency which explores the sources of efficiency differentials, and finally to apply the sources of inefficiency in the basic foundation for the institution of public and private policies designed to improve performance. Efficiency study is based on a simple concept such as the relationship between the quantity of outputs and inputs used to generate in production. In order to obtain the efficient production not only for a firm but also for an industry, each firm should operate using best technological practice and managerial processes. Basically, a measurement of effectiveness and efficiency of a firm or an industry or an organization is done the ability of these firms whether to obtain maximum output in generating with the resources available. As a result, measurement of efficiency is very useful to evaluate the relative performance of production units within the firms, moreover it can measure the causes of inefficiency which explores the sources of efficiency differentials, and finally the results of the sources of inefficiency can apply in the basic foundation not only for the institution of public and private policies but even for a nation design to improve performance.

The efficiency analysis is not a recent topic of interest for economists, the pioneering work of Farrell (1957), a large amount of literature had been published on the measurement of frontier production functions and production efficiency. Within the common concept of a frontier production function, the empirical literatures that focus on frontier production have used two broadly defined approaches: the non-parametric programming approach commonly referred to as data envelopment analysis (Charnes et al. 1978) and the parametric stochastic frontier approach (Aigner et al. 1977).

There were several recent studies that have focused on the estimation and explanation of agricultural efficiency in most of the Asia developing countries, e.g. in India (Battese and Coelli 1992, 1995), Thailand (Krasachat 2000, 2003; Kiatpathomchai, 2008), Indonesia (Souires and Tabor 1991: Brazdik 2006), Pakistan (Shafiq and Rehman 2000; Javed et al. 2008), Bangladesh (Rahman, 2003), the Philippines (Villano and Fleming, 2004), and Vietnam (Tran et al. 1993; Huy, 2009; Khai and Yabe, 2011) etc. All of these studies pointed out substantial inefficiency and the possible potentials to improve the productivity of agricultural production. However, there has been limited empirical attention identifying the factors affecting improvement of rice production efficiency of Myanmar. There are many economic questions related to production efficiency of Myanmar rice farms which are still needed to be answered.

As an agriculture country, Myanmar possessed moderately natural resources which underpinned the production of agricultural products. Due to the various agro-ecological conditions and large land area of Myanmar, several agricultural products can be produced more abundantly compared to other neighboring countries. Among them, rice is the major crop for both economy and food security of the country. When looking back to the history, Myanmar stood as major rice exporter in the world, but this role became dull due to various reasons in the recent days. Still, rice is the most important crop for Myanmar agriculture which dominates the largest and most productive part of the country economy. Therefore, efficient rice production could give more income and export revenue. It will in turn allow Myanmar to make an essential step in reducing poverty, improving food security for all families, fostering a more dynamic rural sector and making agriculture as a dynamic contributor to the national economy. Surely, these outcomes will be achieved only after framing and execution of more effective policies, at the sectorial and national levels.

According to the 2010-2011 published data, agricultural sector contributed 13.7% of total export earnings and employs 61.2% of the labor force in Myanmar (DAP, 2012). At present, about 8 million hectares of rice were harvested annually in Myanmar. In 2012, production was proximately 29 million tons, of which about 0.7 million ton was exported (Myanmar agriculture at a glance, 2012). Figure 1.1 displayed the percentage share of GDP by Myanmar industry in 2010-2011. It can be seen that the agricultural sector contributed the highest proportion (about

37.8%) of the country's total GDP and followed by trade and manufacturing sector. Among the agriculture crops, rice production contributes the highest about 34% of total crop share. Total area of paddy was 8.1 million hectares, comprising 6.8 million hectares under monsoon paddy and 1.3 million hectares under summer paddy and average yield 3.9 metric ton per hectare in 2010-2011. These factors explained the importance of agriculture sector in the country's economy.

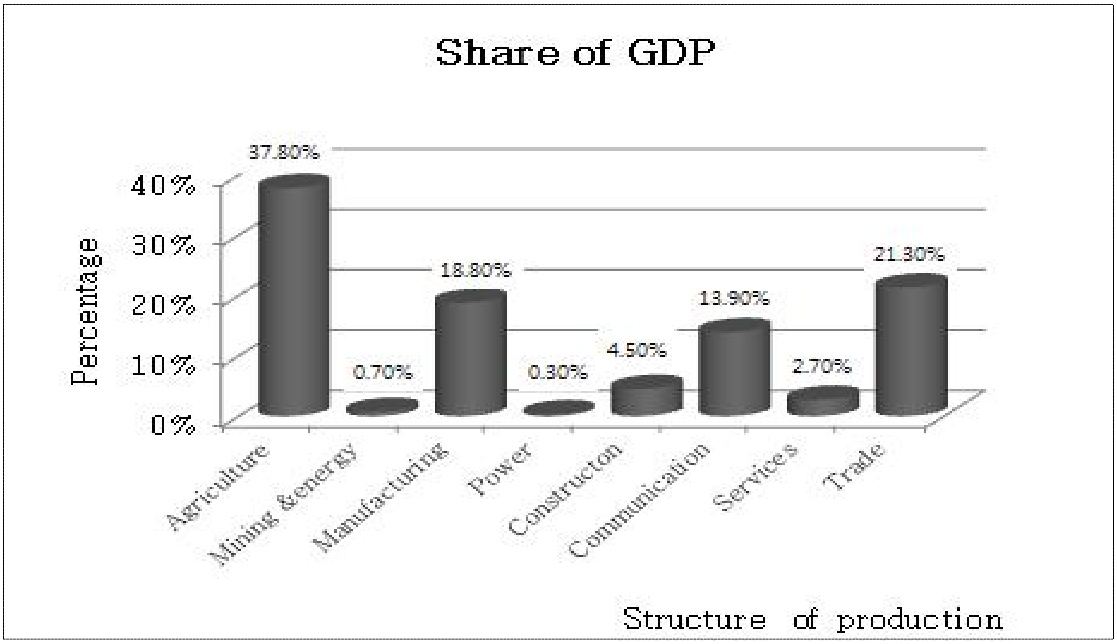

Figure 1.1 Share of GDP by Myanmar industry in 2010~2011

Myanmar's rice output must continually increase to feed the growing population and to boost the country's economy. Likewise, changes in rice productivity have a direct and profound influence on the entire population. Therefore, Myanmar agricultural sector needs to thrive well to increase the country's foreign exchange earnings from crop export as well as to supply foods for the growing population in future. For the development of agricultural production the Ministry of Agriculture and Irrigation (MOAI) is currently emphasizing the following key factors.

1) Creating profitable and sustainable markets for farmers
2) Utilization of good quality seeds in order to maintain high quality produces
3) Adoption of Good Agricultural Practices (GAP)
4) Proper utilization of agricultural inputs, and
5) Reduction of transactional costs along the supply chain

Based on these above factors, it is evident that Myanmar is going to agricultural development through increase productivity. Asides from these key factors, a developing country like Myanmar, a faster shift from the current transition state of self-sufficient and subsistence-oriented agriculture to a more commercially oriented agriculture by allocating crops and scheduling cropping patterns to fix the geographical and seasonal variations of different regions across the country is also needed to be considered by the policy makers. Therefore, this study is designed to contribute to a better understanding of the conditions required for production efficiency improvement of rice sector in Myanmar.

B. Objectives

In this study, the production efficiency will be measured by using the cross-sectional data of rice growing farmers in Myanmar through the two methods: non-parametric (Data Envelopment Analysis) and parametric (Stochastic Frontier Analysis) approaches. Aiming to improve the rice production in the agricultural sector, the overall goal of this study is to measure the production efficiency of the selected rice growing areas and subsequently to explore the determinant factors of production inefficiency of those farms through the use of these two approaches. Based on the results obtained, the policy makers can assess the conditions of rice producing farmers and their requirements. In turn, they can postulate the efficient and reliable policies and regulations in order to obtain the benefit of the rice farmers in Myanmar. In addition, this research can compare the pros and cons between the parametric and non-parametric approaches to the production frontier analysis. Within these frameworks, the specific objectives of the study are delineated as follow.

1) To describe the survey data used
2) To measure the different production efficiencies of sample rice farmers based on their present production technology
3) To identify the economy of scale efficiency and return to scale of the sample rice farmers
4) To examine the influence factors that can hinder the rice production efficiency, and
5) To compare the efficiency performance of productivity outcomes between the non-parametric and parametric and analysis.

The first objective can be done with descriptive analysis by analyzing the data obtained from the field survey visit of the selected individual rice growing farmers in Myanmar. The second objective is carried out by using theoretical models to estimate the production efficiency of sample rice farmers. Along with, the third objectives can be achieved by doing the second objective. Based on the results of the DEA measurement, scale efficiency and the conditions of return to scale of the selected farmers with their current production technology and resources allocation are obtained. Then, the fourth objective is achieved by means of second step regression analysis between the result of the efficiency index scores and the socioeconomic factors of the sample farmers. The fifth objective is realized by estimating the production efficiencies through the use of data envelopment analysis (non-parametric approach) and stochastic frontier production function (parametric approach) to the sample rice growing farmers.

C. The problem statement

Myanmar has a lot of potential to increase rice production from various points of view such as by improving rice yield on current production technology, by expanding the rice cultivation lands and by building and maintaining the irrigation system and infrastructures etc. Much of Myanmar possesses fertile and productive land where food production is unlikely to be limiting. But the impacts of high cost of crop production, low income/wage, declining purchasing power and limited social welfare management depress on non-food producer's access to and utilization of food in the country (Kyaw, 2009). The reasons of varying productivity and rice yield among regions and individual farmers are caused by the difference of agro-ecological zones and uneven used of agricultural inputs and skills. Additionally, the yield gap between the research stations and the farmers' fields is still wide and huge potential to increase the efficient productivity of the individual farmers is foreseeable.

Despite the continuous efforts that have been made by Myanmar government to increase agricultural productivity and economic development for farmers, rice production efficiency in Myanmar is still lagging behind than the neighboring Asia's rice producing countries. The efficient use of production inputs and technological innovation either independently or a combinations of both are necessary to achieve the efficient productivity in agriculture. In some developing countries likes Myanmar, most new agricultural technologies are only partially successful because these technologies need high production costs while the crop produce price remains very low. Furthermore, the present of institutional and cultural constraints resulting from the traditional agricultural system causes a negative impact for achieving the efficient production. Therefore, this study is expected to find out the reasons that hinder the productivity growth of rice farming in Myanmar.

Rice is not only important crop for economy but also for the daily energy requirement. In Myanmar as a whole, much of the population consumes rice in every meal. Rice accounted for more than 70% of the dietary energy requirement of Myanmar people. Therefore, changes in rice production have a direct and profound influence on the entire population. At present, the average yield, the amount of production, and the quantity of export are still low in comparing with the neighboring rice producing countries. Table 1.1 shows the comparison of paddy production in Myanmar and neighboring countries.

Productivity-driven growth in agriculture can have a strong positive impact on the rural non-farm economy through boosting demand for non-agricultural goods and by keeping food prices low (Kyaw, 2009). Accordingly, government needs to restructure and recapitalize to Myanmar agricultural sectors in various ways such as investments in rural area, agricultural infrastructure and establishment of institutions with qualified agricultural extension services. Undoubtedly, improving productivity in agriculture generates a virtuous cycle in which agriculture and off-farm income supports each other. Thus, low agricultural productivity is calling for an important issue to meet the demand of agricultural development policy in Myanmar.

Table 1.1 Paddy productions in Myanmar and neighboring countries (2009)

Country	Harvested area (million ha)	Yield (ton/ha)	Production (million ton)	Export ('000 ton)
World	158	4.3	685	26598
Asia	141	4.4	618	17927
Myanmar	8	4.1	33	666
Thailand	11	2.9	31	8620
Vietnam	7	5.2	39	3411
Indonesia	13	5.0	64	2.4
Malaysia	0.6	3.7	3	0.6
Philippines	5	3.6	16	0.2
Lao PDR	0.8	3.6	3	…
Cambodia	3	2.8	8	13.2
China	30	6.6	197	777
Bangladesh	11	4.2	48	5.2
India	42	3.2	134	2148

Source: DAP, Myanmar Agriculture in Brief, 2012. Note "…" is data unavailable.

In addition, increasing productivity is presently suppressed by the lack of adequate incentives. The state of incentives is such that it is unprofitable for farmers to undertake modernizing investments that would increase the productivity of agriculture (Kyi et al. 2000). The incentives for farmers include not only lower production cost but the reasonable high price for paddy. Another important factor that reduces the country rice production is the waste in the entire food system from production at the farm to final consumption which requires substantial improvement in post-harvest processing, transportation and storage system (Aung, 2011).

Based on the above various reasons, this paper can investigate the current production efficiency in rice production in Myanmar which is important to consider the efficient resources allocation among farmers. In order to march to a more developed nation, the basic foundation of improving the production efficiency is the major role for Myanmar agriculture, especially for rice industry. Coupled with the findings of the study, the policy makers can improve policy formulation for rice farmers in Myanmar agriculture while the government aims at alleviating poverty by increasing productivity-driven growth. The results can seek to improve the efficiency of selected rice industry and its prospects for achieving a higher level of growth and delivering prosperity to the Myanmar people.

D. Outline of the study

This study mainly focused on the production efficiency of selected rice farmers in Myanmar by using two kinds of efficiency measurement methods. The paper is organized as follow. Chapter 1 gives about some background information of the study. And also elucidates the research problem and objectives of the study. Chapter 2 provides the literature reviews related to the efficiency measurements including basic concept of the production efficiency and the usefulness. Again, the advantages and disadvantages of the two methods, the historical empirical studies of these two methods, and emphasized on the rice production efficiency measurements are described in this part.

Subsequently, the chapter 3 illustrates brief information of Myanmar and overview of the Myanmar rice economy which emphasis on the historical development and also the formation of rice policy copping with the respective government generations. Furthermore, the methods of rice production and the trend of rice production in Myanmar were also available in this section. Chapter 4 has been organized with the some facts about the survey area and briefly described contents of the data and consequently exhibited the analytical tools and techniques for measuring the production efficiency used in this study.

In chapter 5, the results of the study were expressed in detail. It deals with the related information about the socioeconomic characteristics of the sample farmers. As well as the outcomes of the measurement results were displayed in this portion. After all, the last chapter, chapter 6 has been discussed and suggested about the estimated outcomes of the rice production efficiency measurements and concluding remarks for the policy makers who can decide the efficient programs for farmers in near future.

Chapter2. Literature Review

In this chapter, the conceptual and measurements of productive efficiency, review of the non-parametric and parametric approaches are presented. After that, the literature reviews of empirical study emphasis on rice productivity on efficiency measurement with the respective parametric and non-parametric methods are followed.

A. Agricultural productivity: Concepts and measurements

Agricultural production is important for many reasons. Among them, providing more food for people is the basic reason and efficient production of farms affects the regions' growth and competitiveness, income distribution and saving, and labor migration etc. Therefore, agricultural production can affect from micro or household level up to macro or global level. If agricultural production in less developed nations is technically inefficiency, then an increase in agricultural output could be achieved by better utilizing existing resources (Fare et al., 1985).

Mundlak (1992) revealed that there are several important reasons for our interest in agricultural production: food supply, growth aspects, and competitive position of agriculture in the factor markets, off farm labor migration, intersectional flow of savings, farmers' income and more. The concept of efficient production calls for a comparison of changes in outputs and inputs, regardless of the actual method used in computing productivity. When the output obtained from a given set of inputs increases, we say that there is an improvement in production or more commonly, technical change. Thus, in order to evaluate changes in production empirically it is necessary to determine the change in inputs and outputs. Studying the sources of growth in agricultural production, examining the extend of inefficiency and identifying the sources of such inefficiency, is an important step forward to improve the likelihood of subsistence farm households in developing countries (Nisrane, 2011).

Coelli (1995) presented the difference between *efficiency* and *productivity*. These words often used interchangeable but they are not precisely the same. The firm in an industry is either efficient if it operates on their production frontier or the firm is not efficient if it operate under their production frontier. Productivity improvements can be achieved in two ways. One can improve the state of the technology by inventing new machines and equipment and alternatively the other/one can implement procedures such as improved farmers' education, to ensure farmers use existing technology more efficiently.

Farewell (1957) proposed that the efficiency of a firm consists of two components: *technical efficiency*, which reflects the ability of a firm to obtain maximal quantity outputs from a given set of inputs, and *allocative or price efficiency*, which reflects the ability of a firm to use the input in optimal proportions, based on their respective prices and production technology. Then, the overall economic efficiency can be obtained by combining these two measures which represent the use of resources so as to maximize the production of goods and services. A situation can be called economically efficient if no one can be made better off without making someone else worse off (Pareto efficiency), no additional output can be obtained without increasing the amount of inputs, and production proceeds at the lowest possible per-unit cost.

Basically there are two types of efficiency measures depending upon the output/input focus. These are input-oriented and output-oriented measures. The concept of input-oriented technical efficiency measurement is based on how much the input quantities can be proportionally reduced without changing the output quantities produced. Alternatively, output-oriented technical measurement is also based on how much the output quantities can be proportionally expanded without altering the input quantities used.

According to the Coelli (1995) a production function represents the maximum output attainable from a given set of inputs. And the two main benefits of estimating frontier functions are (i) estimation of an average function provides a picture of the shape of technology of an average firm, while the estimation of a frontier function will be most heavily influenced by the best performing firms and hence reflects the technology they are using, and (ii) the frontier function represents a best-practice technology against the efficiency of firms within the industry can be measured.

Three different types of economic models have been used to investigate production growth: (i) index numbers or growth according to techniques, (ii) econometrics estimation of production relationships, and (iii) non-parametric approaches. Each approach has different data requirements and has strengths and weaknesses (Zepeda, 2001). In this study, econometrics estimation or parametric approach and non-parametric approach are the two main techniques available for estimating production frontier of rice industry in Myanmar.

B. A review of non-parametric and parametric analysis

Farrell's (1957) described that measuring productive efficiency of an industry is important to both the economic theorists and the economic policy makers. If the theoretical arguments as to the relative efficiency of different economic systems are to be subjected to be empirical testing, it is essential to be able to make some actual measurements of efficiency. Equally, if economic planning is to concern itself with particular industries, it is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing other resources. This is the idea of Farrell's measuring the productive efficiency.

