Measurement of Inputs and Outputs in the Banking Industry

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Abstract. Over the past decade there has been a considerable growth in studies addressing efficiency and productivity in the banking industry. Despite this development, there is still no clear definition of input and output measurements in the industry, which makes research findings difficult to compare. In this paper, we review various definitions of input and output measure-ments in the banking industry and, conduct an experiment on the sensitivity of efficiency scores based on the choice of variables. The results suggest that efficiency scores are very sensitive to the choice of input and output variables.

Key words: Banks, efficiency, intermediation, parametric, nonparametric, inputs and outputs.

1. Introduction

'' The concept of economic activity as an input-output process is perhaps the most basic concept of economics. Nevertheless it is vague, and curious difficulties emerge when an effort is made to specify the inputs and outputs involved and to define the nature of transformation implied" Boulding (1961).

In recent years, substantial research efforts have been devoted to measuring the efficiency of the banking industry. Much attention has been focused on estimating an efficient frontier and measuring the average differences between banks. The major shortcoming of these studies is their failure to define inputs and outputs in the banking industry. Triplett (1992) pointed out that the assessment of the banking industry has been jeopardised by the unresolved question concerning outputs and inputs. This problematic issue has also been highlighted by Wykoff (1992): "When are deposits outputs, why are they so cheap? When they are inputs, why do people provide them to banks?" This unresolved question has handicapped the research effort when comparing results from different studies. Differences in efficiency estimate are not only blamed on input and output definitions, but also depend on variation in data sources, efficient concepts and the measurement methods used.

Despite the increasing interest in studying the banking industry, there is still no coherent definition of inputs and outputs. Attempts to define these concepts were made earlier by Sealey and Lindley (1977), Colwell and Davis (1992) and later by Berger and Humphrey (1997). The measurement problem is worsened by the lack of a theoretical basis for these definitions. For example in the *production approach*, banks are treated as firms that use capital and labour to produce different categories of deposit and loan accounts. Whereas in the *asset approach*, banks are viewed as intermediators of financial services rather than producers of loan and deposit account services. In this case, the value of loans and investments is used as output measures; labour and capital are inputs to this process. These two approaches are basically the same; the only different is that the latter uses value instead of quantity, which may not vary significantly in assets.

There are different opinions among authors with regard to the definition of deposits. Some authors maintain that they should be regarded as input while others take them to be output. For instance, Berg et al. (1991) argued that deposits should be treated as an output mainly because they represent a resource consuming activity while Berger et al. (1993) argued that deposits should be treated as an input in the models that take account of interest paid on purchased funds. This definitional problem makes it virtually impossible to compare the results from these studies (see Table 1).

This paper seeks to (i) review the literature on banking efficiency and productivity, with special emphasis on the measurement of inputs and outputs. (ii) to conduct an experiment on the sensitivity of results based on the choice of variables. The organisation of the paper is as follows. In section 2, we consider the concept of inputs and outputs. Section 3 contains a survey of estimation techniques used in banking studies. In section 4, we present empirical evidence. Finally, we present a summary and conclusions in section 5.

2. Inputs and outputs: A conceptual discussion

Frisch (1965), defined production as "a process of transformation, directed by human beings, which is considered desirable by some individuals." Transformation implies that certain goods or services (inputs) enter a process where they "lose their identity, i.e. cease to exist in the original form" while other goods or services (outputs) are generated. Frisch's conceptualisation of inputs and outputs is applicable to the manufacturing and agricultural sectors. In the manufacturing sector, inputs and outputs are measured in terms of flow, that is, a certain amount of input is used to produce a certain amount of output per unit time. However, the production process in banking involves the use of deposits and other assets. It is therefore a stock concept, representing a given amount at a particular point in time. The output of bank services, unlike the outputs of manufacturing firms, can be measured in terms of quantity once the goal is clearly defined.

Banks mostly provide customers with low risk assets, credit and payment services, and play an important role as intermediaries in directing funds from savers to borrowers. They also perform non-monetary services such as protection of valuables, accounting services and running of investment portfolios (Colwell and Davis (1992).

