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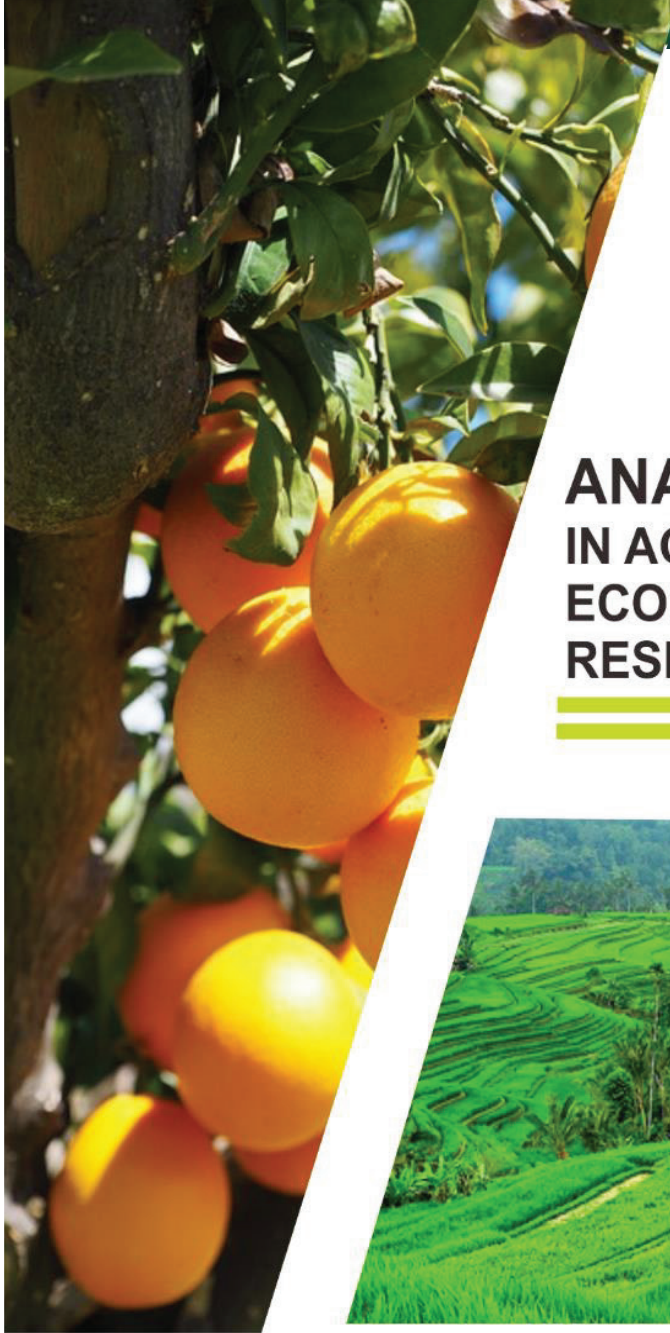
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Himawan Arif Suntanto, Dosen tetap pada Sekolah Tinggi Ilmu Ekonomi (STIE) Bank BPD Jateng Semarang. Lahir di Kabupaten Pemalang Jawa Tengah. Menyelesaikan Sarjana (S1) tahun 2000 di UNS Solo dan Sarjana Ekonomi (S1) Jurusan Ilmu Ekonomi dan Studi Pembangunan pada Fakultas Ekonomi Universitas Diponegoro tahun 2008. Meraih Magister Sain (S2) di bidang Ilmu Ekonomi dan Studi Pembangunan dari Program Pasca Sarjana MIESP Universitas Diponegoro Semarang tahun 2006. Sejak tahun 2010 sampai sekarang

aktif melakukan penelitian dan pengabdian kepada masyarakat baik yang didanai Dikti, Pemerintah Daerah, Bank Jateng maupun internal STIE Bank BPD Jateng. Beberapa mata kuliah yang diampu diantaranya Ekonomi Makro, Ekonomi Mikro, Perekonomian Indonesia, Statistika dan Aplikasi Komputer Statistika. Menjadi Editor In Chief Econbank: Journal of Economics and Banking, Dewan Editor Jurnal Media Ekonomi dan Manajemen Untag Semarang. Sampai saat ini aktif sebagai pengerurus ISEI Cabang Semarang bidang pengembangan Akademik, Riset dan Profesi.

ANALYSIS TOOLS IN AGRICULTURAL ECONOMIC AND SOCIAL RESEARCH



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Sucihatningsih Dian Wisika Prajanti

Rahim M. Sail

Himawan Arif Sutanto



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THE USE OF PRODUCTION EFFICIENCY APPROACHES IN THE DECISION MAKING OF AGRICULTURAL ECONOMIC FIELD

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CHAPTER I

INTRODUCTION

Many students still experience difficulty in analyzing quantitative data. Therefore, this book intends to bridge the students' difficulty in data analysis especially in the field of agricultural economic. The book contains ways to analyze efficiency by using metrical approach (Stochastic Frontier) and non-metric Data Envelopment Analysis (Sucihatiningsih, 2011). Besides, it also discusses how to conduct an analysis for decision making such as in Analytic Hierarchy Process (AHP) via Expert choice software.

Product efficiency measurement can be done through several approaches, namely parametric approach with Stochastic Frontier Analysis (SFA), and non-parametric approach with Data Envelopment Analysis (DEA). DEA is a method used to evaluate the level of productivity or efficiency of a work unit with the variables of multiple output and multiple input through a linear programming approach. The measurement of a unit of activity using DEA produces a measure of relative efficiency level. DEA includes the use of liner programming in calculating efficiency, while stochastic frontier covers the use of Maximum Likelihood method in estimating efficiency.

To carry out product efficiency estimation through Stochastic Frontier Analysis, we can utilize Frontier 4.1 c software, and Data Envelopment Analysis with Banxia Frontier Analysis. Many researchers have applied both SFA and DEA approaches. For example, Baek and Pagan (2003) who used production functions for a company production efficiency and d executive compensation in United State of America. Meanwhile, researchers who applied these approaches in industrial sector are such as Angeles and Sanchez (2002); Parsons (2004), and Yuk-Shing and Dic Lo (2004). The prominent characteristic of frontier production

model in estimating technique efficiency is the presence of the separation of the impact of exogenous shock variables on output by contributing variations in the form of technical efficiency (Giannakas et al 2003). In addition, DEA model has been used as a measurement of various scientific disciplines and various operational activities.

In the basic theory of macroeconomic, production technology is stated as a production transformation function defining the maximum output attainment from various input combination. Thus, the transformation function describes limit or production frontier. When the production frontier is acquired, the technical inefficiency of a business can be estimated through the comparison of business position on its frontier (Lass & Gempesaw in Witono, 1999).

In this book, the author provides guides for Frontier 4.1c software to estimate the technical efficiency of a business along with examples of its application in fisheries sector. Meanwhile, for DEA estimation, the author provides guides for Banxia Frontier Analysis along with its application in agricultural sector.

CHAPTER II

PRODUCTS EFFICIENCY ANALYSIS

2.1 The Theories of Production

Production has many definitions and is not limited to the process of producing final goods (or services). Bogdan (1998) says that production is related to a series of combination of several inputs, process them until the inputs turn into final goods or called as output. For more, production can also be more than that since it is also in association with the processes of packaging, storage, distribution, transportation, and product marketing.

Furthermore, Joesron and Fathorozi argue that to analyze the interrelationships between production inputs and outputs sometimes researchers use production function as its media. In relation to this, there are two major things to understand, namely production function is (i) open to other variables influence in the process of production caused by the physical interaction between the described variables and explanatory variables. (ii) requires the relation between the described variables and explanatory variables as well as other relations. Suppose a company has short-term fixed input (K). Prior to producing outputs, a manager would decide (i) how many inputs (variables) needed. Then (ii) the next step is deciding the amount of additional input causing total production changes. If the input variable is labor (L), and the fixed input is capital (K), then the average product of labor is (APL). According to Salvatore (2007) APL is defined as a total production divided by the number of units of labor used. This situation is presented in the following formula

$$APL = TP / L$$

APL = labor productivity per unit of person (average labor production). AP will be maximum if the first derivative of the AP function is zero ($AP' = 0$). Mathematically, MP will cut the AP at its maximum value. Total production (total product, TP) shows the amount of production produced from the use of total production factors. TP will be maximum if the first derivative of the function value is zero. The first derivative of TP is MP, then if the maximum TP occurs at MP meaning that the value is zero. The following is the sequence of formulations:

$$TP = f(K, L)$$

TP = total production

K = capital goods (which are considered constant) L = labor

Marginal product of labor (MPL) is determined by changes in TP on changes in the amount of labor employed.

$$MPL = TP' = \delta Q / \delta L$$

Soekartawi (2003), Nicholson (1995) elaborate MP with their notation $\Delta Q / \Delta L$, meaning that the addition of one-unit input (L) causes the addition or reduction of one-unit output (Q).

One thing that is most often considered in business is the efficiency of production input usage. Mankiw (2006) states that input efficiency can be generated through technology developments until the business achieves the equal production level with lesser production factors. Technology advances also contribute to the level of productivity. It is because production factors can be minimized to produce maximum output.

Many studies used frontier production function approach to examine efficiency. Based on Soekartawi (2003) frontier production function examines the production function on its frontier position (limit). This function presents physical relations of production factors and production on the frontier which is located on isoquant line. This line is a place for the combination of the use of optimal production inputs. For more, efficiency shows a

comparison between output and input. If the output is large, it shows higher efficiency or vice versa.

Mankiw (2006) states that efficiency is the condition of allocating resources that maximizes the overall surplus accepted by all members of the community. Whereas according to Sucihatiningsih (2010) efficiency is the optimal level of input utilization (such as labor, finance, tools / technology), or the level of input utilization with minimal waste.

According to Soekartawi (2003), Nicholson (2005) this situation will occur if farmers are able to make marginal product value (MPQ) for an input equal to the price of its input (Px). This condition is illustrated in the following formulae:

$MP_x = MPL$. $PQ = PX \rightarrow$ assumption: there is a perfect competition in the goods market

In fact MP_x is not always the same as P_x . What often happens is:

$MP_x / P_x > 1$; meaning that the use of X input is technically not yet efficient. Therefore, to achieve technical efficiency, X input needs to be added.

$MP_x / P_x < 1$; meaning that the use of X input is technically inefficient. Therefore, to achieve technical efficiency, the use of X input needs to be reduced.

