Addis Ababa University
School of Graduate Studies
Institute of Development Research

Efficiency of Microfinance Institutions in Ethiopia

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Arts in Development Studies

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Title
Efficiency of Microfinance Institutions in Ethiopia.

BY
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DEVELOPMENT STUDIES

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Abstract

The main objective of this study was measuring the level of efficiency of Micro finance institutions in Ethiopia. This thesis analyzes the efficiency of Ethiopian Microfinance institutions using Data Envelopment Analysis. Operational and financial models are employed in order to examine the efficiency level of the institutions. It has been identified that the mean operational efficiency of the Microfinance institutions are found to be more than the mean financial efficiency. The results also indicated that only one Micro finance institution, out of twenty, is found to be both financially and operationally efficient as compared to its reference sets. Moreover, it has been identified that the efficiency scores of Ethiopian MFIs highly depends on the age and total assets of the institution and it is negatively related to the return on assets invested. The model used shows that most of the MFIs in Ethiopia are at an increasing return to scale efficiency and this implies that they have a room to further increase their efficiency level. To sustain the micro finance industry in Ethiopia, the management of each MFI shall give emphasis on both operational and financial efficiency in particular and the overall efficiency of the industry in general.

Acknowledgement

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Finally and above all, I am thankful to GOD for all He does to me.

Thank you all!

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Acronyms

MFIs = Microfinance institutions
ACSI = Amahra Credit and Saving Institution
ADCSI = Addis Credit and Saving Institution
Aggar = Aggar Microfinance institution
AVFS = Africa Village Financial Service
Benshangul= Brnshangul Gumz Microfinance institutions
Bussa = Bussa Gonfa Microfinance institution
DECSI= Dedebit Credit and Saving Institution
Eshet= Eshet Microfinance institution
Gasha= Gasha Microfinance institution
Meket = Meket Microfinance institution
Meklit = Meklit Microfinance institution
Metemam = Metemam Microfinance institution
Ocssco = Oromia Credit and Saving Institution
Omo = Omo Microfinance institution
PEACE = Poverty Eradication and Community Empowerment
SFPI = Specialized Financial and Promotional Institution
Shashimene = Shashemene Edir Yelimat Agar
Sidama = Sidama Microfinance institution
Wasasa = Wasasa Microfinance institution
Wisdom = Wisdom Microfinance institution
NBE = National Bank of Ethiopia
DEA= Data Envelopment Analysis
AEMFI= Association of Ethiopian Microfinance Institutions

Chapter One: Introduction

1.1 Background

Many people in developing countries are leading poor living conditions: low income, low quality of life, low level of living, malnutrition, diseases, high infant mortality, low life expectancy; and poor access to health, water supply and education (Chambers, 1985; Todaro and Smith, 2003).In addition, the Ethiopian economy is characterized by weak infrastructure, low productivity, low investment and high population growth (Berhanu et al, 1994).

Ethiopia has an estimated population of 77 million. Agriculture is the mainstay of the economy and approximately 85% of the country's population live in the rural areas and 45% of the population is reported to live below poverty line (CSA, 2006; Getahun, 2000).

Poverty and food insecurity are the main challenges and fundamental issues of economic development in Ethiopia. The major causes of low economic growth and high incidence of poverty in Ethiopia include lack of income, assets, employment opportunities, skills, education, health and infrastructure, among others. These problems have been aggravated by other factors like soil degradation, deforestation, recurrent drought, civil war, and inappropriate policies (Wolday,2000).

Interventions through the delivery of microfinance services have been considered as one of the policy instruments of the Ethiopian government and Non-Government Organizations (NGOs) to enable rural and urban poor increase output and productivity, induce technology adoption, improve input supply, increase income, reduce poverty and attain food security.

The establishment of sustainable microfinance institutions that reach a large number of rural and urban poor has been a prime component of the new development strategy of Ethiopia.Although the development of microfinance institutions in Ethiopia started very recently, the industry has shown a remarkable growth in terms of outreach particularly in number of clients. Since the issuance of Proclamation 40/1996, which provides for the establishment of microfinance institutions, twenty-seven microfinance institutions (MFIs) have been legally registered by the National Bank of Ethiopia (NBE) and started delivering services(AMFI ,2006).

Analysis of the efficiency of Microfinance Institutions in developing countries in light of outreach and profitability has an immense value for mangers, donors, policy makers, and other stakeholders. Performance indicators usually are in the form of ratios, that is, a comparison of one piece of financial data to another. But since ratios are not an end by themselves, proper analysis has to be made to make the best use of calculated ratios (Ledgerwood, 1999).

Measuring and evaluating the operating and financial efficiency of firms or Decision Making Units (DMUs) requires analytic techniques that provide insights beyond those available from accounting ratio analysis. Data Envelopment Analysis (DEA), for example, is a mathematical programming technique, which provides useful insights in locating inefficient DMUs by explicitly considering the mix of outputs provided and the resources used to provide these mix of outputs.

1.2 Statement of the problem

It has been a long held belief among development economists that poor households lack access to adequate financial services for efficient transfers of resources and risk coping. Without some financial support these households do not have adequate prospects for increasing their productivity and living standards. In the case of Ethiopia, both in response to the high need for financial services and in recognition of the critical role that credit can play in alleviating poverty, credit delivery systems have been put in place. Several MFIs have been established both in rural and urban areas to meet this end. However, not much is known about the performance of these institutions particularly in terms of their capacity and efficiency to meet the growing demand for credit (Assefa et al, 2005).

To the researcher's knowledge, most of the efficiency studies that were so far been attempted on the MFIs in Ethiopia have employed ratio analysis method, which is static by its nature. Hence, the studies were limited by the method they used in that they have not been able to consider the institutions operations in its entirety at one point in time and handle multiple inputs and outputs. Besides, judging the validity of the indexes of the findings is also very difficult in so far as there is no consensus among experts with regard to its scientific standard in interpreting findings. Hence, the researcher attempts to answer the following questions using a DEA methodology. The major research questions of this study are:

- Are Ethiopian microfinance institutions operationally efficient?
- Are they financially efficient?

1.3 Objectives of the study

The overall objective of this research is to measure the efficiency levels of MFIs in Ethiopia. More specifically, using the DEA approach, this study will:

- Assess the operational efficiency of Micro finance institutions in Ethiopia.

- Examine the financial efficiency of Micro finance institutions in Ethiopia.
- Suggest viable means of improving performance on both fronts- financial and operational efficiency

1.4 Methodology of the study

Sources of Data

The study has made use of secondary data as sources of information. Secondary data sources like company records, association's reports, unpublished materials and journal articles are used in the study. Balance Sheet and Income Statement data are collected from Association of Ethiopian Microfinance Institutions.

The target population of the study is all MFIs which are operating in Ethiopia. There are twenty seven MFIs in Ethiopia, of which twenty MFIs or 74 % are assessed because of the availability of information for the study and are classified into peers: large-size, medium-size, and small- size microfinance institution and are analyzed accordingly.

Data Analysis

Descriptive approach is first used in the analysis. Hence, charts, tables, and graphs are used in the analysis. Data Envelopment Approach

(DEA) is then used to measure and analyze the efficiency of the selected MFIs.

Model Specification

Efficiency estimation techniques can be classified into two broad categories:

1) Econometric methods; and

2) Mathematical programming techniques.

Econometric methods: This methodology proceeds by estimating primal (production) or dual (cost or profit) functions to define the frontier. These techniques either yield deterministic frontier or stochastic frontier.

The major advantages of this approach are its ability to incorporate and manage statistical noise and handle outliers, and that hypotheses can be statistically tested. However, this methodology need specific functional form in order to estimate efficiency and the technology is assumed to be valid for all observations. Additionally, such models assume distributional assumptions regarding the composed error term to separate the efficiency from the statistical noise. Consequently, the econometric methodology makes the estimation of efficiency burdensome and has the tendency to produce different efficiency measures (Schmidt and Sickles, 1984).

Mathematical programming technique: This technique now is widely known as "data envelopment analysis (DEA)". In contrast to econometric method, the DEA does not require any assumption about the functional form and no need to assume any specific distributional form for the error term. Moreover, the DEA analysis is flexible and accommodates variable returns to scale (VRS) as well. A major disadvantage is of its inability to handle noisy data in a satisfactory manner (Worthington, 2000).

Model used in the study

Data envelopment analysis (DEA) is used in this study to analyze the efficiency of the selected microfinance institutions (MFIs) in Ethiopia. Both input-oriented (IOM) and output-oriented (OOM) versions of the DEA methodology is applied to the data for the sake of efficiency score comparison.

An output-oriented model implies that the efficiency is estimated by the output of the firm relative to the best-practice level of output for a given level of inputs. In order to specify the mathematical formulation of the OOM, let's assume that we have K decision making units (DMU) using N inputs to produce M outputs. Inputs are denoted by X_{jk}

(j=1,....,n) and the outputs are represented by Y_{ik} (i=1,..,m) for each MFIk (k=1,...,K). The efficiency of the DMU can be measured as (Coelli,1998):

$$\mathrm{TE_k} = \sum_{i=1}^{m} U_i Y_{ik} \Big/ \sum_{j=1}^{n} V_j X_{jk}$$

where Y_{ik} is the quantity of the i[th] output produced by the k[th] DMU firm, X_{jk} is the quantity of j[th] input used by the K[th] firm, and U_i and V_j are the output and input weights respectively.

The DMU maximizes the efficiency ratio, TE_k, subject to

$$\sum_{i=1}^{m} U_i Y_{ik} \Big/ \sum_{j=1}^{n} V_j X_{jk} \leq 1 \qquad \text{Where } U_i \text{ and} V_j \geq 0$$

The above equation indicates that efficiency measure of a firm cannot exceed 1, and the input and output weights are positive. The weights are selected in such a way that the firm maximizes its own efficiency. To select optimal weights the following mathematical programming (output-oriented) is specified (Coelli, 1998):

Max TEk Subject to $\sum_{i=1}^{m} U_i Y_{ir} - X_{jr} + W \leq 0 \quad r = 1,........ K$

$$V_j Xr - \sum_{j=1}^{n} U_j X_{jk} \text{ and } U_i \text{ and } V_j \geq 0$$

An input oriented linear programming method is used in order to obtain the minimized inputs. Therefore the following mathematical programming model is specified (Banker and Thrall, 1992; Coelli, 1998; Worthington, 1999).

$$\text{Min } TE_k$$

$$\text{Subject to } \sum_{i=1}^{m} U_i Y_{ir} - Y_{jF} + W \geq 0 \quad r = 1,\dots\dots\dots K$$

$$Xr - \sum_{j=1}^{n} U_j X_{jk} \; , \; U_i \text{ and } V_j \geq 0$$

Selection of Inputs and Outputs

Considering financial institutions as decision making units there are three approaches which are used to define inputs and outputs and the relationship between the input and outputs. These approaches include,
i) the production approach, ii) the intermediation approach, and iii) the assets approach. Under the production approach the financial institutions are considered as the producers of deposits and loans. The number of employees and capital expenditures are important inputs in this approach.

The second approach considers the financial institutions as intermediaries. As intermediaries financial institutions have the responsibility of transferring financial assets from the savers, the surplus unit, to the investors, the deficit unit. In this case the inputs can be defined as labour, capital cost and interest payable on deposits. Whereas, the loans and financial investments are considered as outputs in the intermediation approach. Finally, under the assets approach it is assumed that the basic function of any financial institution is the creation of credit (loan). Whereas the value of assets of financial institutions act as output in this approach. The loans/credit is the most important financial service that MFIs provide to their customers.

Based on its convenience and simplicity to show efficiency measures , this study selected production approach and thus loans disbursed by MFI, and interest income are taken as outputs. Main inputs required to produce loans are labor and expenditures. The research takes two inputs, namely total number of personnel as a proxy for labor and cost per borrower as a proxy for expenditures.

1.5 Significance of the study

This study summarizes the major researches which are carried out in Ethiopia in relation to MFIs. It may be a useful synopsis for getting insight about them. Moreover, further researchers may be able to know the efficiency, status, achievements, challenges and prospects of MFIs in Ethiopia. Most importantly, this study can also provide the management of each microfinance institution an insight into the extent they can increase their profit or decrease their cost without expending additional input.