As non-parametric analysis, Data Envelopment Analysis (DEA) was applied in this study. It was first proposed by Charnes, Cooper, & Rhodes (CCR) in 1978. They extended Farrell's work by developing the fractional linear programming method of DEA which involves the use of linear programming method to construct a non-parametric piece-wise surface (or frontier) over the data (Coelli et al., 1998). Instead of trying to fit a regression plane, DEA is to identify a surface that envelops the data points as closely as possible without violating any assumed properties of the production technology (e.g. convexity). DEA is a relatively data oriented approach for evaluating the performance of Decision Making Units (DMUs). This method also optimizes on each individual observation with an objective of calculating a discrete piecewise frontier determined by the set of Pareto-efficient DMUs. The efficient DMUs lie on the frontier while the inefficient ones lie below the frontier. The inefficient DMUs can improve their performance to reach the efficient frontier by either decreasing their current input levels or increasing their current output levels (Seiford and Zhu, 2002). In DEA, there are a number of DMU and each producer is to take a set of inputs and produce a set of outputs. Each producer has a varying level of inputs and gives a varying level of outputs.

Recent years have seen a great variety of applications of DEA for use in evaluating the performances of many different kinds of entities engaged in different activities in many different contexts in many different countries (Cooper et al., 2011). Moreover, DEA is also used to measure the relative efficiency or performance of DMUs of both private profit organizations and non-profit organizations. DEA application in agricultural production has been shown an increasing trend over last ten years and it can be applied in multiple input-multiple output cases.

The advantages of DEA are noted that it can identify sources and amounts of inefficiency in each input and each output for each entity or farm, and identify the benchmark members of the efficient set used to effect these evaluations (Cooper et al., 2006). DEA approach may be the optimal choices in the cases of random influence are less of an issue, prices are difficult to define, and behavioral assumption, such as cost minimization or profit maximization, is difficult to justify (Coelli, 1998). The majority use of DEA is to calculate technical efficiency of DMUs, which required only quantity data of inputs and outputs (Lovell, 1993). In contrast with SFA, the linear programming technique of DEA does not impose any assumptions about functional form of the production frontier and it does not require any assumptions concerning the distribution of error terms and there are no statistical issues especially endogeneity. However, this method is also sensitive to mis-specification such as measurement error, outlier and exclusion of an important input or output.

Since DEA cannot take account of such statistical noise, the results may be biased if the production function is largely characterized by stochastic elements. But, it is characterized as a central tendency approach and it evaluates producers relative to an average producer. DEA compares individual producer with only the best producers therefore it is not always the right tool for a problem but is appropriate in certain cases.

It has been accepted that econometrics was estimating the average production function before the pioneering work of Farrell (1957) that has been given to the possibility of estimating so-called frontier functions, in an effort to bring the gap between theory and empirical work. The econometrics approach is stochastic and parametric. Continuing the Farrell works, Aigner, Lovell and Schdmidt (1977) and Meeusen and van den Broeck (1977) independently suggested a new approach to the estimation of Stochastic Frontier Analysis (SFA) function as a parametric analysis. Stochastic estimations incorporate the estimation of a stochastic production frontier, where the output of a firm is a function of a set of inputs, inefficiency, and random error. It is an analytical approach that utilizes econometrics (parametric) techniques whose models of production recognize technical inefficiency and the fact that random shocks beyond producers' control may affect the product. Differently from non-parametric approaches that assume deterministic frontiers, SFA allows for deviations from the frontier, whose error can be decomposed for adequate distinction between technical efficiency and random shocks (Constantin et al., 2009).

According to Coelli and Battese (1996), stochastic frontier production function approach has generally been preferred in agricultural economic literature. This is probably related to a number of factors. The assumption that all the deviations from the frontier are associated with inefficiency, as assume in DEA, is difficult to accept in SFA, given the inherent variability nature of agricultural production, due to weather, fires, pests and diseases etc. Furthermore, because many farms are small family-owned operations, the keeping of accurate records is not always a priority. Thus much available data on production are likely to be subjected to measurement errors. This approach has the advantage of being statistical and hence permitting the testing of reliability of the model estimated. It can measure the marginal contribution of each type inputs to aggregate output. Moreover, tests of hypotheses regarding the existence of inefficiency and also regarding the structure of the production technology can be performed in SFA (Coelli et al., 1998).

The main weakness of SFA are that the results may sensitive to the choice of approximating functional form and associated assumptions concerning error distribution, and the results may be unreliable if sample sizes are small (O'Donnell, 2011). The stochastic frontier approach is only well-organized for single-output technologies, unless one is willing to assume a cost-minimizing objective (Coelli et al., 1998).

C. Empirical studies on efficiency measurement with DEA and SFA

This section presents some empirical studies of the measurements efficiency of the production function especially for agricultural sector by using parametric and non-parametric approaches. Kwon and Lee (2004) did the empirical study using panel data spanning a 5-years period, 1993-1997 on Korea rice production by using both parametric and non-parametric production frontiers are estimated and compared with estimated productivity. The non-parametric approach employed based on

Malmquist index and Luenberger indicator, while the parametric approach applied the translog function with time-variant efficiency model. Data set on 1,026 randomly selected farmers and contained observations on one output (un-husked rice in kilogram) and six input variables (land, labor, capital, fertilizer, pesticide and other inputs). Their findings revealed that productivity measures differ considerable between these approaches. It is discovered that measures of efficiency change are more sensitive to the choice of the model than are measure of technical change. The period under analysis, the shift in the Korea rice production frontier has been a steadier source of productivity growth than the improvement in catching up with the frontier. Both approaches described the main sources of growth in Korea rice farming have been technical change and productivity improvements in regions of the country that had been associated with low efficiency.

Ajibefun (2008) compared the estimation abilities of the parametric and non-parametric techniques of frontier models in technical efficiency analyses. He used SFA for parametric and DEA for non-parametric approaches on 200 farmers who operating small scale food crops in Ondo State, Nigeria. Data collected on different outputs of farmers and inputs on land, labor, implement, fertilizer and seed and socioeconomic variables of decision-makers. Results of analysis indicated that the sample farmers have varying the level of technical efficiency, ranging from 22% to 87% for both techniques. Similarly, the results for both parametric and non-parametric techniques showed that age and education level have significant influence on the level of technical efficiency. Mean technical efficiency do not vary widely with the method used, though some differences in magnitude of individual technical efficiencies are noted for both techniques. This study concluded that a combination of the technical efficiency scores obtained from two methods is proposed as a better set of scores.

Huy (2009) investigated the technical efficiency of rice production households in Vietnam by using the DEA and SFA approaches. Data collected from 261 rice farming households in the Mekong Delta were used in the empirical analysis. Results showed that the average technical efficiency (TE) among the surveyed households was above 76% in both the Constant Return to Scale (CRS) and the Variable Returns to Scale (VRS). The average scale efficiency score for these rice producing households is nearly one. The determinants of the quantity of rice or yields and of the TE for the households are significantly related with some variables such as the plot size, seed, and hired labor cost. However, it can be seen that the technical inefficiency significantly depends on the farmers' farming experience and adoption of advanced farming practices.

Constantin et al. (2009) applied the Cobb-Douglas and Translog Stochastic Production Functions for parametric approach as well as the DEA with Malmquist index for non-parametric approach in order to estimate increases or decreases of inefficiency over time and the analysis of TFP sources change for the main Brazilian grain crops of beans, maize, soybeans, wheat and rice throughout the period from 2001 to 2006. Data has been gathered as output on total quantity produced, and inputs as harvested area for each crop annually, agricultural credit and agricultural limestone for the 26 States of the Federation and the Federal Districts, allowing for the creation of regional dummies for the comparative analysis of total factor productivity. In the result of Cobb-Douglas model, the greatest elasticity was in harvested area, followed by agricultural credit and limestone. The translog function found that there was an amelioration of agricultural productivity over time in a decreasing order, the Brazilian regions that have presented the greatest relative degree of efficiency are the Northeast, North, Southeast, South and Center-West regions. Although, there had been positive change exist in TFP for the sample analyzed, a decline in the use of technology has been evidenced for all grain crops which is observed a historical downfall in the use of inputs in Brazilian agriculture.

Ajetomobi (2009) compared the DEA and SFA (translog production function) to assess productivity growth of rice farming in Economic Community of West African States (ECOWAS). The data were taken from Food and Agriculture Organization Statistical (FAOSTAT) database and International Rice Research Institute (IRRI)'s world rice statistics. It covered a 45 year period (1961-2005) separated into pre-ECOWAS (1961-1978) and ECOWAS (1979-2005). For measuring productivity growth, both methods and their extensions to Malmquist index approach are used throughout the study. The results showed consistency between the approaches to the extent that: (1) there are potentials for efficiency improvements, but the magnitudes depend on the model applied and segmentation of the data set, (2) there has been a productivity improvement in the sector, in the interval 0.7–15% in the periods studied and (3) technical change has had the greatest impact on productivity, indicating that producers have a tendency to catch-up with the front runners. The average TFP in pre-ECOWAS period is larger than that of ECOWAS period. In both periods, productivity growth is sustained through technological progress. In general, policy makers should try not to be indifferent with respect to the approach used for productivity measurement as these may give different results.

D. Some studies on data envelopment analysis especially for rice

In this part, some empirical studies by using DEA approach related to the rice production efficiency in developing countries such as Southeast Asia and Africa are presented. Coelli et al. (2002) applied the efficiencies measure with non-parametric approach, DEA in Bangladesh rice cultivation. Data for 406 rice farms in 21 villages during the dry and wet seasons were involved. For the dry season, mean technical efficiency was 69.4%, allocative efficiency was 81.3%, cost efficiency was 56.2% and scale efficiency 94.9%. The wet season results are similar, but a few points lower. Allocative inefficiency is due to overuse of labor, suggesting population pressure, and of fertilizer, where recommended rates may warrant revision. Second-stage regressions show that large families are more inefficient, whereas farmers with better access to input markets, and those who do less off-farm work, tend to be more efficient. The information on the sources of inter-farm performance differentials could be used by the extension agents to help inefficient farmers.

Dhungnana (2004) measured the economic inefficiency of a sample of 76 Nepalese rice farmers by using DEA. A two-step methodology of DEA is used to model efficiencies as an explicit function of discretionary variables and farm specific variables of socioeconomic characteristics' of farmers are used in a tobit regression to explain variations in measured inefficiencies. The efficiency results displayed average relative economic, allocative, technical, pure technical and scale inefficiencies as 34%, 13%, 24%, 18% and 7%, respectively. The significant variations in the level inefficiency across sample farms are attributed to the variations in the 'use intensities' of resources such as seed, labor, fertilizers and mechanical power. In addition, a second stage Tobit regression showed the variation was also related to farm-specific attributes such as the farmers' level if risk attitude, the farm manager's gender, age, educational and family labor endowment

Kiatpathomchai (2008) assessed the economic and environmental efficiency of rice production by using DEA in his PhD dissertation. The totals of 247 rice farm household samples were randomly selected from the main rice farming area in Southern Thailand. Two-stage DEA methodology of efficiency analysis was focused, first, calculating efficiency scores from input-oriented DEA model and then these efficiency scores were used as dependent variables in the second stage by using the tobit regression technique. The empirical results showed that 17%, 2%, and 2% of the sample farms were on the technical, economic, and environmental efficiency frontiers, respectively and the average technical, economic, and environmental inefficiency were 14%, 32%, and 46%, respectively. Moreover, the common significant variables affecting the efficiency were soil type and rice variety. To improve the efficiency of rice farms, therefore, soil quality testing which help to improve soil quality and efficiency use of chemical fertilizers is urgent needed to implement while the research on new technologies: new suitable rice variety and new fertilizer products are considered as long-term policy implementation.

Abu (2011) employed an output-oriented DEA approach to evaluate the impact of fertilizer usage on the technical efficiency of rice farms in Nigeria. Data for this analysis from a cross sectional survey of 200 rice farms contained output as rice production (kg/ha) and five inputs; representing farm size, cost of labor, cost of fertilizer, cost of seeds, and cost of pesticides, respectively. Results suggested that rice farms with fertilizer could expand output potentially by 74% and 61% under constant returns to scale and 77% and 66% under variable returns to scale for rice farms without fertilizer. This can be achieved without altering the quantities of inputs used. Furthermore, the corresponding average scale efficiency of 77% and 79% for rice farms with and without fertilizer respectively suggests that by operating on an optimal scale, a further increase in output can be realized beyond the projected values by as much as 23% and 21% correspondingly. Thus, rice farmers should be encouraged to adopt optimum fertilizer rate in accomplished through education, proper execution of fertilizer price subsidy as well as early distribution of fertilizer to farmers.

Kang and Tun (2012) examined the determinants affecting productive efficiency of rice farmers in a selected area of Myanmar. The data on a total of 54 samples farmers from one of the major rice growing area from Bago Township in Myanmar were collected. Information about the rice production at the farm level and socioeconomic characteristic of the household were involved. The efficiency measures are obtained from non-parametric DEA model using primal production data and especially, this study used a model of DEA bootstrap producer to calculate confidence intervals which correct biases driven by measurement error in the data. In the first stage, bootstrapped DEA-VRS model is employed to estimate the technical efficiency and in the second stage, the bootstrap DEA scores are regressed against a set of farm specific variables using truncated regression analysis. The average efficiency measured by bootstrapping DEA is about 67% and measured by the DEA is approximately 80%. The regression results showed that farm size, share of family labor and modernized farm mechanization positively and significantly influence on the technical efficiency of sample farms.

Okeke et al. (2012) examined the technical and scale efficiencies of irrigated and rain fed rice farmers in Nigeria by using the DEA approach under VRS. Total of 150 observations were randomly selected from the sample areas with structural questionnaires. The mean technical efficiency VRS score of 77.6% and 58.82% for irrigated and rain fed farms, respectively, indicated a significant scope for a reduction in input usage by about 23.40% and 41.18% for the two farm category while maintaining the same output levels. Also, the corresponding scale efficiency of 95.01% and 89.66% for irrigated and rain fed farms respectively suggests that by operating on an optimal scale, a further reduction in input usage by as much as 4.99% and 10.34% is possible for irrigated and rain fed farms respectively. Results indicated that irrigated rice farmers were more efficient in resources utilization. Rice farmers' education level should be improved to enable them take advantage of modern agricultural techniques for improved productivity.

E. Some studies on stochastic frontier approach especially for rice

There have been considerable researches to extend and apply the SFA in the efficiency measurement of various fields. Furthermore, many applications of frontier production functions can be found to agricultural industry over years. This section presents the empirical studies of efficiency measurements related to the agricultural sector especially for rice production. Battese & Coelli (1995) studied the technical inefficiency effects of paddy farmers in India by using stochastic frontier production function with a two-stage approach. The first stage involved the specification and estimation of the SFA and prediction of the technical inefficiency effects and the second stage involved the specification of a regression model for the predicted technical inefficiency effects. A total of 125 observations on ten years period were collected. Data included the value of output and inputs concerning with rice production activities and socioeconomic characteristic of the decision makers of the farm. In the first stage, SFA can be viewed as a linear version of the logarithm of Cobb-Douglas production function in terms of the original production values and then the technical inefficiency effects are assumed to be a function of a set of explanatory variables associated with technical inefficiency of production firms which can be estimated in the second stage equation. The results indicated that the model for the technical inefficiency effects, involving age and schooling of farmers and year of observation, is a significant component in the SFA. The null hypotheses, that the inefficiency effects are not stochastic or do not depend on the farmers specific variables and time observation, are rejected for these data.

Kyi and Oppen (1999) investigated the technical efficiency on irrigated rice farms in Myanmar by using SFA with both Cobb-Douglas and Translog production functions. Taking the cross-sectional data about 162 farms during 1997 crop season was collected. Data included the yields obtained as output, the area grown, the used of inputs and information about social characteristics of sample farmers. The SFA models used in this study was originally based on the analysis of the panel data by Battese and Coelli (1995). In the case of cross-sectional data, the technical inefficiency model can only be estimated if the inefficiency effects are stochastic and have particular distribution properties. The study done based on different farm size groups and fertilizer utilization categories. The empirical results revealed that increase in technical efficiency depends on the increase seed rate used and more labor intensifying in farming activities of the irrigated sample rice farms.

Moreover, improvement of the human resource capacity and extension knowledge are required to increase the efficiency of rice farmers. In the case of technical inefficiency, the effects exist for large farmers who used fertilizer and small and large farmers who do not use fertilizer.

Thiruchelvam (2005) focused on the efficiency issues relating to productivity and the potential to reduce cost of production in paddy in Sri Lanka. A total of 300 farmers were randomly selected from the two study districts in 2001. In this study, the maximum likelihood estimates for the parameters for stochastic frontier and inefficiency model were used. The secondary data analysis revealed that there was an increment in production and productivity of rice in the sample area but the nominal cost of production increased over time. Results from primary data indicated that about 16% and 21% of farmers were performing with a production efficiency of over 90% however more than half of the farmers had less than average yield (5 metric tons/ha). This study also showed the existence of management problem and hence training was required. This paper pointed out the small land holding, high post harvesting losses, and low output quality, high cost of production and poor participation in farmer organization activities had a significant influence in lower production efficiency of the sample districts.

Aung (2011) used a Cobb-Douglas production frontier function to investigate the efficiency of rice farmers in Myanmar. A total of 110 households cover information about rice production and marketing activities as well as household demographic characteristics were collected from the sample areas. The frequency distribution of the mean technical inefficiency is about 16% which indicated that 16% of potential maximum output is lost due to technical inefficiency in these sample areas. While

85% of the sample farms exhibit profit inefficiency of 20% or less, about 40% of the sample farms is found to exhibit technical inefficiency of 20% or less, showing that the technical inefficiency is much lower than the profit inefficiency. For the determinants of efficiency index education was positively and significantly related with the efficiency while the secondary crop production is negatively and significantly associated to the efficiency indexes of the sample area.