$MP_x / P_x > 1$ Adding X input

or

$MP_x / P_x < 1$ Reducing X input

An efficiency achieved by adding or reducing X input is called as price efficiency (allocative efficiency)

To complete Soekartawi's opinion, the author presents the following elaboration: $MC = MR$ assumption: perfect competition market

$$MR = PQ$$

$$MC = PQ \quad PQ = \delta TC / \delta Q$$

$$\frac{\delta TC}{\delta Q} \cdot \frac{\delta X}{\delta X} = P_Q \quad \frac{\delta TC}{\delta X} \cdot \frac{\delta X}{\delta Q} = P_Q$$

$$P_X \cdot 1 / MP_X = PQ \quad P_X = PQ - MP_X$$

$$\frac{\delta X}{\delta X} \cdot P_Q = P_X \quad \frac{\delta Q}{\delta X} \cdot P_Q \cdot \frac{X}{X} = P_X$$

$$\frac{\delta Q}{\delta X} \cdot \frac{X}{X} \cdot \frac{1}{P_X} = \frac{1}{P_Q} \quad \frac{\delta Q}{\delta X} \cdot \frac{X}{P_X} \cdot X = \frac{1}{P_Q}$$

$$MP_X / P_X = 1 / PQ$$

The explanation above shows the use of one production input (in this case is X input). If the input of production is more than one input, then the equation is as follows:

$$MP_{X1} / P_{X1} = MP_{X2} / P_{X2} = \dots = MP_{Xn} / P_{Xn} = 1 / PQ$$

2.2. The Concepts of Efficiency

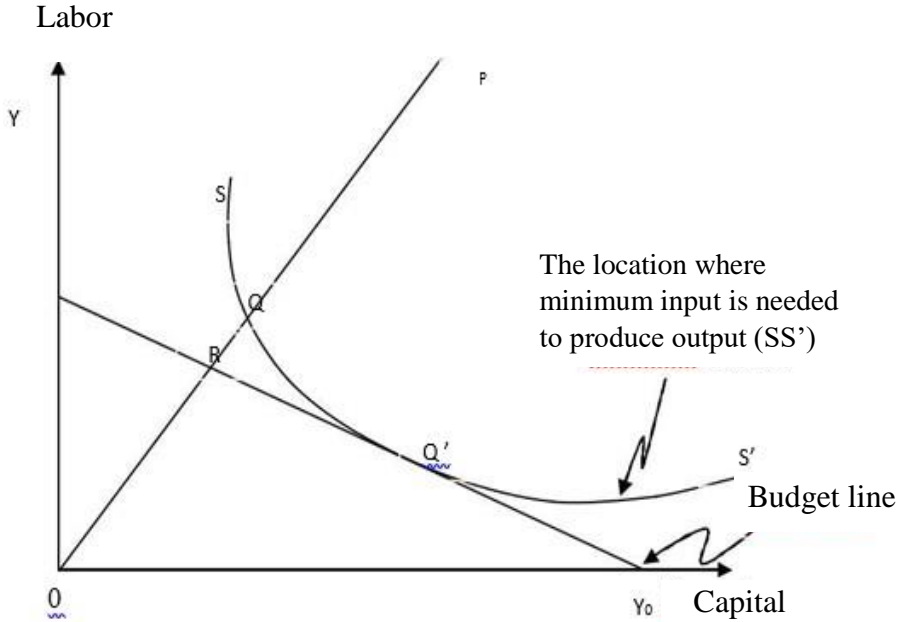
Farel (1957) and Timmer 1970 (in Sucihatiningsih, 2011) distinguish efficiency into: technical, allocative, and economic. Each of these efficiencies has a definition as follows. First, technical efficiency acts as an input ratio that is actually used with the available output. In other words, it is in form of the amount that shows the comparison between actual production and maximum production. Second, Allocative efficiency is achieved if the company is able to maximize profits by equating the marginal product of each factor of production to its price. Third, economic efficiency is a quantity that shows a comparison between actual profits and maximum profits. In another definition, economic efficiency is achieved when price efficiency and technical efficiency are achieved.

Technical efficiency is one component of overall economic efficiency that is often used to measure production. Kumbhakar and Lovell (2000) in Sucihatiningsih, (2010) mention three ways to maximize profits from farm, namely: (i) maximize outputs in the use of particular inputs or commonly defined as technical efficiency; (ii) maximum profits can be achieved through a proper input combination at a particular input price level (allocative efficiency); and (iii) produce a precise production combination at a particular production price level.

By understanding the definition of efficiency, it can be concluded that efficiency (covering technical, allocative, economic) is a common indicator. In addition, the achievement of high technical efficiency (especially for farmers who minimize the use of input factors) is aimed at increasing competitiveness and profits. In managing farm, farmers may make consequential deviations. On the other hand, the dynamics of farm can contribute to continuous technical and economic changes, so it would arise problems for farmers in adjusting their allocative decisions (costs) as a response to changes in their production environment. The following figure 2.2 shows a company dynamics. SS curve is isoquant showing the combination of labor and capital to produce efficient isoquant (technically) as well as shows the frontier line (maximum limit) of Cobb-Douglass production functions.

Figure 2.2

Technical Efficiency and Allocative Efficiency



Source: adapted from Adiyoga (1999), Sucihatningsih (2011)

By looking at figure 2.2 we can obtain the following information:

YY₀: Budget line or production factor price line that connects the dots of the combination of labor and capital to obtain optimal costs.

OP: the distance that describes the technology of a business

SS': Locus where minimum input is needed to produce output, or isoquant slope (the combination of labor input and capital)

OQ / OP: Shows technical efficiency (ET)

OR / OQ: Indicates price efficiency (EH)

ET * EH: Indicates economic efficiency

$(OQ / OP): (OR / OQ) \equiv OQ / OP: OR / OQ = OR / OP$

According to Adiyoga (1999) there are four approaches which can be used to measure efficiency;

(i) Non-Parametric Deterministic Frontier (DEA) based on linear programming (quadratic), introduced by Farrell (1957, in Sucihatiningsih, 2011).

(ii) Deterministic Parametric Frontier. Aigner and Chu (1968) developed from the C-D production function.

(iii) Deterministic Statistical Frontier. Using statistical techniques to estimate the frontier, such as corrected ordinary least squares (COLS), and technical maximum likelihood.

(iv) Stochastic Statistical Frontier. Besides using OLS estimation, this approach also involves disturbance terms. It was introduced by Aigner et al. (1977), then developed by Schmidt & Lovell (1980).

The conclusion of the above explanation is that efficiency can be estimated by parametric (stochastic) and non-parametric approaches. The parametric approach produces the stochastic cost frontier, while the DEA approach produces a production frontier. "The stochastic approach is a production frontier function (FPF) that uses hunch and shows the function of production factors, random errors and inefficiencies. On the other hand, the non-parametric approach does not use the above assumptions so that the model formulation errors can be avoided. Furthermore, this approach does not use random errors, as is usually in the parametric approach.

2.3. Approaches for Efficiency Analysis

There are several approaches that can be used to measure production efficiency, namely parametric approach with stochastic

frontier analysis (SFA), and non-parametric approach with Data Envelopment Analysis (DEA). Data Envelopment Analysis (DEA) is a method that is used to evaluate the level of productivity or efficiency of a unit of work with multiple output and multiple input variables through a linear programming approach. The measurement of a unit of activity using DEA produces relative efficiency level measurement. DEA covers the use of linear programming in calculating efficiency, while stochastic frontier includes the use of Maximum Likelihood method in estimating efficiency.

To estimate production efficiency with stochastic frontier analysis, we can use Frontier 4.1c software and Data Envelopment Analysis with Banxia Frontier Analysis. Many researchers have applied both SFA and DEA approaches. They are such as Baek and Pagan (2003) who used production function to examine the production efficiency of a company and d executive compensation in the United States. Meanwhile, those who have applied the approaches in industrial sectors were such as Parsons (2004); Yuk-Shing and Dic Lo (2004). In addition, the prominent characteristic in frontier production model in estimating technique efficiency is the presence of the separation of the impact of exogenous shock variables on output by contributing variations in the form of technical efficiency (Giannakas et al 2003). The DEA model has been used as a measurement of various scientific disciplines and various operational activities.

In the basic microeconomic theory, production technology is stated as a production transformation function that defines the attainment of maximum output from various input combinations. Thus, the transformation function describes the boundary or production frontier. If the production frontier is known, then the technical inefficiency of a business can be estimated by comparing the position of the business to the frontier.

2.3.1. Parametric Approach with Stochastic Frontier Analysis (SFA)

The use of parametric approach to examine efficiency practiced by Aigner and other researchers has resulted the development of stochastic frontier model. Aigner and Chu (1968) considered the parametric frontier estimation of production function of Cobb-Dauglas in the following model;

$$\ln(Y_i) = X_i\beta_i - u_i, \quad , i = 1,2,3, \dots, n \quad (2.1)$$

That the $\ln(Y_i)$ which shows the value of logarithm output of the i and X_i company is a vector of the number of i company inputs. Meanwhile, β_i is an estimated parameter and u_i is a positive random variable that is related to the technical inefficiency of production from the i -company. Further, the ratio of observation of output to the second company is relative to the potential output indicated by the frontier function of the existing input. Therefore, the technical efficiency values can be formulated as follows:

$$ET = \frac{Y_i}{\exp(X_i\beta)} = \frac{\exp(X_i\beta - u_i)}{\exp(X_i\beta)} = \exp(-u_i) \quad (2.2)$$

Next, Aigner et al. (1977) proposes stochastic frontier production function by adding random error (v_i) in positive random variable, and results the following equation;

$$\ln(Y_i) = X_i\beta + v_i - u_i \quad i=1,2, \dots, n \quad (2.3)$$

V_i random error holds measurement errors and other random factors which are out of control such as climate effects, the condition of a country, luck and others over the value of the output along with the effect of a combination of input variables that are not specified in the production function. Aigner et al. (1977) assume that V_i is distributed independently and identically (independent and identically distributed – i.i.d). It has random

variable with a zero average and constant independent variant σv^2 of the u_i that is assumed i.i.d on the exponential random variable or half normal.

The model of equation 2.3 is called as stochastic frontier production function because the output value is limited by the stochastic variable (random) variable, $\exp(X_i\beta + v_i)$. V_i random error can be positive or negative and also the frontier stochastic output varies limitedly from the frontier model, $\exp(X_i\beta)$ see Figure 2.5. The input is represented on the horizontal axis and the output on the vertical axis. The deterministic component of the frontier model, $Y = \exp(X_i\beta)$ is assumed to be diminishing return to scale. The output and input are observed from two companies, namely i and j and the i company uses the input level X to produce Y_i output. The value of the frontier stochastic output, $Y_i^* = \exp(X_i\beta + v_i)$ is indicated by the point above the production function since the v_i random error is positive. Whereas, the company j uses the input level X_j and produces the output $Y_j^* = \exp(X_i\beta + v_i)$ under the production function because v_i and v_j random errors are not detected. However, the deterministic part of the stochastic frontier model is seen between the output of stochastic frontier. Alternatively, the observation output might be bigger than the deterministic part of the frontier if the random errors related to this matter has bigger inefficiency effect.