1.6 Conceptual Framework

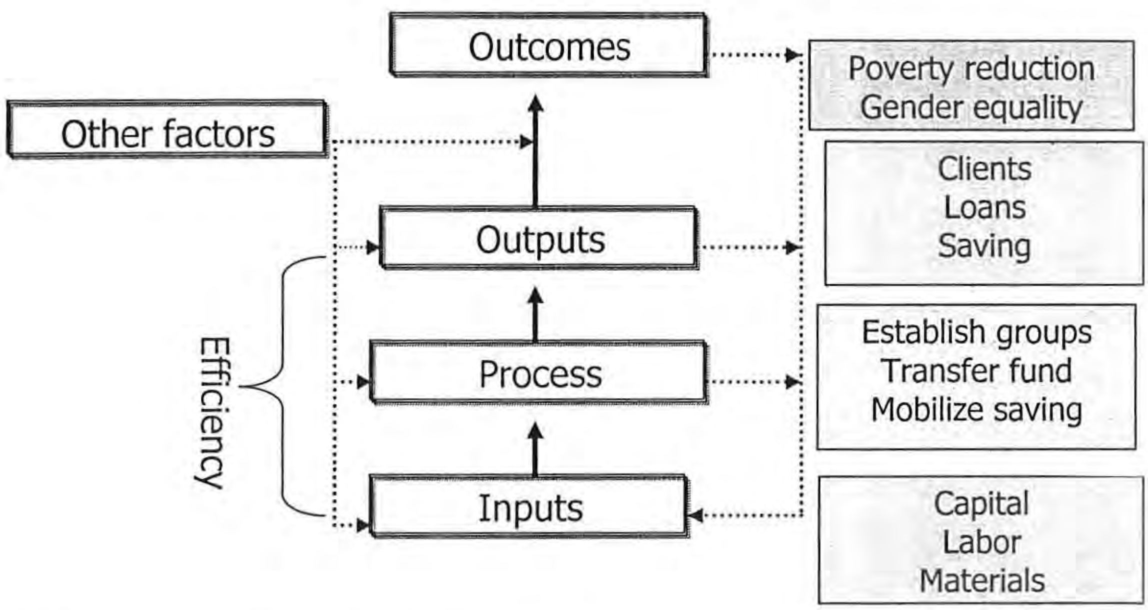

Fig 1.1 Adopted from Hong Son Nghiem (2004)

As it is indicated in Fig. 1.1, efficiency can be considered in terms of the optimal combination of inputs(capital, labor, and materials) to achieve a given level of output (clients, loans, and saving), or the optimal output that could be produced given a set of inputs. It involves a process of establishing groups, transferring funds, and mobilizing saving in the case of MFIs.

The objective of maintaining efficiency in MFIs, together with other development factors, is ultimately bringing about such outcomes as reducing poverty and gender equality among others.

Chapter Two: Review of the Related Literatures

2.1 Overview of Microfinance Institutions

Microcredit is the provision of small loans to very poor people for self-employment projects that generate income. It is a new approach to fight poverty. In its heart are new financial institutions, often non-profit organizations, whose aim is to serve those people who would not have access to a loan from a traditional trading bank.

The fact that Microfinance Institutions (MFIs) tend not to operate in the same way as traditional banks does not mean that they are not interested in profitability and efficiency issues. However, existing tools to assess the performance of traditional banking institutions may not be appropriate within this new context (Nieto et al,2004).

MFIS are defined as the providers of "a broad range of financial services such as deposits, loans, payment services, money transfers, and insurance to the poor and low-income households and their farm or non-farm micro-enterprises"(Charitonenko and Campion,2003).

Financial markets in developing countries do not provide credit to small-scale farmers. It is not accessible to the rural and urban poor. Consequently, establishing development finance institutions began since the 1930s (Hulme et al, 1996). Prior to the 1970's, the emphasis of all the financial services was on availing agricultural credit to farmers for investment and inputs to promote agricultural production. Commercial banks were not also that keen to enter into banking relation with the poor. Hence, this situation demanded an innovative approach to address the lower segment of the population. This resulted in the creation of MFIs (Dale, 1995).

MFIs can be regular banks (private or governmental), specialized branches of commercial banks, or financial intermediaries such as governmental and non-governmental organizations (NGOs) whose main area of expertise is not banking per se.

Services offered include credit extension (for production, consumption and emergency), access to savings facilities, and the provision of basic insurance, such as life, health, and cattle insurance (Fallavier, 1998).

There are many types of MFIs, depending on structure and function/philosophy. In many instances, the MFI market is segmented according to the clients involved (women, agriculturalists, micro-businesses), which in turn determines the various forms of practices and interventions: credit unions, direct credit institutions, and local cooperatives (Gnonhossou, 2001).

2.2 The Roles of MFIs in Development

The main goal of many MFIs, especially Rural Micro-finance Institutions (RMFIs) is to provide sustainable micro-finance facilities to the poor to facilitate income generation and reduce poverty (Baumann, 2001).

Mosher (1966) pointed out that credit is one of the accelerators in the process of agricultural transformation. This has its root in the institutional credit that serves as real capital for the needy rural people. Thus, availability of sufficient credit can play an important role in channeling necessary funds for rural agricultural development activities (Sadeque, 1986).

Credit facilitates agricultural output and thus food security and investment. Furthermore, credit facilitates the transfer of resources between sectors. It promotes the efficient use of scarce capital, thereby expanding income earning opportunities and encouraging saving. Besides, easy access to credit provides an incentive to farm households to improve their productivity and generate savings on their own account (Jazairy et al, 1992; Ximiya ,2000).

2.3 Assessing Microcredit institutions

Microcredit emerges as a new approach to fight poverty. But, is the money lent by MFIs efficiently managed? There is much literature on bank efficiency, but very little on microfinance efficiency. Should we assess microfinance institutions efficiency the way banks do, taking into account financial inputs and outputs? This tends not to be the case: Morduch (1999) observes that discussions on microcredit performance almost ignore financial matters.

Yaron (1994) suggested a framework, based on the dual concepts of outreach and sustainability, that has became popular in the assessment of MFIs performance. Outreach accounts for the number of clients serviced and the quality of the products provided. Sustainability implies that the institution generates enough income to at least repay the opportunity cost of all inputs and assets. Sustainability has two levels: operational and financial.

Microfinance industry evolution stresses more and more the importance of financial viability. A set of performance indicators has arisen, and many of them have become standardized, but there is by no means general agreement on how to define and calculate them. Commonly the ratios used fall into four categories: sustainability/profitability, asset/liability management, portfolio quality, and efficiency/productivity. These measures derive from the financial ratio analysis implemented in conventional financial institutions.

2.4 A Success Story in Microfinance Industry

A successful MFI story that is widely cited is that of the Grameen Bank of Bangladesh, in terms of its staying power and positive impact on disadvantaged groups in enabling them to meet their basic needs. Part of its success has been attributed mainly to its concentration on lending to women groups (Kalyalya, 2003) and its reliance on peer pressure to ensure repayment (Osman, 1999). Grameen was established in 1976 by Dr Mohammed Yunus, an Economics Professor, to deliver bank credit to poverty-stricken villagers in rural Bangladesh. It was converted into an independent bank by government ordinance in 1983. Its services reach an estimated 38,000 villages throughout rural Bangladesh, benefiting some two million families. And as Osman (1999) argues, Grameen's success, highlighted by a remarkable 98 percent loan-repayment rate, has demonstrated convincingly that small loans to villagers are an effective means to encourage self-reliance and boosting incomes.

2.5 Cost Minimization in MFIs

A variety of delivery systems can be used to minimize costs while serving rural areas (Hirschland, 2003). These include:

- *Simple offices.* One cost-effective way to bring services close to rural residents is to establish a part-time, one-room office close to people's homes, work, marketplace, or religious institution.
- *Self-managed groups.* A "self-help" or savings group approach can significantly cut overhead costs by transferring most of the management functions to depositors themselves who access services very close to their homes. The institution does not directly engage in financial intermediation. Instead, it organizes, trains, and supervises savings groups of five to twenty members that collect and manage their own savings.
- *Employing clients as staff.* Excellent clients or members, particularly those who are local leaders, can make strong low-cost field staff: they tend to be local, often prefer part-time work, and start with a good understanding of the local operations.
- *Keeping operations simple.* If a MFI is to use volunteers or staff with very little education, every aspect of its product and systems should be simple and standardized so that they are easy to understand and manage.
- *Distance matters.* Rural savers who do not own transport may be willing to go some distance to deposit or withdraw large sums. But for

accumulating small amounts, a service that requires hours of travel is no service at all. Bank branches, alone, do not seem to be the answer to reaching small rural depositors. Small depositors require services that are delivered close to the places that they frequently come. Delivery options that do this typically also pose trade-offs between the qualities that depositors care about most: security, liquidity, and convenience.

- *Mitigating seasonality risks.* To cope with the heterogeneity, seasonality, and the risk of agriculture, the best rural micro-lenders tailor loans to the production cycles of each borrower and check that the household can repay with non-farm income even if crops fail or if livestock die. Through time and repeated contact, loan officers grow to know the character and cash flows of borrowers and so can judge their risk better (Charitonenko and Campion, 2003).

2.6 Sound Micro Financing Practices

The laws of effective micro-financing projects are very similar (Fallavier, 1998). They include:

- working directly in the community through regular and frequent visits of villages and poor neighborhoods to meet existing clients and secure new ones;
- keeping application procedures simple, relying on peers to choose credit-worthy clients;
- quickly extending credit (often within a week);
- not asking for guarantees that eliminate most potential candidates (such as collateral), rather, rely on the effectiveness of the group dynamics;
- proving larger loans based on successful repayment (incremental lending);
- involving participation of the clients who take a major role in promoting the project within the community by forming groups and providing one another with advice and assistance, reducing costs significantly and developing commitment to the project and to one another;
- developing projects in coordination with local banks to help increase outreach; and
- addressing the needs of poor clients (e.g. flexible hours, field visits).

2.7 Economic, Allocative and Technical Efficiency in MFIs

Efficiency can be considered in terms of the optimal combination of inputs to achieve a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output-orientation).

Ray (1991) defined efficiency in relation to productivity in resource utilization. He stated that a firm is efficient if it is found to produce the maximum level of output (achievements) from a given bundle of resources (inputs) used. A high achievement firm may be effective but inefficient if it is using more of the firm's inputs than necessary to produce that level of achievement (output). On the other hand, a relatively poor firm may be making the best use of inputs (and thus be considered efficient) but may still prove to be ineffective because the achievement levels (outputs) fall short of what is deemed to be acceptable. For a given structure of production possibility set, a DMU is efficient if (i) it is impossible to augment any output without increasing any input and without decreasing any other output, or (ii) it is impossible to decrease any input without decreasing any output and without augmenting any other input. A DMU is inefficient otherwise (Huang, Li, and Rousseau, 1997).

Technical efficiency is just one component of overall economic efficiency. However, in order to be economically efficient, a firm must first be technically efficient. Profit maximization requires a firm to produce the maximum output given the level of inputs employed (i.e. be technically efficient), use the right mix of inputs in light of the relative price of each input (i.e. be input allocative efficient) and produce the right mix of outputs given the set of prices (i.e. be output allocative efficient) (Kumbhaker and Lovell, 2000).

2.7.1 Best Practice Function and the Concept of Efficiency

The best practice or frontier function is an efficient transformation of given inputs into maximum attainable output. In other words, it reflects the ability to produce a well specified output at minimum cost To evaluate efficiency of firms relative to the best practice production, it is necessary to have a quantifiable standard. That standard can only be determined by those productive units which share a common technology. It was Farrell (1957) who first proposed an approach to estimate the productive or economic efficiency (EE) of observed units. He decomposed production efficiency into two elements: (1) technical efficiency (TE), which measures the firm's success in producing maximal output with a given set of inputs; and (2) allocative (price) efficiency (AE), which quantifies the firm's success in choosing an optimum combination of inputs.

2.7.2 Input-Oriented Measures

Figure 2.1 shows the technical and allocative efficiencies of a firm which produces a single output (y) using two inputs (x1 and x2) under the assumption of constant returns to scale.

