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# Productivity and Efficiency Measurement Techniques: Identifying the Efficacy of Techniques for Financial Institutions in Developing Countries

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**Abstract**
*The concepts of efficiency have received a great deal of attention in many organisations. Many different approaches have been applied by many researchers to the measurement of efficiency changes in various types of institutions. The aim of this paper is to review the literature dealing with the concepts of efficiency and to review various techniques used in the measurement of these constructs. Measurement techniques are reviewed and directions are given for future research in data envelopment approach (DEA). Many researchers have used the DEA technique in efficiency analysis of financial institutions. These studies provide evidence that DEA is an appropriate methodology for efficiency analysis for these institutions.*

**Keywords:** productivity, efficiency; small financial institutions; data envelopment analysis

## INTRODUCTION

The concepts of productivity and efficiency have received a great deal of attention in many countries and organisations and by individuals in recent years. In an organisational context, productivity and efficiency reflects overall performance. This could lead to increases or decreases in shareholders' wealth. Hence, governments, economists and professionals are concerned with defining and measuring the concepts of productivity and efficiency.

### Productivity and efficiency

At a basic level, productivity examines the relationship between input and output in a given production process (Coelli, Rao et al. 1998). Thus, productivity is expressed in an output versus input formula for measuring production activities. It does not merely define the volume of output, but output obtained in relation to the resources employed. In this context, the productivity of the firm can be defined as a ratio (Coelli, Rao et al. 1998) as shown in equation 1.

Productivity= Output(s)/Input(s) (1)

The concept of productivity is closely related with that of efficiency. While the terms productivity and efficiency are often used interchangeably, efficiency does not have the same precise meaning as does productivity. While efficiency is also defined in terms of a comparison of two components (inputs and outputs), the highest productivity level from each input level is recognised as the efficient situation. Coelli, Rao and Battese (1998) further suggest that efficiency reflects the ability of a firm to obtain maximum output from a given set of inputs. If a firm is obtaining maximum output from a set of inputs, it is said to be an efficient firm (Rogers 1998).

Alternative ways of improving the productivity of the firm, for example, are by producing goods and services with fewer inputs or producing more output for the same quantity of inputs. Thus, increasing productivity implies either more output is produced with the same amount of inputs or that fewer inputs are required to produce the same level of output (Rogers 1998). The highest productivity (efficient point) is achieved when maximum output is obtained for a particular input level. Hence, productivity growth encompasses changes in efficiency, and increasing efficiency definitely raises productivity (Rogers 1998). Consequently, if the productivity growth of an organisation is higher than that of its competitors, or other firms, that firm performs better and is considered to be more efficient (Pritchard 1990).

### Types of Efficiency

Efficiency consists of two main components; technical efficiency and allocative efficiency (Coelli, Rao et al. 1998). Generally, the term efficiency refers to technical efficiency. As discussed in the previous section, technical efficiency occurs if a firm obtains maximum output from a set of inputs.

Allocative efficiency occurs when a firm chooses the optimal combination of inputs, given the level of prices and the production technology (Coelli, Rao et al. 1998; Rogers 1998). When a firm fails to choose the optimal combination of inputs at a given level prices, it is said to be allocatively inefficient, though

it may be technically efficient (Coelli, Rao et al. 1998). Technical efficiency and allocative efficiency combine to provide overall efficiency (Coelli, Rao et al. 1998). When a firm achieves maximum output from a particular input level, with utilisation of inputs at least cost, it is considered to be an overall efficient firm.

The concepts of productivity and technical efficiency are further illustrated in Figure 1 which describes a simple production process involving a single output (y) and a single input (x).

