CHAPTER 3

LITERATURE REVIEW

The concept of efficiency and techniques of efficiency measurement are presented in this chapter in order to provide the theory aspect. Furthermore, previous studies for crops, which applied the stochastic frontier approach, are reviewed to understand their applications.

3.1 Importance of agricultural productivity as an economic efficiency indicator in agriculture production

The role of agriculture in economic development has been recognized for years. Expected increases in agricultural demand associated with population growth and rising of average capita income will require continuous increases in agricultural productivity. Agricultural productivity of production unit, defined as the ratio of its output to its inputs, varies due to differences in production technology, differences in the setting in which production occurs and differences in the efficiency of the production process.

Measurement of efficiency of economic activity is an attempt to assess the performance of industry or individual firms in using real resources to produce goods and services. The requirement of technical efficiency is that the maximum possible amount is produced with the resources used. An efficiency measure should reflect the difference between actual performance and potential performance. The farmers get the better efficiency as they reach the better utilization of inputs or resources.

Schultz (1964) advanced the celebrated hypothesis that farm families in developing countries were “efficiency but poor”. This hypothesis is an enduring view in the literature on development economics. It had led policy makers to believe that, the improve could not be achieved, since the farmers adhere to their existing outdate production technologies. Consequently, this has resulted in policies emphasizing investments in generating new and more production technologies. Introduction of new technologies requires intensive inputs of managerial skill and information, good education and extension services, and adequate infrastructure. However, farmers in developing countries with low literacy rates, facing poor extension services, lack of credit and capital, and insufficient physical infrastructure has great difficulties in understanding and adopting new technologies. The introduction of new technologies is not a single time phenomenon so long as there is advancement and innovation in new technology in disequilibria due to the introduction of technologies in a continuous pace.

Currently, policy makers have started to believe that an important source of growth for the agricultural sector is efficiency through greater technical and allocative efficiency by producer in response to better information and education. The measurement of efficiency of various economic activities has remained an area of important research both in the developed and developing countries. Especially, in the developing agricultural economies, where resources are meager and opportunities for developing and adopting better technologies are dwindling (Ali and Chaudry, 1990). The efficiency measurement is very essential because it is a factor for productivity growth. The study on efficiency help benefit these economies by determining the extent to which it is possible to raise productivity by improving the neglected resources, the existing resource base and the available technology. Hence, the recommendation of the study on efficiency, they could suggest the producer decide whether he should improve efficiency first or develop a new technology.

3.2 Concept of efficiency

Farrell (1957) distinguished between technical and allocative efficiency (or price efficiency) in production. *Technical efficiency* is the ability to produce a given level of output with a minimum quantity of inputs under certain technology. *Allocative efficiency* refers to the ability of choosing optimal input levels for given factor prices. *Economic* or *total efficiency* is the product of technical and allocative efficiency.

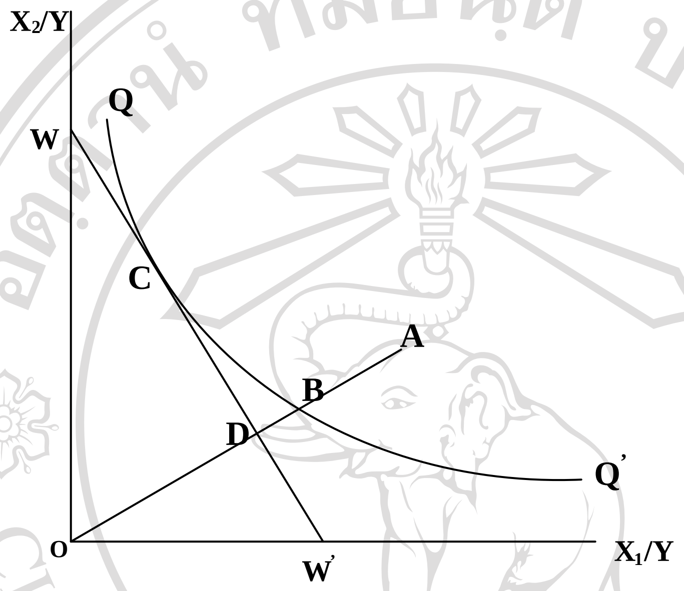

Figure 3.1: Technical and allocative efficiencies (Farrell, 1957)

Figure 3.1 shows that f observation A utilizes two inputs to produce a single output. Given that the production function to be estimated have constant return to scale. The curve QQ' is called *unit iso-quant*. The unit iso-quant defines the input-per-unit-of output ratios associated with the most efficient use of the inputs to produce the output involved. The technical efficiency (TE) of a production unit operating at A is commonly measured by ratio TE = OB/OA, which is equal to one minus BA/OB. It will take a value between zero and one. A value of one indicates the firm is fully technical efficiency. For instance, the firm B is the most technical efficiency or the best practice because it lies on the unit iso-quant. In addition, the deviation of observed input-per-unit-of-output ratios from the unit iso-quant was considered to be associated with *technical inefficiency* of the firms involved.