To simplify the exposition, consider a MFI that uses only two inputs, X1 and X2, to produce a single output, Y. The known efficient production function can be written as

$Y = f(X1, X2)$......... (1)

Assuming constant returns to scale, Equation 1 can be expressed as

$I= f(X1/Y, X2/Y)$...... (2)

Equation 2 implies that the production frontier 1 can be depicted using the efficient unit isoquant (EUI), represented by UU' in Figure 2.1. The EUI shows the technically efficient combinations of X1 and X2 used to produce one unit of output Y. Point A, which lies above the unit isoquant, represents the combination of X1 and X2 actually used in producing Y, while point B represents a technically efficient firm using the two inputs in the same ratio as A . Point B implies that the respective firm produces the same output as

A, but with less inputs. Thus the fraction OB/OA defines the TE of firm A. Hence, the technical inefficiency of firm A is 1-OB/OA which shows the proportion by which the inputs could be reduced, holding the input ratio (X1/X2) constant, without any reduction in output. In other words, firm A should have produced OA/OB times more output with the same input quantities (Farrell, 1957).

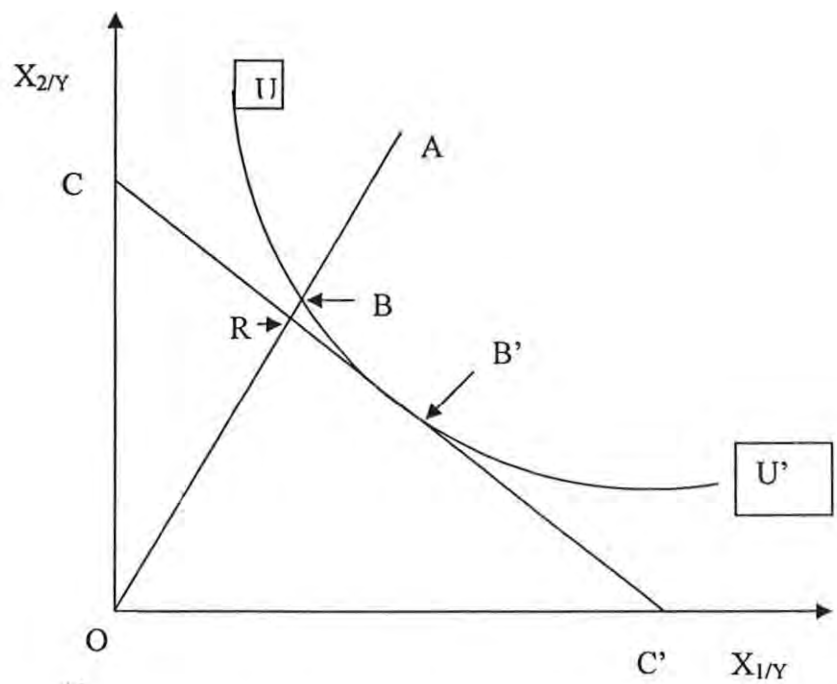

Figure 2.1 Technical and Allocative Efficiencies under input oriented measures

If input prices are considered, then it is possible to examine the optimal combination of inputs which minimize the cost of producing a given level of output.

This optimal combination is where the slope of CC', the price line, is equal to that of unit isoquant UU'. Thus B' is the optimal or minimum cost point of production. Firm B is producing at a higher cost than B', although both points reflect 100 percent technical efficiency. The cost of production at B' is only a fraction OR/OB of that at B. Farrell defines the ratio OR/OB as the allocative efficiency of B. Consequently, the allocative inefficiency of B is 1-(OR/OB), which measures the potential reduction in cost from using optimal input proportions (Schmidt, 1986).

If both technical and allocative efficiencies of firm A are considered, then its production or economic efficiency is given by the ratio OR/OA. Accordingly, 1(OR/OA) is economic or total inefficiency of that firm, which shows the overall efficiency gain of moving from point A to B' (Schmidt, 1986). Moreover, economic efficiency (OR/OA) is the product of technical (OB/OA) and allocative (OR/OB) efficiencies, i.e., EE = (OB/OA) x (OR/OB) = OR/OA (Farrell, 1957).

2.7.3 Output-Oriented Measures

The input-oriented technical efficiency measures the amount of input quantities that can be reduced proportionally without changing the output quantities produced. On the other hand, the output-oriented measure provides the amount of output quantities that could be expanded proportionally without altering the input quantities used. To illustrate the difference between the two measures, a simple example with a single input and single output (x and y respectively) can be used. Figure 2.2 (a) shows a situation were there is a decreasing returns to scale (DRS) technology represented by f(x),and an inefficient firm operating at the point P. The Farrell input-oriented measure of technical efficiency would be equal to ratio AB/AP, while the output-oriented measure of technical efficiency would be CP/CD. The input and output-oriented measures yield similar values of technical efficiency when constant returns to scale (CRS) exists. This situation (constant returns to scale) is shown in Figure 2.2 (b), where the ratio AB/AP = CP/CD, for the inefficient firm operating at point P.

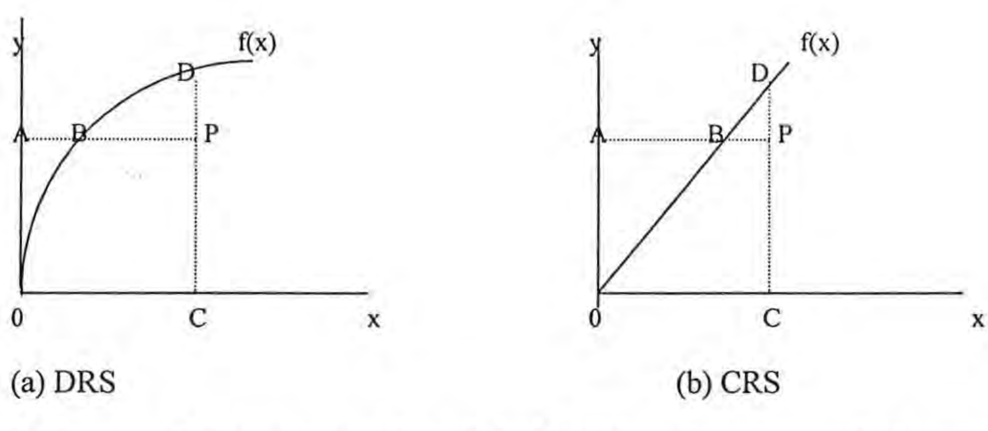

Figure 2.2 Input- and Output-Oriented Technical Efficiency Measures and Returns to Scale.

The output-oriented measure can also be illustrated by considering the case where the production involves two outputs (y_1, and y_2) and a single input (x_1). If the input quantity is held fixed at a particular level, the technology can be represented by a production possibility curve in two dimensions. This is shown in Figure 2.3 and line ZZ' represents the production possibility curve or the upper bound of production possibilities and point A (which lies below the curve) corresponds to an inefficient firm.

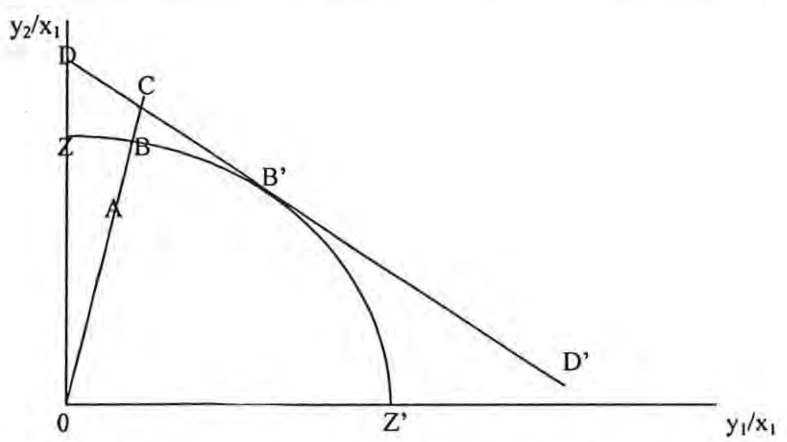

Figure 2.3 Technical and Allocative efficiencies from Output Orientation

In Figure 2.3, the distance AB represents the amount by which outputs could be increased without requiring additional input or the technical inefficiency. The measure of output-oriented technical efficiency is, therefore, the ratio of OA/OB.

$$TEo = 0A/0B.$$

In addition, if price information is available, the isorevenue line, DD', could be drawn, and the allocative inefficiency could be measured by the distance BC. The output-oriented allocative efficiency has a revenue increasing interpretation (similar to the cost reducing interpretation of allocative inefficiency in input-oriented case). Allocative efficiency is the ratio of 0B/0C.

AEo = 0B/0C.

Similar to the case in input-oriented measures the overall economic efficiency is the product of the two measures (technical and allocative efficiencies).

EEo = (0A/0C) = (0A/0B) x (0B/0C)

= TEo x AEo

2.7.4 The Constant Returns to Scale (CRS)

The DEA approach measures efficiency of production units that transform multiple inputs into multiple outputs by the ratio of weighted outputs to weighted inputs. Consider the case of N number of DMUs that convert K inputs into M outputs. For the i^{th} DMU the inputs and outputs are represented by the column vectors x_i and y_i respectively. The K x N output matrix, X, and the M x N output matrix, Y, represent the data for all N DMUs. The relative DEA efficiency score for each DMU can be measured by the weighed ratio of all outputs over all inputs, such as $u'y_i/v'x_i$, where u is an M x 1 vector of output weights and v is a K x 1 vector of input weights, (Coelli, Rao and Battese, 1997). The optimal weights are obtained by solving mathematical programming problem:

(1) $\max_{u,v} (u'y_i/v'x_i)$,

subject to: $u'y_j/v'x_j \leq 1$, $j=1,2,\ldots,N$.

$u, v \geq 0$.

In order to maximize the efficiency measure of the i^{th} firm, subject to the constraints that all efficiency measures must be less than or equal to one, the maximization problem involves determining the values for u and v. Ex post evaluations of how efficient each DMU was with the actual inputs used to produce its outputs without explicit knowledge of the input-output relationship it used is provided by DEA. One of the novelties of DEA is that it doesn't require the specification of a priori weights on the input-output factors involved. DEA evaluates the efficiency of DMUs without imposing a priori weights on the input and output dimensions involved (Golany, 1988). The weights in the form of u and v are not known or given a priori, rather the two values are determined from the data by the above model (and may not correspond to relative values that a DMU would assign to outputs and inputs). They are calculated as (u, v) values to be assigned to each input and output in order to maximize the efficiency ratio of the DMU being evaluated. In this case, the solution sought is the set of (u,v) values that will give DMU being rated the highest efficiency ratio, but not result in an input-output exceeding 1 (100% efficiency) when applied to any and all other DMUs in the sample or data set (Sherman and Gold, 1985). But, as to Coelli, Rao and Battese (1997) this maximization problem has an infinite number of solutions. And this can be avoided by introducing the constraint $v'x_i=1$. Using the duality in linear programming, an equivalent envelopment form of the problem can be derived:

(2) $$\min_{\theta,\lambda} \theta,$$

$$\text{subject to:} \quad -y_i + Y\lambda \geq 0$$

$$\theta x_i - X\lambda \geq 0$$

$$\lambda \geq 0,$$

where (in addition to the variables defined in equation 1) θ is a scalar and λ is a N x 1 vector of constant. It should be clear that the linear programming problem should be solved once for each DMU in the sample (N times), so that a value of θ is obtained for each DMU. Then the value of θ obtained will be the efficiency score for the i^{th} firm (DMU). Input oriented linear programming (LP) problem of the form given in equation (2) can be specified to measure technical efficiency.

The piecewise linear form of the non-parametric frontier in DEA can cause a few difficulties in efficiency measurement. The problem arises because of the sections of the piecewise linear frontier which run parallel to the axes. These are sections of the piecewise linear frontier that run parallel to the x-axis or y-axis, which may lead to inaccurate measurement of technical, pure technical and scale efficiency in the LP problems specified above (Burki and Niazi, 2003). From Figure 2.4, we can see that the isoquant does not "bend back" and display input congestion. The problem can be illustrated by considering different DMUs in Figure 2.4. Even though DMU A' is on the frontier, it is questionable whether it is efficient or not. This is because, the DMU can reduce the amount of input x_2 used (by the amount CA') and still produce the same level of output. This is referred to as input slack or input excess (Coelli, Rao, and Battese, 1997).