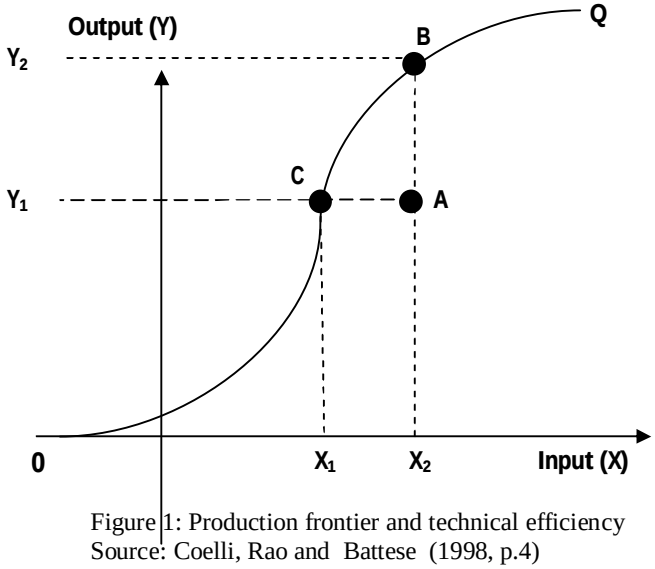


Figure 1: Production frontier and technical efficiency
Source: Coelli, Rao and Battese (1998, p.4)

Points A, B and C define the relationship between the input and the output of three different firms and these points represent the productivity level of each firm respectively. The line OQ represents the maximum level of output which can be attained with the use of each input level. This line is recognised as 'the production frontier' (Coelli, Rao et al. 1998). Firms that produce outputs on the production frontier are operating at maximum possible productivity and are recognised as technically efficient. Firms producing below the frontier line they are considered to be technically inefficient (Coelli, Rao et al. 1998). Thus, firms which operate at points B and C on the production frontier are considered technically efficient firms. The firm operating at point A is considered inefficient because it could increase its productivity by moving from output $Y_1$ to maximum productivity at output $Y_2$. The firm at point C produces output level $Y_1$ by using a lower input level $X_1$, while firm A produces the same output level $Y_1$ by using more inputs. Accordingly, firm A is considered as a technically inefficient firm. Technical efficiency is recognised by operating at maximum possible production, given the input level. The production frontier shows all points of technical efficiency (Coelli, Rao et al. 1998).

Improving productivity and efficiency is one of the main goals considered in organisations in recent years, because productivity gains provide overall information about the firm's performance (Zhu 2003). When considering efficiency analysis in financial institutions, Berger and Humphrey (1997) stress that it is important to determine their efficiency because they are in a competitive environment and their strength is vital for solvency. Further, efficiency analysis not only has important ramifications for institutions themselves, as evident in their competitiveness and solvency, it is also important for other interested parties, such as regulatory authorities and the general public (Berger and Young 1997). Although the basic concepts of productivity and efficiency are clearly discernable measures that have been presented in the literature are diverse. The selection of the appropriate measurement depends on the purpose of the study.

**Measurement of Productivity and Efficiency**

Basically, for a single firm that produces one output using a single input, the ratio of output to input is a measure of the productivity level (Rogers 1998). In this case, productivity is relatively easy to measure. However, in the case of many outputs and many inputs in a production process, the measurement of an output-input ratio is difficult (Diewert 1992). Hence, many different approaches have been applied by many researchers to the measurement of productivity and efficiency changes in various types of institutions, and levels of DMUs as well. Further, different approaches to productivity measurement give different numeric answers. Therefore, it is essential to select appropriate measurements for productivity and efficiency to avoid measurement bias in the results (Bozec, Dia et al. 2006).

**Partial Factor Productivity and Total Factor Productivity**

Figure 2 summarises the various approaches to the measurement of productivity and efficiency identified from the literature. In general, productivity and efficiency can be measured on a 'partial' factor or 'total' factor basis. Partial factor productivity (PFP) refers to the change in output owing to the change in the quantity of one input, whereas total factor productivity (TFP) refers to the change in output owing to changes in the quantity of more than one input (Coelli, Rao et al. 1998; Rogers 1998).

