

# PRODUCTIVITY AND EFFICIENCY MEASUREMENT MODELS: IDENTIFYING THE EFFICACY OF TECHNIQUES FOR FINANCIAL INSTITUTIONS IN DEVELOPING COUNTRIES

*Ariyaratna Jayamaha*

*jayamaha@kln.ac.lk*

*Department of Accountancy, University of Kelaniya, Sri Lanka*

*Joseph M. Mula*

*mula@usq.edu.au*

*School of Accounting, Economics and Finance, USQ, Australia*

## **Abstract**

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 any country, the growth of productivity and efficiency affects national income and inflation. In recent years, small financial institutions (SFIs) have become the most favoured option for poverty alleviation in developing countries. The efficiency of these institutions is highlighted in all aspect of stakeholders' of these institutions recently, due to the collapse of several financial institutions. Many different approaches have been applied by many researchers to the measurement of productivity and efficiency changes in various types of institutions but there is no consensus of opinion on the best measurement method and many measurement obstacles remain. The aim of this paper is to review the literature dealing with concepts of productivity and efficiency and to review various techniques used in measurement techniques of these constructs directions are given for future research.

*Key words: Productivity, Efficiency; Small financial institutions; Data envelopment analysis.*

## **1. Introduction**

Concepts of productivity and efficiency have received a great deal of attention in many countries, organisations and by individuals in recent years. In any country, growth of productivity and efficiency affects national income and inflation, thereby affects quality of life of individuals. In an organisational context, productivity and efficiency reflect overall performance. This could lead to increases or decreases in shareholders' wealth. Hence, governments, economists and professionals are concerned with defining and measuring concepts of productivity and efficiency. The efficiency of small financial institutions is highlighted in all aspect of stakeholders' of these institutions recently, due to the collapse of several financial institutions.

## **2. 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 resources employed. In this context, productivity of a firm can be defined as a ratio (Coelli, Rao et al. 1998) as shown in equation 1.

$$PRODUCTIVITY = \frac{OUTPUT(S)}{INPUT(S)} \quad \text{Equation.1}$$

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 productivity of a 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 has been shown to raise productivity (Rogers 1998). Consequently, if 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).

### 3. *Types of efficiency*

Efficiency consists of two main components; technical<sup>1</sup> efficiency and allocative<sup>2</sup> 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 production technology (Coelli, Rao et al. 1998; Rogers 1998). When a firm fails to choose an optimal combination of inputs at a given level of 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.

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 ( $x$ ). Points A, B and C define the relationship between input and 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).

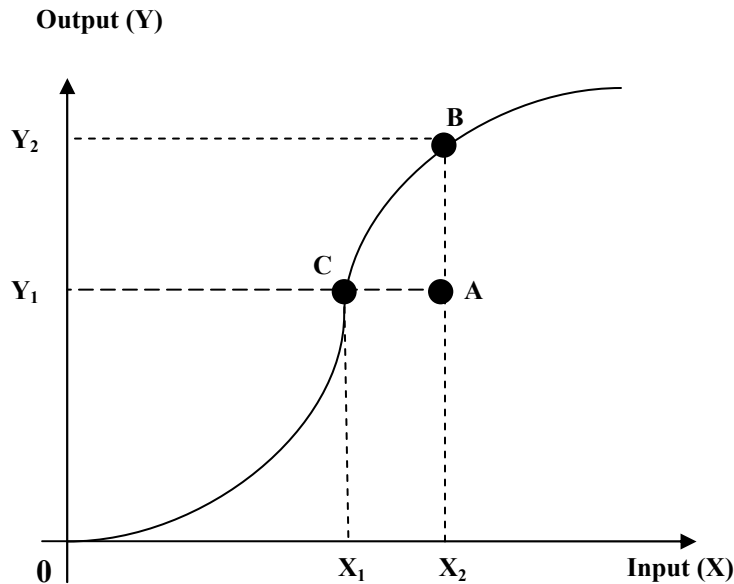
Firms that produce outputs on the production frontier are operating at maximum possible productivity and are recognised as technically efficient. Firms producing below the frontier line are considered to be technically inefficient (Coelli, Rao et al. 1998). Thus, firms which operate at points B and C 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).

Q

---

<sup>1</sup> Also called x efficiency

<sup>2</sup> Also called price efficiency

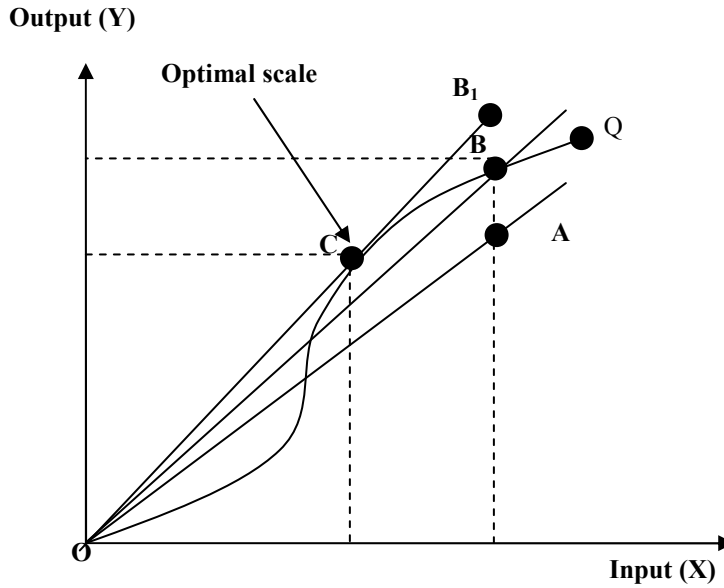


Source: Coelli, Rao and Battese (1998, p.4)