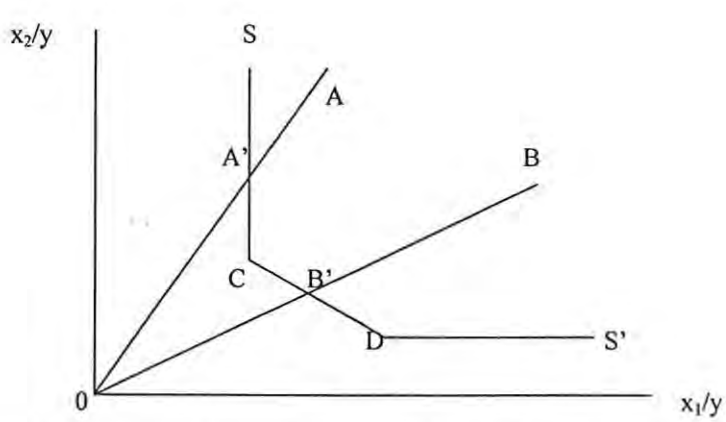

Figure 2.4 Efficiency Measurement and Input Slacks

If we take the multiple input and/or multiple output situations, the diagrams are no longer simple, and the possibility of the related concept of output slack also occurs. Thus, it could be argued that both the Farrell measure of technical efficiency (θ) and any non-zero input or output slacks should be reported to provide an accurate indication of technical efficiency of a DMU in a DEA analysis. For the given optimal values of θ and λ, output slack of i^{th} DMU will be equal to zero only if $Y\lambda - y_i = 0$, while the input slacks of the i^{th} DMU will be equal to zero only if $\theta x_i - X\lambda = 0$ (Coelli, 1996).

In a situation where there are multiple inputs and outputs, however, identifying the "nearest" efficient frontier point (such as C in Figure 2.4) and the subsequent calculation of slacks is not a trivial task. A second-stage linear programming was then suggested by some authors so as to move to an efficient frontier by MAXIMIZING the sum of slacks required to move from an inefficient frontier point (such as A') to an efficient frontier point (such as point C). But the second stage linear programming is not without problems. The first and most obvious problem is that the sum of the slacks is MAXIMIZED rather than MINIMIZED. That means it will identify the FURTHEST efficient point rather than the NEAREST efficient point. The second major problem is that it is not invariant to units of measurement (Coelli, 1996).

To solve these problems, the 'multi-stage DEA methodology' has been introduced by Tim Coelli. Even though the method is more computationally demanding than the other two methods, its use was recommended over the other two. Coelli (1996) stated that the benefits of this approach are (i) that it identifies efficient projected points which have input and output mixes which are as similar as possible to those of the inefficient points, and (ii) that it is invariant to units of measurement.

2.7.5 The Variable Returns to Scale (VRS) and Scale Efficiencies

The Constant Returns to Scale is only appropriate when all firms are operating at an optimal scale. Some factors such as imperfect competition, constraints on (lack of) finance, etc. may cause a firm to be not operating at optimal scale. If all firms (DMUs) are not operating at the optimal scale, use of CRS results TE measures confounded by scale efficiencies (SE). As a result of this Banker, Charnes and Cooper (1984) so as to account for VRS, suggested an extension of CRS DEA model. The use of the VRS specification permits the calculation of TE devoid of these SE effects (Coelli, 1996).

The CRS linear programming can be easily modified to account for VRS by adding the convexity constrain, $N1'\lambda = 1$ to equation (2),

(3) $\min_{\theta,\lambda} \theta$,

subject to: $-y_i + Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

$N1'\lambda = 1$

$\lambda \geq 0$, where N1 is an N x 1 vector of ones.

The convexity constraint ($N1'\lambda = 1$) ensures that an inefficient DMU is only "benchmarked" against DMUs of a similar size. This restriction, however, is not imposed in the CRS case and a DMU may be benchmarked against other DMUs which are substantially larger (smaller) than it. This approach (VRS) thus provides technical efficiency scores which are greater than or equal to those obtained by using the CRS mode (Coelli, 1996, and Jerome, 2003).

If the technology is believed to be VRS, the scale efficiency of each DMU can be determined by conducting both CRS and VRS DEA. The TE score obtained from the CRS DEA is then decomposed into, one due to scale inefficiency and one due to "pure' technical inefficiency. The difference between the CRS and VRS TE score of a DMU indicates the existence of scale inefficiency. But, it is difficult to know whether the DMU is in an area of increasing or decreasing returns to scale, by running only CRS and VRS. Therefore, additional DEA problem with non-increasing returns to scale

(NIRS) imposed is run. This is done by modifying (changing) the DEA model in equation 3 by substituting the $N1'\lambda = 1$ restriction by $N1'\lambda \leq 1$. This constraint ensures that the i^{th} firm will not be 'benchmarked' against firms which are substantially larger than it, but may be compared with firms smaller than it. If there is scale inefficiency and if the NIRS TE score is equal to the VRS TE score, decreasing returns to scale exists for that DMU (Coelli, Rao, Battese, 1997). Otherwise, increasing returns to scale applies to the unit. Increasing returns to scale occurs when a proportional increase in all inputs results in a more than proportional increase in output, while decreasing returns to scale exists when a proportional increase in all inputs results in a less than proportional increase in output.

Chapter Three: An overview of Ethiopian Microfinance Institutions

3.1 Emergence of MFIs in Ethiopia

The emergence of Microfinance institution is a recent phenomenon in Ethiopia. The first microfinance service in Ethiopia was introduced as an experiment in 1994, when the Relief Society of Tigray (REST) attempted to rehabilitate drought and war affected people through rural credit scheme. It was inspired by other countries' experiences and adapted to the conditions of the Tigray region. In the second half of the 1990s, as a result of its success, the microfinance service was gradually replicated in other regions (Berhanu and Thomas, 2000).

The Ethiopian MFIs are established as share companies and are administered by their respective board of directors. Some of the MFIs are primarily operating in rural areas whereas some other institutions are urban-based.

The Microfinance institutions in Ethiopia have been delivering uniform loan and saving products to all clients, with poverty alleviation as a primary objective. Disbursing loans to clients and getting these loans repaid as per schedule has been the focus of Ethiopian MFIs. The products of MFIs are supply driven rather than introducing market based analysis to meet the needs and preferences of their clients, while keeping the MFIs profitable.

Although the needs of all poor people are not the same, all the products (financial services), procedures, manuals, etc. of MFIs are simply copied from other MFIs without making market studies to identify the needs of the people and exploit market niches (Wolday, 2001).

3.2 Regulatory Environment of Ethiopian MFIs

In order to regulate the Microfinance institutions operating in Ethiopia, proclamation 40/1996 has been issued in 1996. This regulatory framework has set the loan ceiling and at the same time the loan size which normally affects the product development. There was also a fixed interest rate ceiling. This proclamation includes issues such as initial minimum capital requirement, organizational set-up, ownership and governance of microfinance institutions, interest rates for saving and loans, disclosure requirement, and the like (Getahun, 2000). But subsequently the National Bank of Ethiopia (NBE) issued directives which are consistent with Proclamation No 40/1996. And as a result of the new directives MFIs are currently free to set their own lending interest rates. Among other things, adjustment was also made regarding the maximum amount that an MFI can lend to a client and the loan repayment period (Itana, et al, 2004). These institutions are also required to comply with the Commercial Code of Ethiopia and other relevant laws.

3.3 Nature of the Existing MFIs

Some of the existing microfinance institutions operating in Ethiopia are region based both in terms of their lending activities and sources of funds, while others depend on donors' fund. Some of the MFIs have registered as national institution and are trying to expand by opening branches, for example, SFPI S.Co. (Gebrehiwot, 2002).

According to Itana and others (2004), the ownership structure of the Ethiopian MFIs is currently diverse including the regional governments, community based organizations, NGOs and individuals. Since the issuance of the proclamation, increase in the number and size of MFIs has been observed. Different studies have shown that there is growth in terms of outreach among poor rural households, the number of active clients, amount of loan disbursed and saving mobilized.

In Ethiopia, regardless of the number of MFIs operating in the market, there is very limited competition among them. This is because there is very high demand for their financial service (even some MFIs consider it as unlimited) as compared to the supply.

Most of the MFIs in Ethiopia currently finance their lending and other operational activities mainly through external donations. According to Getahun (2002), the initial (start up) equity capital for the creation of almost all MFIs was obtained from external donors. This high dependence on external sources, which is also expected to remain for the coming several years, makes the MFI industry in Ethiopia fragile and unsustainable. It is fragile and unsustainable because withdrawal of external donor agencies from funding the sector's operational expenses and growth may lead to the collapse of the industry. The high dependence on external donors is due to low domestic financing structure (Getahun, 2002).

3.4 Performance Measurement in Ethiopian MFIs

There is no standardized way of evaluating the performance of the MFIs operating in Ethiopia. But according to the workshop report prepared by Haftu Berhanu (2004), 5 MFIs reported that they were operationally self-sufficient, and 4 of these institutions achieved financial self-sufficiency. These performance indicators were determined by the respective MFIs. To determine their operational self-sufficiency, the formula used was;

$$\text{Operational self sufficiency} = \frac{\text{Operating revenue excluding grant}}{\text{Operating Expenses}}$$

On the other hand, the financial self-sufficiency was calculated as follows:

$$\text{Financial self-sufficiency} = \frac{\text{Adjusted total revenue excluding grants}}{\text{Adjusted total expense}}$$

Chapter Four: Data Presentation and Efficiency Analysis

Similar to many other parts of the African continent, microfinance in Ethiopia has evolved as means to reduce poverty. However, due to the government's strategy to develop the rural sector and to MFIs' historic ties to pro-poor NGOs, most MFIs in Ethiopia typically serve rural areas, having only recently shifted operations towards urban and semi-urban areas. Indeed, the majority of Ethiopian MFIs see poverty reduction as their main institutional goals and reaching the poorest as a key approach. MFIs in Ethiopia have a combined outreach over one million loan clients accessing both credit and savings products and manage a loan portfolio of Br.996 million and savings of Br. 431 million(AMFI report,2006).

The following table shows the MFIs in Ethiopia which are included in the study based on their size:

Table 4a: Categories of MFIs in Ethiopia

Category	MFI under this category
Small	AVFS,Bussa,Meket,Meklit,Metemamen,Eshet,Gasha,Aggar,Peace, Shashmene and Wasasa
Medium	SFPI,Benshangul, AdCSI & Wisdom
Large	ACSI,DECSI,OCSSCO,Sidama, &OMO

Source: AEMFI, 2006

20 of the 27 MFIs involved in the efficiency analysis are given below in Table 4b and this data is dated as of December 31, 2005.It is entirely used in the model and in the forthcoming analysis. As it is indicated in the table, data about the name of the institutions, interest income, the value of the loans disbursed, cost per borrower and total number of staff of each institution as of December 31,2005 is given .

Table 4b: Data for the analysis

S.N	MFI	Interest Income	Value of loans disbursed	Cost per borrower	Total no. of staff
1	**ACSI**	Br.63553000	Br.4044610000	Br.80.89	1911
2	**ADCSI**	7269000	94285000	69.61	315
3	**Aggar**	305281.65	2711901	413.71	32
4	**AVFS**	786004.62	5488380.74	116.26	51
5	**Bnshgul**	2184708.89	16481560	318.44	19
6	**Bussa**	1080756.81	11979003	148.94	76
7	**DECSI**	118505217.3	1236771027	68.17	1217
8	**Eshet**	2537566.57	15448300	92.04	43
9	**Gasha**	1656910.25	2256535.67	257.84	69
10	**Meket**	148450.54	944080	57.93	15
11	**Meklit**	1019430.17	6643410	115.90	19
12	**Metemam**	273700	2351150	227.21	28
13	**Ocssco**	27603061.12	91313063.46	91.00	472
14	**Omo**	14342341.26	562850441.9	138.24	358
15	**PEACE**	1387415.53	15856440	80.85	47
16	**SFPI**	1413935.58	38282855	67.69	57
17	**Shashim**	360788.27	485604	478.42	20
18	**Sidama**	2298172.75	4220160	136.00	105
19	**Wasasa**	1696384.49	10752550	87.49	87
20	**Wisdom**	4282893.84	50060398	129.99	103

Source: Compiled form AEMFI

As it is shown in the above table, 20 MFIs are taken for the analysis and these are chosen simply because of availability of information for the analysis. Moreover, note that interest income and loans disbursed are used as outputs of the MFIs under study and cost per borrower and total numbers of staff are used as inputs to measure the efficiency of MFIs in Ethiopia. These data is used to make analysis of the overall, operational and financial efficiency of the MFIs.