Khai and Yabe (2011) measured the technical efficiency of rice production and identified some determinants of technical efficiency of rice farmers in Vietnam. By using stochastic frontier analysis method in the Cobb-Douglas production function, 3,733 households were collected through the general statistics office in Vietnam with technical advice from the World Bank. In the second step, the tobit function with a dependent variable of technical efficiency was applied to determine factors that have an effect technical efficiency of Vietnamese rice farmers. The calculated average efficiency in the study was around 81.6%. This study demonstrated that the most important factors having positive impacts on technical efficiency levels are intensive labor in rice cultivation, irrigation and education. These play the important role in terms of efficiency score change, while agricultural policies did not help farmers cultivate rice more efficiency.

Rahman (2011) evaluated the determinants of switching to modern rice and its productivity in the case of Bangladesh rice producers. This study utilized the cross-sectional primary data of total 946 rice farms and it included 324 observations on traditional rice varieties and 622 observations of modern rice varieties. Two set of variables needed for this study: one for probit variety selection equation model and other for the stochastic production frontier model of translog form. Results displayed that adoption of modern rice varieties was higher in underdeveloped regions positively by the availability of irrigation and return from rice and negatively by a rise in labor wage. The result of SFA revealed that land, labor and irrigation were the significant determinants of modern rice varieties. The mean level of technical efficiency was 0.82 with decreasing returns to scale in modern rice varieties.

Chapter3. Overview of Myanmar Agriculture Sector

Based on the historical background, this part discusses the national statistical profiles, poverty and agricultural productivity, and the conditions related to the resources utilization in the agricultural sectors of Myanmar. Moreover, the overview of the Myanmar rice economy under the headings of historical development, major changes in policy, and methods of rice cultivation and trend of the rice production are also presented.

A. Some facts about Myanmar

Myanmar (formerly known as Burma) is geographically situated in South East Asia between latitudes 09° 32' N and 28°31' N and longitudes 92°10' E and 101°11' E. Myanmar is bordered on the north and northeast by China, on the east and southeast by Lao and Thailand, on the south by the Andaman Sea and the Bay of Bengal and on the west by Bangladesh and India, respectively.

According to the area, Myanmar is the largest mainland in South East Asia and the second largest area among ASEAN countries, which has a total area of 678,500 km^2. Myanmar is inhabited by many ethnic nationalities, as many as 135 national groups with bamas (ethnic Burmans) forming the largest group and comprising 70% of the total population. Figure3.1 showed the location of Myanmar in Asia continent. Published from the official data, the population was estimated about 60 million in 2011, with average growth rate round about 1% to 2% annually. Only one third of the population resides in urban areas and the rest are living in rural area with major economy of agriculture. In fact, agricultural sector serves a number of populations and creates food supply, food sufficiency, rural employment, and foreign income in Myanmar.

Figure 3.1 Location of Myanmar in Asia

Approximately 70% of the total population or 41 million of population are engaged in this sector. In the case of agricultural land, 18% or about 12 million hectares of the country areas are utilized to agricultural land with the average land holding of 0.23 hectares per household. In terms of foreign income, as mentioned in the previous section, agricultural commodities and products contributed 28% to the total export value. Table 3.1 showed some key indicators and economic indicators to estimate the Myanmar' socioeconomic condition contributing from 2005 up to 2010.

Table 3.1 Trend of socioeconomic key indicators of Myanmar

Key Indicators	2005	2006	2007	2008	2009	2010
Total population (million)	55.4	56.5	57.5	58.4	59.1	59.8
Population growth (%)	2.0	2.0	1.8	1.5	1.3	1.1
Rural population (% of total population)	70.6	70.1	69.5	69	68.5	67.9
Net sown area (million hectare)	10.9	11.04	11.7	11.88	11.98	12.02
Arable land (hectare per person)	0.22	0.22	0.23	0.23	0.23	…
Agriculture GDP (%)	46.7	43.9	43.3	40.3	38.1	36.4
Agricultural GDP (annual growth rate)	12.1	9.7	7.9	5.6	5.6	4.7
Shared of Agri. export (%)	30.5	29.9	26.5	25.7	27.9	23.9
Consumer price index (2005=100)	100	120	162	205.4	208.5	224.6
Annually inflation (%) (based on consumer price)	9.37	20	35.02	26.8	1.47	7.72
Per capita GDP (000' Kyat) (2005-2006 producers' prices)	222	246	271	293	320	350

Sources: Key indicators for Asia and Pacific2012 (ADB)| DAP, 2012(Ministry of Agriculture and Irrigation). Note: "…" is unavailable.

Agricultural sector has played a significant role in the Myanmar economy though its performance in terms of percentage of GDP has been shown the decreasing trend over the past years. It is accounted that agricultural sector shared 46.7 % of GDP in 2005 and followed by 43.9%, 38.1% and 36.4% in 2006, 2009, and 2010, respectively. Moreover, the share of agricultural export can be seen as a decreasing trend. Consumer price index, Inflation percentage and per capita GDP of the Myanmar economy are also presented in this table.

The climate of Myanmar is roughly divided into three seasons: summer, rainy and cold season. Generally, Myanmar enjoys a tropical monsoon climate while the climatic conditions differ widely from place to place based on different topographical situations. The average annual rainfall ranges from 5,000 millimeters in the coastal plains to 900 millimeters in the central basin. Average daily maximum temperatures ranges between 23 °C and 32 °C in the highlands of the Shan Plateau and 29 °C and 36 °C in Yangon (Rangoon) in the south.

Based on the agro-climatic conditions, the country is basically divided into four regions: namely, the Delta Region, the Coastal Region, the Central Dry Zone Region, and the Mountainous Region. The Delta Region is characterized by the highest population density, highest land productivity (mostly alluvial soil), moderately high rainfall, generally flat topography, and has excellent environment for growing rice. In contrast, the Central Dry Zone is characterized by the lowest annual rainfall, sandy soils, and the second highest population density. The Coastal Region has the smallest land area but has the highest annual rainfall, exceeding 4,000 mm per annum, and this region is highly suitable for growing perennial crops, such as date, coconut, palm oil and rubber etc. The mountainous region engross the largest land area characterized by dense forest accounted for about 34.4 million hectares or about half of the total land area supply with poor road infrastructure, and low population density (Swe, 2011). Based on the above various factors, it is not surprising that the major economy of the country is agriculture. This study is emphasized on the rice production in the Delta region which represents the rice production of the whole country.

B. Poverty and agricultural productivity

The socioeconomic development of a country and increased per capita income especially for the vulnerable group are essential to reduce hunger and malnutrition and to improve standard of living and social situation (Kyaw, 2009). In 2001, the Household Income and Expenditure Survey (HIES) in Myanmar estimated the poverty incidence of 20.7%, 28.4% and 26.6% for urban, rural and overall, respectively. The majority of poor are living mainly in remote and mountainous border areas and semi-arid zone in central part of the country, where agricultural productivity is unstable by adverse weather conditions and inaccessibility to markets.

Rice is the major source of the energy for Myanmar people because it contributes about 73% and 80% of the total daily dietary energy supply in urban and rural households, respectively (CSO, 2001). From the published data of FAOSTAT, Myanmar consumes the highest amount of rice (196 kg per year in 2003) among the Asian countries even though annual per capita consumption of rice has declined gradually since 1998. In addition, most of the people in Myanmar spend about 70% of their income on food, with a small proportion left for health care and education for their family. All these data reflected the people in Myanmar with a low level of the national economy, spend a high proportion of their incomes on food, and a high proportion of the labor force goes to the agricultural sector.

The prevalence of different agroecological zones within the country has enabled the growing of over more than 60 different crops in Myanmar's agriculture, among them, cereal crops remains the most important group with its area constituting more than 50% of the total crop sown area. And among cereal crops, rice as grown widely throughout the country claims a share of about 47% of the total crop sown area and is followed by oilseed crops as the most important next to cereals and with pulses and industrial crops ranking third and fourth respectively The country's recorded historical facts showed in combination with enormous natural resources explore the existence of Myanmar's great potential for rice production and export. However agricultural sector is still beset with low level of production which also leads to low income and investments.

Most of the agricultural activities are rural based and hence the importance of rural economy has been paid attention. For overall development in agricultural sector and for poverty alleviation, Myanmar still need to be equipped with advance modern technologies (including mechanization in farming activities) and the infrastructure development in many aspects.

C. Condition of resource utilization in agricultural sector

In Myanmar, one fourth of total land area is cultivable and according to the data of 2010-2011, the current net sown area was reached only about 18% of the land utilization. Besides, approximately 8% of the total land area is under cultivable waste land. It indicates that there is a potential to expand the area of crop production is possible. Alternately, land improvement can also be undertaken in the exiting agricultural land through proper drainage, irrigation, mechanization structures and farm road facilities etc. Apart from the small-scale traditional cultivation, large and modernized agricultural farming is also important. Therefore, Myanmar government welcomes and encourages the involvement of private organizations in agricultural sectors.

Provision of sufficient irrigation water takes an important role for increasing crop production efficiency. At present, about 6% of the total water resources or about 870 million acres feet per annum are being utilized annually. In 2010-2011, the total net sown area reached up to 13.75 million hectares including the double cropping acreage in which 2.29 million hectare were irrigated which is represented about 16.7% of the total sown area. Both government and NGOs granted projects and irrigation dams, river pumping irrigation stations, exploration of tube wells for underground water were established. In order to increase the crop productivity in terms of yield per unit, efficient irrigation system for farmers is important requirement of the country.

Myanmar has been exploring the use of farm machinery for crop cultivation instead of traditional drought cattle and manpower. However, the effort has not been entirely successful due to luck of skill and experience. Continuous increasing the productivity and cropping intensity needed the efficient utilization of machineries in farming from land preparation to harvesting and post harvesting activities. After independent, the government implemented agriculture mechanization schemes involving the distribution of farm machinery to farmers. Even though the required machineries are being produced and assembled locally or imported the farm mechanization sector, it is not reached the required level. The following table 2.2 describes the current utilization of farm machineries in Myanmar in the period of 2011-2012.

High-yielding varieties and improving the quality seed production include the main purposes of Ministry of Agriculture and Irrigation (MOAI). Although the high yielding varieties HYV's in the 1977-1978 was introduced to increase production, the average grain yield was stagnated round about 3 ton per hectare. In 1992, summer paddy was introduced with irrigated water and fertilizer which results the increase in average yield. Now, Myanmar is going to the market-oriented economy and also capture the rice exporting country, therefore the role of good quality seed is an important task for these policy oriented purposes. Both government and NGOs are now driving this quality seeds utilization to farmers in Myanmar.

Table 3.2 Utilization of machineries and farm implements in Myanmar (2011-2012)

Types of Machinery	Number
Tractors	12,625
Power tailor	188,500
Mono wheel tractor	6,296
Cultivating roller boar	4,372
Threshing machine	38,384
Seeder	46,354
Harvester	3,220
Combine harvester	200
Water pump	178,424

Source: DAP, "Myanmar Agriculture in Brief, 2012", (MOAI).

It is estimated that about 80% of total supply of chemical fertilizers used for paddy production in Myanmar. Before market-oriented policy, the government had distributed the chemical fertilizers to farmers with a subsidy price and contract quota of rice buying from farmers. After the late 1980s, the price of fertilizer increased sharply even though the government subsidy price is low. Beyond the 1990s, the government was obliged to withdraw these subsidies and distribution of fertilizer shrank considerably up to 2005. At present, fertilizer markets become liberalized. Changes in diesel oil supply have also influence paddy cultivation in Myanmar. Similar to the case of fertilizer, most of the diesel oil is imported and domestic price is reflected by the export price and currency exchange. In order to support summer paddy production, the government has been provided diesel at a low cost to farmers who cultivate the summer paddy. Production of summer paddy with intensive care is also the alternative way to improve the rice production efficiency.

D. Overview of Myanmar rice economy

1) Historical development of rice production

Myanmar was the dominant rice exporting country in the world during the first half of this century accounting for nearly three-fourths of the world rice export share. Production was severely disrupted by World War II. Thereafter, Myanmar's exports became less dependable under intervention policies of the new independent government. Thailand rapidly emerged as the dominant world rice exporter while Myanmar's position collapsed because of restricted conditions on output, inferior quality and uncompetitive prices (Young et al., 1998).

As rice is the country's staple food and a great majority of the population in the rice industry, all governments in any agricultural policy aimed at economic development will have focus on rice. However, policy objectives and implementation methods differed from government to government (Win, 1991). Looking back to the past history of rice production in Myanmar, there were a lot of government interventions in rice production system since 1960s in order to maintain national food security of the country. It includes various rice procurement systems from farmers depending on the farmer's land area, rice yield and family size, various procurement prices relative to market prices, overinflating the Myanmar exchange rate causing rice exports to be over priced and a serious shortage of foreign exchange to import inputs and using various forms of persuasion to increase rice production (such as providing special subsidies for rice farmers).

The major economic changes including significant implications on Myanmar agriculture as the drastic political and economic transitions occurred in the later part of 1988. Since 1988 when the economic system of the country shifted from a centrally planned economy to a market-oriented economy, agricultural production was revitalized again. The government had introduced the market-oriented economic system and allowed farmers to cultivate crops in accordance with their choice except paddy production. However, there was still purchase from farmers under a quota system which went to government employees, police, army, hospitals, and other social welfare institutions at subsidized price as rationing system and the rest of the quota was for exports.

Starting from year 2003-2004 cropping season, the government abolished the low price procurement system on rice. After 2003, government adopted new rice trading policy for liberalizing the rice market. However, government cancelled this liberalization after six months to be stable in domestic rice market. Rice export was again permitted to a limited amount of companies in 2007. Because of permission for rice export licenses are granted to few members of traders, price incentive for producers was unstable. Although regional market price showed increasing trend from 2001, the farm gate price for producers are still low due to various reasons such as financial difficulties of farmers and low quality of paddy caused by inadequate, insufficient, and inefficacy storage facilities etc.

Important changes had occurred since May 2010. A new government had assumed control; in an atmosphere of anticipation and some excitement, new and potentially effective policies were being discussed and developed (Dapice et al., 2011) Agricultural efficiency got emphasized attention in the light of market-orientated production and development policies. The new government encouraged the development of the private sectors in order to perform better by replacing the public sectors. Also government recognized the market power to control the price conditions.

2) Some major changes in Myanmar agricultural policy

Until the independent of Myanmar in 1948, Myanmar (Burma in the past) was a British colony. The colonial authorities promoted agriculture by developing the delta region with rice production in order to export to their country. During the 1950s, the capital of Rangoon was one of the commercial centers of Southeast Asia. But independence, democracy, and a free market economy failed to produce political stability or economic prosperity. In 1962, a military takeover the government led to socialism and central economic planning. Economic growth in Myanmar has lagged behind when comparing the other Southeast Asian countries, particularly during the period of increased government interventions from 1962 to 1988. At least, the United Nations declared the country a "Least Developed Nation" in 1987.

Since 1988, the centrally planned economy in Myanmar has been transformed into a more liberalized, market-oriented economic system with the introduction of some economic reforms (Young et al., 1998).

Table 3.3 Development of agricultural policies and major changes

Division of periodization	Major change conditions
(1885~1948): The British Colonial Government	- introduction Burma to rice export business - exchange of Burmese rice and industrial products in Britain - driving the Irrawaddy delta canal area under rice cultivation
(1948~1962): The Burmese Independent Government	- application of scientific methods to agriculture and raising rice exports to pre-war levels - market transactions and the rice buying from government systems (limited price) were going side by side
(1962~1988): The Central Planned Socialist Economy	- nationalization by government including agricultural land and private sector businesses - placing agriculture as a first priority policy in national economy - strongly emphasized on production of 42 major crops including rice
(1988~2011): The State Law and Order Restoration Council (SLORC)	- gradually reduction the role of government in buying and selling of rice - stated rice area expansion through the involvement of private sectors - combine system between nationalization of government dictatorship and market-oriented economy
(2011~at present): The Civil Government	- release the economic sanctions from US and EU nations due to the change route map to democratization - gradually reduce the relationship with China - government invited the foreign direct investment

Source: Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry, and Fisheries, *iPET*, (2012).

After 1988, free trade started to be allowed within the country for all crops, some crops were permitted to export except rice, and subsidy of chemical fertilizer and pesticides for rice farmers was eliminated in 1993-1994. In 2003, rice export will be allowed if there is a surplus of rice in the country and the private exporter must follow the guidelines set by Myanmar Rice Trading Leading Committee. Table 3.3 described the some major changes in the agricultural development policies set up the respective governments from 1885 to the present day.

3) Methods of rice cultivation in Myanmar

In Myanmar, rice production is heavily dependent on the monsoon rain yet some areas suffer from too much rain, other regions receive too little. The paddy fields are flooded occasionally, however most of the farmers rely on the monsoon season for the necessary water. The paddies have an "impermeable subsoil," on top of which is a saturated layer of mud, and lastly around 4-6 inches of water. Rice was traditionally grown once a year in the wet monsoon season and in some delta area doubles rice growing with HYV varieties or short-duration pulses were planted after rice harvest. Rice cultivation follows traditional methods using simple implements. It is labor-intensive, and cattle are the main source of animal power. Generally, rice cultivation starts with tillage operations in the nursery plot (usually one-tenth of the transplanted area). After the seedlings are planted, farmer remains to carry out tillage operations in the fields to be transplanted and usually transplanting is done, solely by women. In areas where soil fertility is poor, labor is scarce, seedlings are insufficient, and water control is lacking, broadcasting instead of transplanting is also practiced. Mostly rice is manually harvested by sickle and left in the field for 3 days for sun drying. The panicles are then bundled and carried to homesteads for threshing, which is done by allowing cattle to walk on the bundles. Finally, the threshed rice is winnowed, when the windy days.