Figure 2.1
Stochastic frontier production function

Frontier output exp
 $(X\beta + v)$ if $A_i v_i > 0$

Frontier output exp
 $(X\beta + v)$ if $v_i > 0$

Source: Coelli et al (1996);

The frontier stochastic production function describes the potential maximum production for a number of production input. Sucihatiningsih (2011) explains that frontier production model can possibly estimate or predict the relative of particular business group obtained from the relationship between production and the observed production potentials. Further, with the basis of production theoretical framework, various models have been developed to estimate the technical efficiency of a business (firm) by considering different theoretical and empirical aspects (Coelli et al, 1998)

The application of this production function is aimed at measuring the level both technical efficiency and inefficiency that has rapidly developed. Baek and Pagan (2003) used this production function application to estimate the production efficiency of a company and d executive compensation in United States. Meanwhile, those who have

applied this application included Angeles and Sánchez (2002); Parsons (2004); Yuk-

Shing and Dic Lo (2004). The prominent characteristic in frontier production model in estimating technique efficiency is the presence of the separation of the impact of exogenous shock variables on output by contributing variations in the form of technical efficiency (Giannakas et al 2003). In other words, the application of this method makes it possible to estimate the inefficiency of production processes without ignoring the default errors of the model. It is possible because there are two error terms of the model which are distributed freely (normal) and equal to each observation. The first error term is a typical standard error that exists in a model (v) and the second error term is for representing inefficiency (U) and $e = vu$ (Baek and Pagan, 2003; Coelli et al, 1998; Giannakas et al, 2003). Technical efficiency can be measured using the ratio of variance parameters with total variance $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda = \sigma_u / \sigma_u$ as follows

(Battese dan Corra, 1977 dalam Coelli et al, 1996)

$$\gamma = (\sigma_u^2) / (\sigma^2) \quad (2.4) \text{ di mana } \sigma^2 = \sigma_u^2 + \sigma_v^2 \text{ dan } 0 < \gamma < 1$$

if γ approaches one, σ_v^2 approaches zero, and u_i is the level of error in equation (2.50), the result indicates inefficiency. In this case, the difference between management and efficiency results is the most important part because of the existence of management specificity. Furthermore, the analysis is aimed at identifying the influence of differences in several factors. In addition, the technical efficiency of a company can also be predicted by using the equation formulated by Bettese and Coelli (1988); Kumbhakar and Lovell (2000) which can then be calculated by the following formula:

The above formula are the representative of normal distribution functions for random variables. Meanwhile, Jondrow et al in Zen et al (2002) present the average conditions of u_i and ε_i in the equation as follows:

$$E(u_i | \varepsilon_i) = (\sigma_u \sigma_v / \sigma) \{ [f(\varepsilon_i \lambda \sigma^{-1}) / (1 - F(\varepsilon_i \lambda \sigma^{-1}))] - (\varepsilon_i \lambda \sigma^{-1}) \} \quad (2.6)$$

Where; ϵ_i is the sum of $v_i + u_i$, σ is the equation for $(\sigma_u^2 + \sigma_v^2)^{1/2}$, λ is the ratio of σ_u over σ_v , f and F is the standard for normal density and the distribution function of evaluation for $\epsilon_i \lambda \sigma^{-1}$. Further, technical efficiency measurements (TE) for each company can be calculated by using:

$$TE_i = \exp [E (u_i | \epsilon_i)] \quad (2.7)$$

where: $0 \leq TE_i \leq 1$

Furthermore, it is assumed that all companies which have done their production efficiently still need to be tested. To test this assumption, the following Likelihood Ratio Test (LRt) test is used:

$$LRt = - 2 [\ln (Lr) - \ln (Lu)] \quad (2.8)$$

Then the LRt calculation results are compared to the critical values of χ^2 (chi-square). If the LRt value is greater than the critical values of χ^2 (chi-square) then there is no evidence

that $\sigma^2 = 0$. In other words, there is no reason to reject that all companies are 100 percent efficient, meaning that there are still companies that are inefficient in doing production.

2.3.2. Non-Parametric Approach with Data Envelopment Analysis (DEA)

DEA is a non-parametric approach that is basically is a linear programming-based technique. It works by identifying units to evaluate as well as their input and output. Next, DEA will count the values of productivity and identify which units use inefficient inputs or do not produce effective outputs. The measured productivity is comparative or relative because this approach only compares between units of measurement from 1 set of the same data. Additionally, DEA model has been applied as a measurement in various scientific disciplines and various operational activities such as banking (Nwaru, J.C., et al. 2006; Oser 1988; Oyewa, 2009)

DEA method was created as a means of evaluating the performance of an activity in an entity unit (organization). DEA is a mathematical programming technique used to evaluate the relative efficiency of a decision making unit (DMEU) in managing resources (inputs) of the same type so that they become the same type of output, where the relationship of the function form from

input to output is unknown. The term UKE or generally known as the Economic Activity Unit (Unit Kerja Ekonomi/ UKE) in DEA method can be various units such as banks, hospitals, schools, super markets, companies and anything that has similar operational characteristics.

DEA is a non-parametric approach that is basically is a linear programming-based technique. It works by identifying units to evaluate as well as their input and output. Next, DEA will count the values of productivity and identify which units use inefficient inputs

or do not produce effective outputs. The measured productivity is comparative or relative

because this approach only compares between units of measurement from 1 set of the same data. DEA is a production factor analysis model used to measure the relative efficiency level of a set of economic activity units (UKE). The efficiency score of many

input and output factor is formulated as follows;

DEA assumes that each UKE will choose a weight that maximize its efficiency ratio (maximize total weighted output / total weighted input). It is because each UKE uses different input combination to produce different output. Therefore, each UKE will choose a set of weight that reflects this diversity. Generally, UKE will assign high weight for the less usage input and the less produced output. These weights are not the economical values of its input or output, but as a determiner for maximizing the efficiency of one UKE. As an illustration, if one UKE is a company which prioritizes profits (profit-maximizing firm) and each input and output has a unit cost and selling price per unit, then the company will try to use as little input as possible with the highest cost per unit and try to produce many outputs with high selling price. DEA for a UKE can be formulated as a fractional linear program whose solution can be obtained if the model is transformed into a linear program with the weight of the UKE input and output as the decision variables. For more, the simplex method can be used to complete the model that has been transformed into a linear program. DEA requires the completion of a linear program for each UKE. The result is a set of weights for a UKE and its relative efficiency rate (Oser, 1988).

DEA has several managerial values. First, DEA produces efficiency for each

UKE. It is relative to other UKEs in the sample. This efficiency number enables analysts to know which UKE requires attention the most and plan for corrective actions for UKE

which are not / less efficient (efficiency $< 100\%$). DEA shows a number of UKE that have perfect efficiency (efficient reference set, efficiency=100%) and a set of multipliers that can be used by managers to develop improvement strategies. This information allows analysts to make UKE hypotheses derived from lesser input and produce output at least the same or more than the UKE that is not efficient so that the hypothetical UKE will have perfect efficiency if it uses inefficient input weights and output weights from UKE. This approach gives a strategic direction for managers to improve the efficiency of an inefficient UKE through the introduction of too many used inputs and outputs whose production is too low. As a result, the manager does not only know the inefficiency of UKE, but he also knows how the level of input and output must be adjusted in order to have high efficiency. Third, DEA provides a cross efficiency matrix. The cross-efficiency of UKE A against UKE B is the ratio of weighted output divided by weighted inputs calculated using UKE A input and output levels and the weight of UKE B inputs and outputs. Cross-analysis can help a manager recognize UKE efficiently, but using the most distinguished combination of inputs and yields output from other UKE. As an illustration, if there are 3 UKEs that use two inputs and one output (Figure 2.6), the input is normalized with the output for each unit. UKE A and B are located in the efficient frontier, while UKE C is located on the OC line which intersects the

efficient frontier lines. Efficient frontier is pieces of line that form linear curves that point up and right and always fulfill certain conditions, namely pieces of line that are the lowest (lowest) scope of UKE in the sample. The efficiency frontier surrounds / covers the points that represent each UKE. This is the origin of Data Envelopment Analysis name.

Figure 2.2

Three Inputs Frontier Efficiency

Input2 leads to one point of the vertical axis in an infinite place

output

B' (inefficient)

B (efficient)

Efficient

C (inefficient)

C (efficient)

efficient

A A' (inefficient)

0

Source: Nwaru (2006)

leads to one point of the horizontal axis in an infinite place

input 1

output

Based on figure 2.2 above, UKE efficiency can be measured according to its relative position on efficient frontier. Each UKE showed by a coordinate point is a ratio at the level of input1 / output and input2 / output level. Meanwhile, UKE in the lower position and more left position from other UKEs are more efficient than the previous two UKEs. It is because the first UKE is able to produce the same output level using two types of input with lower number compared to the second UKE so that O (origin) point turns into an orientation which decides each UKE efficiency. Further OC line cuts efficient frontier at C'. The efficiency of C UKE equals to the ratio between OC' line segments divided by OC line segments. Since $OC' < OC$, the OC' / OC ratio produces less than one value (UKE efficiency $C = OC' / OC < 1$), so C UKE is inefficient. Moreover, a UKE is considered efficient if its efficiency ratio is equal to 1 or 100% and this occurs if a UKE is located in the efficient frontier. If a UKE is located in the efficient frontier, then the two segments of the line will be the same length and the ratio of the two segments is equal to one. If a UKE is located above and

right of an efficient frontier, then the ratio of the two line segments will be less than 1.

A graphical approach can be carried out in a case where a number of UKE only uses 2 types of input and produce 1 type of output. However, if the number of UKE which uses two or more types of input and produces two or more types of output, the graphical approach cannot be applied. Therefore, there is need for using linear programming by assuming a number of UKE is in n and each having input m and s output, where the relative efficiency score of UKE p is obtained from the model proposed by Oser et al (1988);

(2.10)

Where:

$k = 1 \dots s$

$j = 1 \dots m$

$I = 1 \dots n$

y_{ki} = the average output produced by UKE

x_{ji} = the average input j used by UKE

v_k = weighted k output,

u_j = weighted j input.

The formulas showed above (2.10) can be transformed into linear programming as follows (2.11) (Oser et al. (1988).

(2.11)

The above problems are done in n times calculation to identify the precise coefficient of a number of UKE. Each UKE chooses maximum weighted input and output which reflects its coefficient score. Generally, each UKE is said to be efficient if it obtains score 1, but if its score is less than 1 meaning that it is inefficient. For each inefficient UKE, DEA identifies a set of efficient units that are appropriate. It can be used as a reference for improvement. The reference can be obtained from the dual problem indicated by the formula below (2.11).

Where:

θ = efficiency score λ_s = dual variable

Based on the formula (2.12), an UKE is efficient if the consumed combination of UKE (linear combination of units in the set) uses less input than other UKEs that produce the same output. Units involving the calculation of the combined UKE can be used as a reference for increasing inefficient UKE. DEA also considers calculating the necessary improvements in inputs that are inefficient in order to become efficient. Further, efficiency is used to measure the performance of the production process. In a broad sense, it is done by operating variables that have different units. Most of which are in the measurement of public goods or goods that do not have certain markets (non-traded goods). To do this, DEA as a tool of analysis is the most suitable choice. DEA analysis is specifically designed to measure the relative efficiency of a production unit in conditions where there are many inputs and many outputs which are usually difficult to be perfectly investigated by other efficiency measurement analysis techniques. Briefly, the various advantages and disadvantages of the DEA method are as follows:

(a) DEA advantages

- Can handle many inputs and outputs
- No need to assume functional relationships between input and output variables
- UKE (Decision making Unit) is compared directly with each other
- Input and output can have different measurement units. For example, X1 can be in units and X2 can be in dollars without a priori for both.