**Figure 1: Production frontier and technical efficiency**

As discussed earlier, all points on the production frontier are efficient points. The point of maximum possible productivity on the production frontier is considered as the technically optimal scale point (Coelli, Rao et al. 1998). Operations at this point result in the maximum level of productivity whereas any other points on the production frontier show lower productivity, though all points represented are technically efficient (Coelli, Rao et al. 1998). Thus, technically efficient firms may still need to achieve the optimal scale of productivity. Figure 2 illustrates productivity, technical efficiency and optimal scale of productivity.

As shown in Figure 2, OQ is the production frontier as defined earlier to measure technical efficiency. If the firm operating at point A was to move to efficient point B, which is a technically efficient point, there would be higher productivity. However, if the firm could reach point C, which is at a tangent to the production frontier, it would be at maximum possible productivity; C indicates the point of optimal scale of productivity. All other points, except point C, on the production frontier represent lower productivity. Thus, all firms on the production frontier are technically efficient but may not achieve the optimal scale of productivity (Coelli, Rao et al. 1998). Point B is technically efficient but not efficient in scale. The firm at point B can move to point B<sub>1</sub> without increasing inputs. This process is referred to as return to scale (RTS) and the difference between point B and B<sub>1</sub> is referred to as scale efficiency (Coelli, Rao et al. 1998).



Source: Coelli, Rao and Battese (1998, p.5)

**Figure 2: Technical efficiency and optimal scale of productivity**

In the short run, a firm achieves technical efficiency by operating on the production frontier and, in the long run, may improve its productivity by exploiting the scale of operations. Thus, productivity growth may be attributed to improvements in technical efficiency, to technological improvements and to exploitation of scale of operation, or a combination of all three causes (Coelli, Rao et al. 1998). The above discussion focuses on technical efficiency without considering costs of inputs. However, if the minimisation of costs is to be considered in efficiency and is to be achieved, costs of inputs must be taken into account. Although the basic concepts of productivity and efficiency are clearly discernable measures that have been discussed previously are diverse. Selection of appropriate measurement depends on the purpose of the study.

#### **4. 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 a case of many outputs and many inputs in a production process, measurement of an output-input ratio is difficult (Diewert 1992). Hence, many different approaches have been applied by many researchers to measurement of productivity and efficiency changes in various types of institutions, and levels of decision-making units (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 results (Bozec, Dia et al. 2006).

## 5. *Partial factor productivity and total factor productivity*

Figure 3 summarises the various approaches to 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 a change in output owing to a change in quantity of one input, whereas total factor productivity (TFP) refers to a change in output owing to changes in a quantity of more than one input (Coelli, Rao et al. 1998; Rogers 1998).

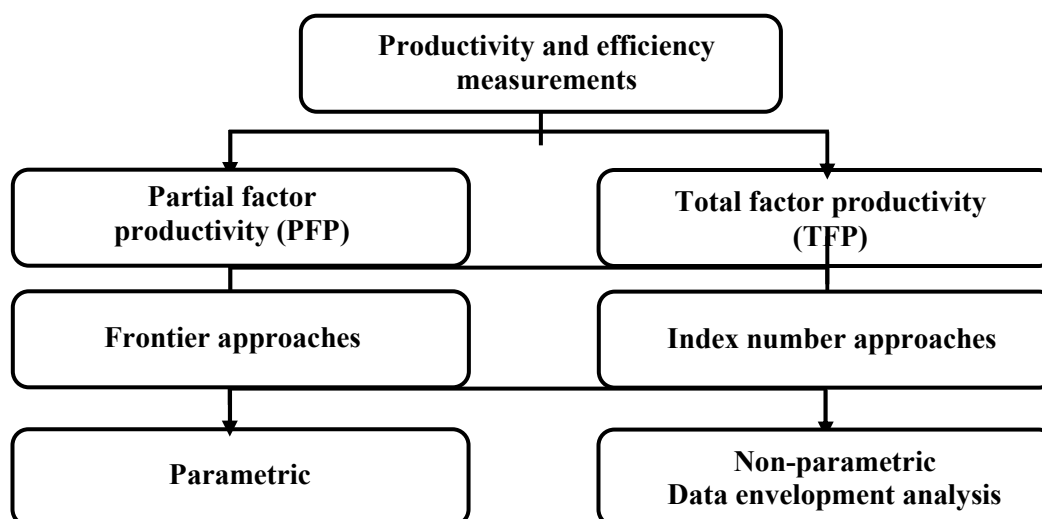


Figure 3: Approaches to measurement of productivity and efficiency

Accordingly, measurement of partial factor productivity considers only one factor and ignores impacts 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 a 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 objectives of producers, or constraints facing them, are either unknown or unconventional.