Traditionally, rice cultivation methods in Myanmar are divided into two categories: dry upland and wet cultivation. The dry upland cultivation methods generally practiced on wooded hillsides are typical slash and burn methods used for subsistence production. The major rice-producing regions are in the delta, including Irrawaddy, Bago, Yangon, and Mon State. These four areas make up more than half of the monsoon crop. Myanmar's major rice ecosystems include rain-fed lowland rice, deep-water submerged rice, irrigated lowland rice, and rain-fed upland rice. The rain fed lowland area is the largest of total rice land. The irrigated lowland rice has been growing as summer paddy with the spread of small scale irrigation through low-lift water pumps. Rain fed lowland and deep-water submerged rice cultivation can be seen in delta region and coastal strip of Rakhine State. Irrigated lowlands are mainly in Mandalay, Sagaing, and Bago divisions. The upland area is mostly in Mandalay, Sagaing and Shan states respectively. The monsoon paddy starts to grow on June-August and harvest on November-January while the summer paddy began from November-December to April-May.

4) Trend of rice production in Myanmar

The cultivated area, average yield and estimated production from 1989 to 2012 are presented in figure 3.2. In 1990, sown area reached about 4.8 million hectors and after the introduction of summer paddy in 1992 the area expansion started to increase significantly but it was slightly decreased from 1996 to 1999. After 2000, there was a continuous increasing trend of rice sown area reached up to about 8 million hectares. It can be seen that sown area and production were significantly increased mostly due to area expansion but the yield per unit base was not much changed.

The figure also expressed a slightly increasing trend in the average rice yield during this period. The average yield of paddy was round about 3.4 tons per hectare during this period, only some years reached maximum up to 4 tons per hectare. Mostly, average yield for summer paddy yield reached approximately 4.6 tons per hectare while for the monsoon paddy got about 3.7 tons per hectare. However, this yield is still lower than the neighboring rice producing countries.

It can be seen that the trend of rice production in Myanmar decreased during 1995-1998, but then increased sharply in 1999 and again increased up to 2007 and then reached to a stable and a little decreasing in 2012. Again in table 2.4 also described the values of cultivated and harvested areas, yield, estimated production, and amount of export condition in Myanmar. Here, the quantity of rice export showed a dynamic fluctuated trend from year to year.

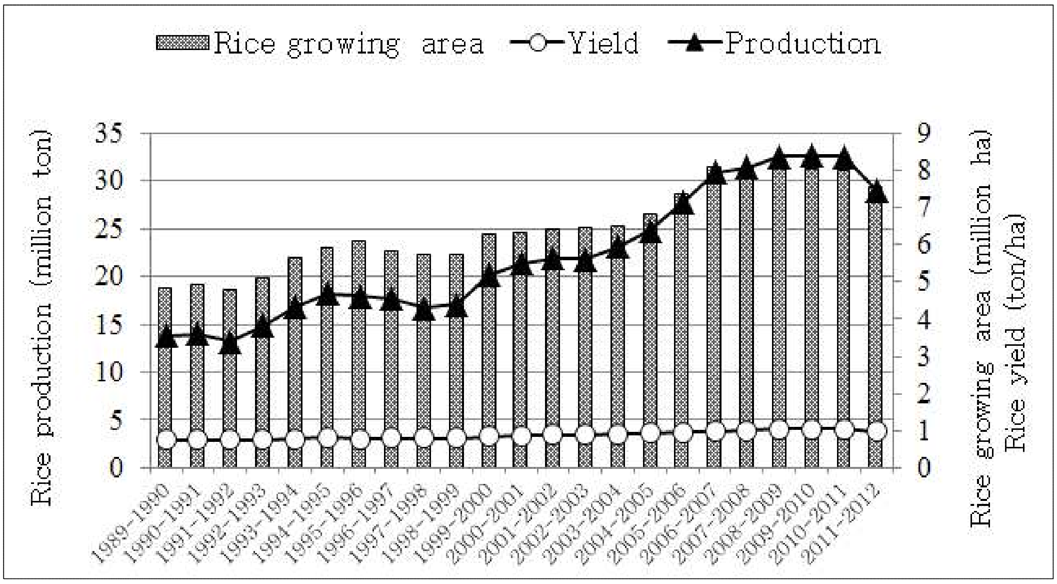

Figure 3.2 Trend of rice production in Myanmar (1989-2012)

Table 3.4 Paddy sown acreage, yield, production and export

Year	Sown area (million ha)	Harvested area (million ha)	Yield (ton/ha)	Production (million ton)	Export ('000 ton)
1989-1990	4.88	4.73	2.92	13.83	168
1990-1991	4.95	4.76	2.94	14.00	134
1991-1992	4.83	4.58	2.89	13.23	183
1992-1993	5.14	5.06	2.94	14.87	199
1993-1994	5.68	5.49	3.06	16.79	261
1994-1995	5.93	5.75	3.17	18.23	1041
1995-1996	6.14	6.03	3.08	17.99	354
1996-1997	5.88	5.77	3.07	17.71	93
1997-1998	5.79	5.41	3.08	16.69	28
1998-1999	5.76	5.46	3.13	17.08	120
1999-2000	6.29	6.21	3.25	21.17	55
2000-2001	6.36	6.30	3.38	21.32	251.4
2001-2002	6.45	6.42	3.42	21.96	939.2
2002-2003	6.49	6.38	3.43	21.81	793.5
2003-2004	6.55	6.53	3.54	23.14	168.5
2004-2005	6.86	6.81	3.64	24.75	182.2
2005-2006	7.39	7.38	3.75	27.68	180
2006-2007	8.13	8.07	3.84	30.92	71
2007-2008	8.09	8.01	3.92	31.45	358.5
2008-2009	8.09	8.08	4.03	32.57	666.4
2009-2010	8.07	8.05	4.06	32.68	818.1
2010-2011	8.04	8.01	4.07	32.58	536.4
2011-2012	7.59	7.57	3.83	29.01	707.2

Source: Central Statistical Organization, Myanmar Agricultural Service and Department of Agricultural Planning, MOAI, 2012.

Chapter4. Research Methodology

This section displays environmental features, the some general information regarding the study area and the methodology used in this study. About the study area, it includes detail facts of the location, nature of agriculture in this area and the contents about the data. In the part of methodology, basic concepts about efficiency measurement and followed by the two methods used in non-parametric and parametric approached are presented.

A. Profile and background facts of the selected study area

In Irrawaddy Division or Ayeyarwaddy Delta, rice is predominantly grown as a principle crop and which is also called the "granary of Myanmar". It lies at the southern end of the central plains of Myanmar and endowed with alluvial soil type which is favor for rice growing. It was dominated by monsoon climate of the tropical region with average annual rainfall about 2500 mm and average temperature is 32°C. Within the total population of 3.5 million people, approximately 80% of the families are primarily farmers, fishermen and farm labors engaged in Agriculture.

During 2011-2012, Irrawaddy delta contributed approximately 5 million acres of paddy cultivation; it is represented about 25% of the whole country total sown acreage. Rice growing in this area is characterized by monsoon paddy production where fresh water is available and summer paddy is produced as a second crop after monsoon. Figure 4.1 displayed the location of Irrawaddy division on Myanmar map.

Figure 4.1 Location of Irrawaddy Division on Myanmar map

Bogalay Township, one of the major rice growing regions of Myanmar, is selected as a sample survey area in this study and it is located in the Irrawaddy Division on the southern part of Myanmar. Bogalay is situated at latitude 16° 16′ 07″ N and longitude 95° 22′ 09″ E and it can be reached by water transportation and by land. So, this study could be reflected the average representative of Myanmar rice growing conditions. This area is also designated as main rice bowl of Myanmar because of its ideal location of the rice cultivation base on delta.

The total area of Bogalay is 2,250 km^2 with a population of 351,476 people and including total village-tracts of 71. Farming is given first priority as main source of income. Livestock and fisheries are also a major food source and second priority source of income for farmers in this area. Usually, paddy is the main crop in both monsoon and summer season and other second crops include black gram, green gram, and sunflower. Monsoon paddy started from the last week of June and harvested at November and December depending on the condition of varieties and weather. Most of the traditional varieties (e. g. famous variety: Paw-san-mew) with longer growing period were grown in this season. As a summer paddy farmers used to grow the varieties with short growing season mostly HYV carried out with irrigation and fertilizers applications. This season goes from March until June. According to the 2011-2012 growing season data, a little over 300,000 acres of monsoon paddy and about 90,000 acres of summer paddy were grown as the whole township.

1) Source and contents of the data

Data were collected from a cross sectional survey of rice-specific farmers in the township of Bogalay, Irrawaddy division, Myanmar in December, 2012. Twenty nine villages among fifth teen village-tracts were selected by simple random sampling because the population was heterogeneous with respect to different agro-ecological zones and farm size. The data gathered for the 2012 rice growing seasons including monsoon paddy and summer paddy productions.

The questionnaire was constructed to ask for details about rice production at the individual farms and they have similar level of rice production technology except various level of input used and management skill. In particular, there was interest in the area grown, the yields obtained, and the use of inputs, such as labors, fertilizer, seed, and pesticides etc. Information was also obtained on social characteristics of the sample farmers. Data on a total of 220 sample farmers of both summer and monsoon paddy production were obtained in the survey. However, to tackle the missing data problem only 195 sample farmers were taken into account in this study.

Secondary data were gathered from various sources such as books, journals, research reports, statistic reports which related to productivity and efficiency analysis, rice production, agricultural production, etc. In addition, data of regional, provincial and community levels were collected which give precise information for selecting the research areas. It includes agricultural areas, rice planted areas, number of agricultural households, number of rice farming households, demographical, social and economic characteristics in rice production in this region.

B. Efficiency measurement: Basic concept and model

Efficiency and productivity are two cooperating concepts. Efficiency of a firm usually means its success in producing as large as possible an output from a given set of inputs. Alternately, efficiency indicates how well an organization uses its resources to produce goods and services. Instead of defining the efficiency as the ratio of between outputs and inputs, it can describe as a distance between the quantity of input and output, and the quantity of input and output define a frontier. Production technology is the basic concept in measuring the efficiency of an industry. It can be described by using isoquants, production functions, cost functions and profit functions, respectively. Although these four models provide different tools for measuring efficiency, they constitute the same basic approach and their results are similar with each other.

The basic concept of efficiency measurement can be described as the following production set. Figure 4.2 represents a production curve or production frontier OF which may be used to define the relationship between the maximum outputs (Y) attainable from each input level (X). A firm said that technically efficient, if it will operate on this production frontier or if it will operate below the frontier, it is said to be technically inefficient. Therefore, in figure, a firm operating at point A is said to be inefficient because technically it could increase output and where operating at points B and C represent are efficient. So, the points along the production frontier define the efficient subset of the feasible production set.

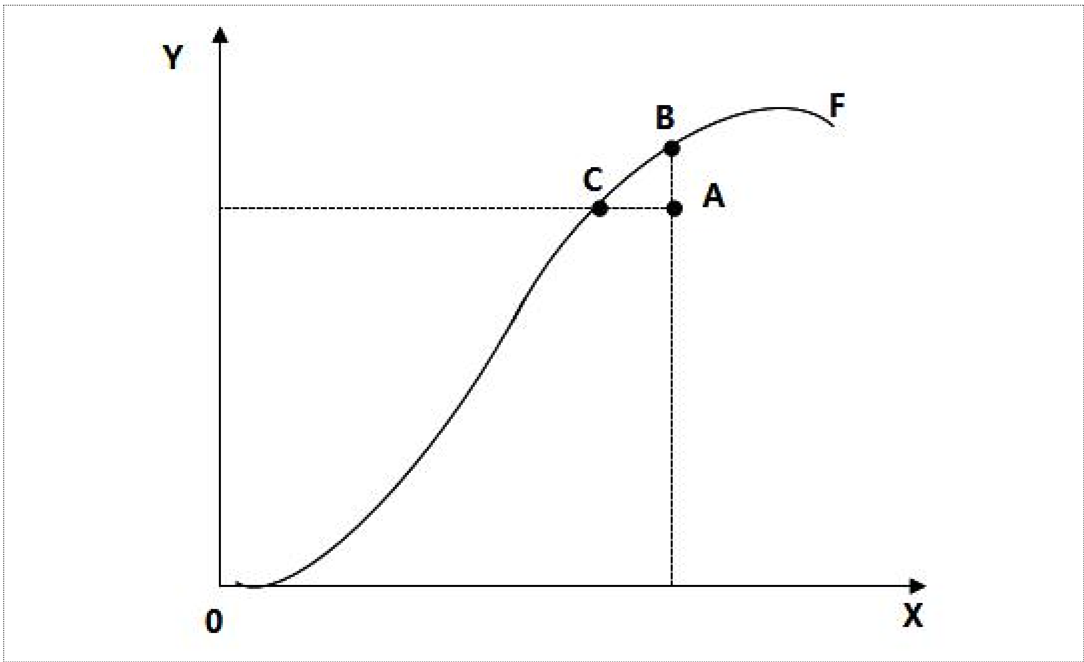

Figure 4.2 Production frontier and technical efficiency

(Source: Adapted from Tim Coelli et al., 1998)

To illustrate the distinction between technical efficiency and productivity, a ray was draw through the origin to measure productivity at a particular data point in figure 4.3. The slope of this ray is y/x and hence provides a measure of productivity. If the firm operating at point A were to move to the technically efficient point B, the slope of the ray would be greater, implying higher productivity at point B. However, by moving to the point C, the ray from the origin is at a tangent to the production frontier and hence defines the point of maximum possible productivity. This latter movement is an example of exploiting scale economies. The point C is the point of (technically) optimal scale. Operation at any other point on the production frontier results in lower productivity. It can be concluded that a firm may be technically efficient at C. Therefore, a firm may still be able to improve its productivity by exploiting scale economies from technically efficient point B up to point C. When considers a firm has increased its productivity through time, its represents not only the efficiency improvement alone, but involving the technical change due to advances in technology or exploiting the scale economies or the combination of these three factors. Due to the data limitation, this study cannot reflect the technical changes.

The two main benefits of estimating frontier functions, rather than average functions, are that: (a) the estimation of an average function will provide a picture of the shape of technology of an average firm, while the estimation of a frontier function will be most heavily influence by the best performing firms and hence reflect the technology they are using, and (b) the frontier function represents a best-practice technology against which the efficiency of firms within the industry can be measured (Coelli, 1995). Nevertheless, in reality, firms operate at less than the potential technical efficiency owing to incomplete knowledge of best technical practices or to other uncontrollable factors.

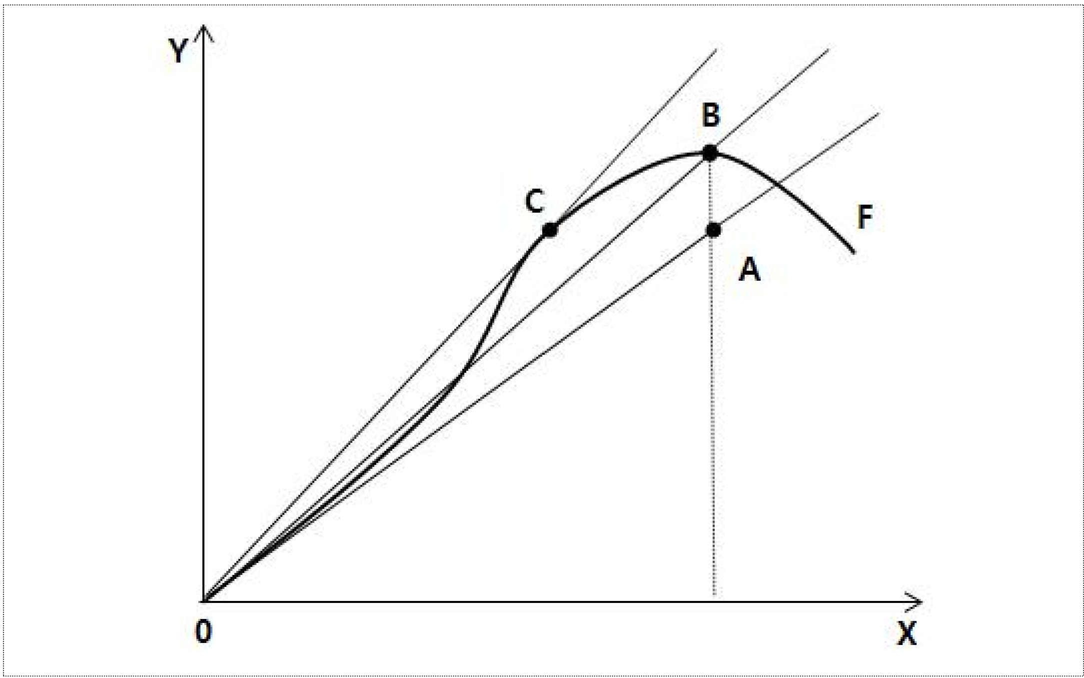

Figure 4.3 Productivity, technical efficiency and scale economies

(Source: Adapted from Coelli et al., 1998)

C. Non-parametric approach: Data envelopment analysis

In this study, Data Envelopment Analysis (DEA) technique was used to measure as a non-parametric analysis method of farm-level technical efficiency includes both summer and monsoon paddy of rice growing farmers in Myanmar. DEA identifies a "frontier" on which the relative performance of all utilities in the sample can be compared against the best producers. It can be characterized as an extreme point method that assumes that if a firm can produce a certain level of output utilizing specific input levels, another firm of equal scale should be capable of doing the same.

DEA was first introduced by Farrell (1957), as input and output-oriented technical measures. However, DEA did not receive wide attention until the paper presented by Charnes, Cooper & Rhodes CCR (1978). The simple model started that a firm using two inputs to produce a single output under constant returns to scale condition and then he generalized this model to the case of many inputs and outputs. Farrell (1957) proposed that the evaluation of farm (the decision-making unit or DMU) performance is usually based on economic efficiency, which is generally composed of two major components: technical efficiency and price or allocative efficiency as mention in the literature review. Unfortunately the detail price information is very difficult to obtain in this study and therefore, allocative efficiency has been omitted from the analysis as it is outside the scope of this study.