Due to the integrated nature of production in the banking industry there is confusion in the definition of output measurement (Fixler and Zieschang 1992; Beger and Humphrey 1992a). This is mainly due to the non-tangible nature of the outputs and the theoretical gap in the banking literature on multi-input multi-output production structure. Various authors have tried to get around this problem by adopting either the production approach[1] or the asset approach. The former, also known as service provision or value added approach, is used for technological efficiency analysis, while the latter, known as the intermediation approach and is used in analysing economic efficiency.

Although many authors adopt one of the above approaches, they still face definitional problems related to the economic theory (Wykoff 1992). Input and output are flow concepts and unfortunately, data on physical quantities such as the number of cheques cashed, or loans issued are generally not available.[2]

2.1. The production or service provision approach[3]

In this approach, banks provide services to customers by administering customers' financial transactions, keeping customer deposits, issuing loans, cashing cheques and managing other financial assets (Berg et al. 1991; Berg et al. 1993; Parson et al. 1993; and Schaffnit et al. 1997). Productivity and efficiency can be analysed by comparing the quantity of services given with the quantity of resources used. This is a flow concept and it follows the standard production approach. Berg et al. (1991) identified five activities performed by a bank: (i) supplying demand, facilitating deposit services (ii) short and long-term loan services (iii) brokerage and other services, (iv) property management and (v) the provision of safe deposit boxes. They pointed out that a bank incurs positive operating costs in terms of (a) labour (b) machines (c) materials and (d) buildings.

2.2. The asset or intermediation approach

In this approach the bank accepts deposits from customers and transforms them into loans to clients. The inputs are labour, materials and deposits, and the outputs are loans and other income generating activities (banking services) (Mester 1997). In the intermediation approach, banks performing two major roles of mobilising and distributing resources efficiently in order to smoothen investment activities in the economy. Colwell and Davis (1992) pointed out that the major disadvantage of this approach is the absence of the trust operation that causes increases in the unit cost of large banks. The asset approach has two major sub-groups: (a) the profit approach and (b) the risk management approach.

2.2.1. The profit approach[4]

The economic efficiency of a bank is mostly analysed using either a profit approach or a cost approach. In the profit approach, the bank manager's purpose is to maximise the bank's profit function. The manager must evaluate all types of costs and the income generated in the production process. This approach measures simultaneously inefficiency in the input and output side. This reduces problems associated with mis-specification and mis-measurement (Berger et al. 1993; Thompson et al. 1997).

2.2.2. The risk-management approach

This approach is used to evaluate risks attached to various forms of assets in a bank. In risk-management, banks take some risks to produce acceptable returns. A bank's performance will affect its valuation in the market, its ability to acquire other banks or to be acquired at a good price, and its ability to be funded in deposits and financial markets (Mester 1996; Heshmati 1997). The risk-management approach translates into inputs and outputs classification by considering management decisions making process and its implementation on one-side as inputs and shareholders value and bank profit as outputs on the other side.

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[1] Production in the banking industry involves the use of intermediate inputs, which take part in the production of final or semi-final outputs. For example the use of deposits funds for the provision of loans or risk taking behaviour of some bankers by channelling deposits and other available funds into the stock markets with the aim of making more money. The wide range of bank activities make it difficult to have a clear definition of inputs and outputs which fits the roles performed by the bank. The problem of intermediate inputs in the production process can be avoided by adopting one of these approaches.

[2] Some author(s) have used the monetary flows taken either from the profit and loss account or stock variables such as the amount of deposits and loans.

[3] Also known as "the value-added approach".

[4] This is known as "the user cost approach" The user cost approach determines whether a financial product is an input or an output based on its net contribution to bank revenue. If the financial return is greater than the opportunity cost of funds, then the items involved are considered as bank outputs, otherwise it is considered as bank input. [see. e,g., Hancook (1985)]. The down side of this approach is that, return depends on the pricing and market conditions for that financial product. This would imply that during an economic downturn, many products would turn into inputs, which lender this to be unstable definition.