(b) DEA Limitations:

- Simple specific
- Is an extreme point technique, measurement errors can be fatal

- DEA is very good for estimating the real efficiency of UKE (economic activity unit), but is very slow to measure absolute efficiency. In other words, it can compare the same units of UKE, but not compare maximization in theory.
- Difficult statistical hypothesis testing of DEA results
- Using separate linear programming formulations for each UKE (manual calculation is difficult, especially for large-scale problems)
- Weight and input produced by DEA cannot be interpreted in economic values.

DEA model

In DEA approach, there are two models used, namely CCR (Charnes-Cooper- Rhides) model and BBC (Banker-Charnes-Cooper) model. The CCR model is used in form of constant return to scale, while the BBC is used in form of constant return to scale variable. Additionally, the basic form of DEA assumes the presence of constant return to scale where proportional changes at all input level will result proportional changes in output. Further model development is constant return to scale variable where changes at all input level will result greater changes in output.

(1) DEA CCR model (Charnes-Cooper-Rhodes)

DEA CCR model was first discovered by Charnes, Cooper and Rhodes in 1978. The CCR model introduces a measure of efficiency for each Economic Activity Unit (UKE) which is the maximum ratio between weighted output and weighted inputs. Each weight value used in the ratio is determined by the limitation that the same ratio for each UKE must have a value of less than or equal to one. Thus, it will reduce multiple inputs and multiple outputs into one "virtual" input and "virtual" output without requiring initial weight values. Therefore, the measurement of efficiency is a function of the weight value

of a combination of virtual inputs and virtual output. The measure of UKE efficiency can be calculated by solving the following mathematical programming problems:

x_{ij} is the input value observed with the i -type of UKE in j time and $x_{ij} > 0$ for $i = 1, 2, 3,$

\dots, m and $j = 1, 2, \dots, n$. Similarly, y_{rj} is the output value observed with the i -type of UKE-

$y_{rj} > 0$ for $i = 1, 2, \dots, m$ and $j = 1, 2, \dots, n$.

u_r and v_i variables are weight values to determine the above programming problems. However, this problem has an unlimited solution because if $(u^*$ and $v^*)$ are optimal, each $\alpha > 0$, $(\alpha u^*$ and $\alpha v^*)$ should also be optimal. By following Charnes-Cooper transformation, the solution we can choose is a solution (u, v) that is representative with the conditions:

$$\sum_i v_i = 1$$

Through the above formulae, the obtained linear programming is equivalent to the problem of linear fractional programming. The dividers in the efficiency measures above are made equal to one and the linear problems that have been transformed can be written as follows:

The linear programming problem above is often called input-output oriented CCR model. Maximization is done by selecting "virtual" multiply of (the weight value) u and v which results in the largest rate of "virtual" output per "virtual" input. For each UKE_0 , the problem can be written as follows:

The above linear programming obtains optimal solution of θ^* , which is an efficiency value or also called as the value of technical efficiency or CCR efficiency for certain UKE. Meanwhile, the efficiency values for all UKE are obtained by repeating the above process for each UKE_j, $j = 1, 2, \dots, n$. The value of θ is always smaller or equal to one. For UKE which gets $\theta^* = 1$, it is called relatively efficient, where the combination of "virtual" input-output is located in the efficient frontier.

(2) DEA BCC Model (Banker-Charnes-Cooper)

To scale return variable, it is necessary to add a convexity condition for the weight values of λ by entering the following limits to the above model:

The result of DEA model which provides a scale return variable is called BCC, Banker, Charnes and Cooper model. The input-output oriented BCC model for UKE₀ can be written as follows:

BCC efficiency values are obtained by running the above model for each UKE. The efficiency values of BCC performance

measurement are called pure technical efficiency. This is related to the values obtained from the model that permits the scaled return variable so that the existing scale can be eliminated. In general, CCR efficiency values for each UKE will not exceed BCC efficiency values which are intuitively clear. It is because BCC model analyzes each UKE locally than globally. If we have obtained the pure technical efficiency, then scale efficiency can be calculated by this equation: SE

= Technical Efficiency / Pure Technical Efficiency

(3) The Comparison of BCC and CCR

In DEA CCR model or widely known as constant return to scale, the comparison between output and input values is consistent and the addition of input and output values is comparable. In this model, there is also a term called as return to scale variable in which the increase in input and output is not in the same proportion. For more, the increase in

proportions can be in form of increasing return to scale (IRS) or can be decreasing return to scale (DRS)

Figure 2.3

The Comparison of CCR and BCC Models

Source: Oser, 1988

(4) The Figure of Output Orientation BCC Model, and The Figure Input

Orientation BCC Model

The figure below will illustrate the efficient and inefficient relationship of UKE

in the output-oriented BCC model.

Figure 2.8

Output and Input Orientation BCC Model

The figure of output orientation BCC Model The figure of input orientation BCC Model

Source: Hadinata and Manurung, 2000 (in Himawan, 2010)

In the figure of output orientation BCC model, it is known that UKE 1,5,3 and 6 are the efficient UKE which forms frontier efficiency. UKE 2 will be efficient if the output variable and frontier efficiency values is minus one ($\Phi 2-1$) or multiply the output value with the efficiency value ($\Phi 2$) to get the output value at the frontier, then reducing the input value by the slack input value (because UKE2 is outside envelopment surface). Whereas, UKE 4 and UKE 7 seem do not have slack. The efficiency of those UKE will be achieved by increasing the output value and also reducing the input value.

(5) Input and Output Orientation CCR Model

The CCR model invented by Charnes, Cooper and Rhodes is also known as CRS (constant return to scale). Both CCR, input and output oriented model, are derivatives of the BCC model. In other words, the two models are almost the same. In input oriented BCC, there is a convexity constraint requirement different from the CCR model. In this model, convexity constraints are omitted. The same thing happens to the CCR model with output orientation. In the model, convexity constraints are also omitted. Removal of this condition will result in a reduction in the efficiency of the two CCR models.

CHAPTER III

THE EFFICIENCY ESTIMATED TOOLS AND GUIDES

There are many softwares to analyze efficiency such as Frontier 4.1 software which is used to estimate the efficiency with parametric approach and Banxia Frontier analysis to estimate the efficiency with non parametric approach.

3.1 Frontier 4.1

There are several programs to estimate the Stochastic Frontier Analysis (SFA) such as STATA, LIMDEP, and Frontier 4.1c. Some of those programs are paid and others are free. We can freely use the Frontier 4.1c. Therefore, this book gives Frontier 4.1c program guides to estimate the Stochastic Frontier Analysis (SFA) analysis. The program can be downloaded on the following website

<http://www.une.edu.au/econometrics/cepa.htm>

Program Installation

After we get the downloaded file from the website in the form of compression file (Zip), we need to install the Frontier program by double clicking front41-xp zip file. Then, the following figure will appear.

Click [here](#) to move files to Frontier folder

Click extract, then make a new folder by clicking “new folder” and type

“FRONTIER” on the name column as showed in the following figure.

Click here to make
FRONTIER folder

Make sure all file has been extracted to C:/FRONTIER

Running the program

1. Preparing the file

The file data used in FRONTIER program are in text format (*.dta). To change the notepad format into file.dta, it is necessary to use dos operation. Previously, if the estimated model is in the form of logarithm, so the data have to be transformed into logarithm through excel operation or another computer program.

2. Trasforming the data into logarithms through Excel

To transform the data into logarithm, the writer provides an example of 125 samples of the fishing gear used in Pematang regency. The steps are as follows.

Click insert menu select function.

Put the cursor here to see the log result of A3 cell data

Select LN function (for natural logarithm) as presented in the following figure.

Click OK, and the command box will appear

Fill the number column for cell that will be logged, in this case is A3 cell

The data logarithm result on A3 cell of 75

Click OK on I3 cell, and it will be filled with log 75 value (A3 cell data)

Put the mouse cursor on the bottom right corner of I3 cell, so + sign will appear

Copy the log formula by putting the cursor on the bottom right corner of I3 cell, so + sign will appear. Then, drag and slide up to 5 columns to the right.

After that, copy the first line formula down until line 125 (sample) by blocking the first line of I3 until N3. Next, put the cursor on the blocked bottom right line until the + sign appear, then drag and slide down until the sample line to 125.

All of the skipped cells will show the number of log result as showed in the following figure.

The sequence of data read by Frontier program starts from the sequence of individual number and observation frequency. In this case, as the assumption is only one observation, so after the sample serial number, number 1 is written. It shows that the observation period is only conducted once. The result is showed in the following figure.

Copy all the data into notepad by blocking all the data, in this case from H3- H125 until O3-O125.

Click start menu All program Accessories notepad

Click edit click paste

Save as the file name "him"

Now, we already have the file him.txt which will be processed by Frontier 4.1c program.

3. Changing file *.txt to *.dta

Click start All program Accessories Command Prompt

The following figure will appear

Go to frontier folder

Typing cd\ until it becomes c prompt c:\>

To go to the frontier folder, click `cd FRONTIER`. The following figure will appear.

After that, click edit menu to open the data file that we will change into *.dta format by typing `c:\FRONTIER>edit` then click ENTER.

Once you are in edit menu, there are some PULL-DOWN menus above the screen, such as File-Edit-Search-View-Option-Help. To open the file, click File menu above the screen then select Open (to open the file) as showed in the following figure.

Find the file location (in the FRONTIER folder), in this case the file is `him.txt.`, highlight it, then click OK.

Next, to change the notepad file (*.txt) to be frontier file (*.dta), click File,

Save As.

For the storage location, keep it in the FRONTIER folder so the folder can be read by the program. The file name can be the same. We only need to change its extension into dta, for instance the file was him.txt, and changed into

him.dta (see the file name in the following figure), then click OK.

Change the him.txt file to him.dta, then click OK

4. Making a Command File Program

Once the estimated data file is ready, prepare its command file program. It is almost the same as changing the file that we still work on the screen on command prompt-edit.

Click File Open, select command instruction file program. To default

Frontier program select EG1.INS file and click OK.

Change the frontier default program file with the name of data file which will be used to estimate the efficiency, as follows

Change eg1.dta into file which has been previously made, such as him.dta, as well as the output file.

The result of changes is presented in the following figure.

After that, click File Save As to save the file and give a name as we wish

Give a name as we wish. Remember, command file (instruction) extension is *.INS as showed in the following figure.

This is the command program file name for estimation. Then click OK

Once the file saved, click the pulldown menu File Exit.

Then back to Command Prompt of Frontier folder, as presented in the following figure.

On the command dos prompt Frontier, run the program by typng

FRONT41 click ENTER

There will be information as attached in the following figure. Enter the command file which has been made by typing Enter Instruction File Name:

for instance him.ins. Then click ENTER. The program will automatically excute and process the estimation as we wish and

also create the output file in line with the file name which has been previously written. See the following figure.

Type the previous instruction file name. Then click ENTER

There will be information that your output file has been sent to result notepad file.

If there is an error, your instruction program and data file may have some mistakes. Therefore, you have to recheck from the beginning.

If this information appears, the estimation is successful. The result is automatically transferred into notepad form. Then check on the folder

To see the result, open the file on Explorer. Then find the extension file *.out (for

instance him.out)

The output file of FRONTIER estimation result

There is another way to run the FRONTIER 4.1 program. It can be run by choosing terminal (t) and file (f) as informed in the figure above. For terminal instruction, choose t and follow the steps as showed in the following figure.