4.1 Overall Efficiency of MFIs in Ethiopia

The DEA technical efficiency is calculated by assuming both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) technology. While measuring the efficiency of MFIs in Ethiopia both input oriented as well as output oriented methods are used. Interest income and loans disbursed are used as output in the model and cost per borrowers and total number of staff are used as an iuput in the model to measure the overall efficiency of MFIs in Ethiopia.In other words, two inputs and two outputs are run into the DEA program. Results are presented in Table 4.1. The results show that six MFIs are on the efficiency frontier when constant returns to scale is assumed under input oriented measures. These are ACSI, Benshangul, DECSI,Eshet, meklit,and SFPI.In addition, eight MFIs are on the efficiency frontier when variable returns to scale is assumed. These are

ACSI,Benshangul,DECSI,Eshet,Meket,Meklit,Omo and SFPI. All the MFIs that are efficient under CRS remain efficient under VRS assumption and these are ACSI, Benshangul, DECSI,Eshet, meklit,and SFPI institutions. MFIs which are efficient or on the efficiency frontier under input oriented measures will remain the same under output oriented measures.

Average input oriented technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) are 92.7%, 94.1% and 98.5%, respectively. On the other hand, the average output oriented TE, PTE and SE are 92.7%, 95% and 97.4% respectively.

In the first case it can be conclude that 5.9 percent of inputs(cost per borrower and total number of staff) can be decreased without affecting the existing output level ,that is, gross loan portfolio or the interest income of the MFIs or both. Whereas under the output oriented measures, the MFIs can increase their loan portfolio by 5 % with the existing level of input by efficient utilization of these inputs.

The pure scale efficiency is greater than the technical efficiency in both measures. It implies that most of the technical efficiency of MFIs is due to the scale efficiency rather than the pure technical efficiency (i.e., managerial efficiency).

Further, the results suggest that most of the MFIs in Ethiopia experienced economies of scale, that is, 85.7% of MFIs under input oriented measures and 7 % of MFIs under output oriented measures are at the stage of increasing returns to scale. However, under input oriented measures, 14% of MFIs are at the stage of decreasing returns to scale; and under output oriented measures, all MFIs except MFIs No. 10 or MEKET are at the stage of decreasing return to scale. This implies that MFIs in Ethiopia are more efficient from input utilization point of view than from output maximization orientation. In other words, it is simple for MFIs in Ethiopia to reduce their input to get the same level of output than to increase their output using the same resources.

Table 4.1: OVERALL EFFICIENCY SUMMARY:	
Input Oriented	Output Oriented
MFI crste vrste scale	MFI crste vrste scale
1 1.000 1.000 1.000 -	1 1.000 1.000 1.000 -
2 0.946 0.981 0.964 irs	2 0.946 0.947 0.999 drs
3 0.785 0.807 0.973 irs	3 0.785 0.859 0.913 drs
4 0.883 0.892 0.989 irs	4 0.883 0.905 0.975 drs
5 1.000 1.000 1.000 -	5 1.000 1.000 1.000 -
6 0.850 0.854 0.995 irs	6 0.850 0.902 0.942 drs
7 1.000 1.000 1.000 -	7 1.000 1.000 1.000 -
8 1.000 1.000 1.000 -	8 1.000 1.000 1.000 -
9 0.820 0.820 0.999 irs	9 0.820 0.904 0.906 drs
10 0.990 1.000 0.990 irs	10 0.990 1.000 0.990 irs
11 1.000 1.000 1.000 -	11 1.000 1.000 1.000 -
12 0.823 0.838 0.982 irs	12 0.823 0.863 0.954 drs
13 0.955 0.956 0.999 irs	13 0.955 0.971 0.983 drs
14 0.926 1.000 0.926 drs	14 0.926 1.000 0.926 drs
15 0.980 0.983 0.997 irs	15 0.980 0.980 1.000 -
16 1.000 1.000 1.000 -	16 1.000 1.000 1.000 -
17 0.862 0.930 0.926 irs	17 0.862 0.874 0.986 drs
18 0.873 0.880 0.991 irs	18 0.873 0.910 0.959 drs
19 0.921 0.935 0.985 irs	19 0.921 0.924 0.998 drs
20 0.923 0.941 0.981 drs	20 0.923 0.967 0.955 drs
Mean 0.927 0.941 0.985	Mean 0.927 0.950 0.974

4.2 Operational and Financial Efficiency of MFIs in Ethiopia

As it has been mentioned in the previous chapter, the multistage DEA model was used to see the efficiency of selected Ethiopian MFIs from two perspectives: finance and operation. The two (financial and operational) models are also solved using the DEA version 2.0 software developed by Tim Coelli.. Summary of efficiency results obtained from the multistage DEA model are presented in Table 4.2.1 and 4.2.2.

Table 4.2.1 Operational efficiency									
Input oriented					Output oriented				
MFI	crste	vrste	scale		MFI	crste	vrste	scale	
1	0.519	1.000	0.519	drs	1	0.519	1.000	0.519	drs
2	0.566	0.764	0.740	drs	2	0.566	0.918	0.616	drs
3	0.757	0.807	0.939	irs	3	0.757	0.859	0.882	drs
4	0.699	0.726	0.964	irs	4	0.699	0.872	0.802	drs
5	1.000	1.000	1.000	-	5	1.000	1.000	1.000	-
6	0.667	0.674	0.990	irs	6	0.667	0.891	0.748	drs
7	0.522	0.922	0.566	drs	7	0.522	0.970	0.538	drs
8	0.780	0.781	0.998	irs	8	0.780	0.941	0.829	drs
9	0.612	0.657	0.932	irs	9	0.612	0.805	0.760	drs
10	0.900	1.000	0.900	irs	10	0.900	1.000	0.900	irs
11	0.945	0.974	0.970	irs	11	0.945	0.945	1.000	-
12	0.780	0.835	0.934	irs	12	0.780	0.859	0.908	drs
13	0.527	0.709	0.744	drs	13	0.527	0.895	0.589	drs
14	0.607	1.000	0.607	drs	14	0.607	1.000	0.607	drs
15	0.763	0.764	0.999	irs	15	0.763	0.936	0.815	drs
16	0.765	0.902	0.849	drs	16	0.765	0.973	0.786	drs
17	0.774	0.904	0.857	irs	17	0.774	0.785	0.987	drs
18	0.581	0.608	0.955	irs	18	0.581	0.817	0.711	drs
19	0.642	0.651	0.986	irs	19	0.642	0.878	0.732	drs
20	0.678	0.835	0.812	drs	20	0.678	0.951	0.713	drs
mean	0.704	0.826	0.863		mean	0.704	0.915	0.772	

Table 4.2.1 indicates that only Benshangul is efficient operationally when CRS is assumed in both input and output oriented measures. But four MFIs viz. Benshangul,ACSI, Meket and Omo are on operational efficiency frontier in both input and output oriented measures.

36.8% of the MFIs under study are at decreasing return to scale in operational efficiency analysis and 63.2% of the MFIs are at an increasing return to scale in operational efficiency measures. This implies that most of the MFIs have the opportunity to increase their operational efficiency and seven MFIs are still loosing their operational efficiencies.

Table 4.2.2 Financial Efficiency	
Input oriented	Output Oriented
MFI crste vrste scale	MFI crste vrste scale
1 0.929 0.958 0.970 irs	1 0.929 0.966 0.961 drs
2 0.846 0.979 0.864 irs	2 0.846 0.850 0.995 drs
3 0.476 0.677 0.704 irs	3 0.476 0.679 0.701 drs
4 0.648 0.862 0.752 irs	4 0.648 0.730 0.888 drs
5 0.575 0.716 0.804 irs	5 0.575 0.785 0.733 drs
6 0.631 0.821 0.768 irs	6 0.631 0.747 0.844 drs
7 1.000 1.000 1.000 -	7 1.000 1.000 1.000 -
8 0.741 0.913 0.811 irs	8 0.741 0.793 0.934 drs
9 0.586 0.742 0.790 irs	9 0.586 0.770 0.760 drs
10 0.666 1.000 0.666 irs	10 0.666 1.000 0.666 irs
11 0.661 0.864 0.765 irs	11 0.661 0.744 0.888 drs
12 0.524 0.751 0.698 irs	12 0.524 0.673 0.778 drs
13 0.863 0.928 0.929 irs	13 0.863 0.922 0.936 drs
14 0.759 0.846 0.897 irs	14 0.759 0.886 0.857 drs
15 0.731 0.936 0.781 irs	15 0.731 0.761 0.961 drs
16 0.763 0.976 0.782 irs	16 0.763 0.774 0.986 irs
17 0.471 0.661 0.712 irs	17 0.471 0.688 0.684 drs
18 0.677 0.840 0.806 irs	18 0.677 0.788 0.859 drs
19 0.729 0.921 0.791 irs	19 0.729 0.772 0.944 drs
20 0.712 0.851 0.837 irs	20 0.712 0.821 0.867 drs
Mean 0.699 0.862 0.806	Mean 0.699 0.808 0.862

Table 4.2.2 indicates that only DECSI is financially efficient under CRS assumption in both input and output oriented measures.On the other hand, Meket and DECSI are identified to be financially efficient under VRS assumption.

As it can be seen from Tables 4.2.1 and 4.2.2, based on CRS, the mean operating and financial efficiencies for the MFIs included in the sample were 0.704 and 0.699, respectively. On average (i.e. the mean result), the MFIs included in the sample showed higher operational efficiency than financial efficiency.

According to the CRS assumption, the number of institutions, which were financially efficient, are equal to those considered as operationally efficient. Based on data provided on outputs and inputs, DEA has identified only one MFIs as both operationally and financially efficient in relative terms.

According to VRS assumption, for all the MFIs included in the study, the mean operating and financial efficiencies were 0.826 and 0.862 respectively. Under this assumption four MFIs were identified as both operationally and financially efficient.

As it has been mentioned in earlier chapters, our measurement of efficiency is only in relative terms, and the relatively efficient firms have DEA results equal to one.

4.3 Analysis of specific MFIs

It has been pointed out that efficiency rating suggests the degree of inefficiency of each DMU compared with its own reference set or peers. As an example, let us take MFI No.2 or ADCSI. The peers of MFI No. 2 for operational efficiency measurement were MFIs No. 14, and 5 or Omo and Benshangul. As shown in Table 4.2.1, this MFI has obtained a DEA score of 0.764 or 76.4% in operational efficiency. The efficiency rating shows the degree of inefficiency of a MFI compared with its efficient reference set. Hence, MFI No.2 is about 76.4% operationally efficient compared to MFIs No.14 and 5. MFI No. 6 or Bussa, on the other hand is about 66.7% operationally efficient but compared to MFIs No.5 and 14 (i.e. with its own reference set).

MFI No. 7 or DECSI is inefficient with 92.2% operational efficiency and is efficient 100% in relation to financial efficiency scores. But this MFI is identified as inefficient as well as efficient based on different reference sets in both models. MFIs No. 1 or ACSI, and 14 or Omo are peers (reference sets) of MFI No. 7, in the operational model. However, the reference sets of MFI No. 7 in the financial model were MFIs No. 7 itself. That means the efficiency of MFI No. 7 is evaluated based on different set of references or DMUs (peers) in both cases. The same analysis can also be made to all other MFIs.

Table 4.3

SUMMARY OF PEERS:	SUMMARY OF PEERS:
Operational	Financial
firm peers:	firm peers:
1 1	1 7
2 14 5	2 7
3 14 5	3 7
4 14 5	4 7
5 5	5 7
6 14 5	6 7
7 1 14	7 7
8 14 5	8 7
9 14 5	9 7
10 10	10 10
11 5	11 7
12 14 5	12 7
13 1 14	13 7
14 14	14 7
15 14 5	15 7
16 14 5	16 7 10
17 14 5	17 7
18 14 5	18 7
19 14 5	19 7
20 14 5	20 7

Amahra Credit and Saving Institution (ACSI)

ACSI is one of the largest credit and saving institutions in Ethiopia and has an age of more than nine years. The overall efficiency measures of the institution indicate that ACSI is efficient both operationally and financially relative to its peers .It is 100% efficient operationally and 100% efficient financially as compared to itself and DECSI respectively. This result is found after analyzing and running all the input and output at the same time.

Moreover, the operational efficiency measures of ACSI, while analyzed separately, shows that ACSI is 51.9% efficient operationally while CRS is assumed and 100% efficient operationally while VRS is assumed.

On the other hand, the financial efficiency measures of ACSI, while analyzed separately, shows that ACSI is 92.9% efficient financially while CRS is assumed and 95.8% efficient financially while VRS is assumed.