Accordingly, the measurement of partial factor productivity considers only one factor and ignores the impact of changes in all other factors (Rogers 1998). Labour productivity, productivity of power and return on assets are a few examples of partial measures (Coelli, Rao et al. 1998). If measures of productivity and efficiency are based on the return on assets, all other inputs involved in a firm's production are ignored, such as assets quality, capital adequacy, and

liquidity (Zhu 2003). Coelli, Rao and Battese (1998) argue that partial measures provide a misleading indication of the overall productivity and efficiency of the firm because they provide an indicator for only one section of the firm. Nonetheless, Fried, Lovell and Schmidt (1993) note that PFP measures are sometimes useful when the objectives of producers, or the constraints facing them, are either unknown or unconventional.

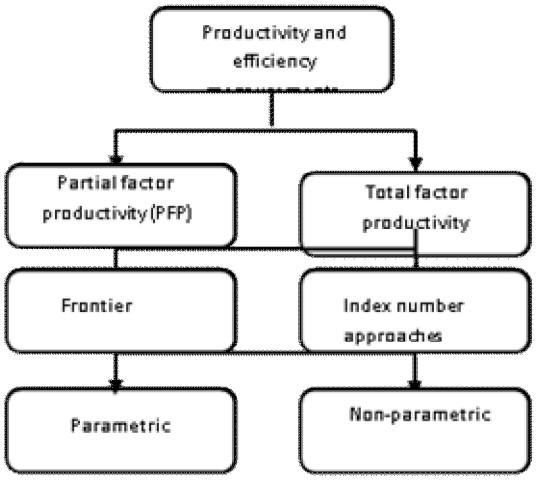


Figure 2: Approaches to the measurement of productivity and efficiency
Source: Developed by researcher

In general, in an industrial context, goods and services are produced by a combination of many factors or inputs. The output of goods and services can not be used as a measure of the productivity of any one of the inputs. The output is only a measure of the joint power of inputs to achieve results (Zhu 2003). This is the main disadvantage of measuring productivity and efficiency using the PFP approach. To overcome this shortcoming of PFP, TFP has been developed (Coelli, Rao et al. 1998). TFP measures overall productivity and efficiency by considering all inputs and all outputs in the production process. Coelli, Rao and Battese state that the TFP approach provides a better understanding of an institutions productivity and efficiency than does the PFP approach.

**The Production Frontier Approach**

The production frontier approach (PFA) is more popular in empirical studies of productivity and efficiency than the index number approach. The majority of researchers have relied on relative productivity measures based on the PFA because the index number approach assumes that all firms are fully efficient. However, this would not be expected in reality (Rogers 1998). The PFA approach uses observed data to construct the production frontier for estimating productivity and efficiency. Construction of the production frontier assumes that firms operate with full technical efficiency, producing maximum potential output from the allocated inputs (Coelli, Rao et al. 1998).

**Data Envelopment Analysis**

The DEA model for constructing a production frontier, and for the measurement of productivity and efficiency relative to the constructed formula, is an increasingly popular tool used in the nonparametric approach (Zhu 2003). Generally, DEA evaluates the efficiency of a given firm, in a given industry, compared to the best performing firms in that industry (Coelli, Rao et al. 1998). Thus, it is a relative measurement technique. In efficiency analysis, most researchers generally use DEA to measure the efficiency in public sector organisations, non-profit making organisations and private sector organisations. Productivity indices for each firm are determined on the basis of the inputs and outputs of each firm. Such an index is called a DEA score. From these DEA scores, productivity and efficiency can be measured for a whole organisation or a unit within an organisation (Coelli, Rao et al. 1998). The evaluation unit is also referred to as a decision-making unit (DMU). For example, one bank branch of the parent bank or a section, such as loan section, in a bank branch can be considered as a DMU.