## 6. *The index number approach*

In determining productivity and efficiency of all factors, TFP can be measured in two ways, namely, the index number approach and the frontier approach (Coelli, Rao et al. 1998; Rogers 1998). The index number approach obtains a single index by using all inputs and outputs. For example, a single index can show movements in prices of goods over time, when there are many goods. The TFP index produces a measure of input quantity use over output changes over a given period. The Laspeyres, Paasche, Fisher Ideal and Tornqvist indices are commonly used in productivity measurement<sup>3</sup>

<sup>3</sup> Diewert (1992) shows additional index number applications.

(Rogers 1998) . However, Diewert (1992) argues that index number applications are not dependable measures of productivity growth, as they are not based on any statistical theory. Therefore, their reliability cannot be tested using any statistical method. In addition, the problem associated with these index number approaches is specifying functional forms for indices of outputs and inputs (Diewert 1992).

## **7. *The production frontier approach***

The production frontier approach (PFA) is more popular in empirical studies of productivity and efficiency than the index number approach. A 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 a production frontier for estimating productivity and efficiency. Construction of a production frontier assumes that firms operate with full technical efficiency, producing maximum potential output from allocated inputs (Coelli, Rao et al. 1998). Berger and Humphrey (1997) identify several advantages of frontier analysis as a tool for measuring productivity and efficiency. Firstly, frontier analysis selects best performing firms within an industry. Secondly, it allows management to identify objectively areas of best practice within complex service operations. Although there are many possibilities, the frontier approach provides the best way to identify efficiency amongst comparable firms (Berger and Humphrey 1997). However, Farrell (1957) argues that, in the frontier approach, an efficient production function has to be recognized before discussing the significance of efficiency measures. He suggests two approaches to construction of a production frontier: the econometric (parametric) approach and linear programming (non-parametric) approach. The following section briefly discusses these two approaches.

## **8. *Parametric and nonparametric approaches***

The parametric approach to construction of a production frontier and measurement of productivity and efficiency differs from the non-parametric approach. The two approaches use different techniques to envelop data, more or less compactly, in different ways. Farrell (1957) notes that the parametric approach is a functional form that is specific and restrictive. Hence, parametric models can be categorised according to the type of data, such as cross section or panel, and the type of variables used, such as quantities or prices (Farrell 1957). The most widely used models in the parametric approach are the single-equation cross sectional model, the multiple-equation cross sectional model and the panel data model. However, Favero and Papi (1995) argue that parametric approaches:

- use a specific functional form - the shape of a production frontier is pre-supposed;
- need to make a specific assumptions;
- make it impossible to implement diagnostic checking; and
- are difficult to implement in multiple input and multiple output settings.

Non-parametric approaches are often used in place of parameterized counterparts when certain assumptions about the distribution of underlying population are questionable. In contrast, the parametric approach assumes that the population will fit any parameterized distribution. However, non-parametric approaches do not estimate population parameters and make no assumption about the frequency distribution of variables being assessed (Fried, Lovell et al. 1993). DEA develops a range of models in non-parametric approaches used for measuring productivity and efficiency. DEA produces benchmark indices for evaluating the relative productive efficiency of a firm in a given industry, or of sub-units in a firm (Cooper, Seiford et al. 1999). However, Berger and Mester (1997) highlight weaknesses of this method of analysis. DEA does not allow for random error, ignores price information and only focuses on technical efficiency rather than allocative efficiency (Berger and Mester 1997).

Although the above discussion focuses on measurement of productivity and efficiency, there is no consensus of opinion on the best measurement method and many measurement obstacles remain. Neither approach strictly dominates the other (Rogers 1998). However, this discussion points to the obstacles and the way in which possible solutions could be developed.

## **9. Data envelopment analysis**

The DEA model for constructing a production frontier, and for measurement of productivity and efficiency relative to a 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 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 efficiency of public sector organisations, non-profit making organisations and private sector organisations. Productivity indices for each firm are determined on the basis of 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 an unit within an organisation (Coelli, Rao et al. 1998). The evaluation unit is also referred to as a DMU. For example, one bank branch of a parent bank or a section, such as loan section, in a bank branch can be considered as a DMU.