Then follow the following instructions: Enter the data file name:
him.dta

Are you estimating a production or cost function? : 1 (1 for production function) Is the dependent variable logged? : y (the variable data on the log form)

How many cross section in the data? 125 (fill the sample number)
How many time-periods in the data? 1 (1 if only one period)

How many observations in the total in the data? 125 (fill the sample number) How many regressors (Xs) are there? 5 (the number of independent variable) Does the model include mu? no (choose no for no)

Click ENTER

5. FRONTIER program Output (Version 4.1c)

Instruction file = him.ins

Data file = him.dta

Error Components Frontier (see B&C 1992). The model is a production function.

The dependent variable is logged.

The old estimates are:

	Coefficient	Standard-error	t-ration
Beta 0	0.18818500E+01 0.10175665E+01	0.18493632E+01	
Beta 1	0.37986525E+00 0.16155350E+01	0.23513279E+00	
Beta 2	0.47688554E+00 0.35691224E+01	0.13361423E+00	
Beta 3	0.86803555E-01 0.39629360E+01	0.21903850E-01	
Beta 4	0.42850089E-01 0.14803951E+01	0.28945036E-01	
Beta 5	-0.31601270E	0.14147413E+00	-0.22337137E+00
Sigma-squared	0.70067944E-01		

Log likelihood function = -0.81498056E+01

The estimates after the grid search were:

beta 0	0.20047458E+01	beta 1	0.37986525E+00	beta 2	0.47688554E+00
beta 3	0.86803555E-01	beta 4	0.42850089E-01	beta 5	-0.31601270E-01

sigma-squared 0.81808066E-01 gamma 0.29000000E+00

mu is restricted to be zero beta is restricted to be zero

iteration = 0 func evals = 19 llf = -0.80987886E+01

0.20047458E+01 0.37986525E+00 0.47688554E+00
0.86803555E-01

0.42850089E-01

-0.31601270E-01 0.81808066E-01 0.29000000E+00 gradient step
iteration = 5 func evals = 45 llf = -0.80945099E+01

0.20042816E+01 0.37676207E+00 0.46797440E+00
0.86190274E-01

0.44160446E-01

-0.28416341E-01 0.81762459E-01 0.29006074E+00 iteration =
10 func evals = 83 llf = -0.80932341E+01

0.19325647E+01 0.37131957E+00 0.47022735E+00
0.86045620E-01

0.44080654E-01

-0.22494875E-01 0.82260498E-01 0.29775182E+00

The final mle estimates are:

Frontier regression result

	Coefficient	Standard-error	t-ratio	
Beta 0	0.19325647E+01 0.10723524E+01	0.18021731E+01		
Beta 1	0.37131957E+00 0.16220704E+01	0.22891705E+00		
Beta 2	0.47022735E+00 0.35758904E+01	0.13149937E+00		
Beta 3	0.86045620E-01 0.39949603E+01	0.21538542E-01		
Beta 4	0.44080654E-01 0.15585688E+01	0.28282778E-01		
Beta 5	-0.22494875E-01 0.16086373E+00	0.13983808E+00		-

sigma-squared 0.82260498E-01 0.31078681E-01
0.26468465E+01

gamma 0.29775182E+00 0.44627104E+00
0.66719951E+00

mu is restricted to be zero beta is restricted to be zero

log likelihood function = -0.80932341E+01

LR test of the one-sided error = 0.11314288E+00 with number of
restrictions = 1

[note that this statistic has a mixed chi-square distribution]

number of iterations = 10

(maximum number of iterations set at : 100)

number of cross-section = 125 number of time periods = 1

total number of observations = 125 thus there are: 0 obsns not in
the panel

covariance matrix:

If $t\text{-ratio} > t\text{-table}$, H_0 is rejected. If $t\text{-ratio} < t\text{-table}$, H_0 is accepted

The sign (+) which shows decimal is moved to the right.

+ 0 1 means shifting one number to right to be 1,072. In contrast, negative sign (-)

0.32478277E+01 -0.39763301E-01 -0.81644312E-01
0.74716908E-02

0.64508640E-02

-0.23474266E+00 -0.24744092E-02 -0.40171682E-01

-0.39763301E-01 0.52403016E-01 0.61469338E-03 -
0.66375336E-03 -

0.44649776E-03

-0.32512326E-02 -0.53901479E-03 -0.83338806E-02

-0.81644312E-01 0.61469338E-03 0.17292085E-01 -
0.77449498E-03 -

0.71872661E-03

0.10011255E-02 -0.43654956E-03 -0.67094252E-02

0.74716908E-02 -0.66375336E-03 -0.77449498E-03
0.46390879E-03 -

0.15533228E-03

-0.40194761E-03 -0.51766008E-04 -0.79470871E-03

0.64508640E-02 -0.44649776E-03 -0.71872661E-03 -
0.15533228E-03

0.79991552E-03

-0.49141251E-03 0.90209487E-04 0.13878436E-02

-0.23474266E+00 -0.32512326E-02 0.10011255E-02 -
0.40194761E-03 -

0.49141251E-03

0.19554688E-01 0.67627308E-03 0.10445941E-01

-0.24744092E-02 -0.53901479E-03 -0.43654956E-03 -
0.51766008E-04

0.90209487E-04

0.67627308E-03 0.96588439E-03 0.13066171E-01

-0.40171682E-01 -0.83338806E-02 -0.67094252E-02 -
0.79470871E-03

0.13878436E-02

0.10445941E-01 0.13066171E-01 0.19915784E+00

Technical efficiency estimates:

firm eff.-est.

1 0.78673066E+00

2 0.71257372E+00

3 0.83776739E+00

4 0.89263562E+00

5 0.84173071E+00

6 0.88564630E+00

7 0.86369018E+00

8 0.87800936E+00

.....

.....

.....

120 0.89789335E+00

121 0.87206561E+00

122 0.88961481E+00

123 0.89677200E+00

124 0.84248681E+00

125 0.87805872E+00

mean efficiency = 0.88659313E+00

3.2 Banxia Frontier Analysis (BFA)

The technical efficiency mean value from 125 analyzed data

To analysis the efficiency with non-paramatrix approach, we may use Banxia Frontier Analyisi 3.0 software. Its demo version can be downloaded on www.banxia.com. Once the file downloaded, the next step is to install the file to your computer by double clicking on the downloaded file. DEA program is ready to use. Banxia program demo version only can be used to analyse 11 Economy Activity Units (UKE).

Data Envelopement Analysis (DEA) is linear program non-paramatrix analysis. DAE is used to measure the relative score of UKE which uses many input and output.

The relative efficiency of an UKE is UKE efficiency compares with other UKEs in a sample which uses the same input and output. In relative efficiency, DEA is defined as total weighted output to weighted input ratio. In DEA, the weight for each UKE input and output is determined. It is not permitted having the negative value and universal. Each UKE will choose the weight which maximizes the efficiency ratio (maximize total weighted output/input). Therefore, each UKE uses combination of different input to result

the different output combination too. As a result, each UKE will choose the weight which represents the diversity. In general, UKE will determine the high weight for the less input usage and for more output produced.

Furthermore, to use the BF A V.30 software for counting the efficiency, here is the example of data input and output.

No

UKE

Instruct

(Score)

Building

(Score)

Tools

(Score)

Blj_Goods

(Rp.000)

Capital

(Rp.000)

Human

Resource

(person)

Production

(Ton)

Kunkapal

(unit)

Contribution

(%)

1

Jakarta

1.89

1.03

1.41

392.489

3.970.227

211

7.664

5.991

8.09

2	Belawan	0.99	0.33	0.66	131.543
	3.030.377	93	40.465	9.022	22
3	Bungus	0.1	0.88	1.2	196.898
	2.866.482	83	3.729	551	2.39
4	Cilacap	0.68	0.56	0.38	154.358
	7.710.607	127	1.628	4.691	1.42
5	Kendari	0.78	0.88	0.56	318.920
	2.962.383	91	6.986	5.708	5.07
6	Brondong	0.18	0.61	0.25	196.467
	3.186.713	108	29.229	18.195	4.94
7	Sibolga	0.53	0.71	0.25	223.124
	54.798 67	832	3.638	0.11	
8	Pelabuhan ratu	0.69	0.74	0.96	210.329
	3.853.402	94	3.368	38.498	1.41

9

Kejawanan

0.48

0.12

0.18

134.505

738.372

94

2.481

1.001

0.47

10	Pekalongan	0.31	0.32	0.64	144.079
		3.560.191	164	58.771 5.844	20.3

Tanjung

11	Pandan	0.26	0.39	0.46	156.870	3.909.476
		62 185	5.612	0.14		

12	Pemangkat	0.61	0.2	0.56	200.906
		3.576.270	52	9.406 18.110	5.94

13	Tual	0.18	0.44	0.13	132.336	3.330.192
		46 41.992	373	42.27		

14	Prigi	0.89	0.31	0.2	145.324	1.542.171
		111 14.200	27.317	2.1		

15	Ternate	0.34	0.19	0.14	263.183
		3.685.079	63	3.470 6.837	2.53

16	Ambon	0.17	0.16	0.23	114.622
		2.978.153	71	551 287	0.1

17	Sungailiat	0.42	0.29	0.54	138.469
		3.605.743	41	4.318 13.543	3.59

18	Karangantu	0.16	0.1	0.25	165.022
		2.649.450	26	1.004 19.556	1,043

Teluk

19	Batang		0.22	0.23	0.2	127.496
1.725.456	39	295	551	0.24		

First, prepare the data that will be calculated with DEA. Initially, enter the data into MS-EXCEL with the format as showed in the figure in the top coloumn, namely input, then followed by output. Meanwhile, the left coloumn is filled with the name of the economic activity unit (UKE).

Second, block the data of UKE, input and output. After that, copy it by clicking

edit menu, select copy as presented in the following figure.

Open Banxia Frontier Analysis program by clicking START ALL PROGRAM Banxia Frontier Analysis 3. The following figure will appear.

Click

OK

The following figure will appear.

Choose data paste from clipboard and

Leave the other as they are (default) as showed in the following figure then click

next.

Click

Next

Then click Finish.

Click

Finish

The result will be as follows.

Before calculating the data, we should sort the input and output by selecting the type of input/ output as showed in the figure. To display the input/output type, click menu then move to the left.

Click here and move to
the
left

After that, put the cursor on the production column and select as
the output. The

result is presented in the following figure.

Click here to select it as the

output

Similarly the process carried out for kunkapal and contribution variables as the output, is done by determining the production as the output

Select the DEA model option, namely CCR model (Charnes-cooper-Rhodes) → CRS model (Constant Return to Scale) and BCC model → VRS model (Variable Return to Scale)

Determine the optimization → (1) Maximize the same/constant output and input

(2) minimize the input on the constant output.

Click here to select the optimization model and type

[Click here](#) to select maximalization output

In this case, choose VRS and Max out (Maximizing output) model. See the

following figure

Click [here](#) to choose VRS model

To calculate DEA, click EDIT Analyse now. The result can be seen in the

following figure.