The basic DEA analysis requires two choices of formulation: choice of orientation and choice of envelopment surface. The choice of orientation or focus of analysis is possible as maximization of outputs or minimization of inputs or no orientation. The choice of envelopment surface is possible as CRS (conical hull) or VRS (convex hull) (Lovell, 1993). In addition, DEA analysis requires one solution of linear programming (LP) problem for each DMU; n DMUs need n solutions of LP problem. The outcomes of DEA analysis are efficiency scores, which represent as performance indicators: one is best performance and zero is worst performance (Kiatpathomchai, 2008).

Technical efficiency (TE) relates to the degree to which a farmer produces the maximum feasible output from a given bundle of inputs, or uses the minimum feasible amount of inputs to produce a given level of output. These two definitions of technical efficiency lead to what are known as output-oriented and input-oriented efficiency measures. These two measures of technical efficiency will coincide when the technology exhibits constant returns to scale, but are likely to differ, otherwise (Coelli et al., 2002). Also, technical efficiency of a firm obtained from CRS indicates whether the firm is operating at an optimal scale. The optimal weights are obtained by solving the following mathematical programming envelopment form.

$$
\begin{aligned}
&\text{Max}_{\Phi,\lambda}\Phi, \\
&\text{Subject to } -\Phi y_i + Y\lambda \geq 0 \\
&x_i - X\lambda \geq 0 \\
&\lambda \geq 0 \qquad (1)
\end{aligned}
$$

Here, there are assumed K inputs and M outputs for each of N farms. For the i^{th} firm, these are specified by the column vectors x_i, and y_i, respectively. The KxN input matrix, X, and the MxN output matrix, Y, represent for all N farms. Again, Φ is a scalar and λ is an Nx1 vector of constants. Where, $1 \leq \Phi < \infty$, and $\Phi - 1$ is the proportional increase in outputs for the i^{th} farm, while input quantities held constant. Note that $1/\Phi$ defines a TE score which varies between zero and one.

On the other hand, imperfect competition, constraints on finance, etc., may cause a firm to be not operating at optimal scale (Coelli et al., 1998). Therefore, Banker, Charnes and Cooper (1984) proposed an extension of the CRS DEA to a variable return to scale (VRS) model. In the case of CRS when not all firms are operating at the optimal scale, the results TE is confounded by the scale efficiencies (SE). However, as mention above, the use of VRS application obtains the results of TE free from these scale effects. The CRS DEA can be modified to VRS DEA by adding the convexity constraint: $N1'\lambda=1$ to provide the following output-oriented VRS DEA model.

In this study, TE is calculated by using the output-oriented variable return to scale DEA model. This study want to know how much maximum output can be produced based on the current inputs usage. Therefore, it is assumed that output-oriented VRS model would be more appropriate in this study. Here, output variable used for estimating technical efficiency includes total rice production (Y). The inputs used in this study represented the paddy sown acres of individual farmer (X_1), number of total labor used in each farm (X_2), material costs of rice production (X_3),and operation costs (X_4), respectively. Following Coelli et al., 1998, an output oriented variable return to scale DEA model for technical efficiency was defined as:

$$
\begin{aligned}
&\text{Max}_{\Phi,\lambda}\Phi, \\
\text{Subject to} \quad & -\Phi\ y_i + Y\lambda \geq 0 \\
& x_i - X\lambda \geq 0 \\
& N1'\lambda = 1 \\
& \lambda \geq 0 \qquad (2)
\end{aligned}
$$

Where, Y represents an output for N farms, Φ represents the input technical efficiency score having a value $0 \leq \Phi \leq 1$, X represents an input matrix for N farms, λ is an Nx1 vector of weights which defines the linear combination of the peers of i^{th} farm. y_i represents the total rice production of the i^{th} farm in baskets and x_i denotes the input vector of the i^{th} farm.

X_{1i} represents paddy sown acreage (land) of individual farmers on the i^{th} farm,

X_{2i} indicates the number total labors used on the i^{th} farm,

X_{3i} represents the material costs of seeding and agrochemical application on the ith farm, and

X_{4i} shows the operation costs including the land preparation, harvesting and threshing activities expenses used on the ith farm.

1) Calculation of scale efficiencies and return to scale

TE can be decomposed into two parts: pure technical efficiency and scale efficiency. According to Dhungana et al., (2004), the pure technical efficiency can be drawn out from the technical efficiency by separating the scale effect. The VRS DEA is more flexible and envelopes the data more exactly than VRS DEA. Scale efficiency measure can be done by conducting both CRS DEA and VRS DEA. The decomposition obtained from the TE of the CRS DEA into two components: one is scale inefficiency and the other is pure inefficiency. It there is a difference in the CRS and VRS efficiency scores for a farm, indicating the farm has scale inefficiency and it can be calculated from the difference between the VRS and CRS efficiency scores.

This can be illustrated in figure 4.4 by using one output and input example. The frontier of CRS and VRS are displayed in the figure and the technical inefficiency for point B with CRS is the distance AB. However, the inefficiency is only BC with VRS frontier. So the scale inefficiency is the difference between these two TE scores, AC. Alternately, when one separates the scale effect from the technical efficiency, the pure technical efficiency is obtained. Scale efficiency relates to the most efficient scale of operation in the sense of maximizing average productivity.

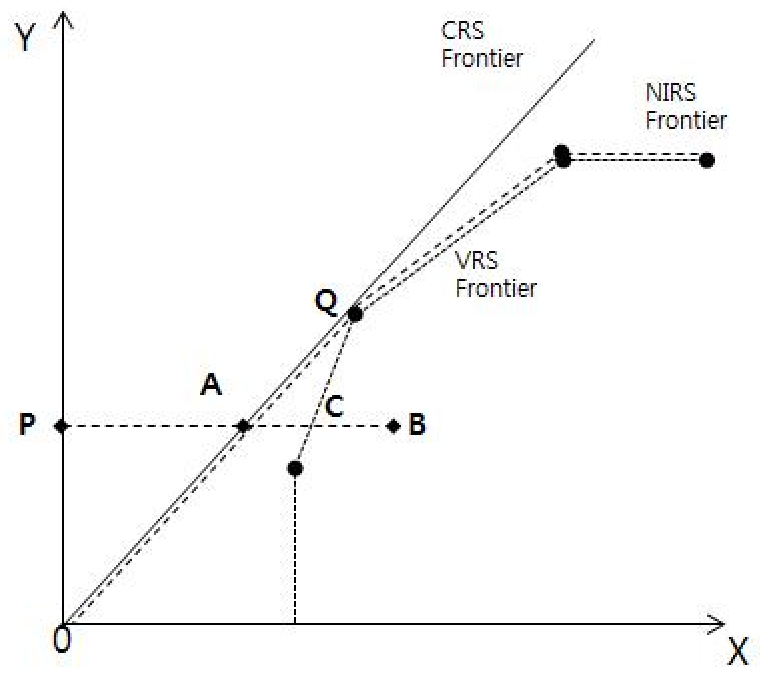

Figure 4.4 Relationship of scale efficiency

A scale efficient farm has the same level of technical and pure technical efficiency. Based on the results of the TE scores, scale efficiency measure of each farm can be calculated simply as follow.

$$SE_i = PA/PC \text{ (or) } TE_{iCRS} / TE_{iVRS} \qquad (3)$$

Where $SE=1$ implies scale efficiency and $SE<1$ implies scale inefficiency. However this scale efficiency measure cannot indicate whether the farm is operating in an area of increasing or decreasing returns to scale which can be captured by running an additional DEA problem with non-increasing return to scale (NIRS). The NIRS frontier is also plotted in the above figure. Therefore, the return to scale analysis can be done by altering the DEA model in equation (1) by replacing the

$N1'\lambda=1$ *with* $N1'\lambda\leq1$, to provide;

$$\text{Max}_{\Phi,\lambda}\Phi,$$
$$\text{Subject to} \quad -\Phi\, y_i + Y\lambda \geq 0$$
$$x_i - X\lambda \geq 0$$
$$N1'\lambda \leq 1$$
$$\lambda\geq0 \qquad (4)$$

The nature of the scale inefficiencies (increasing or decreasing returns to scale) can be pointed out by seeing whether the NIRS TE score is equal to the VRS TE score. If the NIRS TE score is equal to the VRS TE score, it indicates the increasing return to scale. On the other hand, if the scores are unequal, it is decreasing return to scale. Note that the constraint $N1'\lambda\leq 1$ means the i^{th} firms cannot be captured which are larger than 1, butit maybe compared with firms smaller than it. Here, DEAP 2.1 software program developed by Coelli (1994) was used to conduct data envelopment analysis.

2) Measurement of the factors explaining in production efficiency

According to the objective, to examine the influence factors that can hinder the rice production efficiency, tobit regression analysis is used as a second stage of the relationship between the technical efficiency measure and other relevant variables. Tobit analysis, a model devised by Tobin (1958) in which it is assumed that the dependent variable has a number of its values clustered at a limiting value, usually zero (McDonald and Moffitt, 1980). Because the ordinary least square (OLS) regression is not appropriate for this regression analysis that the technical efficiency score is limited between 0 and 1. Therefore, the dependent variable does not have normal distribution. Tobit regression is more convenient to have data censored at zero that at 1. In this study employs the following tobit regression model and expresses as follow.

$$TE_i = TE_i^* = \beta_0 + \beta_1 Z_{1i} + \beta_2 Z_{2i} + \beta_3 Z_{3i} + \beta_4 Z_{4i} + \beta_5 Z_{5i} + \beta_6 Z_{6i} + \mu_i \qquad if\ \ TE_i > 0$$

(or)

$$TE_i = 0, \quad if\ \ TE_i \leq 0 \qquad (5)$$

Where, i refer to the i^{th} farm in the sample.

TE_i is an efficiency measures representing technical efficiency of the i^{th} farm.

TE_i^* is the latent variable.

Z_{1i} expresses age of the farm household head of the i^{th} farmers

Z_{2i} expresses age square of the farm household head of the i^{th} farmers

Z_{3i} is denotes an educational category variables of farmers for their respective education levels

Z_{4i} specifythesharedoffamilylaborratioonthetotallaborused

Z_{5i} represents the dummy value off-farm income except rice:1 for having off-farm income and 0 for otherwise

Z_{6i} is the numbers mechanical tools using in farming operations in this area

β's are unknown parameters to be estimated

μ_i is the error term

D. Parametric approach: Stochastic frontier production function

According to the Farrell (1957) stated that technical efficiency of a firm is the ability to obtain maximal output from a given set of inputs. A parametric approach recognizes inherent randomness in production due to variations in weather and other conditions (Kang,2007). Therefore, this study uses the parametric stochastic approach to estimate the technical efficiency of farms. Parametric frontier functions require the definition of a specific functional form for the technology and for the inefficiency error term (Murillo-Zamorano,2004). The basic form of the production function in terms of a cross-sectional framework; a parametric frontier can be represented as followed.

$$Y_i = f(X_i, \beta) TE_i \qquad (6)$$

Where i = 1, 2…N indexes the i^{th} of N farms in a sample to be analyzed. Y is the scalar output, X represents a vector of N inputs and f (.) is the production function relationship depends on inputs and a technological parameters vector, β. TE_i indicates the output-oriented technical efficiency of producer i^{th} defined as the ratio of the observed output to the maximal potential output. Aigner and Chu(1968) considered the parametric frontier production function of Cobb-Douglas form with sample N as follow:

$$\ln y_i = x_i \beta - u_i \qquad (7)$$

Where, $\ln y_i$ is the logarithm of the output for the i^{th} farms, x_i is the logarithms of inputs quantity used by the firms, β is a vector of unknown parameters to be estimated and u_i is a non-negative random variable associated with technical inefficiency of i^{th} farm production activities in the industry, respectively. The production model will usually be linear in the logs of the variables, so the empirical form is:

$$\ln y_i = \ln f(x_i, \beta) + \ln TE_i = \ln f(x_i, \beta) - u_i \qquad (8)$$

Where $u_i \geq 0$ is a measure of technical inefficiency since $u_i = -\ln TE_i \approx 1 - TE_i$, and again, $TE_i = \exp(-u_i)$. Then, technical efficiency of i^{th} farm which can be defined as follow.

$$
\begin{aligned}
TE_i &= y_i / \exp(x_i \beta) \\
&= \exp(x_i\beta - u_i) / \exp(x_i\beta) \\
&= \exp(-u_i) \qquad (9)
\end{aligned}
$$

Here, TE_i present technical efficiency indexes of the i^{th} firm which takes a value between zero and one. Subsequently, this model was criticized that no taken account of the measurement error and other noise upon frontier. Therefore, an alternative approach to these noise problem has been widely used is the stochastic frontier approach (SFA). Schmidt (1976) observed that the Aigner and Chu (1968) parametric production function could be constructed as the log-likelihood functions. The SFA permits the estimation of standard errors and test of hypothesis by using maximum-likelihood methods which involves specification of the distribution of v_i and u_i. The random variables v_i and u_i are assumed to be mutually independent and independent of the input variables in the model.

Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) independently proposed the stochastic frontier production. The original specification involved a production function specified for cross-sectional data which had an additional random error; v_i is added to the non-negative random variable u_i, in equation (6) and it is accounts for measurement error and other random factors on the value of output variables and inputs variables in the production function. This model can be described as follow.

$$\ln\ y_i = \ln f\,(x_{i,}\beta) + v_i - u_i \qquad (i = 1,2,\cdots,N) \qquad (10)$$

The parameters of this model are estimated by ML with suitable distributional assumptions for the error terms. Aigner, Lovell and Schmidt (1977) assume that v_i has normal distribution and u_i has either the half normal or exponential distribution (Coelli,1995). Where v_i is assumed to be independent and identically distributed (i.i.d.) normal random variables with mean zero and constant variance σ_v^2, independent of the u_is. This model is called the stochastic frontier production function because the output is bounded by the stochastic (random) variable, $\exp(x_{i,}\beta + v_i)$. The random error, v_i can be positive or negative and so the stochastic frontier outputs vary depends on this v_i .This model can be expressed the likelihood function in terms of the two variance parameters: σ_u^2 and σ_v^2; and they can be extended as $\sigma_s^2=\sigma_v^2+\sigma_u^2$, $\lambda=\sigma_u/\sigma_v$ and $\gamma=\sigma_u^2/\sigma_s^2$, because the γ parameter has value between zero and one, whereas the λ -parameter could be any non-negative value. For example, if a value of γ of zero indicates that the deviations from.

1) Empirical application with a specific functional form

There are a number of functional forms have also been used in the frontier analysis. In this study, a functional form for the stochastic frontier is the translog function which has been adopted widely in frontier studies. According to Kwon and Lee (2004) this functional form is flexible and computationally straightforward. The general form of the translog form with time-invariant model of stochastic frontier used in this study is described as follow.

$$\ln y = \beta_0 + \sum_{j=1}^{4} \beta_j \ln x_{jit} + 0.5 \sum_{j=1}^{4} \sum_{k=1}^{4} \beta_{jk} \ln x_{jit} \ln x_{kit} + v_i - u_{i\mathrm{i}} \qquad (11)$$

Where, i indicates an observation for the i^{th} sample farmer in the survey, i=1, 2, …, n, y_i represents the total rice production of the i^{th} farm expressed in baskets, x_j and x_k are the quantity of inputs used in rice production; and

j and k = paddy sown acreage (land) of individual farmers on the i^{th} farm;

= the number total labors used on the i^{th} farm;

= the material costs of seeding and agrochemical application on the i^{th}farm;

= the operation costs including the land preparation, harvesting and threshing activities expenses used on the i^{th}farm;

$\beta_{jk} = \beta_{kj}$ are parameters to be estimated;

v_is are assumed to be independent and identically distributed as normal random variables following an *iid* normal distribution of zero mean and variance of σ_v^2, independent of the u_is;

σ_u^2, u_is represent non-negative technical inefficiency of i^{th} producers which are also assumed to be non-negative, independently distributed as truncations at zero.

2) Modeling inefficiency effects

Although the SFA model was originally proposed for the analysis of the panel data by Battese and Coelli (1995) however, a general SFA function for the cross-sectional data also considered. They extended the stochastic production frontier model by suggesting that the inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific variables. The determinants of technical inefficiencies can be obtained by regressing the estimated inefficiency effects resulted from an estimated stochastic frontier, upon a vector of farm-specific factors (such as demographic variables of individual farm).

This is a two-stage approach: first, the inefficiency effects are assumed to be independently and identically distributed and second, the predicted inefficiency effects are assumed to be a function of a number of farm-specific factors, which implies that they are not identically distributed, unless all the coefficients of the factors are simultaneously equal to zero. The inefficiency effects model proposed by Battese and Coelli (1995) are assumed to be independently (but not identically) distributed non-negative random variables. The technical inefficiency effect model is described by:

$$u_{it} = \delta_0 + \delta_i z_{it} \tag{12}$$

Where u_{it}, the technical inefficiency effects, are assumed to be a function of explanatory variables, z_{it} is a vector of observed explanatory variables related to the technical inefficiency effects in the t^{th} period and δ is a vector of unknown parameters to be estimated. Here, the determinants of the explanatory variables are described as follow. They are the same variables as in non-parametric approach.

z_{1i} expresses age of the farm household head of the i^{th} farmers

z_{2i} expresses age of the farm household head of the i^{th} farmers

z_{3i} denotes an educational category variables of farmers for their respective education levels

z_{4i} specify the shared of family labor ratio on the total labor used

z_{5i} represents the dummy value off-farm income except rice:1 for having off-farm income and 0 for otherwise

z_{6i} is the numbers mechanical tools using in farming operations in this area.

This model assumes the normal distributions, which are truncated at zero to obtain the distributions of the technical inefficiency effects.

Combining equation (11) and (12) yields a single stage equation of the production frontier model as in the above equation (10). Where u_i are assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance, σ^2. The parameters of the stochastic frontier production function are simultaneously estimated with the one-step model by maximum likelihood in which the technical efficiency effects are specified as a function of the respective variables. Producer-specific estimates of technical inefficiency are then given by $\exp(-u_i)$.

Chapter5. Estimation Results

This chapter shows the empirical estimated results of the efficiency study by using non-parametric and parametric approaches of the sample rice farmers in Myanmar.