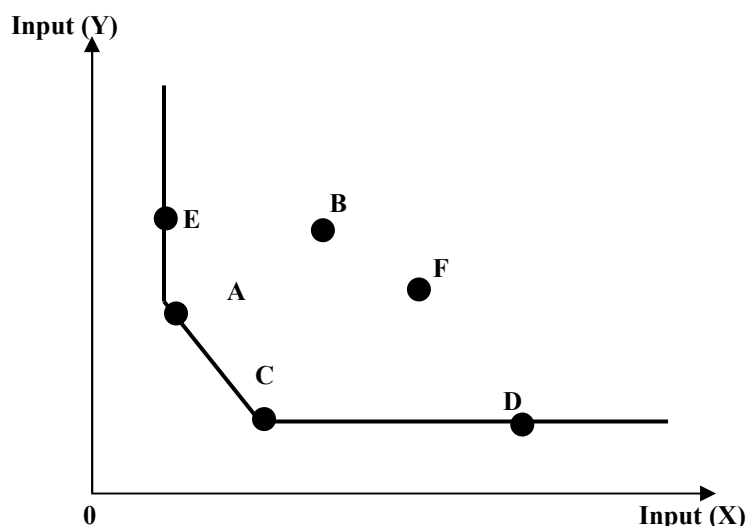
In a production process, each DMU has a varying level of inputs and a varying level of outputs. DEA constructs a smooth curve based on available data. A distribution of sample points is observed and a line is constructed enveloping them (Fried, Lovell et al. 1993), hence the term “Data Envelopment Analysis (DEA)”. From this line, DEA shows which producers are more efficient and identifies inefficiencies of other producers. Hence, Fried, Lovell and Schmidt (2002) suggest that DEA<sup>4</sup> is an appropriate method of measuring 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).

---

<sup>4</sup>DEA is a linear programming methodology developed by Charnes, Cooper and Rhods in 1978. It was originally applied to public sector and non-profit making organisations.



In parametric analysis, a single optimised regression is assumed to apply to each DMU and requires imposition of a specific functional form relating the independent variables to dependent variables (Fried, Lovell et al. 1993). In contrast, DEA optimises a performance measure of each DMU and does not require any assumption about its 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 4. It presents a sample of six firms in an industry that use two inputs (X and Y) to produce one output.



Source: Coelli, Rao and Battese (1998, p.143)

**Figure 4: An efficient frontier in data envelopment analysis**

Based on each firm's usage of inputs, data are plotted in Figure 4. 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 firms closest to the origin. Thus, a line can be drawn from firms E, A, C to firm D. This frontier line envelops all data points and approximates the efficient frontier line (Coelli, Rao et al. 1998).

The efficiency frontier defines the best combination of inputs that can be used to produce an output. Firms on the frontier line are assumed to be operating at best practices in the sample. Firms which are on the upper side of the frontier (B and F) are considered to be less efficient compared with the performance of 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 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). Coelli, Rao and Battese (1998 p.180) highlight the following limitations in DEA measurements:

- *measurement error and other noise may influence the shape and position of the frontier;*
- *the selection of inputs and outputs;*
- *the measurement of the inputs and outputs; and*
- *the selection of a sample.*

It is, therefore, imperative in modelling productivity and efficiency to use the correct methodology so that results may be interpreted appropriately (Rogers 1998).

## **10. Data envelopment analysis models**

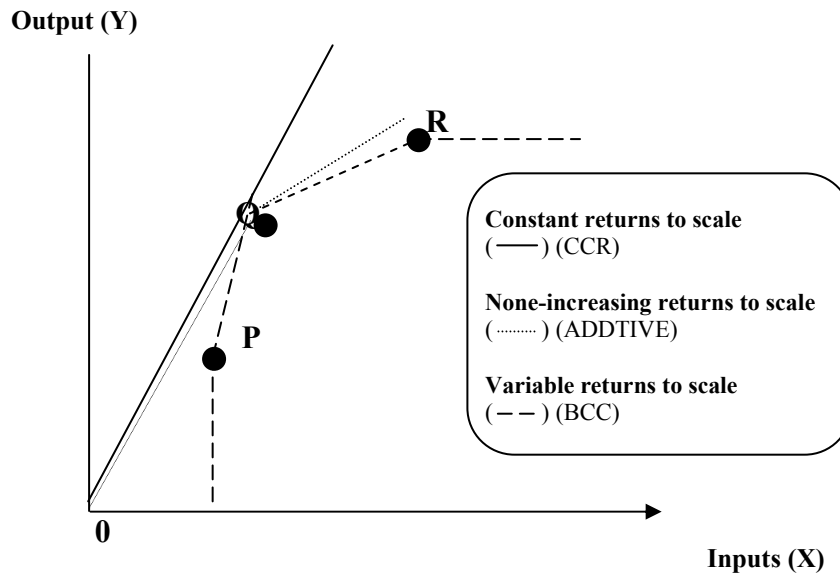
Various models in DEA encompass a number of alternative approaches to efficiency analysis. The selection of an appropriate model facilitates the evaluation of productivity and efficiency of firms (Fried, Lovell et al. 1993). The DEA model discussed earlier is also known as the CCR model. This model was introduced by Charnes, Cooper and Rhodes (CCR) in 1978. Comprehensive reviews of the methodology of the CCR model are presented by Ali and Seiford (1993) in Fried, Lovell and Schmidt (1993). The CCR model uses an optimisation method of mathematical linear programming to generalise the single output/input technical measures to the multiple output/input cases (Fried, Lovell et al. 1993). This model operates under the assumption of constant returns to scale (CRS). The CCR model determines efficiency by maximising the weighted outputs to inputs based on the condition that there is a similar ratio for all DMUs and all firms are operating at an optimal scale. Hence, if the activity is feasible, every positive scalar is also feasible. Any increase in output always involves increasing inputs in the same proportion (Coelli, Rao et al. 1998).