In the production process, each DMU has a varying level of inputs and a varying level of outputs. DEA constructs a smooth curve based on the available data. The distribution of sample points is observed and a line is constructed enveloping them (Fried, Lovell et al. 1993), hence the term “Data Envelopment Analysis (DEA)”. From this line, DEA shows which producers are more efficient and identifies the inefficiencies of other producers. Hence, Fried, Lovell and Schmidt (2002) suggest that DEA is an appropriate method of measuring the relative efficiency of multiple decision-making units by enveloping observed input-output elements as tightly as possible. Further, it is useful to estimate relative efficiency for discussion of the relative importance of inputs and to observe the marginal contribution of each input (Fried, Lovell et al. 2002).

In parametric analysis, the single optimised regression is assumed to apply to each DMU and requires the imposition of a specific functional form relating the independent variables to the dependent variables (Fried, Lovell et al. 1993). In contrast, DEA optimises the performance measure of each DMU and does not require any assumption about the functional form (Charnes, Cooper et al. 1997). DEA constructs the efficient frontier from the sample data (Coelli, Rao et al. 1998). The DEA approach to evaluating productivity and efficiency is demonstrated in Figure 3. It presents a sample of six firms in an industry that use two inputs X and Y to produce one output.

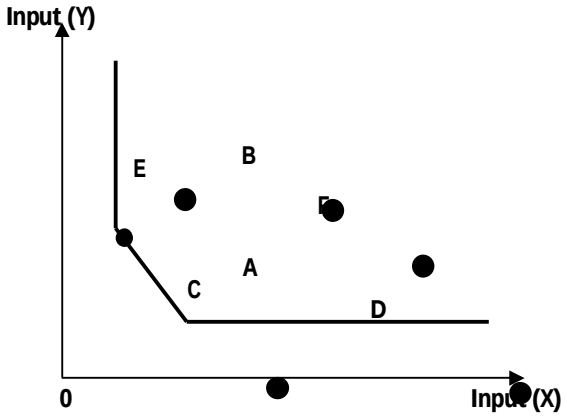


Figure 3 The efficient frontier in data envelopment analysis
Source: Coelli, Rao and Battese (1998, p.143)

Based on each firm's usage of inputs, data are plotted in Figure 3. As a large difference in the combination of inputs for obtaining the output of these firms exists it is very difficult to evaluate their productivity and efficiency by a single score. However, a frontier line can be drawn using the firms closest to the origin. Thus, a line can be drawn from firms E, A, C to firm D. This frontier line envelops all the data points and approximates the efficient frontier line (Coelli, Rao et al. 1998). The efficiency frontier defines the best combinations of inputs that can be used to produce an output. The firms on the frontier line are assumed to be operating at best practices in the sample. The firms which are on the upper side of the frontier (B and F) are considered to be less efficient compared with the performance of the best practice firms. However, it is questionable whether firm E or A on the frontier line are efficient as firm E can reduce its use of the input Y to produce the same outputs as firm A produces. Hence, firm A is more efficient than firm E. This is considered an example of input slack or input excess in frontier analysis (Coelli, Rao et al. 1998).

It is relatively easy to implement the DEA approach in this example because firms use only two inputs and produce only one output. However, when inputs and outputs are multiple, it becomes complex and it is necessary to use mathematical formulas and a computer package (Fried, Lovell et al. 1993). In contrast to parametric approaches, which try to optimise a single regression function, DEA optimizes each individual observation with an objective function (Zhu 2003). DEA is a widely recognised and applied method to evaluate productivity and efficiency in many organisations, particularly in the financial services sector (Berger and Humphrey 1997). According to Ali and Seiford (1993), the DEA approach has been used extensively in over 400 efficiency studies. However, failure to understand the limitations of DEA can lead to systematic errors or sample selection bias (Brown 2001). It is, therefore, imperative in modelling productivity and efficiency to use the correct methodology so that results may be interpreted appropriately (Rogers 1998).