3. Estimation techniques for banking studies

Many previous studies dealing with inputs and outputs in banking used two major estimation techniques: (a) non-parametric and (b) parametric approaches. These estimation methods can be grouped into five different categories: (i) data envelopment analysis (DEA), which is a non-parametric, linear programming technique that assumes that there is no random error. It is used to calculate technological efficiency. Efficient firms are those that produce as much or more of every output (given inputs) or use as little or less of every input (given outputs) compared to other firms (Rangan et al. 1988; Elysiani and Mehdian 1990; Berg et al. 1993; Bukh 1994; Schaffnit et al. 1997; Taylor et al. 1997). (ii) Free disposal hull (FDH), is another nonparametric and nonstochastic technique, which can be regarded as a generalisation of data envelopment analysis variable-returns to scale model. This model does not require the estimated frontier to be convex (Tulkens 1993; Tulkens and Malnero 1994). (iii) The econometrics stochastic frontier approach (SFA) is a method that assumes a two part or composed error term. In this approach, inefficiency is assumed to follow an asymmetric distribution, usually half normal, while the random error is assumed to follow a standard symmetric distribution (Ferrier and Lovell 1990; Chaffai 1997; Kumbhakar et al. 1998). (iv) The thick frontier approach (TFA) developed by Berger and Humprey (1991) compares the average efficiencies of groups of firms instead of estimating frontier edge (Bauer et al. 1993; DeYoung 1994; Lang and Welzel 1996; Clark 1996). (v) The distribution free approach (DFA) which employs the average residuals of the cost function estimated with panel data to construct a measure of cost frontier-efficiency. It does not impose a specific shape on the distribution of efficiency but assumes that there is a core efficiency or average efficiency for each firm that is constant over time. Berger 1993; Berger and Humphrey 1992b; DeYoung 1997 give analysis examples on the effects of mergers in banking industry.

Few studies have attempted to compare different estimation techniques. Hjalmarsson et al. (1996) compared DEA, DFA and SFA and found that efficiency estimates varied substantially across models.[5] Resti (1997) found contradictory results and concluded that econometric and linear programming results do not differ dramatically when based on the same data and conceptual framework. Berger and Mester (1997) compared DFA, SFA, and Fourier-Flexible functional form versus the translog form. They found out that the choices made concerning efficiency measurements usually make very little difference in terms of either average industry efficiency or the ranking of individual firms, which suggests that the efficiency estimates are robust to different methodologies (Bauer et al. 1998).

4. Empirical evidence

Most studies carried out among European and North American banks found that inefficiency ranges between 20-30 percent. For a critical review of 130 studies for 21 countries see Berger and Humphrey (1997). Bauer et al. (1998) proposed a set of conditions that would make it possible for efficiency estimates derived from various approaches to correspond with each other. These conditions are: (i) the efficiency scores generated by different approaches should have comparable means, standard deviations, and other distributional properties; (ii) the different approaches should rank the institutions in approximately the same order; (iii) these approaches should in general identify the same institutions as those with “best-practice” and those with “worst practice”; (iv) all the approaches should demonstrate reasonable stability over time, i.e., consistently identify the same institutions as relatively efficient or inefficient in different years, rather than varying markedly from year to year; (v) the efficiency scores generated by the different approaches should be reasonably consistent with competitive conditions in the market and (vi) the measured efficiencies from all the approaches should be reasonably consistent with standard non-frontier performance measures, such as returns on assets or the cost-revenue ratio. However, these are not good measures of efficiency in differentiated markets.

This proposal has two major limitations. First, a nonparametric approach such as DEA does not require price data for technological efficiency analysis and it can be performed using cross section data as well. DFA is limited to panel data that may not be at the disposal of a researcher who has to work with the available data. Second, it is difficult to define inputs and outputs in the banking industry (Table 1). Berg et al (1991) found that efficiency scores highly depend on the choice of inputs and outputs.

In summary, efficiency studies can be divided into those that measure technological efficiency, using nonparametric techniques such as DEA and FDH, and those that measure economic efficiency using parametric approaches such as SFA DFA and TFA. The former are usually based on the production or service provision approach and take deposits to be output based on positive consumption of labour and material. The latter are based on the asset approach and regard deposits as an input for the production of loans and other financial assets.