The assumptions of the CCR model have been extended and different types of production possibilities have been incorporated by a number of researchers to overcome problems and weaknesses of the initial CCR specifications. The BCC model, proposed by Banker, Charnes and Cooper (1984), is one extension of the CCR model. The BCC model assumes variable returns to scale (VRS) for identifying the envelopment surface. Cooper, Seiford and Tone (1999) consider that a production frontier leads to variable returns to scale characteristics with:

- increasing returns-to-scale occurring in the first solid line segment;
- decreasing returns-to-scale in the second solid line segment; and

- constant returns-to-scale occurring at the point of transition from the first to the second segment.

The BCC model is appropriate when all firms are not operating at optimal scale. Hence, production frontiers span the convex hull of the existing DMUs with variable returns to scale. The additive model has been formulated with the combination of the CCR model and BCC model specifications. The additive model has the same production possibility set as the BCC model and its variants but treats the slack directly in the objective function. Figure 5 graphically illustrates the shape of envelopment surfaces for a single input-output case under CCR, BCC and additive models. Points P, Q and R represent the performance of DMUs. The straight line from P to Q is the production frontier of the CCR model, assuming that all firms are at optimal scale. The convex dashed line represents the BCC model and the dotted line represents the additive model. The BCC model allows benchmarking of the inefficient DMUs with similar sized DMUs (Cooper, Seiford et al. 1999).



Source: Fried, Lovell and Schmidt (1993, p.29)

**Figure 5: Returns to scale in data envelopment analysis**

The CCR model (CRS specification) assumes that all firms are operating at the optimal scale. However, when all firms are not operating at the optimal scale, results of technical efficiency (TE) in CRS specification combine with scale efficiency (SE). The BCC model (VRS specification) does not assume that all firms are at optimal scale and efficiency scores are completely devoid of scale effects. Hence, TE calculated with BCC (VRS specification) is called 'pure-technical efficiency' (PTE). The difference between the TE (from CRS) and PTE (from VRS) indicates the scale efficiency (SE) (Coelli, Rao et al. 1998).

## **11. 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, 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 an 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) investigated Mexican banks, Brockett et al. (1997) study of American banks, Schaffnit, Rosen and Paradi (1997) analysed large Canadian banks, Soteriou and Zenios (1999) research on commercial banks in Cyprus, Kao and Liu (2004) explored Taiwanese commercial banks, Portela and Thanassoulis (2007) study of Portuguese banks, while Spanish savings banks were 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) used 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 studied 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) used 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 investigated Indian banks' efficiencies, 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) used DEA to study the productivity and efficiency of commercial banks and reports that deregulation did not make a substantial 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 micro finance institutions (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, 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) studied Latin American MFIs, and Tucker and Miles (2004) studied African, Asian, European and Latin American MFIs using PFP measurements to analyse performance. Hesse and Cihak (2007) studied 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. Desrochers and Lambert (2002) studied cooperative banks in the Philippines, Sharma and Kawadia (2006) study of cooperative banks in India, Sufian (2006) investigated non-bank financial institutions in Malaysia and Gutiérrez-Nieto, Serrano-Cinca and Moliner (2007) analysed 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).

The above discussion shows the importance of DEA in efficiency studies of financial institutions. However, research on methodological issues associated with DEA is important for theoretical soundness and for accurate analysis in research. As discussed previously, estimated efficiency entirely depends on inputs and outputs included in a model. Input-output specifications, selection of the number of inputs and outputs, and measurement of inputs and outputs are problems still to be resolved in DEA studies of financial institutions. The next section addresses these issues.

## **12. Application of input-output**

A variety of 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. Moreover, the selection of inappropriate inputs and outputs can lead to biased results in performance measurements (Ruggiero 2005). Often financial institutions have multiple activities and it is difficult to capture all activities of an institution. Different approaches for the selection of appropriate inputs and outputs based on services provided by financial institutions can be identified in the literature.

Berger and Humphrey (1997) provide a detailed discussion of problems involved in selection of inputs and outputs to be used for evaluating the efficiency of financial institutions. They suggested two main approaches, namely 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 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 borrowers (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 minimisation of all costs to enable maximisation of profits. In addition, this approach is important to banking institutions because interest expense is used as a key input as it often comprises two-thirds of 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 a 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 relative efficiency of single branches within institution. Further, the production approach places less emphasis on transfers of funds as a bank's main role as a financial intermediary. In contrast, the intermediation approach evaluates an 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 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). The value-added approach defines outputs as assets and liabilities, which add substantial value to a firm, while the labour and value of

fixed assets are inputs. Moreover, Tortosa-Ausina (2002) reports a significant difference between the assets approach and the value-added approach in measuring bank efficiency. The user-cost method requires additional information on interest and other income, and it is difficult to implement in some cases. In addition the value-added and the user-cost approaches give roughly similar results, but these results are not consistent (Berger and Humphrey 1997).