**Application of Data Envelopment Analysis**

Many researchers have used the DEA technique in the productivity and efficiency analysis of several different types of DMUs including hospitals, educational institutions, cities, courts and financial institutions (Tavares 2002). Tavares (2002), in an analysis of efficiency studies during the period from 1978 to 2001, reports more than 3000 DEA applications in various forms of organisations. His bibliography includes 1259 journal articles, 50 books and 171 dissertations, written by 2152 distinct authors. Most of these studies are based on the analysis of the efficiency of service-oriented organisations, including financial services institutions. Berger and Humphrey (1997) identified 130 studies in 21 countries which apply frontier efficiency analysis to different types of financial institutions, such as deposit taking institutions, commercial banks, savings banks, credit unions and insurance firms. Amongst these, 14 focused on savings associations and credit unions in the USA, the UK, Spain and Sweden. These studies provide evidence that researchers in a number of fields recognise that DEA is an appropriate methodology for efficiency analysis in various types of organisations. Moreover, the technique has become popular in evaluating efficiency in service sector institutions because it handles multiple variables and does not require price data (Ruggiero 2005). DEA studies of banks and other financial institutions have been conducted in different countries in different contexts. For example, Taylor et al. (1997) investigate Mexican banks, Brockett et al. (1997) study American banks, Schaffnit, Rosen and Paradi (1997) analyse large Canadian banks, Soteriou and Zenios (1999) research on commercial banks in Cyprus, Kao and Liu (2004) explore Taiwanese commercial banks, Portela and Thanassoulis (2007) study of Portuguese banks while Spanish savings banks are analysed by Tortosa-Ausina, Emili et al. (2007). In addition, DEA has been used as an indicator of successful institutions in a competitive market.

Sathye (2001) uses cross sectional Australian data to analyse the efficiency of banks using DEA and the relationship between efficiency and the ownership of banks. Sathye (2001) finds that domestic banks are more efficient than foreign owned banks in Australia. Avkiran (1999) also studies the operating efficiency of Australian trading banks, using DEA to determine efficiency gains and the extent to which these are passed to the public. The importance of productivity and efficiency in the institutions of developing countries has not received much attention in the empirical literature. However, in India,

Bhattacharyya, et al. (1997) use DEA to study the efficiency of commercial banks. Their results show that publicly owned Indian banks are most efficient, followed by foreign banks. Sathye (1998) also investigates Indian banks' efficiency, using DEA to determine the relationship between ownership and efficiency. In a study by Saha and Ravisankar (2000), Indian banks are rated by the level of achievement in each of the efficiency indicators from DEA analysis. In the Sri Lankan context, Seelanatha (2007) uses DEA to study the productivity and efficiency of commercial banks and reports that deregulation did not make a sustantial contribution to the improvement of efficiency.

The above discussion indicates that there has been an increase in the application of the DEA tool in measuring efficiency in financial services sector organisations. However, most prior research is based on data from developed countries and, in most cases, deal with country specific institutions. In a developing country context, most rural banks and MFIs provide general financial services, particularly in rural areas. However, these institutions differ from other financial institutions as they are structured on cooperative principles. Mostly, the owners are depositors and are also borrowers. Moreover, these institutions' not-for-profit motives suggest the use of DEA as the most appropriate tool for efficiency analysis. However, a search of the literature does not indicate many efficiency studies that use the TFP measure. Many studies use PFP measures to analyse efficiency in cooperative model SFIs. For example, Tucker (2001) studies Latin American MFIs, and Tucker and Miles (2004) study African, Asian, European and Latin American MFIs using PFP measurements to analyse performance. Hesse and Cihak (2007) study the financial stability of cooperative banks in Europe banks using partial measures. However, most recent efficiency studies in SFIs go beyond the PFP measurements to TFP measurements. Desrochersa and Lamberteb (2002) study cooperative banks in the Philippine's, Sharma and Kawadia (2006) study cooperative banks in India, Sufian (2006) investigates non-bank financial institutions in Malayasia and Gutiérrez-Nietoa, Serrano-Cincaa and Molinerob (2007) analyse Latin American MFIs. The advantage of using DEA to analyse efficiency in these types of institutions is that DEA performs a multiple comparison between a set of homogeneous units within the industry, which simple ratios do not explore. Further, cooperative model institutions have unique business features, thus analysis of efficiency by comparing the same types of institutions becomes more important (Sharma and Kawadia 2006).