Addis Credit and Saving Institution (ADCSI)

ADCSI is also one of the medium sized credit and saving institutions in Ethiopia and has an age of more than six years. The overall efficiency measures of the institution indicate that ADCSI is inefficient both operationally and financially relative to its peers .It is 94.6% efficient operationally and 98.1% efficient financially as compared to Omo and Benshangul respectively. This result is found after analyzing and running all the input and output at the same time.

Moreover, the operational efficiency measures of ADCSI, while analyzed separately, shows that ACSI is 56.6% efficient operationally while CRS is assumed and 76.6% efficient operationally while VRS is assumed.

On the other hand, the financial efficiency measures of ADCSI, while analyzed separately, shows that ADCSI is 84.6% efficient financially while CRS is assumed and 97.9% efficient financially while VRS is assumed.

Aggar Microfinance institution (Aggar)

Aggar is one of the small sized MFIs in Ethiopia and has an age of less than five years. The overall efficiency measures of the institution indicate that Aggar is inefficient both operationally and financially relative to its peers .It is 78.5% efficient operationally and 80.7% efficient financially as compared to itself and DECSI respectively. This result is found after analyzing and running all the input and output at the same time.

Moreover, the operational efficiency measures of Aggar, while analyzed separately, shows that Aggar is 75.7% efficient operationally while CRS is assumed and 80.7% efficient operationally while VRS is assumed.

On the other hand, the financial efficiency measures of Aggar, while analyzed separately, shows that Aggar is 47.6% efficient financially while CRS is assumed and 67.7% efficient financially while VRS is assumed.

The above cases for ACSI, ADCSI and Aggar which are large, medium and small size institutions respectively indicated that largest institution tend to have a high rate of efficiency scores than the relatively small size institutions. The same analysis can also be made to all other MFIs.

4.4 Analysis of Efficiency Determinants in Ethiopian MFIs

This section investigates the possible determinants of efficiency of MFIs in Ethiopia. Hence, correlation and regression analysis are used to identify determinant factors of efficiency. In order to do this, return on asset (ROA), Age of the MFIs and total assets (TA) are related with efficiency results under CRS and VRS assumptions for each MFI.

4.4.1 Correlation Analysis

The correlation coefficients between different efficiency measures and variables have been calculated. The correlation coefficients are presented in Table 4.4.1 below:

Table 4.4.1: Correlation Results

		TA	AGE	ROA
CRSTE	Pearson Correlation	.367	.007	-.048
	Sig.(2-tailed)	.122	.981	.849
VRSTE	Pearson Correlation	.337	-.060	-.019
	Sig.(2-tailed)	.159	.839	.941

** Correlation is significant at the 0.01 level (2-tailed).

The results show that the value of total assets and the age of MFIs are positively correlated with all efficiency measures under CRS. However, the return on assets is negatively related to VRSTE and CRSTE. This implies that as the total assets and age of MFIs increases, their efficiency tends to increase. However, in both VRSTE and CRSTE assumptions, ROA is negatively related to efficiency of the MFIs and this means that as the returns of MFIs in Ethiopia from their assets increase, their efficiency decreases.

4.4.2 Regression Analysis

The results of regression analysis are presented in Table 4.4.2. The value of R square shows that 19.3% of variation in the technical efficiency (efficiency under CRS assumption) is explained by the variables included in the model-Return on Assets, Age of the MFIs and Total Assets. In case of pure technical efficiency (efficiency under VRS assumption), this variation is 22.2%.In both cases, the result shows that variation in efficiency highly influenced by or arises from factors other than included in the model.

Table 4.4.2.: Regression Results

	R	R Square	Adjusted R Square	Std. Error of the Estimate
CRSTE	.439	.193	-.110	8.6044E-02
VRSTE	.471	.222	-.070	8.6042E-02

a Predictors: (Constant), ROA, AGE, TA
b Dependent Variable: CRSTE and VRSTE

The parameter estimates of the size variable represented by AGE and Total assets are significant having positive sign. It implies that the AGE and Total assets of the MFI are important in determining both TE and PTE levels.

The correlation coefficients under both CRS and VRS assumptions indicate that the ROA, Age &TA and efficiency have relationship with 0.439 and 0.471 degrees. However, the strength of their relationship seems to be weak because it is far from 1 or a perfect goodness of fit.

Chapter Five: Summary, Conclusion and Policy Implications

5.1 Summary and Conclusion

Evaluating the efficiency of MFIs is very important to different parties. The evaluation can therefore be made considering different approaches. Using DEA is one way of evaluating the efficiency of MFIs. Unlike the case with accounting ratios, which aggregate many aspects of performance such as financing, marketing and operation, DEA can be used to see different aspects separately. In addition to this, efficiency measurement using DEA does not require comparison with 'bench marks' stated in advance. It uses the relative concept of measuring efficiency and is different from the averaging techniques. It is a method, which seeks to identify a relatively efficient DMU(s) from a set of DMUs. Each DMU is compared with the DMUs making the efficient production frontier.

If MFIs are going to render their services sustainably they have to be efficient both financially and operationally. The study revealed that four of the MFIs included in the sample were operationally efficient. On the other hand, only two of the institutions were identified as financially efficient. But this does not necessarily mean that the other MFIs, which were identified as relatively inefficient, are fully (absolutely) inefficient. It is only in relative terms, compared to their respective reference sets with in the sample.

According to the DEA results, the mean operating efficiency of the MFI included in the study was 70.4% with the efficiency scores ranging from 51.9% to 100%. However, the mean financial efficiency of the MFIs was 69.9% (lower than the mean operating efficiency), with a minimum efficiency score of 66.1%. From the MFIs included in the study, about 5% (1 MFIs out of 20) was relatively efficient both financially and operationally. All the MFIs which were identified as operationally efficient were found to be financially inefficient except one MFIs. The DEA results have also shown that, most of MFI which were having scale efficiencies were operating in increasing returns to scale.

The correlation results show that the value of total assets and the age of MFIs are positively correlated with all efficiency measures under CRS. However, the return on assets is negatively related to VRSTE and CRSTE. This implies that as the total assets and age of MFIs increases, their efficiency tends to increase. However, in both VRSTE and CRSTE assumptions, ROA is negatively related to efficiency of the MFIs and this means that as the returns of MFIs in Ethiopia from their assets increase, their efficiency decreases.

In the results of regression analysis, the value of R square shows that 19.3% of variation in the technical efficiency (efficiency under CRS assumption) is explained by the variables included in the model-Return on Assets, Age of the MFIs and Total Assets. In case of pure technical efficiency (efficiency under VRS assumption), this variation is 22.2%.In both cases, the result shows that variation in efficiency highly influenced by or arises from factors other than included in the model.

5.2 Implications of the Results

MFIs are primarily established so as to participate in the poverty alleviation or reduction programs. These institutions can be considered as one of the most powerful instruments of reducing poverty. The MFIs may discharge their responsibilities if they manage to reach large part of the poor (i.e. social responsibility) and if they can manage to sustain for long period of time. MFIs can serve part of the society who are in need of their financial service. By serving those needy, the institutions will achieve their social objective. In order to do this, among other things, they have to efficiently utilize their resources (inputs) and at the same time increase the number of loan clients and savers.

On the other hand, if the MFIs are going to sustainably serve the needy, they have to be profitable. They have to cover their costs from their revenue. Otherwise, they will be forced to consume their capital and end up being out of market. In the study 18 MFIs were identified as relatively financially inefficient. All the institutions, including the relatively efficient ones, have to work hard to maximize their revenue and minimize their operational costs. The maximization of revenue should not, however, discourage the clients from taking loans. In addition, being operationally efficient has its own contribution on financial efficiency. Therefore, primarily those MFIs which are financially inefficient should work on maximizing their revenue, reducing their cost, and becoming operationally efficient.

The recommendation is applicable not only to the inefficient MFIs but also to those MFIs which are identified by the DEA model as relatively efficient. This is because the efficiency measurement was in relative terms, and as a result to this there can be a ground for further improvement.

There are no well-developed and standardized performance measurement criteria. And AEMFIs can use this model in evaluating the relative efficiency of Ethiopian MFIs. Some other performance indicators, so as to make it more useful, can supplement this model. Besides, the MFIs can use this model so as to evaluate the efficiency of their respective branches in order to achieve institution-wide (overall) efficiency.

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Annex-1: Output orientated DEA results

```
Results from DEAP Version 2.1

Instruction file = eg2-ins.txt
Data file        = eg2-dta.txt

 Output orientated DEA

 Scale assumption: VRS

 Slacks calculated using multi-stage method


 EFFICIENCY SUMMARY:

  firm  crste  vrste  scale

     1  1.000  1.000  1.000  -
     2  0.946  0.947  0.999 drs
     3  0.785  0.859  0.913 drs
     4  0.883  0.905  0.975 drs
     5  1.000  1.000  1.000  -
     6  0.850  0.902  0.942 drs
     7  1.000  1.000  1.000  -
     8  1.000  1.000  1.000  -
     9  0.820  0.904  0.906 drs
    10  0.990  1.000  0.990 irs
    11  1.000  1.000  1.000  -
    12  0.823  0.863  0.954 drs
    13  0.955  0.971  0.983 drs
    14  0.926  1.000  0.926 drs
    15  0.980  0.980  1.000  -
    16  1.000  1.000  1.000  -
    17  0.862  0.874  0.986 drs
    18  0.873  0.910  0.959 drs
    19  0.921  0.924  0.998 drs
    20  0.923  0.967  0.955 drs

   mean  0.927  0.950  0.974

Note: crste = technical efficiency from CRS DEA
      vrste = technical efficiency from VRS DEA
      scale = scale efficiency = crste/vrste


Note also that all subsequent tables refer to VRS results
```

SUMMARY OF OUTPUT SLACKS:

firm	output:	1	2
1		0.000	0.000
2		0.000	0.000
3		0.100	0.000
4		0.000	0.000
5		0.000	0.000
6		0.000	0.000
7		0.000	0.000
8		0.000	0.000
9		0.000	0.773
10		0.000	0.000
11		0.000	0.000
12		0.057	0.000
13		0.000	0.444
14		0.000	0.000
15		0.000	0.000
16		0.000	0.000
17		0.000	0.732
18		0.000	0.618
19		0.000	0.000
20		0.000	0.000
mean		0.008	0.128

SUMMARY OF INPUT SLACKS:

firm	input:	1	2
1		0.000	0.000
2		0.000	0.000
3		0.178	0.000
4		0.000	0.000
5		0.000	0.000
6		0.000	0.000
7		0.000	0.000
8		0.000	0.000
9		0.116	0.000
10		0.000	0.000
11		0.000	0.000
12		0.000	0.000
13		0.000	0.000
14		0.000	0.000
15		0.000	0.000
16		0.000	0.000
17		0.185	0.000
18		0.000	0.000
19		0.000	0.000
20		0.000	0.000
mean		0.024	0.000

SUMMARY OF PEERS:

firm	peers:			
1	1			
2	16	8	5	7
3	5	14		
4	8	16	5	7
5	5			
6	7	16	5	1
7	7			
8	8			
9	7	5		
10	10			
11	11			
12	14	5	16	
13	8	7	5	
14	14			
15	16	8	10	11
16	16			
17	7	5		
18	8	7	5	
19	8	16	5	7
20	7	16	5	1

SUMMARY OF PEER WEIGHTS:
(in same order as above)

firm	peer weights:			
1	1.000			
2	0.398	0.028	0.010	0.565
3	0.822	0.178		
4	0.493	0.157	0.251	0.099
5	1.000			
6	0.119	0.255	0.493	0.133
7	1.000			
8	1.000			
9	0.310	0.690		
10	1.000			
11	1.000			
12	0.063	0.753	0.184	
13	0.066	0.759	0.175	
14	1.000			
15	0.454	0.499	0.001	0.046
16	1.000			
17	0.012	0.988		
18	0.232	0.366	0.403	
19	0.716	0.049	0.023	0.212
20	0.283	0.251	0.414	0.051

PEER COUNT SUMMARY:
(i.e., no. times each firm is a peer for another)

firm	peer count:
1	2
2	0
3	0
4	0
5	11
6	0
7	9
8	6
9	0
10	1
11	1
12	0
13	0
14	2
15	0
16	7
17	0
18	0
19	0
20	0