Or click [here](#) to analyze DEA

To show the whole report click VIEW → Report. To see the report in detail select

Complete Detail A4 as presented in the following figure

To display the frequency of fishery port as the graphic set reference and table click

VIEW → Reference frequencies.

Chart

Table

To see the correlation of each input and output, click VIEW → X-Y Plot. The following figure will appear.

Select input and output that will be correlated

To see the graphic efficiency, click VIEW → Efficiency Plot as presented in the following figure.

Choose input and output that will be plotted its efficiency

To see the whole improvement potential, click VIEW →
Improvement summary

To see the efficiency score distribution, click VIEW → Score Distribution as presented in the following figure.

The calculation result as showed in the following figure comes from 19 fishery ports. There are 5 inefficiency in combining the input (the efficiency score is under 100%)

The ports that reached 100% score will be the set reference for others that have not reached 100% score.

Number 1 shows that Ambon becomes the reference for only 1 anchorage that get score

The fishery ports that have not reached the efficiency score 100% are suggested to improve its efficiency by referring to fishery ports (UKE) that has successfully reached the score. To perform the

improvement, they may see the potential improvement on each input and output on DEA.

5 shows the anchorages that refer to 5 anchorages that have reached the score 100%

The reference UKE
that achieved 100%

The (-) sign indicates input usage is more than it should be and

the reverse for positive sign

To save, click File Save Project

Decide the storage location and the file name as desired. Click Save as showed

in the following figure.

Type the file name as desired

[Click here](#) to decide the storage location.

CHAPTER IV

ANALYTIC HIERARCHY PROCESS (AHP)

4.1 Definition

AHP processes were developed by Thomas L. Saaty in the 1970s. AHP was initially designed for capturing one's rational perceptions related to particular problems through several procedures aimed to rationally capture the preference scale among alternatives. It is a comprehensive decision making model that considers qualitative and quantitative matters. For more, AHP model can help arranging either priorities or objectives from various options through the use of criteria (Dalalah, 2010).

This AHP method helps solving complex problems by structuring hierarchical criteria and including many considerations in order to develop portion or priority. This method also combines the

strength of the feelings and logic of the people concerned on various problems, and synthesizes various considerations into results which are suitable for our intuitive expectations based on what has been presented in the considerations (Saaty, 2006).

The hierarchy processes of a model contribute chances for individual or groups to build up ideas and define problems by making assumptions and obtaining solutions from them. In addition, there are two main reasons for stating an action will be better than the other. First, the effects of these actions are sometimes not comparable because of different sizes and different fields. Second, the effects of these actions sometimes are in contrast with each other, meaning that the improvement in the effect of one action can be achieved by another deterioration. Both of these reasons will make it difficult to make equivalence between the effects so that there is a need for a flexible scale called priority. (Pearce, 1990).

4.2 Strengths and Weaknesses of AHP Method

Strengths

1. It has a hierarchical structure as a consequence of the chosen criteria until the deepest sub-criteria.

2. It takes into account the validity until the unconcentrated tolerance limits as criteria and alternatives chosen by decision makers.
3. It takes into account the durability or resistance of the output of the sensitivity analysis of decision making.
4. AHP "pairwise comparison" method has the ability to solve problems investigated by multi objects and multi criteria based on the preferences comparison of each element in the hierarchy. Therefore, this model is a comprehensive. Moreover, decision makers determine the choice of a simple pair of comparisons, establish all priorities for alternative sequences. Further, AHP "Pairwise comparison" uses qualitative data based on perception, experience, intuition so that it is felt and observed, but the completeness of numerical data does not support quantitative modeling.

Weaknesses

1. AHP model depends on its main input. The main input is in the form of an expert's perception so that in this case, AHP involves the subjectivity of the expert. Besides, the model becomes meaningless if the expert gives a wrong assessment.
2. AHP method is only a mathematical method without statistical testing so that there is no limit of trust from the truth of the model formed.

4.3 The Concepts of AHP

Saaty (2006) argues that the priorities of elements in a decision problem can be done by making pairwise comparison, namely each

element is compared in pairs to a specified criterion. The form of this pairwise comparison is showed in the following matrix:

C

A1

A2

A3

A4

Notes: C = Criteria, A = Alternatives

The pairwise comparison matrix filling involves numbers that describe the relative importance of an element above the others. This scale defines and explains the values range from 1-9 which are set for consideration in comparing the pairs of similar elements at each hierarchical level on a criterion on its next level. Moreover, experiences have proven that a scale with nine units is acceptable and reflects the degree that can distinguish the intensity of the relationship between elements.

The pairwise comparison scale used in the preparation of AHP aims to determine the alternative priority arrangement of the criteria to achieve the objectives. The scale is presented as follows:

Table 2 Pairwise Comparison Scale

Value 1	Both factors are important
Value 3	One factor is quite important than the other one
Value 5	One factor is essential or more important than the other one
Value 7	One factor is obviously more important than the other one
Value 9	One factor is absolutely more important than the other one
Value 2, 4, 6, 8	Median between the two compared values
Opposite Value	If the i activity obtains the value of 2 when compared to others.

Sumber: Saaty, 2006; Sucihatiningsih, 2012

After all the considerations are converted numerically, their validities are evaluated by using a consistency test. In case of decision making, consistency to a certain degree in deciding priorities for related elements or activities with several

criteria are required to obtain valid results in empirical reality. AHP measures overall consistencies from various considerations through consistency ratio. The value of consistency ratio must be 10% or less ($CR < 0.1$). If it is more than 10%, the consideration might be random and needs to be corrected.

AHP principle is to give weight to each factor, variable, and indicator with a comparison between factors, and each other indicator. Before examining further the process of AHP method, it is necessary to know the axioms AHP model has. Axiom is something that is undeniable for the truth or is certain to happen. There are four axioms to consider by the user of AHP model. In addition, violations of each axiom will result invalid model being used.

In a broad way, the application of AHP model is carried out in two stages, namely hierarchy organization, and hierarchy evaluation. First, hierarchy organization or decomposition covers three sequential and related of processes, namely levels and elements identification, concept definitions, and questions formulation. The organization of hierarchy must include relevant matters to show the existing problems as thorough as possible, but do not give it too much portion because the hierarchy might lose its sensitivity to changes in elements. Next, it is also necessary to consider the surrounding environment, identify any possibilities which can support solving the problems, and examine participants' contribution to the problems solving. Basically, organizing hierarchy is outlining reality into a homogeneous 'cluster' and re-outlining it into smaller parts and so on so much information can be integrated into the structure of a problem and form a complete whole system.

After decomposition, the next step is hierarchy evaluation. There are two things that must be done in this stage, namely the assessment and synthesis of results. Assessment is realized by converting available information and its perception into element pairwise comparison (Permadi 1992 in Sucihatiningsih, 2012).

Consistency testing is done to see the consistency of answers to the pairwise comparison assessment and hierarchical structure of problems. This is due to the fact

that it is very unlikely to obtain absolute consistent participant answers (Permadi, 1992 in Sucihatiningih, 2012).

The formulations for calculating the consistency index are as follows:

1. Consistency Index

Notes:

n = the number of non-respondent criteria

λ = the average of vector consistencies

2. Consistency Ratio

Notes:

RI = random index

Data processing is carried out by tabulating the results of interview in form of table which then its geometric mean is calculated, namely the central values considered to represent the values of overall data obtained from the perception qualification values multiplied by one and another for further being ranked (Puspitasari, 2008). Meanwhile, the geometric mean formulae is:

The next step is to form matrix pairwise comparison which compares various factors for the development of food crop commodities using the reverse principle and then filled with the geomean numbers obtained from the tabulation. The next step, the ratio of each element on the overall values of elements on matrix pairwise is calculated, and then transferred to be converted into a matrix priority vector. The weight of the values of each

determinant factor of regional investment attraction will be obtained by looking for the row average value of the matrix priority vector.

The last step is to calculate the consistency ratio. The first step is calculating the weighted sum vector gained from the sum between the multiplication of the matrix priority vector average values and the value of elements in the matrix priority vector. This step results vector consistency. Once the value of lambda is collected, the next step is calculating the consistency index values using equation (1) and calculating the ration consistency by equation (2). These steps apply to the calculation of factor weight calculation (first level) and variable weight (second level) of the hierarchical structure. After the weight of each factor (first level), and each variable (second level) are obtained, then the final weight is achieved by multiplying the value of each weight of the second level with each of the first level factor weights.

4.4. Expert Choice Software Guides for AHP

There are various software that can be used to analyze data using AHP. The followings are the analysis guides for Analytic Hierarchy Process using Expert Choice 9 software. First, run Expert Choice 9 program through the following steps.

→ Start → ,All Program → Expert Choice for windows → Evaluation and Choice

→ Click FILE and choose NEW

→ The following figure will appear:

Write down the desired file name in this box and click OK

→ The following figure will appear:

Click here

→ After that, the following dialogue box will appear. Write down your goal and click OK

Next, click OK, and the following figure will appear

→ the next step is to create the criteria. To do so, click Edit Insert

→ Write down the criteria

Toko (Outlet) = Di buat toko Eskrim (Outlet for ice cream)

Pesaing (Competitors) = Jumlah pesaing yang ada di lokasi the number of competitors at the location

Pelanggan (Customers) = Jumlah orang yang akan menjadi pelanggan (the number of customer candidates)

Sewa (Rent) = Sewa tempat bulanan per meter (monthly rental fee per meter)

Fill the criteria here (abbreviation) and click enter

Fill the definition of criteria and click OK

→ Once all criteria have been inputted, the following figure will appear

→ Next, make alternatives of the previously created criteria. To do this, double click on

the criteria we wish to add alternatives. For example, outlet criteria is added an alternative.

Double click here

→ Click Edit Insert

→ Insert the alternatives

PSR_PK = Lokasinya di Pasar Pinggir Kota (Located in the suburban market) Mall_PK = Lokasinya di Mall Pinggir Kota (Located in the suburban mall) Jln_Utm = Lokasinya di jalan Utama (Located on the main road)

Type the alternative here and click ENTER

→ Then, input the definition as showed below

→ input all the alternatives until you see the following figure

→ since the alternatives are the same for all criteria, you can do replication by clicking

Edit Replicate as showed in the following figure

the following dialogue box will appear

click to all leaves. After that, the following message will appear

→ Click Yes until the following figure appear. All alternatives will be copied to all

criteria.

→ the next step is data input.

→ to calculate criteria priority, click GOAL box and click Assessment and select

Pairwise as showed in the following figure

→ Once you click pairwise, the following dialogue box will appear

→ click OK, and you will see the following figure

Click here

→ Click Skip Preliminary Questions

→ Choose Questionnaire tab as showed in the following figure

→ choose the number which shows the priority among the criteria by clicking the

number you desire. When the number chosen is on the left side (the blue color number), it means that the left criteria is more important than the right one, and vice versa.

→ After that, click Calculate, and the results can be seen in the following figure

→ to see the complete results, click print preview

→ To move the results to MS-Word, click copy to clipboard.

→ Once MS-Word is open, click edit and choose Paste Special.