If the input price ratio, represented by the slope of the iso-cost line, WW' in Figure 3.1, is also know, allocative efficiency may be calculated the allocative efficiency (AE) of firm A to be the ratio AE = OD/OB. Since the distance DB represents the reduction in production costs that would occur if production were to be at the allocative and technically efficiency cypoint C, instead of point B (is technical efficiency, but allocative inefficiency). Finally, the total economic efficiency (EE) is defined to be the ratio EE = OD/OA

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3.3

Techniques of efficiency measurement

In order to measure economic efficiency, it is assumed that the production function of fully firm is to beknown. Since the production function is never known in practice. Farrell (1957) suggested the function be estimated from sample data using either a non-parametric piece-wise-linear technology or a parametric function. The first suggestion was taken up by Charnes *et al* (1978), resulting in the development of the DEA (Data Envelopment Analysis) approach. The latter, parametric approach was taken up by Aigner *et al.* (1977) and Meeusen and van den Broeck (1977), subsequently resulting in the development of the stochastic frontier approach.

DEA is base on mathematical programming techniques. The main feature of DEA method is that it do not require the specification of a functional form. According to Thiam *et al.* (2001), nevertheless, a major drawback of this method is that it do not allow for random noise or measurement error. Another characteristics of DEA method are the potential sensitivity of the efficiency scores to the number of observations as well as to the number of outputs and inputs. Nunamaker (1985) concluded that variable set expansion can be expected to produce an upward trend in efficiency scores. A relatively small but growing number of agricultural applications have used the DEA approach to frontier estimation namely,(Just, 2000; Shafiq and Rehman, 2000; Sharma *et al.*, 1999; Chavas and Aliber, 1983).

The parametric approach considers frontier production function as a parametric function of the inputs and start from a particular function (Cobb-Douglas, CES, Translog, etc.). The estimation technique of stochastic frontier approach deals with the use of econometric method.

The way, in which econometricians look at production frontiers, has undergone substantial modification in the recent years. The earlier work on frontier is a *deterministic frontier*. This idea was developed by Farrell (1957), Africat (1972), and tested by Aigner and Chu (1968), Seitz (1971), Richmond (1974), and others. There are severe statistical problems with a deterministic frontier. One of the primary criticisms of the deterministic frontier is that no account is taken of the possible influence of measurement errors and other noise upon the frontier. All deviations from the frontier are assumed to be the result of technical inefficiency (Coelli *et al.*, 1998).

It is this second deficiency that led to the development of probabilistic production frontier by Timmer (1971). He adopted the suggestion of Aigner and Chu (1968) of deleting a percentage of the sample firms closet to the estimated frontier, and re-estimated the frontier using the reduced sample. The arbitrary nature of the selection of percentage of observations to delete, has meant that this so-called probabilistic frontier approach has not widely followed.

Finally, Aigner and *et al*. (1977) (hereafter ALS) and Meeusen and van den Broeck (1977) have sought to ameliorate the problems associated with both deterministic and probabilistic production frontier. Alternative approach the solution of the 'noise' problem has, however, been widely adopted, , (Coelli *et al.*, 1998). This is the method known as the *stochastic frontier* approach.

There are also some conceptual advantages to using a stochastic approach, as it allows for statistical noise rather than attributing all deviations to efficiency difference. In addition, this approach is relatively straightforward to implement and interpret, Xu and Scott, (1998). Taking many advantage of the stochastic frontier approach, many studies have been studied by adopting this method. In this study, it mainly concerns on technical efficiency. The concept of stochastic frontier and technical efficiency measurement is presented in detailed in Chapter 4. However, the subsequent section is to review the finding of previous studies using the stochastic frontier method.

3.4 Previous related studies

Many studied applied the stochastic frontier approach to estimate the technical efficiency and allocative efficiency in agricultural production, i.e. crop production, livestock breeding, fishery and integrated farm (including both crop production and livestock). The following part just would refer the studies on crop production.