SUMMARY OF OUTPUT TARGETS:

firm	output: 1	2
1	7.803	9.607
2	7.245	8.421
3	6.484	7.489
4	6.514	7.446
5	6.339	7.217
6	6.692	7.850
7	8.074	9.092
8	6.404	7.189
9	6.877	7.798
10	5.172	5.975
11	6.008	6.822
12	6.356	7.381
13	7.661	8.639
14	7.157	8.750
15	6.269	7.349
16	6.150	7.583
17	6.361	7.240
18	6.988	7.896
19	6.745	7.613
20	6.858	7.962

SUMMARY OF INPUT TARGETS:

firm	input: 1	2
1	1.908	3.281
2	1.843	2.498
3	2.439	1.505
4	2.065	1.708
5	2.503	1.279
6	2.173	1.881
7	1.834	3.085
8	1.964	1.633
9	2.295	1.839
10	1.763	1.176
11	2.064	1.279
12	2.356	1.447
13	1.959	2.674
14	2.141	2.554
15	1.908	1.672
16	1.830	1.756
17	2.495	1.301
18	2.134	2.021
19	1.942	1.940
20	2.114	2.013

FIRM BY FIRM RESULTS:

Results for firm: 1
Technical efficiency = 1.000
Scale efficiency = 1.000 (crs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	7.803	0.000	0.000	7.803
output	2	9.607	0.000	0.000	9.607
input	1	1.908	0.000	0.000	1.908
input	2	3.281	0.000	0.000	3.281

LISTING OF PEERS:

peer	lambda weight
1	1.000

Results for firm: 2
Technical efficiency = 0.947
Scale efficiency = 0.999 (drs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	6.861	0.384	0.000	7.245
output	2	7.974	0.446	0.000	8.421
input	1	1.843	0.000	0.000	1.843
input	2	2.498	0.000	0.000	2.498

LISTING OF PEERS:

```
 peer   lambda weight
  16      0.398
   8      0.028
   5      0.010
   7      0.565


Results for firm:      3
Technical efficiency = 0.859
Scale efficiency     = 0.913   (drs)
 PROJECTION SUMMARY:
  variable             original         radial          slack      projected
                          value       movement       movement          value
 output     1             5.485          0.900          0.100          6.484
 output     2             6.433          1.056          0.000          7.489
 input      1             2.617          0.000         -0.178          2.439
 input      2             1.505          0.000          0.000          1.505
 LISTING OF PEERS:
  peer   lambda weight
   5      0.822
  14      0.178


Results for firm:      4
Technical efficiency = 0.905
Scale efficiency     = 0.975   (drs)
 PROJECTION SUMMARY:
  variable             original         radial          slack      projected
                          value       movement       movement          value
 output     1             5.895          0.618          0.000          6.514
 output     2             6.739          0.707          0.000          7.446
 input      1             2.065          0.000          0.000          2.065
 input      2             1.708          0.000          0.000          1.708
 LISTING OF PEERS:
  peer   lambda weight
   8      0.493
  16      0.157
   5      0.251
   7      0.099


Results for firm:      5
Technical efficiency = 1.000
Scale efficiency     = 1.000   (crs)
 PROJECTION SUMMARY:
  variable             original         radial          slack      projected
                          value       movement       movement          value
 output     1             6.339          0.000          0.000          6.339
 output     2             7.217          0.000          0.000          7.217
 input      1             2.503          0.000          0.000          2.503
 input      2             1.279          0.000          0.000          1.279
 LISTING OF PEERS:
  peer   lambda weight
   5      1.000
```

```
Results for firm:      6
Technical efficiency = 0.902
Scale efficiency     = 0.942   (drs)
 PROJECTION SUMMARY:
  variable             original          radial          slack      projected
                          value        movement       movement          value
 output      1            6.034           0.658          0.000          6.692
 output      2            7.078           0.772          0.000          7.850
 input       1            2.173           0.000          0.000          2.173
 input       2            1.881           0.000          0.000          1.881
 LISTING OF PEERS:
  peer    lambda weight
    7       0.119
   16       0.255
    5       0.493
    1       0.133


Results for firm:      7
Technical efficiency = 1.000
Scale efficiency     = 1.000   (crs)
 PROJECTION SUMMARY:
  variable             original          radial          slack      projected
                          value        movement       movement          value
 output      1            8.074           0.000          0.000          8.074
 output      2            9.092           0.000          0.000          9.092
 input       1            1.834           0.000          0.000          1.834
 input       2            3.085           0.000          0.000          3.085
 LISTING OF PEERS:
  peer    lambda weight
    7       1.000


Results for firm:      8
Technical efficiency = 1.000
Scale efficiency     = 1.000   (crs)
 PROJECTION SUMMARY:
  variable             original          radial          slack      projected
                          value        movement       movement          value
 output      1            6.404           0.000          0.000          6.404
 output      2            7.189           0.000          0.000          7.189
 input       1            1.964           0.000          0.000          1.964
 input       2            1.633           0.000          0.000          1.633
 LISTING OF PEERS:
  peer    lambda weight
    8       1.000
Results for firm:      9
Technical efficiency = 0.904
Scale efficiency     = 0.906   (drs)
 PROJECTION SUMMARY:
  variable             original          radial          slack      projected
                          value        movement       movement          value
 output      1            6.219           0.658          0.000          6.877
 output      2            6.353           0.672          0.773          7.798
 input       1            2.411           0.000         -0.116          2.295
```

```
 input      2            1.839          0.000          0.000          1.839
 LISTING OF PEERS:
  peer   lambda weight
    7       0.310
    5       0.690

Results for firm:      10
Technical efficiency = 1.000
Scale efficiency     = 0.990  (irs)
 PROJECTION SUMMARY:
  variable             original         radial          slack      projected
                          value       movement       movement          value
 output     1            5.172          0.000          0.000          5.172
 output     2            5.975          0.000          0.000          5.975
 input      1            1.763          0.000          0.000          1.763
 input      2            1.176          0.000          0.000          1.176
 LISTING OF PEERS:
  peer   lambda weight
   10       1.000

Results for firm:      11
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable             original         radial          slack      projected
                          value       movement       movement          value
 output     1            6.008          0.000          0.000          6.008
 output     2            6.822          0.000          0.000          6.822
 input      1            2.064          0.000          0.000          2.064
 input      2            1.279          0.000          0.000          1.279
 LISTING OF PEERS:
  peer   lambda weight
   11       1.000

Results for firm:      12
Technical efficiency = 0.863
Scale efficiency     = 0.954  (drs)
 PROJECTION SUMMARY:
  variable             original         radial          slack      projected
                          value       movement       movement          value
 output     1            5.437          0.862          0.057          6.356
 output     2            6.371          1.010          0.000          7.381
 input      1            2.356          0.000          0.000          2.356
 input      2            1.447          0.000          0.000          1.447
 LISTING OF PEERS:
  peer   lambda weight
   14       0.063
    5       0.753
   16       0.184
```

```
Results for firm:    13
Technical efficiency = 0.971
Scale efficiency     = 0.983   (drs)
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output      1           7.441         0.220         0.000         7.661
 output      2           7.961         0.235         0.444         8.639
 input       1           1.959         0.000         0.000         1.959
 input       2           2.674         0.000         0.000         2.674
 LISTING OF PEERS:
  peer   lambda weight
    8      0.066
    7      0.759
    5      0.175


Results for firm:    14
Technical efficiency = 1.000
Scale efficiency     = 0.926   (drs)
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output      1           7.157         0.000         0.000         7.157
 output      2           8.750         0.000         0.000         8.750
 input       1           2.141         0.000         0.000         2.141
 input       2           2.554         0.000         0.000         2.554
 LISTING OF PEERS:
  peer   lambda weight
   14      1.000


Results for firm:    15
Technical efficiency = 0.980
Scale efficiency     = 1.000   (crs)
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output      1           6.142         0.127         0.000         6.269
 output      2           7.200         0.149         0.000         7.349
 input       1           1.908         0.000         0.000         1.908
 input       2           1.672         0.000         0.000         1.672
 LISTING OF PEERS:
  peer   lambda weight
   16      0.454
    8      0.499
   10      0.001
   11      0.046
```

```
Results for firm:     16
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable            original         radial          slack      projected
                         value       movement       movement          value
 output     1            6.150          0.000          0.000          6.150
 output     2            7.583          0.000          0.000          7.583
 input      1            1.830          0.000          0.000          1.830
 input      2            1.756          0.000          0.000          1.756
 LISTING OF PEERS:
  peer   lambda weight
   16       1.000


Results for firm:     17
Technical efficiency = 0.874
Scale efficiency     = 0.986  (drs)
 PROJECTION SUMMARY:
  variable            original         radial          slack      projected
                         value       movement       movement          value
 output     1            5.557          0.804          0.000          6.361
 output     2            5.686          0.822          0.732          7.240
 input      1            2.680          0.000         -0.185          2.495
 input      2            1.301          0.000          0.000          1.301
 LISTING OF PEERS:
  peer   lambda weight
    7       0.012
    5       0.988


Results for firm:     18
Technical efficiency = 0.910
Scale efficiency     = 0.959  (drs)
 PROJECTION SUMMARY:
  variable            original         radial          slack      projected
                         value       movement       movement          value
 output     1            6.361          0.627          0.000          6.988
 output     2            6.625          0.653          0.618          7.896
 input      1            2.134          0.000          0.000          2.134
 input      2            2.021          0.000          0.000          2.021
 LISTING OF PEERS:
  peer   lambda weight
    8       0.232
    7       0.366
    5       0.403


Results for firm:     19
Technical efficiency = 0.924
Scale efficiency     = 0.998  (drs)
 PROJECTION SUMMARY:
  variable            original         radial          slack      projected
                         value       movement       movement          value
 output     1            6.230          0.515          0.000          6.745
```

```
 output     2           7.032          0.581          0.000          7.613
 input      1           1.942          0.000          0.000          1.942
 input      2           1.940          0.000          0.000          1.940
 LISTING OF PEERS:
  peer   lambda weight
    8      0.716
   16      0.049
    5      0.023
    7      0.212



Results for firm:     20
Technical efficiency = 0.967
Scale efficiency     = 0.955  (drs)
 PROJECTION SUMMARY:
  variable             original         radial          slack      projected
                          value       movement       movement          value
 output     1           6.632          0.226          0.000          6.858
 output     2           7.699          0.263          0.000          7.962
 input      1           2.114          0.000          0.000          2.114
 input      2           2.013          0.000          0.000          2.013
 LISTING OF PEERS:
  peer   lambda weight
    7      0.283
   16      0.251
    5      0.414
    1      0.051
```

Annex-2: Input orientated DEA results

```
Results from DEAP Version 2.1

Instruction file = eg2-ins.txt
Data file        = eg2-dta.txt

 Input orientated DEA

 Scale assumption: VRS

 Slacks calculated using multi-stage method


 EFFICIENCY SUMMARY:

  firm  crste  vrste  scale

     1  1.000  1.000  1.000  -
     2  0.946  0.981  0.964 irs
     3  0.785  0.807  0.973 irs
     4  0.883  0.892  0.989 irs
     5  1.000  1.000  1.000  -
     6  0.850  0.854  0.995 irs
     7  1.000  1.000  1.000  -
     8  1.000  1.000  1.000  -
     9  0.820  0.820  0.999 irs
    10  0.990  1.000  0.990 irs
    11  1.000  1.000  1.000  -
    12  0.823  0.838  0.982 irs
    13  0.955  0.956  0.999 irs
    14  0.926  1.000  0.926 drs
    15  0.980  0.983  0.997 irs
    16  1.000  1.000  1.000  -
    17  0.862  0.930  0.926 irs
    18  0.873  0.880  0.991 irs
    19  0.921  0.935  0.985 irs
    20  0.923  0.941  0.981 drs

 mean  0.927  0.941  0.985

Note: crste = technical efficiency from CRS DEA
      vrste = technical efficiency from VRS DEA
      scale = scale efficiency = crste/vrste


Note also that all subsequent tables refer to VRS results
```

SUMMARY OF OUTPUT SLACKS:

firm	output:	1	2
1		0.000	0.000
2		0.172	0.000
3		0.118	0.000
4		0.000	0.000
5		0.000	0.000
6		0.000	0.000
7		0.000	0.000
8		0.000	0.000
9		0.000	0.660
10		0.000	0.000
11		0.000	0.000
12		0.112	0.000
13		0.000	0.417
14		0.000	0.000
15		0.000	0.000
16		0.000	0.000
17		0.000	0.699
18		0.000	0.572
19		0.000	0.062
20		0.000	0.000
mean		0.020	0.120