A. Farmers characteristic and socioeconomic conditions

The descriptive statistic analysis is used to summarize the important characteristics of the respondent (sample farmers) by using simple statistical analysis such as mean, standard deviation, minimum and maximum values, respectively. The summary statistic of the socioeconomic conditions and the farm assets of the sample farmers are presented in table 5.1.

The mean value of the age of farm operator is 50 years with a range of 23 to 77 years, showing a high variability of ages among farmers. The result also describes that the farmers who have much experience on rice cultivation with a mean value of 25 years and vary with a range of minimum 2 to maximum 60 years. Accordingly, most of the farms operators' possess the average education level not more than the secondary school level; it shows about 1.5 levels of the educational category variables. The number of each farm family reveals 5 persons in average with a range of 1 to 11 persons. Off-farm income dummy variables of 0.43 indicate that most of the farm families have no much off-farm income activities in this sample area.

Table 5.1 Socioeconomic variables of the sample farmers

Variables	Unit	Mean	Standard deviation	Minimum	Maximum
Farmer age	Year	50	12	23	77
Farming experience	Year	25	12	2	60
Education level	Category variable	1.44	0.76	0	4
Number of family	Person	5	2	1	11
Off-farm income	Dummy variable	0.43	0.50	0	1
Farming assets					
Plough	Number	0.53	0.53	0	2
Harrow	Number	0.14	0.43	0	3
Bullock	Number	0.37	0.90	0	5
Power tiller	Number	0.44	0.54	0	3
Seeder	Number	0.01	0.10	0	1
Sprayer	Number	0.44	0.54	0	2
Water pump	Number	0.41	0.51	0	2
Threshing machine	Number	0.38	0.50	0	2
Ware house	Number	0.44	0.51	0	2

Source: Calculated from the survey data. Zero represents the non-use of the corresponding variable. Education levels identified 0, 1, 2, 3, and 4 representing illiterate, primary, secondary, high school and graduate levels, respectively. Off-farm income dummy specified 0 for no off-farm income and 1 for having off-farm income.

Moreover, the summary statistics of the farming assets representing the farm equipment and machineries used in rice cultivation activities are also displayed in this table. Among these socioeconomic variables years of farming experiences, education levels of farms' head, and off-farm income are included in the analysis of the determinants of production inefficiency.

B. Data and definitions of the variables used in efficiency measures

Table 5.2 describes the selected characteristics of the variables used in the efficiency measures. Here, each farm household is aggregated for their respective output and inputs used in rice production for both summer and monsoon paddy. For each farm household, data are aggregated into one output and four input variables. The output represents the total un-husked rice production of the individual farms which is measures in basket. The average total rice production is about 940 baskets per farm with a range of minimum 120 baskets up to maximum 4,340 baskets of each farm production for both seasons. The input data are aggregated into four categories: (i) rice growing area, (ii) labor, (iii) material costs, and (iv) operation costs. The data collected on inputs are in quantity for land and labor while the value terms for materials and operation costs.

Table 5.2 Descriptive statistics of output and inputs based on each sample farm

Variables	Unit	Mean	Standard deviation	Minimum	Maximum
Paddy production	Basket	940.13	631.11	120	4,340
Sown area	Acre	14.40	9.29	2	62
Labor	Person	5	1.55	2	12
Material cost	Kyats	887,291	601,198	101,700	4,179,850
Operation cost	Kyats	488,359	338,305	72,800	2,600,900

Source: Calculated from the survey data. Note: “Kyats” is the Myanmar currency and one dollar is equal about 900 Kyats during 2011~2012.

Sown area includes the combine area planted of rice for each sample farm for both summer and monsoon paddy cropping seasons when the survey is done. This variable is particularly measured in acres. The average value of rice growing area per farm is 14.4 acres (approximately 5.24 ha) with a range of 2 to 62 acres in this survey area. Labor measured the total labor used in rice production activities including the numbers family labor and permanent hired labor for each farm. The mean value of labor used per farm is 5 persons with a minimum 2 to a maximum labor of 12.

In the above table, the material costs represent the cost of materials used in farming which represents the expenses on seeding and agrochemical used for each farm. The seeding cost is calculated based on seed cost and application cost. There are two types of seeding method in this area: direct seeding and transplanting. Some sample farmers used direct seeding method and transplanting either independently or a combination of both. Mostly, direct seeding method is used in HYV varieties and summer season paddy production. So, the seeding costs include total expenses on seeding and its' application costs too.

As the government is going to market liberalization policy, there have no subsidy plans of price and input to farmers. It is said that the inputs prices were not different since most of the private companies came and distributed fertilizer directly to farms in the survey area. Fertilizer costs is measured the total expenditure on fertilizer kilogram also covered the transportation. The mean value of the material costs display 887,291 Kyats varies from 101,700 to 4,179,850 Kyats per farm. In the case of operation cost, it is calculated based on the summing of land preparation cost, harvesting and threshing costs, respectively. Here, the average operation cost is 488,359 Kyats with a range from 72,800 to 2,600,900 Kyats per farm.

C. Results from non-parametric analysis

1) Distribution of technical efficiency index

The result of output-oriented technical efficiency indexes of the sample rice producing farmers is displayed in table 5.3. Here, the average overall technical efficiency (CRS-TE) is 63% with a minimum level of 44% and maximum level of 100%. Then, the pure technical efficiency (VRS-TE) results the mean index of 69% with a range of 46% up to 100%. Similarly, the observation of scale efficiency finds 92% of average value with a minimum value of 55% and a maximum value of 100% of the sample farmers.

Based on these results, it can be concluded that the sample farmers have pure technical inefficiency accounts approximately 31% and scale inefficiency accounts approximately 8%. Because technical inefficiency scores from CRS DEA is made up of two components, one due to technical inefficiency and one due to scale inefficiency. Alternately, this implies that the sample farms have the potential to reduce their physical input on average, by 39%, and still produce the same level of rice output. Again, technical inefficiency can be reduced without reducing the level of output with existing technology and levels of input used. Frequency and percentage distributions of the technical efficiency indexes of the sample farmers are also shown in the same table. It is evident from the results that the majority of the sample farmers' overall technical efficiency indexes and the pure technical efficiency indexes are fallen within the range of 0.51 and 0.70.

Table 5.3 Frequency distribution technical efficiency index of DEA approach

Efficiency Level	Technical Efficiency					
	CRS-TE (Overall TE)		VRS-TE (Pure TE)		Scale Efficiency	
	Number of farm	%	Number of farm	%	Number of farm	%
0.01 - 0.10	0	0%	0	0%	0	0%
0.11 - 0.20	0	0%	0	0%	0	0%
0.21 - 0.30	0	0%	0	0%	0	0%
0.31 - 0.40	0	0%	0	0%	0	0%
0.41 - 0.50	16	8%	5	3%	0	0%
0.51 - 0.60	82	42%	51	26%	4	2%
0.61 - 0.70	58	30%	70	36%	5	3%
0.71 - 0.80	20	10%	34	17%	5	3%
0.81 - 0.90	12	6%	13	7%	34	17%
0.91 - 1.00	7	4%	22	11%	147	75%
Mean TE	0.63		0.69		0.92	
Minimum TE	0.44		0.46		0.55	
Maximum TE	1.00		1.00		1.00	

Source: Calculated from survey data.

Among them, 42% of the sample farms get the overall technical efficiency score of 0.51~0.60, 30% for 0.61~0.70 and 10% for 0.71~0.80 indexes, respectively. The other farms of 8% and 6% have overall technical efficiency of 0.41~0.50 and 0.81~0.90 whereas the remaining sample farmers 4% have the index of 0.91~1.0. In the case of pure efficiency indexes 36% farm possesses 0.61~0.70, 26% for 0.51~0.60, and 17% for 0.71~0.80. Among them, 11% of farms get pure technical efficiency index of 0.91~1, 7% for 0.81~0.90, and only 3% of farms have between 0.41~0.50 indexes.

As mention from the previous chapter, the effect of scale efficiency can be measured by conducting both a CRS-TE and a VRS-TE. In this study, the average scale efficiency indicates 92% and the majority of the sample farmer (75%) falls the scale efficiency score of 0.91~1.0 followed by 0.81~0.90, 0.61~0.80 and 0.51~0.60 respectively. For simplicity, the histogram charts of the technical efficiency index distribution are also presented in figure 5.1.

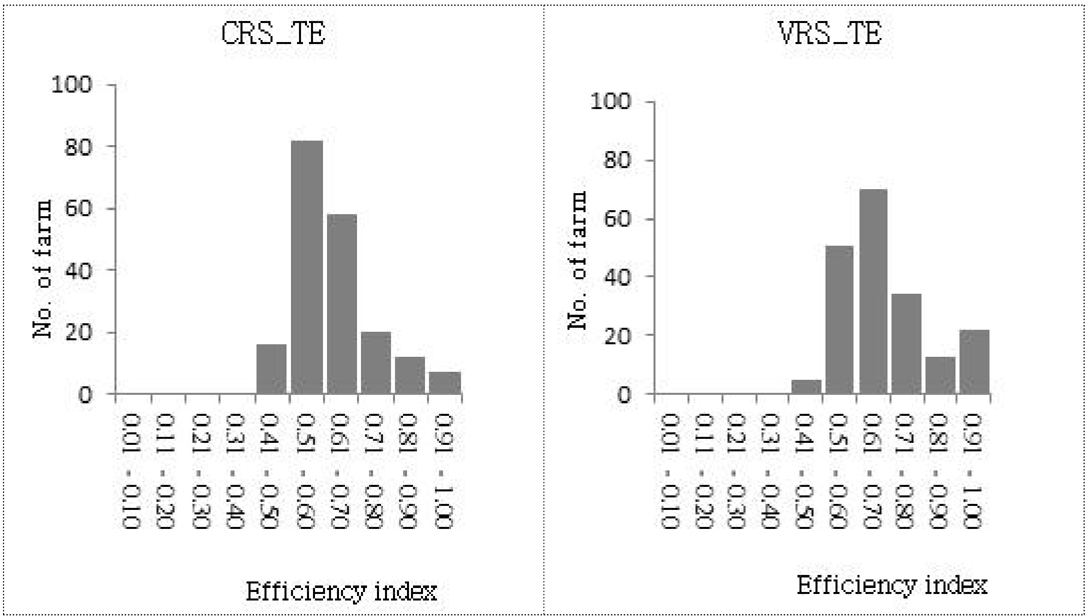

Figure 5.1 Frequency distribution of the technical efficiency of CRS and VRS

2) Returns to scale result

The results of return to scale of the sample farmers are summarized in table 5.4. Return to scale (RTS) is a long-run concept which reflects the degree to which a proportional increase in all inputs increases output. The results contributed that 89% of the sample farm is under IRTS, 5%

is DRTS and 6% is CRTS. In turn, it can be said that majority of the sample farms are operating at increasing return to scale, indicating that these farmers can get more output by having additional input. This condition is similar in the case of small farms conditions. Again, 5% of the farms working at decreasing return to scale pointed out that they can get more output by reducing the use of the inputs. One possible reason for DRTS is the case where a farm becomes so large that the management cannot reach to all aspects of the production process. The remaining 6%, which is operate at CRTS mean that when a proportional increase in all inputs results in the same proportional increase in output. This is one of the reasons of this study, in which the results can be used to provide information to rice farmers encouraging more farms to operate towards the optimal scale.

Table 5.4 Summary of return to scale results

Characteristic	Frequency	Percentage
Constant return to scale (CRTS)	12	6%
Decreasing return to scale (DRTS)	9	5%
Increasing return to scale (IRTS)	174	89%
Total	195	100%

Source: Calculated from survey data.

3) Measurement of the factors determining the efficiency

In this portion, the impact factors which could have influence the rice technical efficiency are analyzed by using the Tobit regression model. This model applied to VRS-TE as a dependent variable and some key socioeconomic independent variables related to technical inefficiency, instead of using the ordinary lease square (OLS) estimate that might produce biased results. Because the OLS regression is not appropriate for this regression analysis that the technical efficiency score is limited between 0 and 1. Therefore, the dependent variable does not have normal distribution. Tobit regression is more convenient to have data censored at zero that at 1. The parameter coefficients are interpreted to analyze the directional relationship between efficiency and covariance.

Table 5.5 displays the results of tobit regression function for the technical efficiency. The technical efficiency scores are regressed against the age of the farm household head, educational level, off-farm income dummy, labor ratio, mechanical tools used in farming operations. The results showed that age of the sample farmer's has a negative, but a positive quadratic effect on efficiency indexes even though there is not significant related to the technical efficiency indexes. This suggests that the lesser the year of farming experiences farmers are more likely to be efficient comparing with their older counterparts. However, it can be assumed that the efficiency can be increased again when a certain years of age is reached.

The category variables of education level of the farm operators are negatively and significantly related at 10% level to the efficiency scores. Here the education variables represent only for the primary and illiterate education levels. Alternately, it can be said that if the technical efficiency will be increased when the head of households possess higher education level. As expected, the share of family labors which included in the total number of labors has positively and significantly related to the technical efficiency scores. This tends to show that the more intensive the family labors in rice production, the higher the efficiency of production for the sample households. Then the off-farm income variable is negatively related to the efficiency indexes and showed that if the lesser off-farm income work can increase the efficiency of rice production in this area.

Table 5.5 Result of tobit regression coefficients

Variables		Coefficients
Age	β_1	- 0.00966 (0.00076)
Age^2	β_2	0.00009 (0.00006)
Education category variable	B_3	- 0.04376 (0.02465)*
Family labor ratio	B_4	0.10949 (0.04472)**
Off-farm income	B_5	- 0.00395 (0.02266)
Mechanical tools	B_6	0.01093 (0.00432)**
Constant	β_0	0.85636 (0.14308)***
Wald chi2 (6):14.53 Log likelihood:85.783107**		

Note: *, **, and *** indicate significant at the 10%, 5%, and 1% level, respectively. Standard deviations of estimates are expressed in parentheses. The education category variables representing the education level of farm operators' up to the secondary level of education; above secondary education levels is dropped as the reference education dummy variable. The family labor ratio variable representing the share of family labor on total labors used in rice production.

Subsequently, the next variable is the mechanical tools used in farming activities, which is positive and significantly related to the efficiency indexes at 5% level of significant. It means one more unit of mechanical tools used in rice production; the efficiency score will increase approximately 1%. The utilization of mechanical tools displays the more efficiency in this sample area. Agricultural mechanization includes the use of tools, implements and machines for enhancing productivity. Even though the sample area was devastated by Cyclone Nargis in 2008 and most of the farmers lost their agricultural mechanical tools during this time, the result of the analysis showed the important role of these mechanical tools in efficient rice production.

D. Results from parametric analysis

1) Distribution of technical efficiency index

This section first considers the preliminary step by presenting the results of the estimation of the rice production frontier, and then technical efficiency effects are discussed. Table 5.6 expresses the distribution of the technical efficiency resulted from the maximum likelihood estimates of the parameters based on normal/truncated normal distribution of analysis of stochastic frontier function (variable return to scale) of the sample farmers. The estimates for technical efficiency index show that on average farmers are 78% efficient with a range of minimum 69% up to maximum 100%, implying that the average farms produced 78% of the maximum attainable output for a given input levels. On the other hand, based on the efficiency results, technical efficiency of the sample rice farmers in these areas could increase by 22% based on their current production conditions. In the case of percentage distribution, most of the sample farmers (57%) fall under the efficiency index of 0.71~8.0, followed by 27% under 0.81~0.90, 11% for 0.61~7.00. and among them 5% of the sample farmers got the highest efficiency index between 0.91~1.00. Figure 5.2 showed the histogram distribution of the efficiency indexes.

Table 5.6 Frequency distribution of the efficiency index of SFA approach (N=195)

Efficiency level	Frequency	percentage
0.01 - 0.10	0	0%
0.11 - 0.20	0	0%
0.21 - 0.30	0	0%
0.31 - 0.40	0	0%
0.41 - 0.50	0	0%
0.51 - 0.60	0	0%
0.61 - 0.70	21	11%
0.71 - 0.80	112	57%
0.81 - 0.90	52	27%
0.91 - 1.00	10	5%
Mean TE	0.78	
Minimum TE	0.69	
Maximum TE	1.00	

Source: Calculated from survey data.

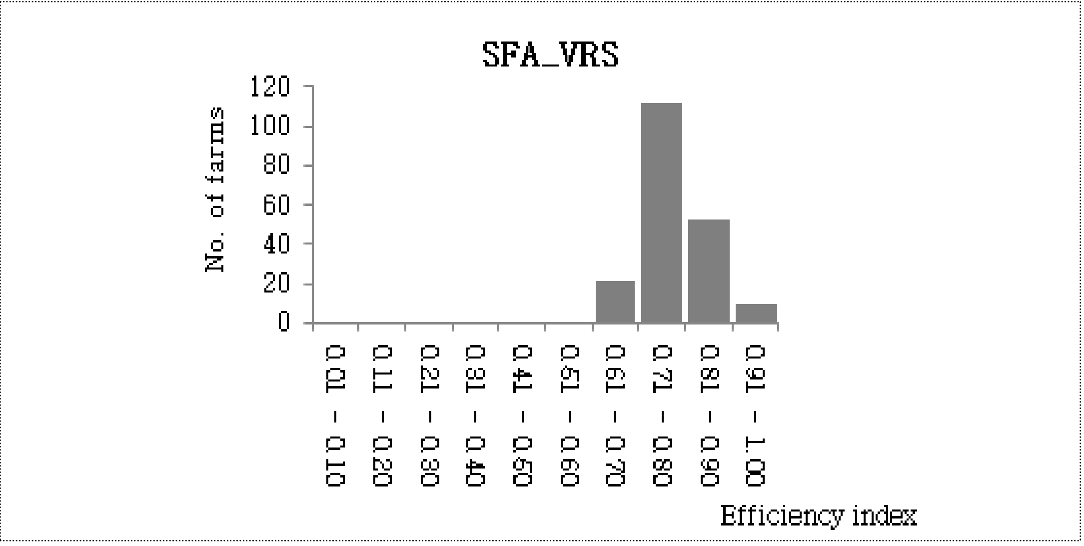

Figure 5.2 Frequency distribution of the technical efficiency of SFA_VRS

2) Results from the parameters estimated

This section presented the results of parameter estimates after considering the efficiency indexes with parametric approach. The maximum likelihood estimates of the parameters employ the translog functional form that has been adopted widely in frontier studies. To examine the technical efficiency, the translog production frontier is estimated by maximum likelihood assuming a truncated normal distribution for u_i. Table 5.7 presents the estimated parameter results of the frontier function. The wald-chi square test for the significance of the regression rejects the null hypothesis that the parameter coefficients of the explanatory variables are all zero at the one percent level. The variance parameters σ^2 and γ are different from zero means that there are differences in technical efficiency among farmers.