Xu and Scott (1998) employed a dual stochastic frontier efficiency decomposition model to examine the productive efficiency (technical, allocative, and economic efficiency) of hybrid and conventional rice production in three various regions in Jiangsu province in China. It was found that the use of labor, chemical fertilizer, manure, machinery service, and pesticide positively affected rice yield. Furthermore, the result found that hybrid rice production increased the potential economics of scale for Chinese rice production and the productive efficiency of hybrid rice were lower than that of conventional rice. Moreover, the study revealed that a positive relationship between technical efficiency and education for hybrid rice production, thus emphasizing the importance of considering farmer's abilities to receive and understand information relating to new agricultural technology. In addition, this also determined that land size was a positive factor in explaining the efficiency of hybrid rice in modern agricultural areas. It implied that in modern agricultural regions, the predominantly small farm size might pose a restraint to technical change.

Sriboonchitta and Wiboonpongse (2001) employed both transcendental logarithmic (translog) and Cobb-Douglas stochastic production frontier simultaneously to explore the influences of production inputs, technical efficiency and other factors on Jasmine and Non-jasmine rice yield in Thailand. The results for policy implications were derived from Cobb-Douglas frontier. It showed that the crucial factors influencing Jasmine rice yield were technical efficiency, chemical fertilizer, labor, irrigation, severe drought, and neck blast whilst those for the non-jasmine rice were the same, except labor and neck black. The factors affecting the technical inefficiency for non-jasmine in a negative relationship were male labor to total labor ratio and experience reflected by age while the labor influencewas in the positive direction. However, there was only male labor to total ratio influencing on technical inefficiency significantly for jasmine rice.

Kebede (2001) used frontier production approach to measure technical efficency of rice producers in the mid hills on Nepal, identify its determinants, and establish its relation to farmer's environmental orientation. The study found that land area, labor use and amount of seed use positively correlated to rice output and were statistically significant. Animal power expressed in number of oxen day and manure use also positively affected the rice output but was insignificant. It was explained that this may by that, because the farming system in the study area was labor intensive to the extent that the contribution of oxen day was negligible and manure use did not had direct influence on the amount of output. With regarded to technical efficiency, farming experience and education were both significant factors for improving technical efficiency. Moreover, female household head were found to be more efficient demonstrating their good management capacity. Female household heads would have better opportunities to carry out frequent follow up and supervision of the farm activities on their plot. This implied that strengthening the supervision and coordination capacity of farmers could enable them to increase efficiency. In addition, farmer households who had access to credit were found to be more efficient than those did not.

Tadesse and Krishnamoorthy (1997) used stochastic frontier along with Maximum Likelihood Estimate to examine the level of technical efficiency across ecological zones (zone I, II, II, and IV) and farm size groups in rice farms of the southern Indian state of Tamil Nadu for the year 1992-1993. This study had not considered ecological effect as an importance issue in that time. Therefore it employed dummies for ecological zones, farm size groups, and their interactions as variables of Tobit model. It was found that land area, labor use, expenses on irrigation, pesticide, and fertilizer positively affected the rice output. Animal power negatively influenced the output, but it was also highly significant. This was explained that animal power may be overused. Moreover, the results indicated that

90% of the variation in output among rice farms in the state was due to differences in the technical efficiency, and the mean technical efficiency was 0.83. In addition, the level of technical efficiency differed significantly from across agro-ecological zones and size groups as well. The study further showed that small-sized rice farm in zone II and medium-sized rice farms in zone III achieved higher technical efficiency as compared with zone I and zone IV with larger holding land areas.

Kalirajan and Flinn (1983) applied the translog stochastic frontier production function to study on 79 rice farmers in Philippines. The individual technical efficiency ranged from 0.38 to 0.91. It was concluded that the practice of transplanting rice seedlings, level of fertilization application, years of farming, and number of extension contacts had significant influence on the variation of the estimated farm technical efficiencies.

Kalirajan (1989) used the translog stochastic frontier production function with the panel data for estimating technical efficiency of India rice farmers. The farm effects were to be found to be a highly significant component of the variation of rice output, given the specifications of a translog stochastic production frontier. Individual technical efficiencies ranged from 0.64 to 0.91. The estimated technical efficiencies on farm-specific variables indicated that farming experience, level of education, accessing to credit, and extension contacts had significant influences on the variation of the farm technical efficiencies.