→ After that, the figure can be enlarged by putting the cursor on the bottom right corner while dragging it to the bottom right side based on the need

→ The results can be seen in the following figure!

→ After the coping process is done, do not forget to go back to output menu, print

preview AHP, click Exit and click Record as showed in the following figure

→ To insert a value to each criterion, double click on the first criterion (Toko). Click

Assessment menu Pairwise

→ The following dialogue box will appear. Click OK

→ Then, choose Questionnaire tab as presented in the following figure

→ The result is as follows

→ After that, click Record to save the results of the output

→ For Pesaing (Competitors) criterion, the data input is the same as what has been explained earlier, namely double click on Pesaing criterion, and click Assessment menu

Pairwise

→ Choose Questionnaire tab. Input the data the same as what is showed in the following figure

→ Click Calculate and the output will be as follows

→ For Pelanggan (Customers) criterion, the data input is the same as what has been

explained earlier, namely double click on Pelanggan criterion, and click Assessment menu Pairwise

-> Choose Questionnaire tab. Input the data the same as what is showed in the following figure

→ Click Calculate and the output will be as follows

→ Do not forget to click Record

→ for SEWA (Rent) criteria, the data can be directly inputted since they are in form of number or Rupiah. Click Assessment Data and insert the numbers as showed in the following figure

→ Next, click Calculate, and the results will be as follows

→ to calculate the overall priorities, double click on GOAL box, then click Synthesis

menu, and select From Goal. The results will be as follows

→ The results of overall priorities can be seen in the following figure

→ The results of the Output Preview is presented in the following figure

CHAPTER V

DATA ANALYSIS IN SOCIAL RESEARCH

Introduction

This chapter discusses data analysis in social research comprising quantitative and qualitative data as well as procedures of mixing both sets of data in a mixed methods inquiry. The discussion assumes that both quantitative and qualitative data have been collected using appropriate procedures with appropriate instruments. In quantitative research, statistics is used to analyse and understand the logic behind some statistical tools used as well as how and when to use them in a particular research situation. It is the 'logic' that is being emphasized rather than the equations and formulas of the statistics used. The research questions usually direct the logic of statistical analyses with level of measurement of variables (nominal and interval) influences the analyses (Punch,1998, p. 113-136).

Analysis of Quantitative Data

Statistical tools and procedures are usually used in analyzing quantitative data with the intention of identifying and recognizing present situations and relationships in a research endeavour. Statistics is used to effectively analyse and translate data into findings, make conclusions, implications and recommendations for practical actions and for future research endeavours. Several statistical methods are used to summarize and to determine relationship between and among study variables. Usually, in quantitative studies, measures of central tendencies form the starting points in analyzing the data collected. The mean, mode and median are common measures of central tendencies, with the mean being the most frequently used. The mean is simply adding up the scores and divide by the number of scores. The mode is the value that occurs most frequently with the median is the middle value in a given set of data. There are several ways to measure variance in a set of measurements, one of which is the range where the highest score in the sample minus the lowest score. Standard deviation is a measure of variability with the mean where deviations of individual measurements from the mean of the distribution. The more spread out the score, the larger the standard deviation (Punch,1998, p.114). Frequency distributions of respondents' responses to questionnaire are useful to summarize and understand the data. Absolute numbers and/or percentages may be used in frequency distributions where the results of the analysis can be arranged in descriptive tables, graphs, histograms, pie charts and bar charts.

Relationship Between Study Variables

Quantitative research data analysis, beyond the measurement of central tendencies, is usually focussed on to determine relationships between variables. A number of ways have been developed to study these relationships. One of them is the cross-tabulation or contingency table which is easy to construct and interpret. Table 3 shows that 73% of Indonesian farmers were active in seeking technology information while 49% of their Malaysian counterparts indicated the same behaviour. In relation

to technology adoption, those who were active in technology seeking behaviour tend to adopt a higher rate of technology compared to those who

Table 1: Technology information seeking behaviour of Indonesian and Malaysian farmers

Technology information seeking behaviour (%)	Indonesian farmers (%)	Malaysian farmers (%)
Active	73	49
Passive	27	51
Total	100	100

were passive (45% versus 33%). This comparison between the observed and expected frequencies in each cell of the cross-tabulations is called chi-square. Chi-square statistics would allow a researcher to decide on the importance of the difference between observed and expected distributions and to decide whether or not the variables are related.

Comparison Between Groups: The Analyzing Variance

The simplest form of comparison between groups is when there is only one way of classifying the people, or one-way ANOVA. When there are two groups, ANOVA becomes equivalent to the t-test (Punch:1998, p. 117) to compare on some dependent variable of interest. There are two possible sources of variance: one is variance of scores within groups, and variance of scores between groups. The basic logic of analysis of variance is variance of scores within the groups and variance of scores between the groups. A ratio called F is calculated to compare the two variances: $F =$

between groups variance divide by within groups variance. When the value of F is large, between groups variance is greater than within groups variance and there exist significant differences between the groups. When the value of F is small, between groups variance is not much bigger than within groups variance and group differences are not significant.

A similar logic is used to compare two groups simultaneously in two ways to form a two-way ANOVA with interaction effect. The effect of one independent variable on the dependent variable is influenced by (or depends on, or interacts with) another independent variable (Punch,1998, p. 118-119).

Relationships between Variables: Correlation and Regression

The Pearson product moment correlation analysis provides direction and strength of relationships between two continuous variables. It shows how the variables are related and how much they are related. It can be shown in algebraic form with 'r' value where r value varies between 0 and 1, positive or negative. The closer numerically the coefficient is to 1 (positive or negative), the stronger the relationship. Thus, a correlation of + 0.50 between two variables indicates quite strong relationship between the two variables. If one were to square the r value, one could estimate the proportion of the variance in one variable which is held in common with, or accounted for by, the other (Punch,1978, p. 123). In other words, the variance explained by the correlation between the variables is 25% ($0.5 \times 0.5 = 25$).

Multiple correlation and regression have more than one independent variable and one dependent variable. In many social researches, a study usually has several independent variables and one dependent variable measured across a sample of respondents. The study has four sets of actual score, one for each independent variable and one for dependent variable for each respondent.

Actual scores are used to determine the relationship between the independent variable and the dependent variable. The multiple correlation coefficient is written as R . R^2 indicates how much of the variance in the dependent variable is accounted for by each, independent variable as well as the variance for the overall independent variables. The squared multiple correlation coefficient (R^2) indicates how accurate the prediction is on the dependent variable with the set of independent variables under study. R^2 value varies from 0 and 1 (or 100%). The more the variance in the dependent variable can be accounted for or can be explained, the more accurate is the prediction of the independent variables in a study. The squared multiple correlation coefficient measures the predictive efficiency of any particular regression model.

Structural Equation Modelling (SEM)

Structural Equation Modelling (SEM) is a multivariate statistical technique that incorporates factor analysis, path analysis and multiple regression. SEM is popular among social researchers due to its explanatory ability and statistical efficiency for model testing with a single comprehensive procedure using AMOS software (Bahaman Abu Samah, 2016).

Bahaman Abu Samah showed how SEM improves statistical estimation of two separate analysis that employed multiple linear regression (Figure 1) and structural equation modelling (Figure 2). The coefficient of determination for multiple linear regression is $R^2 = .517$ while for SEM is $R^2 = .641$. The four independent variables in the multiple linear regression explained 51.7% of the variance in telecenter sustainability while in SEM, the same set of independent variables explained 64.1%. There was 12.4% increase in statistical estimation of the variance explained in telecentre sustainability using SEM. The increase is attributed to the use of measurement errors in SEM.

Figure 2: Result of SEM, AMOS

(Source: Bahaman Abu Samah, 2016, p. 16)

Analysis of Qualitative Data

As with analysis of quantitative data, analysis of qualitative data also assumes that the methodology and procedure of sampling and data collection are carefully designed and appropriate with the focus and objectives of the study. In analyzing qualitative data, several stages are usually done (Esterberg,2002, p. 151-178):

- i. find a way to physically manage or organize the data;
- ii. get oneself familiar with what have been gathered;
- iii. generate themes or categories or identify patterns in the data, and
- iv. find ways to present the analysis to others.

Managing the data

The first task in analyzing qualitative data is to arrange or organize the data in a way, so that a researcher can begin to make sense from them. Make sure all documents gathered are arranged according to specific titles, tape interviews are transcribed verbatim and field notes related documents are compiled according to categories. In other words, all collected data could be easily assessed when needed to fit in the analysis plan. Managing qualitative data is an important step to give meaning to qualitative research work. Start analyzing qualitative data as soon as possible and continue on a regular basis. Don't leave the analysis work for too long, as you may forget what had been done the last time you did it. The more frequent one analyses the qualitative data, the more intimate one gets with them. The goal is to immerse oneself in the data so as to reap its meaning fully and completely. Ensure a system is devised for easy reference in the process of analyzing.

It is wise and practical to have multiple backup copies of documents, field notes and transcribed interviews and stored them at several places, at home, office and even in your car. This is to ensure safety and availability of your collected data if any unwarranted accident were to occur.

Coding

Coding begins to make sense of qualitative data by focussing on potential meanings to identify relevant phenomena,

examples of these phenomena and analyzing these phenomena to find commonalities, differences, patterns and structure (Coffey & Akkinso, quoted by Estesberg, 2002). In the beginning, open coding is used where the data are analysed line by line, identifying themes and categories of interest.

Development of themes

After coding is done in all the qualitative data, a researcher begins to identify recurring themes emerging, some interesting and relevant to the focus of the study. Refer to the codes that have been developed and continuous on to identify more themes that would help shape the overall analysis of the study. At this stage, focused coding is necessary, examining in detail line by line using themes identified earlier. A computer software program can help store and retrieve codes, or can use an ordinary word processing program to do a computerized search for key words or phrases. Some popular websites for computer-assisted qualitative data analysis are NVIVO and NUDIST. These computer-assisted programs are readily available in the market.

Developing an analysis of quantitative data

The analyzing of qualitative of data is not a mechanical process, but rather it comprises several methods that a researcher can choose from to suit available data as well as the nature and focus of the study. Esterberg (2002) outlines several methods which include; (i) looking for patterns in the data (similarities and differences); (ii) comparing cases; (iii) building typologies; and (iv) conducting a content analysis.

Looking for patterns

Different informants may give different responses to the same issue or topic. Example, an agriculture extension education agent ensures that her/his clients are involved thoroughly in the process of technology transfer, explaining the 'whats', 'whys' and 'how' before introducing the technology to clients to be adopted. Another agriculture extension agent education agent introduces a new technology, to her/his clients with no explanation of the procedures and benefits. She/he let the clients make their decision to accept or to reject the technology. The responses of the clients, in this case, vary with the first group makes an informed decision, while the second group lacks the understanding of why they should or should not accept the technology.

Comparing cases

When patterns have been identified, the next step would be to compare cases. If in-depth interviews among agricultural extension education agents or focus group discussions (FGD) had been conducted, a researcher may want to compare individual agents' interview scripts as a case or to compare each transcription as a case. Rate of adoption of new technology among clients may become the focal point where clients that have been exposed to capacity building elements (problem-solving skills, decision making skills, basic leadership skills) before the introduction of a new technology are compared to these who do not receive capacity building elements at all. In this case, the more the number of clients adopting and continue to practise the new technology, the more successful is the technology transfer process.