Even though the appropriateness of each approach varies according to circumstances, there is agreement over the definition of most of the inputs and outputs of financial institutions. However, there is controversy about the treatment of deposits. Some researchers treat deposits as inputs because a financial institution pays for deposits and so interest are considered as the main expense of financial institutions (Brockett, Chames et al. 1997; Drake and Hall 2003; Kao and Liu 2004). However, other researchers treat deposits as outputs because they may be associated with the liquidity of an institution (Bhattacharyya, Lovell et al. 1997; Saha and Ravisankar 2000; Sathye 2001). These researchers argue that treating deposits as inputs makes financial institutions look artificially efficient. A summary of input and output variables identified from previous studies is presented in Appendix 2.

### **13. Conclusion**

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 small financial institutions.

This study reviews the literature relate to efficiency studies on total factors. Thus, there are future research opportunities for assessing efficiency in different types of SFIs in developing countries, which may lead to a better understanding of the efficiency of the entire rural financial sector.

## Appendices

### Appendix 1: Different models in data envelopment analysis

Model	Features
CCR model (1978) (Charnes, Cooper et al. 1978)	Assumes that the production frontier has constant returns to scale. Yields an objective evaluation of overall efficiency and identifies sources and estimates amounts of inefficiencies. Further, assumes that all firms are operating at the optimal scale and scores represent TE.
BCC model (1984) (Banker, Charnes et al. 1984)	Assumes that the production frontier has variable returns to scale. Production possibilities are set by means of existing DMUs and their convex hull. Scores represents PTE and avoid the scale effect.
Additive model ( 1985 ) (Charnes, Cooper et al. 1985)	Deals with input excesses and output shortfalls simultaneously.

### Appendix 2: Input and output variables in data envelopment analysis applications

Authors	Inputs	Outputs
Aly et al (1989)	Labour Capital Loanable funds	Real estate loans Commercial and industrial loans Consumer loans Other loans Demand deposits
Athanassopoulos and Giokas (2000)	Labour hours Branch size Computer terminals Operating expenditure	Credit transactions Deposit transactions Foreign receipts
Avkiran (1999)	Interest expense Non-interest expense Deposits Staff numbers	Net interest income Non-interest income/Other income Net loans
Bhattacharyya, Lovell and Sahay (1997)	Interest expense Operating expenses	Advances Investments Deposits
Brockett et al. (1997)	Interest expense Non-interest expense Deposits Provision for loan losses	Net interest income Non-interest income/Other income Total loans Allowance for loan losses
Charnes et al. (1990)	Operating expenses Non-interest expense Provision for loan losses Actual loan losses	Total income Total interest income Total non- interest income Total net loans
Das and Ghosh (2006)	Deposits Capital rated operating expenses Labour Interest expenses	Advances Investments Deposits Interest income non-interest income
Desrochersa and Lamberteb (2003)	Deposits Capital Wages	Loans Investments



Drake and Hall (2003)	Deposits General administration expenses Fixed assets Problem loans	Non-interest income/Other income Loans and advances Liquid assets and other investments
Drake and Weyman-Jones (1992)	Labour Capital Retail funds and deposits Wholesale funds and deposits Number of branches	Loans Commercial assets Liquid assets
Elyasiani and Mehdiian (1990)	Deposits Labour Capital	Loans Investment
Favero and Papi (1995)	Labour Capital Loanable funds	Loans to other banks and non-financial institutions Investment in securities and bonds Non-interest income
Gutiérrez-Nieto, Serrano-Cinca and Molinerob (2007)	Credit officers Operating expenses	Interest and fee income Gross loan portfolio Number of loans outstanding
Havrylchyk (2006)	Capital Labour Deposits	Loans Government bonds Off-balance sheet items
Jayamaha (2010)	Total expenses Deposits Other funds Number of employees	Loans Pawning Investments Interest income Other income
Kao and Liu (2004)	Interest expense Non-interest expense Deposits	Interest income Non-interest income Total loans
Miller and Noulas (1997)	Interest expenses Non-interest expenses Deposits	Total non-interest income Loans Investments
Neal (2004)	Loanable funds Bank branches	Non-interest income/other income Demand deposits Loans and advances
Park and Weber (2005)	Total deposits Capital/total assets	Commercial Loans Personal loans Securities
Saha and Ravisankar (2000)	Interest expense General administration expenses Fixed assets Non establishment expenses	Net interest income Non-interest income/other income Loans and advances Demand deposits Liquid assets and other investments