SUMMARY OF INPUT SLACKS:

firm	input:	1	2
1		0.000	0.000
2		0.000	0.051
3		0.074	0.000
4		0.000	0.000
5		0.000	0.000
6		0.000	0.000
7		0.000	0.000
8		0.000	0.000
9		0.000	0.000
10		0.000	0.000
11		0.000	0.000
12		0.000	0.000
13		0.000	0.000
14		0.000	0.000
15		0.000	0.000
16		0.000	0.000
17		0.485	0.000
18		0.000	0.000
19		0.000	0.000
20		0.000	0.000
mean		0.028	0.003

SUMMARY OF PEERS:

firm	peers:			
1	1			
2	7	10		
3	10	5		
4	16	8	7	10
5	5			
6	16	8	7	10
7	7			
8	8			
9	11	8	10	
10	10			
11	11			
12	11	5	10	
13	7	8	10	
14	14			
15	7	16	8	10
16	16			
17	10	5		
18	7	8	10	
19	8	7	10	
20	16	5	7	8

SUMMARY OF PEER WEIGHTS:
(in same order as above)

firm	peer weights:			
1	1.000			
2	0.641	0.359		
3	0.631	0.369		
4	0.047	0.355	0.083	0.516
5	1.000			
6	0.382	0.319	0.033	0.266
7	1.000			
8	1.000			
9	0.270	0.666	0.063	
10	1.000			
11	1.000			
12	0.119	0.238	0.643	
13	0.646	0.319	0.034	
14	1.000			
15	0.022	0.410	0.411	0.158
16	1.000			
17	0.670	0.330		
18	0.195	0.507	0.299	
19	0.163	0.295	0.542	
20	0.341	0.180	0.195	0.285

PEER COUNT SUMMARY:
(i.e., no. times each firm is a peer for another)

firm	peer count:
1	0
2	0
3	0
4	0
5	4
6	0
7	8
8	8
9	0
10	11
11	2
12	0
13	0
14	0
15	0
16	4
17	0
18	0
19	0
20	0

SUMMARY OF OUTPUT TARGETS:

firm	output:	1	2
1		7.803	9.607
2		7.033	7.974
3		5.602	6.433
4		5.895	6.739
5		6.339	7.217
6		6.034	7.078
7		8.074	9.092
8		6.404	7.189
9		6.219	7.013
10		5.172	5.975
11		6.008	6.822
12		5.549	6.371
13		7.441	8.377
14		7.157	8.750
15		6.142	7.200
16		6.150	7.583
17		5.557	6.385
18		6.361	7.197
19		6.230	7.093
20		6.632	7.699

SUMMARY OF INPUT TARGETS:

firm	input: 1	2
1	1.908	3.281
2	1.808	2.401
3	2.036	1.214
4	1.843	1.524
5	2.503	1.279
6	1.855	1.606
7	1.834	3.085
8	1.964	1.633
9	1.978	1.509
10	1.763	1.176
11	2.064	1.279
12	1.975	1.213
13	1.873	2.556
14	2.141	2.554
15	1.875	1.643
16	1.830	1.756
17	2.007	1.210
18	1.879	1.780
19	1.817	1.814
20	1.990	1.895

FIRM BY FIRM RESULTS:

Results for firm: 1
Technical efficiency = 1.000
Scale efficiency = 1.000 (crs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	7.803	0.000	0.000	7.803
output	2	9.607	0.000	0.000	9.607
input	1	1.908	0.000	0.000	1.908
input	2	3.281	0.000	0.000	3.281

LISTING OF PEERS:

peer	lambda weight
1	1.000

Results for firm: 2
Technical efficiency = 0.981
Scale efficiency = 0.964 (irs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	6.861	0.000	0.172	7.033
output	2	7.974	0.000	0.000	7.974
input	1	1.843	-0.034	0.000	1.808
input	2	2.498	-0.047	-0.051	2.401

LISTING OF PEERS:

peer	lambda weight
7	0.641
10	0.359

```
Results for firm:      3
Technical efficiency = 0.807
Scale efficiency     = 0.973   (irs)
 PROJECTION SUMMARY:
  variable            original         radial          slack       projected
                         value       movement       movement           value
 output     1            5.485          0.000          0.118           5.602
 output     2            6.433          0.000          0.000           6.433
 input      1            2.617         -0.506         -0.074           2.036
 input      2            1.505         -0.291          0.000           1.214
 LISTING OF PEERS:
  peer    lambda weight
   10       0.631
    5       0.369


Results for firm:      4
Technical efficiency = 0.892
Scale efficiency     = 0.989   (irs)
 PROJECTION SUMMARY:
  variable            original         radial          slack       projected
                         value       movement       movement           value
 output     1            5.895          0.000          0.000           5.895
 output     2            6.739          0.000          0.000           6.739
 input      1            2.065         -0.222          0.000           1.843
 input      2            1.708         -0.184          0.000           1.524
 LISTING OF PEERS:
  peer    lambda weight
   16       0.047
    8       0.355
    7       0.083
   10       0.516


Results for firm:      5
Technical efficiency = 1.000
Scale efficiency     = 1.000   (crs)
 PROJECTION SUMMARY:
  variable            original         radial          slack       projected
                         value       movement       movement           value
 output     1            6.339          0.000          0.000           6.339
 output     2            7.217          0.000          0.000           7.217
 input      1            2.503          0.000          0.000           2.503
 input      2            1.279          0.000          0.000           1.279
 LISTING OF PEERS:
  peer    lambda weight
    5       1.000
```

```
Results for firm:      6
Technical efficiency = 0.854
Scale efficiency     = 0.995  (irs)
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1            6.034         0.000         0.000         6.034
 output     2            7.078         0.000         0.000         7.078
 input      1            2.173        -0.318         0.000         1.855
 input      2            1.881        -0.275         0.000         1.606
 LISTING OF PEERS:
  peer   lambda weight
   16       0.382
    8       0.319
    7       0.033
   10       0.266


Results for firm:      7
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1            8.074         0.000         0.000         8.074
 output     2            9.092         0.000         0.000         9.092
 input      1            1.834         0.000         0.000         1.834
 input      2            3.085         0.000         0.000         3.085
 LISTING OF PEERS:
  peer   lambda weight
    7       1.000


Results for firm:      8
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1            6.404         0.000         0.000         6.404
 output     2            7.189         0.000         0.000         7.189
 input      1            1.964         0.000         0.000         1.964
 input      2            1.633         0.000         0.000         1.633
 LISTING OF PEERS:
  peer   lambda weight
    8       1.000


Results for firm:      9
Technical efficiency = 0.820
Scale efficiency     = 0.999  (irs)
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1            6.219         0.000         0.000         6.219
 output     2            6.353         0.000         0.660         7.013
 input      1            2.411        -0.433         0.000         1.978
```

```
 input       2          1.839         -0.330         0.000          1.509
 LISTING OF PEERS:
  peer   lambda weight
   11      0.270
    8      0.666
   10      0.063


Results for firm:     10
Technical efficiency = 1.000
Scale efficiency     = 0.990  (irs)
 PROJECTION SUMMARY:
  variable              original        radial          slack      projected
                           value      movement       movement          value
 output      1          5.172          0.000         0.000          5.172
 output      2          5.975          0.000         0.000          5.975
 input       1          1.763          0.000         0.000          1.763
 input       2          1.176          0.000         0.000          1.176
 LISTING OF PEERS:
  peer   lambda weight
   10      1.000


Results for firm:     11
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable              original        radial          slack      projected
                           value      movement       movement          value
 output      1          6.008          0.000         0.000          6.008
 output      2          6.822          0.000         0.000          6.822
 input       1          2.064          0.000         0.000          2.064
 input       2          1.279          0.000         0.000          1.279
 LISTING OF PEERS:
  peer   lambda weight
   11      1.000


Results for firm:     12
Technical efficiency = 0.838
Scale efficiency     = 0.982  (irs)
 PROJECTION SUMMARY:
  variable              original        radial          slack      projected
                           value      movement       movement          value
 output      1          5.437          0.000         0.112          5.549
 output      2          6.371          0.000         0.000          6.371
 input       1          2.356         -0.382         0.000          1.975
 input       2          1.447         -0.234         0.000          1.213
 LISTING OF PEERS:
  peer   lambda weight
   11      0.119
    5      0.238
   10      0.643
```

```
Results for firm:      13
Technical efficiency = 0.956
Scale efficiency     = 0.999   (irs)
 PROJECTION SUMMARY:
  variable              original        radial         slack     projected
                           value      movement      movement         value
 output      1             7.441         0.000         0.000         7.441
 output      2             7.961         0.000         0.417         8.377
 input       1             1.959        -0.086         0.000         1.873
 input       2             2.674        -0.118         0.000         2.556
 LISTING OF PEERS:
  peer   lambda weight
    7      0.646
    8      0.319
   10      0.034


Results for firm:      14
Technical efficiency = 1.000
Scale efficiency     = 0.926   (drs)
 PROJECTION SUMMARY:
  variable              original        radial         slack     projected
                           value      movement      movement         value
 output      1             7.157         0.000         0.000         7.157
 output      2             8.750         0.000         0.000         8.750
 input       1             2.141         0.000         0.000         2.141
 input       2             2.554         0.000         0.000         2.554
 LISTING OF PEERS:
  peer   lambda weight
   14      1.000


Results for firm:      15
Technical efficiency = 0.983
Scale efficiency     = 0.997   (irs)
 PROJECTION SUMMARY:
  variable              original        radial         slack     projected
                           value      movement      movement         value
 output      1             6.142         0.000         0.000         6.142
 output      2             7.200         0.000         0.000         7.200
 input       1             1.908        -0.033         0.000         1.875
 input       2             1.672        -0.029         0.000         1.643
 LISTING OF PEERS:
  peer   lambda weight
    7      0.022
   16      0.410
    8      0.411
   10      0.158
```

```
Results for firm:     16
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable             original        radial         slack      projected
                          value      movement      movement          value
 output      1            6.150         0.000         0.000          6.150
 output      2            7.583         0.000         0.000          7.583
 input       1            1.830         0.000         0.000          1.830
 input       2            1.756         0.000         0.000          1.756
 LISTING OF PEERS:
  peer    lambda weight
   16       1.000

Results for firm:     17
Technical efficiency = 0.930
Scale efficiency     = 0.926  (irs)
 PROJECTION SUMMARY:
  variable             original        radial         slack      projected
                          value      movement      movement          value
 output      1            5.557         0.000         0.000          5.557
 output      2            5.686         0.000         0.699          6.385
 input       1            2.680        -0.188        -0.485          2.007
 input       2            1.301        -0.091         0.000          1.210
 LISTING OF PEERS:
  peer    lambda weight
   10       0.670
    5       0.330

Results for firm:     18
Technical efficiency = 0.880
Scale efficiency     = 0.991  (irs)
 PROJECTION SUMMARY:
  variable             original        radial         slack      projected
                          value      movement      movement          value
 output      1            6.361         0.000         0.000          6.361
 output      2            6.625         0.000         0.572          7.197
 input       1            2.134        -0.255         0.000          1.879
 input       2            2.021        -0.242         0.000          1.780
 LISTING OF PEERS:
  peer    lambda weight
    7       0.195
    8       0.507
   10       0.299
```

```
Results for firm:    19
Technical efficiency = 0.935
Scale efficiency     = 0.985  (irs)
 PROJECTION SUMMARY:
  variable             original          radial          slack       projected
                          value        movement       movement           value
 output     1             6.230           0.000          0.000           6.230
 output     2             7.032           0.000          0.062           7.093
 input      1             1.942          -0.125          0.000           1.817
 input      2             1.940          -0.125          0.000           1.814
 LISTING OF PEERS:
  peer   lambda weight
    8       0.163
    7       0.295
   10       0.542


Results for firm:    20
Technical efficiency = 0.941
Scale efficiency     = 0.981  (drs)
 PROJECTION SUMMARY:
  variable             original          radial          slack       projected
                          value        movement       movement           value
 output     1             6.632           0.000          0.000           6.632
 output     2             7.699           0.000          0.000           7.699
 input      1             2.114          -0.124          0.000           1.990
 input      2             2.013          -0.118          0.000           1.895
 LISTING OF PEERS:
  peer   lambda weight
   16       0.341
    5       0.180
    7       0.195
    8       0.285
```

Declaration

I, the undersigned, declare that the thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

Declared by:

Tagay Tilahun

Candidate

Confirmed by:

Getachew Yoseph

Advisor