**Application of Input-Output**

A variety inputs and outputs are used to estimate the efficiency of financial institutions by the studies discussed in previous sections. In many industries, physical measures of inputs and outputs are readily available. In contrast, physical measures are not readily available in financial institutions (Humphrey 1991) and there is disagreement on the definition and measurement of inputs and outputs related to financial services; a problem still to be resolved in the literature. Hence, selection of input-output combinations in efficiency analysis of financial institutions has become crucial.

Berger and Humphrey (1997) provide a detailed discussion of problems involved in the selection of inputs and outputs to be used for evaluating the efficiency of financial institutions. They suggested two main approaches, namely the production and intermediation approaches that can be used to identify appropriate inputs and outputs in efficiency analysis. Furthermore, they suggest that the asset approach, the user-cost approach and the value-added approach are also important in the measurement of efficiency. Similarly, Favero and Papi (1995) emphasise that the intermediation approach, the production approach, and the asset approach produce better input-output combinations than the other approaches in efficiency analysis. The intermediation approach, the production approach, and the asset approach have dominated the selection of inputs and outputs in the measurement of efficiency in the banking literature (Berger and Humphrey 1997).

The intermediation approach is appropriate for institutions where deposits are converted into loans. Funds are intermediated between savers and barrowers (Avkiran 1999). Yue (1992) also emphasises that the intermediation approach views banks as intermediaries whose core business is to borrow funds from depositors and lend for profit. Thus, deposits and loans are considered as outputs with loanable funds, interest expense and labour cost as inputs. This approach is used frequently in the literature for measuring efficiency in the banking industry (Sathye 1998; Avkiran 1999; Drake and Hall 2003; Kao and Liu 2004). With the frontier analysis of efficiency, the intermediation approach is more suitable for the minimisation of all costs to enable the maximisation of profits. In addition, this approach is important to banking institutions because the interest expense is used as a key input as it often comprises two-thirds of the total costs of financial institutions (Berger and Humphrey 1997).

The production approach views deposit taking institutions as producers of services for account holders. This approach assumes that these services are produced by utilizing capital and labour inputs (Berger and Humphrey 1997). Further, the production approach considers that financial institutions provide transactions on deposit accounts and also provide loans and advances. Thus, the number of accounts in

different loans and deposit categories are generally taken to be the appropriate measures of outputs under this approach (Drake and Weyman-Jones 1992). Berger and Humphrey also stress this argument and suggest that the best measure of output is number and type of transactions for the period. However, this approach is inconvenient because all such data are not readily available. Hence, the production approach is more suitable for the evaluation of the relative efficiency of single branches within the institution. Further, the production approach places less emphasis on the transfer of funds as the bank's main role as a financial intermediary. In contrast, the intermediation approach evaluates the entire institution (Berger and Humphrey 1997).

The assets approach, the value-added approach and the user-cost approach provide guidelines on how to identify variables in different ways. According to Favero and Papi (1995) in the assets approach, outputs are strictly defined by assets and mainly by the production of loans in which firms have advantages over other institutions in the industry. Under the asset approach, loans and other assets are considered as outputs, while deposits, other liabilities, labour and physical capital are considered as inputs (Drake and Weyman-Jones 1992).

## CONCLUDING REMARKS

This paper provides an overview of the approaches to productivity and efficiency measurement, particularly in financial institutions. The theoretical and empirical literature on productivity and efficiency is reviewed, with special reference to studies based on the DEA technique. Discussion in this paper provides the necessary background for the identification of the appropriate DEA model for assessing productivity and efficiency of financial institutions.

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