Sathye (2001)	Labour Capital Loanable funds	Demand deposits Loans and advances
Seelanatha (2007)	Interest expenses Personnel cost Establishment expenses Deposits Other loanable funds Number of employees	Loans and other advances Interest Income Other income Other earning assets
Sharma and Kawadia (2006)	Owners fund Operating expenses Physical assets	Deposits Advances Interest spread Net profit
Sufian (2006)	Total deposit Fixed assets	Non-interest income Total loans
Taylor et al. (1997)	Non-interest expense Total deposits	Total Income
Yue (1992)	Interest expense Non-interest expense Deposits	Interest income Non-interest income Total loans

## References

- Ali, A. I. and L. M. Seiford (1993). The mathematical programming approach to efficiency analysis New York, Oxford University press.
- Aly, H., R. Grabowski, et al. (1989). "Technical, scale and allocative efficiencies in U.S banking: an empirical investigation." The Review of Economics and Statistics **72**(2, May): 211-218.
- Arun, T. G. and J. D. Turner (2002). Corporate governance of banks in developing economies: concepts and Issues. Paper presented in the conference on 'finance and development' IDPM, The University of Manchester, viewed 10th October 2007,.
- Athanassopoulos, A. D. and D. Giokas (2000). "The use of data envelopment analysis in banking institutions: evidence from the commercial bank of Greece." Interfaces **30**(2): 81-95.
- Avkiran, N. K. (1999). "The evidence on efficiency gains: The role of mergers and the benefits to the public." Journal of Banking and Finance **23**(7): 991-1013.
- Banker, R. D., A. Charnes, et al. (1984). "Some models for estimating technical and scale inefficiencies in data envelopment analysis." Management Science **30**(9): 1078-1092.
- Berger, A. N. and D. B. Humphrey (1997). "Efficiency of financial institutions; international survey and directions for future research." European Journal of Operational Research **98**(2): 175 - 212.
- Berger, M. N. and h. J. Mester (1997). "What explains differences in the efficiencies of financial institutions?" Jourml of Banking and Finance **21**( Issue 7 ): 895-947.
- Bhattacharyya, A., C. A. K. Lovell, et al. (1997). "The impact of liberalization on the productive efficiency of Indian commercial banks." European Journal of Operational Research **98**(2): 250-268.
- Bozec, R., M. Dia, et al. (2006). "Ownership-efficiency relationship and the mesurement selection bias." Accounting and Finance **46**: 733-754.
- Brockett, P. L., A. Charnes, et al. (1997). "Data transformations in DEA cone ratio envelopment approaches for monitoring bank performances." European Journal of Operational Research **98**(2): 250-268.
- Brown, R. (2001). Data Envelopment Analysis: application issues in the financial services sector. Department of Finance, University of Melbourne, research paper series-01-05
- Charnes, A., W. W. Cooper, et al. (1985). "Foundation of data envelopment analysis for Pareto-Koopmans efficient empirical production functions." Journal of EconometricS(30): 91-107.
- Charnes, A., W. W. Cooper, et al. (1997). Data envelopment analysis: theory, methodology and application. London, Kluwer Academic Publishers.
- Charnes, A., W. W. Cooper, et al. (1978). "Measuring the efficiency in decision making units." European Journal of Operational Research **2**(6): 429-444.
- Charnes, A., W. W. Cooper, et al. (1990). "Polyhedral cone-ratio models with an application to large commercial banks." Journal of Econometrics **46**: 73-91.
- Coelli, T., D. Rao, et al. (1998). An Introduction to efficiency and productivity Analysis. London, Kulvwer Academic Publishers group.
- Cooper, W. W., L. M. Seiford, et al. (1999). Data Envelopment Analysis, a comprehensive text with models. Boston/Dordrecht/London, Kluwer academic publishers.