Subsequently, the regression results for the determinants of technical inefficiency are displayed in table 5.8. The efficiency determinants are estimated with the production frontier simultaneously. Here, technical inefficiency scores, as measured relative to the technically efficient producers, are regressed against the determinant factors of explanatory variables such as the age of the farms' household head, education levels, family labor ratio, off-farm income, and mechanical tools which are the same variables used in non-parametric analysis. It can be seen that the results signs of all the determinants variables are similar to the results from the DEA analysis except the off farm income and ratio of family labor variables.

Table 5.7 Result of parameters estimate of the stochastic frontier function

Variable		Coefficient	Standard deviation
$\ln X_A$	β_1	7.2965	7.0015
$\ln X_L$	β_2	- 2.6145	3.3344
$\ln X_M$	β_3	- 1.4064	3.6601
$\ln X_O$	β_4	- 2.0908	4.9950
$0.5\ln X_A \ln X_A$	β_5	0.8056	0.7183
$\ln X_A \ln X_L$	β_6	- 0.1470	0.3005
$\ln X_A \ln X_M$	β_7	- 0.3905	0.3824
$\ln X_A \ln X_O$	β_8	- 0.2486	0.4899
$0.5\ln X_L \ln X_L$	β_9	0.0071	0.2477
$\ln X_L \ln X_M$	β_{10}	0.3633	0.2705
$\ln X_L \ln X_O$	β_{11}	- 0.1487	0.1967
$0.5\ln X_M \ln X_M$	β_{12}	0.1350	0.3520
$\ln X_M \ln X_O$	β_{13}	0.0100	0.2862
$0.5\ln X_O \ln X_O$	β_{14}	0.2302	0.4033
Constant	β_{15}	27.0123	35.1936
Variance parameters	σ^2	0.0098	
	γ	0.0222	
Wald $Chi^2(14)$:2829.23***			
Log likelihood: 174.49792			

Note: *, **, and *** indicate significant at the 10%, 5%, and 1% level, respectively. X_A X_L, X_M, and X_O are the inputs of land, labor, material cost and operational cost, respectively.

The positive coefficient of the age of the farm heads indicates the technical inefficiency increases as the age of the farmers increase. However, this condition is limited up to a range, the negative coefficient value of its' quadratic effects expresses the technical inefficiency will be reduced if the farmer get at their older age. Highly educated operators are more likely to improve technical efficiency. These results confirm that the positive and significantly related at 5% level of the lower education variable to the technical inefficiency scores. Farm size or area of rice growing show a positive but negative quadratic effects on the technical inefficiency scores.

Table 5.8 Result of the parameters determinants on technical inefficiency index

Variables		Coefficients
Age	β_1	0.00620 (0.0046)
Age^2	β_2	- 0.00006 (0.00004)
Education category variable	β_3	0.05648 (0.01890)**
Family labor ratio	β_4	0.02429 (0.03622)
Off-farm income	β_5	- 0.025548 (0.01771)
Mechanical tools	β_6	- 0.02434 (0.00455)***
Constant	β_0	0.11567 (0.14989)

Note: *, **, and *** indicate significant at the 10%, 5%, and 1% level, respectively. Standard deviations of estimates are expressed in parentheses. The education category variables representing the education level of farm operators' up to the secondary level of education; above secondary education levels is dropped as the reference education dummy variable. The family labor ratio variable representing the share of family labor on total labors used in rice production.

The share of family labor participated to the total labors has a positively and insignificantly associated to the inefficiency indexes. Also, the off-farm income variable is negatively and insignificantly related to the technical inefficiency. However, it can be seen that the number of the mechanical tools used in rice farming variable is negatively and significantly related at 1% level. It is suggested that of 100% increase in the use of mechanical tools in rice production would increase the efficiency by to 2.4%.

E. Comparison of non-parametric and parametric productivity measures

Comparison of the technical efficiency scores between the non-parametric and parametric approaches are based on their calculation of variable return to scale for both methods are discussed in this section. Table 5.9 presents the distribution of the technical efficiency scores and mean efficiency of non-parametric and parametric approaches.

In this table, the parametric estimation tends to produce higher efficiency scores than non-parametric estimation. This is due to the fact that the non-parametric method attributes any deviation from the frontier to inefficiency, while the parametric method refers the stochastic component in constructing the frontier. Moreover, the non-parametric approach does not allow stochastic terms and imposed less structural restrictions therefore, the non-parametric efficiency scores are expected to show fewer systematic patterns than the parametric scores. However, it can be seen that the comparison results of the VRS-TE is more compactable with SFA-TE than CRS-TE in their respective mean technical efficiency scores.

Table 5.9 Comparison of technical efficiency scores

Efficiency Level	Non-parametric approach				Parametric approach	
	CRS-TE (Overall TE)		VRS-TE (Pure TE)		SFA-TE	
	Number of farms	%	Number of farms	%	Number of farms	%
0.01 - 0.10	0	0%	0	0%	0	0%
0.11 - 0.20	0	0%	0	0%	0	0%
0.21 - 0.30	0	0%	0	0%	0	0%
0.31 - 0.40	0	0%	0	0%	0	0%
0.41 - 0.50	16	8%	5	3%	0	0%
0.51 - 0.60	82	42%	51	26%	0	0%
0.61 - 0.70	58	30%	70	36%	21	11%
0.71 - 0.80	20	10%	34	17%	112	57%
0.81 - 0.90	12	6%	13	7%	52	27%
0.91 - 1.00	7	4%	22	11%	10	5%
Mean TE	0.63		0.69		0.78	
Minimum TE	0.44		0.46		0.69	
Maximum TE	1.00		1.00		1.00	

Source: Calculated from survey data.

Chapter6. Conclusions and Suggestions

Rice farming in Myanmar is not only significant in the area food security but also in rural employment, biodiversity, cultural, and traditional conservation. As mention above, rice production in Myanmar is constrained by some bio-physical and economic factors of the famers especially high cost of production and instable paddy prices etc. Therefore, improving the production efficiency in the rice industry has the same meaning of developing the Myanmar agricultural sector. The purpose of this study is to obtain a better understanding of the current rice production efficiency and to find the ways to overcome the constraints faced by the farmers. This study focuses to measure the rice production efficiency of the sample farmers by using non-parametric and parametric approaches, then to investigate the factors affecting the efficiency of some major rice production regions of Myanmar. In non-parametric approach DEA and Tobit regression were used for determining efficiency and factors affecting the efficiency of rice production. Subsequently, a SFA approach for parametric analysis was applied to estimate the technical efficiency of the sample farmers. First, this chapter summarized and discussed the results and outlined the conclusions of the efficiency analysis. Then the constraints of rice farming in Myanmar were highlighted, and finally short and long term suggestions as well as the limitations of this study were discussed.

A. Summary of main findings

1) Summary of findings on the field survey

In this study, Bagolay townships under Irrawaddy delta region of the main rice growing areas of Myanmar, was selected as the study area. Primary questionnaire of the study were based on the farm level cross-sectional data of the rice growing years of 2012. Among the survey data, 195 sample farm households were analyzed based on their seasonal growing: summer paddy and monsoon paddy. Most of the farmers are semi-subsistence or semi-commercial rice producers and in case of farm land holding, most are small farm size holders on fragmented land holdings. On the rice farming practices, rice is double culture farming system in these areas. The length of duration from land preparation till harvest varies depending on the varieties grown. As double farming area, rice is grown as mainly crop in monsoon. During the monsoon season, most of the rice growing farmers grow the traditional rice varieties which take about 5~6 months period. As a second crop in summer season, most of the rice growing farmers grow HYV varieties with irrigation while other farmers grow peas and beans, oil seed crops, corn or vegetables etc.

Bogalay is situated beside the Irrawaddy River and all of the sown acres cannot be fully grown in the rainy season. The reason is that most parts of the area submerged with salted water during that time. So, farmers faced difficulties with low yield. Most specifically, during the 2012 growing season in Bogalay, only about 52% of the total sown area was harvested giving an average yield of about 61 baskets per acre. This is because of the late rain during the harvest season which seriously affected the normal average yield. Bogalay was devastated by Nargis on 2008 which affected huge amount of death toll and animals. At present, power tiller is widely used for rice production of the study area. Before the cyclone Nargis in 2008, bullocks were the major animals for rice production in this area. After 2008, like small machines, power tiller and land-stir boat etc. becoming very useful for rice growing farmers in this region.

Furthermore, government officials and NGO groups are trying to improve this area again introducing seedling transplanting methods and application of healthy seedling. Even though the farmers knew that the transplantation of the rice seedling got more yield per unit, most of the farmers could not apply this methods due to various constraints. Among them, the labor shortage during the peak season is the main reason. As mention early, the government is going to the market-oriented policies, the agrochemical markets are now opened for farmers without any restrictions. The problem is that the various types and brands of agrochemical are coming to these markets which make farmers confused to select the one with fully secured and guaranteed. Most farmers used fertilizer about 100~300kg per unit for rice production for summer rice cultivation while a little amount of fertilizer were applied in monsoon paddy.

2) Summary of findings on the variables

Based on the information of the socioeconomic variables, the age of the sample farm households ranges 23 to 77 with an average value of 50 years. The average year of farming experience is about 25 years with varying from 2 to 60 years. Additionally, the average education levels of farm household's heads seem very low. Most of the farms' operators merely have just above the primary education level and that with the higher educational level is very rare case. Because of these lower educational levels, simple and clear educational training for the modernized rice growing technologies are the major requirement for these farmers.

The average number of family member in these areas is 5 people per household with a range of minimum family member 1 to 11 people. On the other hand, the number of family members expressed the main potential source for the participation of the family labor in farming operation. Based on the off-farm income dummy variable, about 40 % of the sample has the off-farm income rather than farming. Off-farm works reduce farm-level technical efficiency, but increase household-level technical efficiency (Fernandez-Cornejo, 2007). Assets of the farming tools and machineries used in farming operation expressed relatively low number, pointing out that farmers should have more equipment and facilities to improve the rice production.

According to the data of inputs and output of rice production, the mean value of rice production per sample farm is about 940 baskets with a range of minimum 120 up to maximum 4,340. The average farm size is approximately 14.4 acres ranging from 2 to 62 acres per farm among the sample farms. It can be seen that the number of labor used per farm is 5 people in average varying from 2 to 12 people per farm. The mean value of the material cost used per farm is about 887,291 Kyats with a range of 101,700 Kyats up to 4,179,850 Kyats while the mean operation cost per farm is approximately 488,359 Kyats ranging from 72,800 Kyats to 2,600,900 Kyats, respectively. Here the material cost per farm is higher than the operation cost. Therefore, the variables mentioned above influenced the efficiency of the rice production of the sample farmers.

B. Summary of findings on technical efficiency analysis

1) Summary of findings and discussion on the result of non-parametric analysis

To analyze the technical efficiency of the sample farmers, the input-output data of the individual rice farms were used. The combination of inputs: land, labor, material costs and operation costs were allocated to produce a single desirable output. The results from the non-parametric approach (DEA) showed that the average technical efficiency values are 63% with CRS-TE and 69% with VRS-TE scores, respectively. It implies that the average technical inefficiency ranges from 31% to 37% indicating that there is a potential to improve the existing technical efficiency of the sample farmers without reducing both the levels of input used and the existing technology. According to the theoretical assumption of the non-parametric approach, the farm which possesses the highest efficiency score is situated on the production frontier line. Therefore, the estimated results from non-parametric approach indicate that the inefficient samples farmers can improve their rice production efficiency to catch up the efficient sample farmers in these regions.

Next, scale efficiency and returns to scale are related terms that describe what happens as the scale of production increases in long run, when all inputs levels are variables. Scale efficiency refers to the achieving the optimal size of a farm. In this study, the average value of scale efficiency 92% revealed that there has been a reasonable scale efficiency of the sample farms with exception to those with 9%. Similarly, the returns to scale rises in the production function refers to changes in output resulting from a proportional change in all inputs. Typically, increasing return to scale could be seen at relatively low output levels, decreasing return to scale at relatively high output levels and constant return to scale at one output level between those ranges. Returns to scales results from the sample farmers were 6% for CRS, 12% for DRS and 89% for IRS, respectively. These findings expressed 89% of the sample farmers run only at increasing return to scale region (means region I), indicating that the farmers are operating at irrational region Which still need to use more inputs to reach the efficient production point. Additional 12% of the sample farmers found at DRS region (region III) described that the sample farms cannot operate the perfect management farming activities. Based on the results of the survey data, some of the farmers used the input more than the recommended rate, but the returns were still low. It can be concluded that there is insufficient and imperfect knowledge in the area of inputs utilization and farming operations activities.

Thereafter, the determinants factors which influence the technical efficiency of the sample farmers are discussed. By using tobit regression analysis, VRS_TE applied as a dependent variable and some socioeconomic indicators of the individual farmers such as the age of farm decision makers, educational level of the farm household head, rice growing area, off-farm income, labor ratio, numbers of mechanical applicants used in rice production and seasonal paddy growing dummy variable were analyzed.

For age of the farm decision maker, there is a negative but a positive quadratic effect on technical efficiency of individual sample farmers. This indicated that the younger farmers were not getting the better efficiency levels than the more experiences and older farmers. However, when the age of the sample farmers reached a certain level, the efficiency seem to be high again. In Myanmar, farmers are not easily adopting the modern technologies and also they do not want to discard their traditional customs and practices easily. This finding might suggest the policy implications should emphasize the younger farmers' education for the dissemination of the best farming practices.

The educational category variables which represent only for illiterate and primary level of education of the farm households' head and technical efficiency are negatively and significantly related. According to these results the lower education levels of the farm operators seem to have lower efficiency scores. In contrast, highly educated operators are more likely to improve technical efficiency which agrees with Ajibefun (2008) who reported that education is expected to make farmers less conservative and more respective to new technology and innovation, which will consequently lead to higher technical efficiency. Therefore, increasing private and public investment in education might lead to better improvement in agricultural sector.

The next determinant is the labor ratio which stands for the share of family labor in total labor used. As in the conditions of developing worlds, the farm family labors usually work more efficiently compared to the hired labors. It is found that in this study the value of using family labor might be more efficient and it is also due to the fact that the result of the scarcity of employed seasonal labor especially during the peak cultivation time in this study. Based on this finding, the rice farming in Myanmar should consider the role of efficient modernized farm mechanization system however this condition is accomplish with the systematic land reclamation condition. At present, in Myanmar the structure of agricultural land is very fragmented and it is the constraints for efficient modernized farm mechanization system. According to the study of Korea agriculture by Kang (2004), high productive efficiency resulted from the larger farms and greater human capital. Based on this fact, Myanmar agricultural development can be obtained through farm consolidation in order to improve productivity and competitiveness.

Subsequently, the variable machines used in farming showed a positive and significantly associated to the efficiency of the rice production in these areas. In order to leap forward developed farming, the applications of modernized farming machineries are essential. It can improve not only the production efficiency in farming but also mass production being aided by modern technology. Therefore, the policy makers should consider the role of farming machinery as an important issue.

Above all, there are many constraints in Myanmar such as many small farm sizes, maintenance of machines and financial status, etc., that are still challenging to become modernized mechanization farming system. So the current study reveals all of these limited conditions of Myanmar farmers. Therefore, the decision makers of Myanmar should give more emphasis to support more infrastructure development and modernized farming system than the current conditions.

2) Summary of findings and discussion on the result of parametric analysis

As an alternative version of measuring the technical efficiency, parametric analysis, stochastic frontier analysis with translog functional form was applied in this study. The translog production function has been widely used in empirical analysis because of its flexible property in modeling. The input-output data of the individual sample farmers in this analysis were same variables as in non-parametric approach. The outcomes technical efficiency of parametric analysis in this study showed higher efficiency indexes than non-parametric analysis. The overall mean value of efficiency index is 0.78, indicating that the average farm produced only 78% of the maximum attainable output for a given input levels. The sample farms accounted with a range of minimum value from 0.69 to a maximum value to 1.00 of efficiency indexes also. This result suggested that the average farm technical efficiency could increase by 22% under the existing production operations. Additionally, based on the results of the variance parameters σ^2 and γ are expressed again the present of inefficiency effects in this analysis. Alternately, under the current using technological practices and input usages are still not sufficient to obtain the fully efficient production in these areas.

Simultaneously, the results of the determinants of the technical inefficiency can be seen with this production frontier model. In this analysis, technical inefficiency indexes is used as regressand and the determinants of the technical inefficiency (regressors) variables in this analysis are same the variables as in non-parametric approach. Among the all regressors, the variable such as education category variables and mechanical tools variables expressed significantly associated with the inefficiency scores in the parametric approach. And also, the signs of correlation directions are the same with the outcomes of non-parametric approach except family labor ratio and the off-farm income variables.

3) Summary of comparison between non-parametric and parametric approaches

Finally, the comparison results of technical efficiency prediction for the sample farmers are presented in this section. For both the data envelopment analysis for non-parametric approach and the stochastic frontier production function for the parametric approach, there is not much differences in their respective technical efficiencies. While the predicted technical efficiencies vary widely across farms for both estimation methods, there are only slight variations across the two different estimation techniques. The mean technical efficiency based on the variable return to scale (0.78) for the SFA production function which is higher than the mean technical efficiency (0.69) for the VRS_DEA. The reason is that these two approaches in measuring the technical efficiencies are attributable relative to different frontiers. Since the DEA model is non-stochastic, noise is reported as inefficiency, hence there has a lower mean technical efficiency. The results of the analysis indicate variation in distribution patterns of technical efficiency scores from two methods. It is concluded here that a combination of the technical efficiency scores obtained from the two techniques are proposed as the preferred set, given the importance of accurate technical efficiency estimates in decision making.