Building typologies

A typology is a system for categorizing types of activities or events. Showing clients a demonstration plot where the owner has adopted the new technology indicates a 'success' story in that the crop grows well, healthy and produce a much higher yield than a

plot that does not adopt the technology. Technology adoption is a typology for successful farming compared to clients who do not adopt a technology. Technology adoption and practices with integration of capacity building elements seem to create a more permanent change among clients. This can be another typology.

Conducting a content analysis

Content analysis usually involves a systematic analysis of texts. Texts include written materials, minutes of meetings, field notes, interview transcripts, transcripts of FGD sessions, and in-depth interviews with relevant stakeholders. Content analysis can be in the form of simple counting of related activities in the content of study. Using the example of capacity building and technology transfer, a researcher could count how many clients attend a method demonstration session of a new technology? How many clients are given the opportunity to try out the new technology with the guidance of the extension education agent? Are the clients given the opportunity to ask questions, interact freely with the extension education agent?

In content analysis, words that appear in the text could be counted directly. The more the same words appear in the text, the more likely themes could be developed around the identified words. Some words may carry interpretive meaning that may indicate certain activities as potential activities. These words could be categorized into patterns and/ or themes in relation to the focus of the study.

Triangulation

Triangulation is used to mean bringing different kinds of evidence to bear on a problem (Esterberg, 2002, p. 176). If a researcher uses in-depth interview transcripts with key stakeholders, FGD transcripts sessions with a few groups of extension education

agents and field notes in direct observation of clients' practices, the data analyses would be much stronger than if only one source of evidence is used. Usually each source of data has its strengths and weaknesses and by using multiple data sources would strengthen the evidence on a problem.

Computer-assisted data analysis

Qualitative researchers use computers for some aspect of their field research. Most researchers use word processing software, simple search capabilities or sorting procedures to assist them in qualitative data analysis. Qualitative researchers work with texts (words), not numbers and computers recognize numbers more easily than words. The time will come when computers are designed to recognize words and able to help in making judgements in a set of themes or categories or patterns identified.

However, computers can help to store and retrieve a large amount of texts which could be easily assessable when needed. Figure 3 lists some websites for computer-assisted qualitative data analysis.

Web Sites For Computer-Assisted Qualitative Data Analysis

CAQDAS Network (a general site for computer-assisted qualitative data analysis)

[http:// caqdas.soc.surrey.ac.uk/](http://caqdas.soc.surrey.ac.uk/)

ATLAS.ti

www.atlasti.de/

The Ethnograph

www.qualiserach.com

HyperRESEARCH

www.researchware.com

NVivo and NuD*IST

www.qsr.com.au or www.scolari.com

Figure 3: Website for computer-assisted qualitative data analysis.

(Source: Esterberg, K.G.,2002, p. 178)

Table 1: Elements of qualitative and quantitative research in the process of research.

Elements of qualitative

Research tend toward... Process of research Elements of
quantitative research tend forward

- Understand meaning individuals give to phenomenon inductively Intent of the research • Test a theory deductively to support or refute it
- Minor role
- Justifies problem How literature is used • Major role

- Justifies problem
- Identifies questions and hypotheses
- Ask open-ended questions
- Understand the complexity of a single idea (or phenomenon) How intent is focused • Ask closed-ended questions
- Test specific variables that form hypotheses or questions
- Words and images
- From a few participants at a few research sites
- Studying participants at their location • How data are collected • Numbers
- From many participants at many sites
- Sending or administering instruments to participants
- Text or image analysis
- Themes
- Larger patterns or generalizations
- How data are analysed • Numerical statistical analysis
- Rejecting hypotheses or determining effect sizes
- Identifies personal stance
- Report bias • Role of researcher • Remains in background
- Takes steps to remove bias
- Using validity procedures that rely on the participants, the researcher, or the reader • How data are validated •

Using validity procedures based on external standards, such as judges past research, statistics

(Source: Creswell & Clark, 2007, p. 29)

Designing mixed methods research

Creswell and Clark (2007:5) define mixed methods research as collecting, analyzing and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone. Bryman, A., 1998, as quoted by Punch, K. F., 1998, p. 245-246 indicates that methodological justification for bringing quantitative and qualitative methods together is to capitalize on the strength of the two approaches and to compensate for the weakness of each approach.

Mixed research methods involve both quantitative and qualitative data. Qualitative data are close-ended information found on such measurements as performance of extension education agents, attitudes and behaviours. Quantitative data on the other hand, are open-ended information that a researcher gathers through interviews, FGDs, observations and collecting of related documents such as minutes of meetings and annual reports. The analysis of qualitative data (text or images) usually aggregates the words or images into categories of information. The open versus close ended nature of the data differentiate quantitative and qualitative research method.

As indicated earlier, the combination of quantitative and qualitative approaches provides a better understanding of research problems than either research alone. Creswell and Clark (2007, p. 9-10) outline six values of mixed research methods.

1. Mixed methods research provides strength that offset the weaknesses of both quantitative and qualitative research. Quantitative research is weak in understanding the context or setting in which people talk as well as their voices are not heard directly. Quantitative research researchers are influenced by that own personal biases and interpretations and these are seldom discussed. Qualitative research makes up for these weaknesses. Qualitative research is seen as deficient because of personal interpretations made by the researcher. These create biases on the findings. Qualitative research has difficulty in generalizing findings to a large group due to its limited number of informants studied. Quantitative research, it is argued, does not have these weaknesses.

2. Mixed methods research provides more comprehensive evidence for studying a research problem than either quantitative or qualitative research alone. Researchers have the option to use several tools of data collection available with qualitative research or quantitative research.

3. Mixed methods research helps answer questions that cannot be answered by qualitative or quantitative approaches alone. For example, “Do respondent views from interviews (in-depth interview) and from standardized instruments converge or depart?” “What explains the quantitative results of a study?” (using qualitative data to explain the quantitative results)

4. Mixed methods research encourages researchers to collaborate across the sometimes-adversarial relationship between quantitative and qualitative researchers.

5. Mixed methods research encourages the use of multiple paradigms rather than the typical association of certain paradigms for quantitative and others for qualitative researchers.

6. Mixed methods research is “practical” in the sense that a researcher is free to use all methods possible to address a research problem. It is also “practical” because individuals tend to solve

problems using both numbers and words. They can combine inductive and deductive thinking.

Conducting mixed methods research is not an easy endeavor. It takes time and resources to collect and analyze both quantitative and qualitative data. A researcher must have the basic knowledge of quantitative research method and procedures, as well as having a basic competency in collecting, analyzing and interpreting qualitative data.

Types of mixed methods designs

Triangulation design

The most common and well-known approach to mixing methods is the triangulation design (Creswell & Clark, 2003 & 2007). The purpose of this design is “to obtain different but complementary data on the same topic” (Morse, 1991 as quoted by Creswell & Clark, 2007) to understand the research problem. The triangulation design is used to directly compare and contrast quantitative statistical results with qualitative findings or to validate or expand quantitative results with qualitative data.

(a) Triangulation design

(b) Triangulation design: Convergence model

(c) Triangulation design: Data transformation model (transforming quantitative data into qualitative)

(d) Triangulation design: Validating Quantitative data model

(e) Triangulation design: Multilevel model

Figure 4: The Triangulation Design

(Source: Creswell & Clarks, 2007: 63)

There are some challenges in using triangulation design. Some of them are: (i) requires expertise due to concurrent data collection as well as to require a team of quantitative and qualitative researchers; (ii) researchers may face the question of what to do if the quantitative and qualitative results do not agree; and (iii) if additional data are required, what data to collect: quantitative data, qualitative data or both.

The embedded design

The correlational model (Figure 5) can be used where qualitative data are embedded within a quantitative design. In this design, researchers collect qualitative data as part of their correlational study to explain how the mechanisms work in the correlational model (see Figure 5).

Figure 5: The embedded correlation design

(source: Creswell & Clark,2007:68)

The embedded design is a mixed methods design where one data set provides a supportive and secondary role in a study based primarily on the other data type. The premises of this design are that a single dataset is not sufficient, that different questions need to be answered, and that each type of question requires different types of data. Researchers use this design when they need to include qualitative or quantitative data to ensure a research question within a largely quantitative or qualitative study (Creswell & Clark, 2007, p. 67 & 68). The embedded design mixes the different data sets at the design level, with one type of data being embedded within a methodology framed by the other data type.

Figure 6: Embedded design

(source: Creswell & Clark,2007, p. 68)

The explanatory design

The purpose of explanatory design is to help qualitative data explain or build upon initial quantitative results. It is well suited to a study in which a researcher needs qualitative data to explain

significant (or non-significant) results, outlier results or surprising results (Morse, 1991 as quoted by Creswell & Clark, 2007, p. 72). The design starts with the collection and analysis of quantitative data, and then followed by or connected to the results of the first quantitative phase.

Figure 7: Explanatory Design

(source: Creswell & Clark, 2007, p. 73)

The exploratory design

This design is based on the premise that an exploration is needed for: (i) measures or instruments that are not available; (ii) variables that are unknown; and (iii) a guiding framework or theory (Green et al, as quoted by Creswell & Clark, 2007, p. 75).

Figure 8: Explanatory Design

(source: Creswell & Clark, 2007, p. 76)

This design starts with quantitative data, to explore a phenomenon and then builds to a second, quantitative phase. Researchers use this design to develop an instrument, identifying variables, or stating propositions for testing based on an emergent theory or framework (Creswell & Clark, 2007, p. 77).

Table 2: The Major Mixed Methods Design Types

Design Type	Variants	Timing	Weighting	Mixing
Triangulation	- Convergence			
	- Data transformation			
	- Validating quantitative data			
	- Multilevel	Concurrent:	quantitative and qualitative at same time	Usually equal Merge the data during the interpretation or analysis
				QUAN + QUAL
Embedded	- Embedded experimental			
	- Embedded correlational	Concurrent	or	sequential
	Unequal	Embed one type of data within a larger design using the other type of data		QUAN (qual)
				or
				QUAL (quan)
Explanatory	- Follow-up explanations			
	- Participant selection	Sequential:		
Quantitative followed by qualitative	Usually		quantitative	
	Connect the data between the two phases		QUAN	->
qual				
Exploratory	- Instrument development			
	- Taxonomy development	Sequential:		
Qualitative followed by quantitative	Usually		qualitative	
	Connect the data between the two phases		QUAL	->
quan				

Source: (Creswell & Clark, 2007, p. 85)

Mixing the data

Mixing the data sets is a unique procedure of mixed methods design where a better understanding of the problem is enhanced if either data set is used alone. There are three ways of mixing the data (Creswell & Clark, 2007, p. 7-8).

- (i) merging or converging the two data sets by actually bringing them together,
- (ii) connecting the two data sets by having one build on the other; and
- (iii) embedding one data set within the other so that one type of data provides a supportive role for the other data set.

Merge the data

Connect the data

Embed the data

Figure 9: Three ways of mixing quantitative and qualitative data

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