- Das, A. and S. Ghosh (2006). "Financial deregulation and efficiency: An empirical analysis of Indian banks during the post reform period." Review of Financial Economics **15**(3): 193-221.
- Desrochersa, M. and M. Lamberte (2002). "Efficiency and expense preference in Philippines' cooperative rural banks." Discussion paper 2002-12, Philippine Institute of Development Studies, Philippine.
- Desrochersa, M. and M. Lamberte (2003). "Efficiency and expense preference in Philippines' cooperative rural banks." CIRPEE working paper no. 03 -21.
- Diewert, W. E. (1992). "The measurement of productivity." bulletin of Economic Research **44**(3): 163-199.
- Drake, L. and M. J. B. Hall (2003). "Efficiency in Japanese banking: An empirical analysis " Journal of Banking and Finance **27**(05): 891-917.
- Drake, L. and T. G. Weyman-Jones (1992). "Technical and scale efficiency in UK building societies." Applied Financial Economics **2**(1): 1-9.
- Elyasiani, E. and S. Mehdi (1990). "Efficiency in the commercial banking industry, a production frontier approach." Applied Economics **22**(4): 539-551.
- Farrell, M. J. (1957). "The measurement of productive efficiency." Journal of the Royal Statistical Society. series A (General) **120**(3): 253-290.
- Favero, C. A. and L. Papi (1995). "Technical efficiency and scale efficiency in the Italian banking sector: a non-parametric approach." Applied Economics **27**(6): 385-395.
- Fried, H., C. Lovell, et al. (1993). The measurement of productive efficiency, Techniques and applications. London, Oxford University Press.
- Fried, H., C. Lovell, et al. (2002). "Accounting for environmental effects and statistical noise in data envelopment analysis." Journal of Productivity Analysis **17**(2): 157-174.
- Gutiérrez-Nieto, B., C. Serrano-Cinca, et al. (2007). "Microfinance institutions and efficiency." International Journal of Management Science **2007**(35): 131-142.
- Havrylchyk, O. (2006). "Efficiency of the Polish banking industry: foreign versus domestic banks." Journal of Banking and Finance **30**: 1975-1996.
- Hesse, H. and M. Cihak (2007). Cooperative banks and financial stability. IMF working paper. Washington, D.C.
- Humphrey, D. B. (1991). "Productivity in banking and effects from deregulation " Economic Review; Federal Bank of Richmond **March/April 1991**: 16-28.
- Jayamaha, A. (2010). A comparative analysis of accounting and financial practices associated with efficiency of cooperative rural banks in Sri Lanka,. University of Southern Queensland, Australia, unpublished thesis for PhD.
- Kao, C. and S.-T. Liu (2004). "Predicting bank performance with financial forecasts: A case of Taiwan commercial banks." Journal of Banking and Finance **28**(10): 2353-2368.
- Miller, S., M and A. Noulas, G (1997). "Portfolio mix and large-bank profitability in the USA." Applied Economics **29**(4): 505-512.
- Neal, P. (2004). "X-efficiency and productivity change in Australian banking." Australian Economic Papers **43**(2): 174-192.
- Park, K. H. and W. L. Weber (2005). "A note on efficiency and productivity growth in the Korean banking industry, 1992-2002." Journal of Banking & Finance **30**: 2371-2386.

- Portela, M. C., A. Silva and E. Thanassoulis (2007). "Comparative efficiency analysis of Portuguese bank branches." European Journal of Operational Research **177**.
- Pritchard, R. D. (1990). Measuring and improving organisational productivity. New York, Westport, Connecticut.
- Rogers, M. (1998). The definition and measurement of productivity. The university of Melbourne, Australia, Melbourne institute of applied economics and social research. **working paper 9/98**.
- Ruggiero, J. (2005). "Impact assessment of input omission on DEA." International Journal of Information Technology & Decision Making **4**(3): 359-368.
- Saha, A. and T. S. Ravisankar (2000). "Rating of Indian commercial banks: A DEA approach." European Journal of Operational Research **124**: 187-203.
- Sathye, M. (1998). "Efficiency of banks in a developing economy: the case of India." <http://rspas.anu.edu.au/papers/asare/novion2001>, viewed on 09th April 2007.
- Sathye, M. (2001). "X-efficiency in Australian banking: an empirical investigation." Journal of Banking & Finance **25**: 613-630.
- Schaffnit, C., D. Rosen, et al. (1997). "Best practice analysis of bank branches: an application of DEA in a large Canadian bank." European Journal of Operational Research **98**(2): 269-289.
- Seelanatha, S. L. (2007). An analysis of efficiency and productivity changes of the banking industry in Sri Lanka, University of Southern Queensland.
- Sharma, G. and G. Kawadia (2006). "efficiency of Urban cooperative banks of Maharashtra: a DEA analysis." The ICFAI Journal of Bank Management **v**(4): 25-38.
- Soteriou, A. C. and S. A. Zenios (1999). "Using data envelopment analysis for costing bank products." European Journal of Operational Research **114**: 234-248.
- Sufian, F. (2006). "The efficiency of non-bank financial institutions: Empirical evidence from Malaysia." International Research Journal of Finance and Economics(6): 49-65.
- Tavares, G. (2002). "A Bibliography of data envelopment analysis (1978-2001)." Retrieved 12th December, 2007, from [http://rutcor.rutgers.edu/pub/rrr/reports2002/1\\_2002.pdf](http://rutcor.rutgers.edu/pub/rrr/reports2002/1_2002.pdf).
- Taylor, W. M., R. G. Thompson, et al. (1997). "DEA/AR efficiency and profitability of Mexican banks; a total income model." European Journal of Operational Research **98**(2): 346-363
- Tortosa-Ausina, E., E. Grifell-Tatje, et al. (2007). "Sensitivity analysis of efficiency and malmquist productivity indices: an application to Spanish savings banks." European Journal of Operational Research (**forthcoming**).
- Tucker, M. (2001). "Financial performance of selected microfinance institutions; benchmarking progress to sustainability." Journal of Microfinance **3**(2): 107-123.
- Tucker, M. and G. Miles (2004). "Financial performance of microfinance institutions." Journal of Microfinance **6**(1): 41-54.
- Yue, P. (1992). "Data envelopment analysis and commercial bank performance: a primer with applications to Missouri banks." Review, Federal Reserve Bank of St. Louis **74**(2): 31-43.
- Zhu, J. (2003). Quantitative models for performance evaluation and benchmarking. London, Kluwer Academic Publishers.