In the case of the factors determining the technical efficiency of rice production, the educational variables and the utilization of the mechanical tools in rice operation are the same results and significantly related to technical efficiency for both analyses. So, it can be concluded that in order to obtain the efficient rice production in Myanmar the basic factors of human resources and modernized farming system are urgently needed. However in the case of going to modernized farming is always accompanied with systematic land reclamation and consolidation.

C. General suggestions and policy recommendations

1) Constraints of rice production

Myanmar rice industry has the potential to grow in many aspects. Therefore, it is necessary to analyze the surrounding factors of Myanmar rice industry into strengths, weakness, opportunities and threats and then reduces weaknesses and risks and makes the best use of strengths and opportunities. Based on the field study and empirical analysis, this study can draw the basic highlight constraints or weaknesses which are necessary for the improvement of efficient rice production in Myanmar. Before going to the developed world, Myanmar is needed to renovate the basic constraints which are essential to improve the all- round development efficiency. When making the policy decisions concerning with the rice productive efficiency improvement for Myanmar farmers, the constraint factors showing in figure 6.1 should be considering carefully.

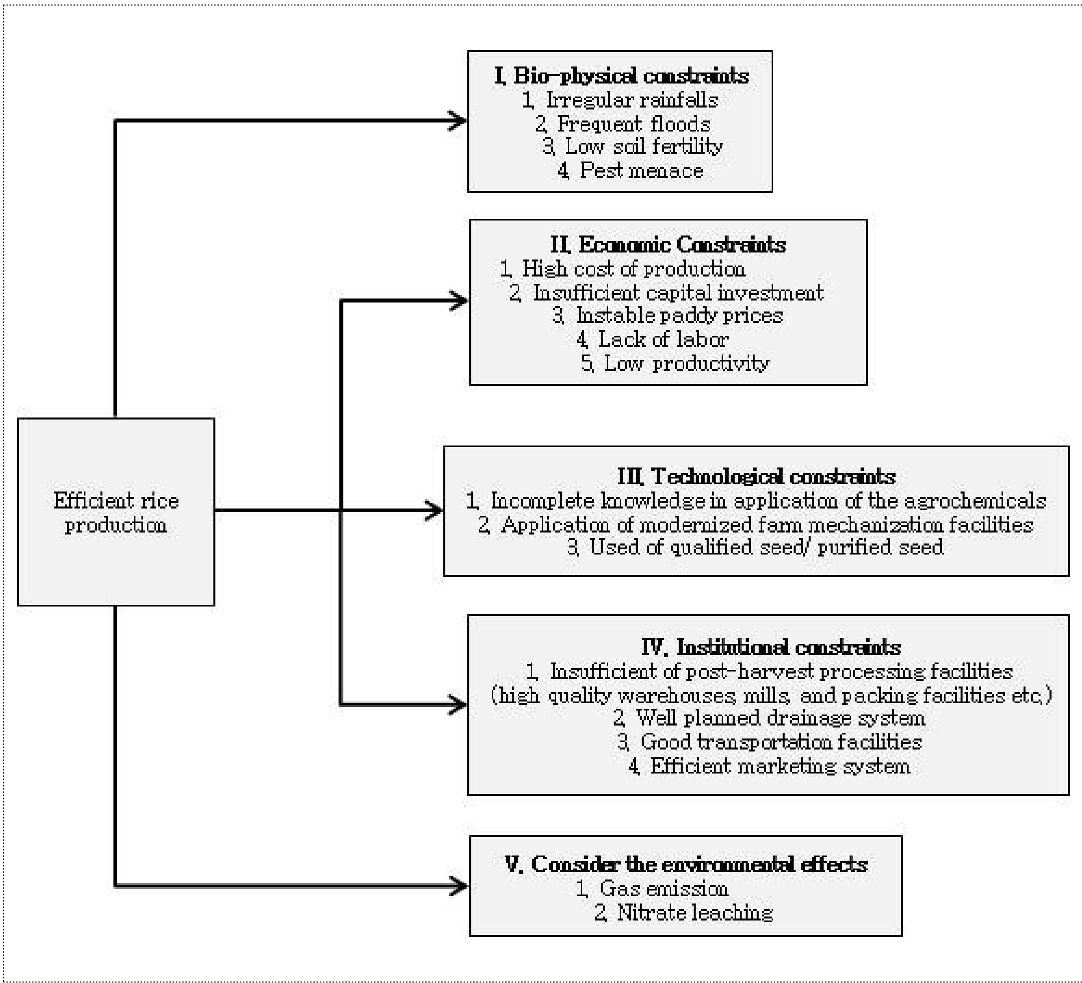

Figure 6.1 Constraints of efficient rice production in Myanmar

In this figure, these constraint factors divided by five categories such as bio-physical constraints, economic constraints, technological constraint, institutional constraints and environmental affects constraints, respectively. Among these five types, except bio-physical constraints, the other constraints can seem to be managing together with government policy makers and farmers themselves. When looking back to the Myanmar agricultural development, the support and encouragement from government is the most important. So, the policy makers are needed to participate as the major role in the development of Myanmar agriculture.

2) Some example from Korea agriculture and rice industry

As an example of policy changes, the some historical changes in the agriculture and rice industry in Korea are presented. Korea was released from Japanese colony at the end of the Second World War. However, some ideology conflicts separated two parts of government, in the South and the North. This section is mention about the South Korea agriculture during the transaction period from agrarian to industrial country.

As all known, Korea was formally an agrarian economy prior to industrialization (1950s). But, agriculture had weak production capabilities resulted in food aid from the United States (1980s) and then through the Green Revolution and Saemaeul Undong (1971-1979), Korea began to achieve self-sufficiency and rural development. After the mid-1980s, the Korea economy became increasingly integrated into the trend of market liberalization, so the agricultural sector had to adapt to the international standards and the government had to reforms the agricultural policies to the market oriented agriculture. Korea start achieved rice self-sufficiency in 1978 ever since and rice production exceeds demand. Nevertheless, 2004 rice negotiation agreement Korea import mandatory quotas of rice from China, US, and other countries. Until now Korea had a lot experiences in policy implementations especially for rice (KREI, 2010).

Table 6.1 Major policies change in Korea

Periods	Major contents and characteristics
First half of the 1990s (based on production policy)	- operated *a procurement program* aimed at achieving self-sufficiency to rice production by fixing government procurement price above market price **1990~1994**: procurement price were kept at high level which equal 180% of the production cost and 120% of the market price at harvest - purchased amount was ranged from 22% to30% of production. However, this condition led over-supply of rice due to this guaranteed price which reflected increase income of the farm household. **1993~1995**: due to the Uruguay Round negotiation and the World Trade Organization, the environment of rice policy was changed - govt. conceded to reduce the domestic subsidy (Aggregate Measurement of Support: AMS) by stopping its procurement in 1995 to 2004 - hence, govt. froze its procurement prize prior to 1995, however, the market price had increased according to the supply and demand; it surpassed the govt. price in 1996. So, procurement price rose again by 4~5.5% every year up to 1998, leading to increase procurement price than the market price.
2002	Discussed the abolition of procurement program and introduction of new alternative ways to stabilize farm income.
2004~ at present (based on income policy)	- fundamental changes of dilemma faced in Korea rice policy - changes whatever leading to fall the income of domestic farm households - govt. introduced the *income compensation program* in 2005 in order to alleviate instability of domestic farm income. The program set a target price to compensate 85% of the difference in the market price, this enable to stabilize farm income despite the fall in market price which included the direct payment. This payment include the fixed and variable payments to farmers: fixed payment was paid regardless of market price while variable payment was subject to reduction, related to the market price. Fixed payments were limited as only given for rice produced land in the basis year (1998~2000), provided that the land maintains the shape and form of paddy fields, or the farmland is cultivated with other crops while the variable payments were based on the same conditions as fixed payments. Accordingly, the direct payment program was introduced meanwhile the procurement program was abolished in 2005.

Source: Agriculture in Korea 2010, Korea Rural Economic Institute.

Table 6.1 presented the major policy changes in rice sector in Korea from 1990 up to present condition. Based on this example, whenever the conditions change, Korea government is ready to protect her domestic producers and consumers. First, Korea changed its national economy from agriculture to industrialized country and then they encouraged and tried to improve the agricultural sector again by using various methods. According to the presented examples above, Myanmar should take some lessons from these changes policies in Korea and Japan agriculture also.

3) Short-term and long-term suggestions

There are many reasons why Myanmar should give priority to agriculture, first the majority of the people in Myanmar are working in the agriculture sector. Therefore, raising farm productivity raises the income of these people and improves the living standard of the majority of the people that will reduce the poverty. Second, rise in agricultural productivity through modern farming technology will release workers from agriculture to other sectors which may result the improvement of other sectors. Currently, Myanmar still lags behind in modern agricultural production. The use of modernized machinery in agriculture will raise productivity, cut the production costs and bring about the economies of scale in long run. Moreover, technology, qualified and efficient application of inputs are also important in boosting production efficiency in agriculture.

At present, agricultural production in Myanmar is relying more or less traditional methods and equipment. In order to change it towards more modernized agriculture a huge capital and modern technology investment in agricultural sector is required. To fulfill these requirements, government is now inviting and encouraging the private sectors participation inside the country and foreign direct investment; however these affect can be seen in long-run. Alternatively, the government can encourage the self-reliance policy like Saemaeul Undong in Korea. To improve rice production efficiency in Myanmar, farmers will require ready access to several key production services as a short-term requirement, including the following actions;

(a) timely and sufficient seasonal credit to fund crop production
(b) a reliable supply of improved seed and planting materials
(c) an adequate and guaranteed supply of good quality farm inputs, fertilizers and sprays etc.
(d) the ability to sell their crop in an open and competitive market place, and
(e) timely access to relevant technologies to improve farm incomes in a sustainable and resource efficient manner.

After acquiring these urgent short-term requirements, the most critical steps required to stimulate significant growth in production efficiency mainly involve policy, process and institutional reform to provide an improved production environment coupled with strengthened farm support services. Consequently, the detail information to support program of long-term development are described as follow.

(a) Rice area renovation

To develop the rice economy, not only rice area expansion but also the renovation includes land reclamation and farm consolidation are required. Land reclamation project should include the new settlement of villages in remote and underdeveloped areas for the landless workers, irrigation and drainage program, credit scheme, communication and transportation facilities are needed. Farm consolidation is presented as one of the best ways to improve productivity and competitiveness because low farm income is the result of small farm sizes, or lack of consolidation. To obtain a more efficient farm, it is necessary to prepare well-organized farm land management programs for farmers.

(b) R&D programs for rice

In order to obtain the continuous development in rice economy, research and development programs are essential for not only farmers and extension workers but for the scientists who may be inspired to explore. Programs should be emphasized on the domestic and international market requirement demand especially in long-run. Alternately, research and development programs should be considered to improve the productivity and profitability of rice farming and quality of rice.

(c) Post-harvest technology

As all know, post-harvest treatment also largely determines the final quality of the product. It includes a set of operations which covers the period from harvesting through to consumption such as drying, milling, cleaning, sorting and packing. Improved post-harvest technologies for reducing post-harvest losses and increasing of farmer incomes from their rice harvest play an important role in Myanmar rice industry. The reasons of farmer becoming price takers are indebtedness, poor storage facilities and lack of market knowledge and little change to value added product etc. Therefore, educating and facilities related to the effective post-harvest management programs are need for rice producers in Myanmar.

(d) Pricing policy

Concerning with rice policy, mutual benefits of both farmers and consumers are essential. Generally rice farmers expect higher price for their paddy and consumers want lower price to buy it. This conflict should be compromised by setting a rationalized price policy by the government which will ensure the stable rice production.

(e) Inventory credit system

In Myanmar, sufficient working capital is essential for rice farmers to increase rice production and marketing. Most farmers cannot use sufficient inputs and adopt proven technology due to the lack of them. Moreover, the paddy price is usually low at harvest time. However, only those farmers who have enough working capital have options when and where to sell. Majority of farmers have to sell their product immediately after harvesting. Therefore, efficient inventory credit system should be introduced to overcome these constraints.

(f) Quality seed and agro-input

Most of the rice farmers in Myanmar usually used the seeds from their previous growing season for growing purpose. So rice farmers need to be aware of maintaining the seed to improve the yield and quality of produce in the successive year. Furthermore, to increase the rice production, agro-inputs such as chemical fertilizers, organic manure, insecticide and small scale agricultural machineries are needed. As for agro-input, it is needed to consider is not only the domestic demand requirement but the quality of the input is also essential.

(g) Well-organized marketing system

It is said that an efficient and organized marketing system is necessary to enable producers to realize a just price for their produce and to reduce their exploitation by middlemen, commission agents and traders. For this purpose, it is necessary to improve the economic conditions of the farmers and protect them from the clutches of traders by providing better selling facilities, basic infrastructure etc.

(h) Educational programs

Education for human resources mainly referred to allocative ability such as: to recognize the changes are occurring, to gathering, retrieving, and examining the information on those changes, to bring the effective decisions based on the information in hand, and performing this decision without hesitation etc. These abilities gain from schooling, by getting information and in experience from reallocating resources etc. Other than the current training programs to farmers, educational program through the various media related to the systematic rice production is required. For example, when the rice growing time comes, the continuous broadcasting about land preparation activities, the effective application methods of fertilizers, etc. should be considered.

(i) Infrastructure development in agriculture

The importance of Infrastructure development in agriculture is the crucial role to play productivity and agricultural development in Myanmar. It includes the development of land and water resources for farmers, the increase the access to and from isolated rural areas through the construction of roads, electricity supplies and telecommunications etc. Moreover, infrastructure development leads to an increase in real income of both agriculture and non-agriculture sectors leading to a decline in poverty level. Therefore, investment in infrastructure is essential to increase farmers' access input and output markets, this in turn affects to improve the agricultural productivity in Myanmar.

4) Limitation of the study

The present study used only one year cross-sectional data for rice production efficiency analysis in Myanmar. In order to estimate the long-term technological change, panel data for rice production should be required. Due to the various reasons, this study cannot estimate the technological change and allocation efficiency, but for further study the panel data should be used to analyze the efficiency of technological changes in Myanmar. Technology change is used to describe the overall process of invention, innovation, and diffusion of technology or processes. Therefore, the further study for technology change analysis can give more sound and specific requirements for the short and long term development of rice industry in Myanmar. Additionally, the further studies should include the comparison of the conditions of the production efficiency with Myanmar and neighboring rice producing countries which are the similar climate conditions and rice growing patterns. By comparing the conditions, the results can find out the strong and weak points of the efficient production situations.

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미얀마 쌀 농가의 생산효율성 계측 및 효율성 요인 분석

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(초록)

미얀마의 쌀 농업은 식량안보뿐만 아니라 농촌지역 고용확대, 경제 활성화, 생태계 그리고 전통 보호 등 아우르는 중요한 분야이다. 그러므로 쌀 산업의 생산 효율성 개선은 미얀마 농업의 발전이라 말 할 수 있다. 이 연구에서는 최근 미얀마 쌀 농업의 생산 효율성을 계측하고 현재 쌀 농가들이 직면한 문제의 해결 방법을 제시하였다. 또한 분석방법으로는 모수적 분석방법과 비모수적 분석방법을 이용하여 표본농가의 쌀 생산 효율성을 계측하고 미얀마의 쌀 생산 효율성에 영향을 주는 요인을 알아 보았다.

분석 자료는 미얀마 쌀 주산지 농가를 대상으로 조사한 횡단면 자료이다. 총 표본농가는 2012년에 쌀을 경작한 195농가를 대상으로 하였다. 비모수적 접근방법인 DEA[1]를 이용하여 분석한 결과 CRS_TE[2]에서는 평균 기술 효율성이 63%로 나타났다. 그리고 VRS_TE[3]에서는 평균 기술 효율성이 69%로 나타났다. 모수적 접근방법인 SFA[4]를 이용하여 분석한 결과 평균 기술 효율성은 78%로 나타났다. 비효율적인 생산 효율성을 나타내는 22% ~ 37% 표본농가는 투입량

1) DEA: Data Envelopment Analysis
2) CRS_TE: Constant Return to Scale Technical Efficiency
3) VRS_TE: Variable Return to Scale Technical Efficiency
4) SFA: Stochastic Frontier Analysis

과 기술을 유지하면서 현재보다 더 높은 기술 효율성에 도달할 수 있는 가능성을 가지고 있는 것으로 나타났다.

생산 효율성 계측 후 표본농가의 생산 효율성에 영향을 미칠 수 있는 결정요인들에 대해서 분석하였다. 결정요인변수는 경영주의 연령, 경영주의 학력수준, 농외소득에 대한 더미변수, 가족노동 비율, 그리고 농기계 수 등을 포함하였다. 경영주의 낮은 학력은 낮은 생산 효율성을 가져오는 것으로 나타났다. 따라서 미얀마 쌀 생산효율성을 높이기 위해서는 민간교육 투자를 확대하는 것이 필요 한다. 농기계사용은 쌀 생산 효율성을 향상시키는 것으로 나타났다. 따라서 정부는 농업기계화 확대를 위해 노력해야 한다. 그러나 농업기계화를 활성화하려면 재배면적이 증가되어야 하므로, 미얀마 농업의 생산성과 경쟁력 향상을 위해서는 영농규모화도 필요할 것이다.

미얀마 농촌 개발을 위해 농업생산성을 높이려면 극복해야 할 제약이 많다. 현재 미얀마 정부도 제약들을 극복하기 위해 농업생산시스템의 현대화를 진행하고 있다. 더불어 미얀마의 농업부문 생산 효율성 개선을 통한 농촌 개발과 미얀마 경제 발전을 위해서 농업분야에 대한 투자를 이끌어내는 정책과 계획, 적절한 생산 기술과 양질의 투입요소를 이용할 수 있는 기회, 교육 구조와 마케팅 구조의 개선이 시급하다.