Rola and Quintala-Alejandrino(1993) applied stochastic frontier production and used data taken from the PhiliRice project on regular monitoring of rice farms in the different agro-climate environments, e.g., irrigated lowlands, rainfed lowlands, and upland rice system to estimate technical efficiencies of rice farms. The study showed that means of technical efficiencies were different among environments. Farmers in the same environment with the same technologies had different rice yield. The study concluded that farmers with higher efficiency used less cash inputs, and institutional support could be geared more toward rainfed and upland where farmers were less efficient. Change in tenure status could potentially increase yields, especially in upland environment.

Seyoum *et al*. (1998) studied on technical efficiency and productivity of maize producers in eastern Ethiopia. The study investigated the technical efficiency of two samples, one involving farmers within the extension project which targeted to small-scale farmers and the other dealing with farmers outside this program. The study used stochastic frontier production functions in which the technical inefficiency effects were assumed as functions of age and education of farmers, together with the time spent by extension advisers in assisting farmers in their agricultural production preparation. Furthermore, Cobb-Douglas stochastic frontier was found to be adequate representation of the cross-sectional data, given the specifications of the translog stochastic frontiers for each farmer group. The result showed that the small-scale farmers within the project had significantly higher outputs than those for the farmers outside the project. The information revealed the important contribution of this project and the government should promote the agricultural program to improve on the level of efficiency and productivity of maize farmers.

Battese and Hassan (1998) used a stochastic frontier production function, in which technical in-efficiency effects were assumed as a function of other observable variables related to the farming operations of cotton farmers in Pakistan. The result showed that there were the positive impacts of cotton land, seed sown, pesticide expenses, and quantity of irrigation water on the cotton output. Furthermore, first irrigation was associated with higher technical efficiency of cotton production, which may be due to development of the root system, when the cotton crops may be under some moisture stress. It was expected that the later irrigated crops were more vigorous and perform better when infested with pests and diseases. Moreover, an increase in the number of intercultural had positive influence on the technical inefficiency. The authors were expected that this was associated with the greater disturbance to growth of the cotton plants and the dropping of the flowers and bolls. Furthermore, the practice of rogging of the cotton crops resulted in a decrease in the technical inefficiency.

Bakhshoodeh and Thomson (2001) applied stochastic production function to estimate technical efficiency of wheat production function in Kerman, Iran. The result showed that wheat cultivated land, amount of seed use highly positive correlated with the wheat output. In addition, the level of in-efficiency was found to be related to farm size. S,mall and large farms were show to be more technically efficiency than medium-sized farms, and efficiency was found be affected the ratio of fertilizer to seed.

Technical efficiency of wheat farms in eastern England were measured through the estimation of a stochastic frontier production function using panel data for the 1993-1997 crop years by Wilson *et al*. (2001). The study examined the influence of management characteristics on technical efficiency. It was indicated that fertilizer use, crop protection expenditure, labor use, and machinery use positively related in wheat yield. The result also showed that the objectives of maximizing annual profits and maintaining the environment were positively correlated with, and had the largest on technical efficiency. Moreover, those farmers, who sought information, had more years of managerial experience, and larger farm associated with higher level of technical efficiency.

Tzouvelekas *et al*. (2001) studied on technical efficiency of organic and conventional olive-growing farms in Greek by using stochastic frontier method. It was exhibited that olive cultivated land, labor use, chemical fertilizer, pesticide, and other cost expenses (consisting of fuel and electricity, depreciation, fixed, and current assets interest) affected olive output. The finding also indicated that organic olive-growing farms had slightly higher technical efficiency than conventional ones. Moreover, share of family in total labor use, farm size, and the stock capital inputs (including machinery, inventories, and building) were crucial factors affecting technical efficiency.

Kurkalova and Jensen (2000) applied stochastic frontier method and cross-sectional data to study on technical efficiency of grain production in Ukraine. The finding indicated that the use of labor, fertilizer, chemicals, and diesel positively correlated with total of the grain output. On the other hand, ratio of number workers on off-farm activities and number of workers on-farm activities, ratio of agricultural workers, and the total of land area, and distance from a given farm to nearest city negatively impacted on the farm inefficiency. The number of agricultural worker per hectare was found to have positive impact on technical efficiency, which suggested that abundance of labor resource for production was important for achieving effective utilization of inputs. The coefficient of the share of non-agricultural in total number of farm workers was negative and indicated that technical inefficiency in grain production decreased with an increase of this share, and presumably, with an increase of infrastructure quality of the farm.