4.1. The efficiency of Swedish banking in 1996

In this section, we calculate DEA efficiency scores for the Swedish banks using 1996 data. The objective is to investigate the sensitivity of the results with respect to the choice of variables. We compare the outcome of different specifications in variable (VRS) as well as in constant returns to scale (CRS).

4.1.1. The data

The output variables in this data set are defined as: *loans, guarantees* and *deposits*. However, we also add *net provisions* i.e. the difference between commissions and other service charges

[5] They used cement industry data because it approximates the putty-clay industry quite well and thus gives a more stable efficiency structure which facilitate comparisons.

received and the related costs. For the input, we use the *number of branch offices*, *inventories, other costs*, *credit losses*, *labour costs or alternatively hours worked.* The exclusion of net provisions may "punish" especially the commercial banks or the larger banks. On the other hand, banks with large net provisions may also have more high salary staff; therefore we also use labour costs as a quality adjusted labour input variable. See Table 3 for the differences between the models. However, we will also look at labour efficiency, i.e. we calculate the efficiency distribution according to Models 1-4 with only labour input.

4.1.2. Empirical results All inputs

The empirical results are illustrated in Figure 1 – 6. We regard Model 1 as the base model, while Models 2-4 are used for sensitivity analysis. In general, one should expect a large number of fully efficient units (efficiency score = 1) in the case of variable returns to scale, VRS. More than half of the units are on the frontier in Model 1; see Figure 1. In the constant returns to scale, CRS, less than one fourth of the units are on the frontier. Mean efficiency decreases from 0.90 in VRS to 0.79 in CRS. All 17 units, which are on the frontier in VRS but not in CRS, are savings banks.

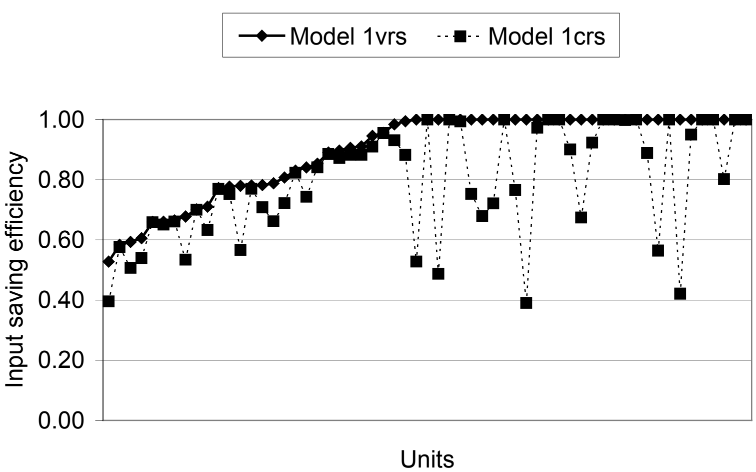

Figure 1. Input saving efficiency for Swedish banks 1996. A comparison between variable and constant returns to scale.

A reduction in the number of variables has also a strong impact on the number of frontier units; see Figure 3, where the number of outputs is decreased from 4 to 3 or Figures 5 and 6 with only labour as input. In the former case, the number of frontier units decreased from 31 to 25.

With regard to the sensitivity, the choice between labour costs and labour hours has only a minor impact on the efficiency distribution; see Figures 2 and 4. Models 1 and 2 almost coincide and so does Models 3 and 4. In VRS, between four and six units (all savings banks) which are on the frontier in Model 1 become inefficient in the other models. In CRS, between four and seven banks become inefficient when moving from Model 1 to the other models; all these are savings banks, with the exception of the Nordbanken which becomes inefficient in Models 2 and 4(efficiency scores 0.94 and 0.88 respectively), i.e. when labour hours are substituted for labour costs. However, there is a substantial difference between Models 1 and 2 on the one hand and Models 3 and 4 on the other, i.e. the results are very sensitive to the inclusion or exclusion of the net provisions output variable.

This is even clearer from Figure 3, which illustrates the difference between Model 1 and Model 3. Mean efficiency decreases from 0.89 in Model 1 to 0.73 in Model 3. All commercial banks (except Östgöta Enskilda Bank) are on the frontier in both models.

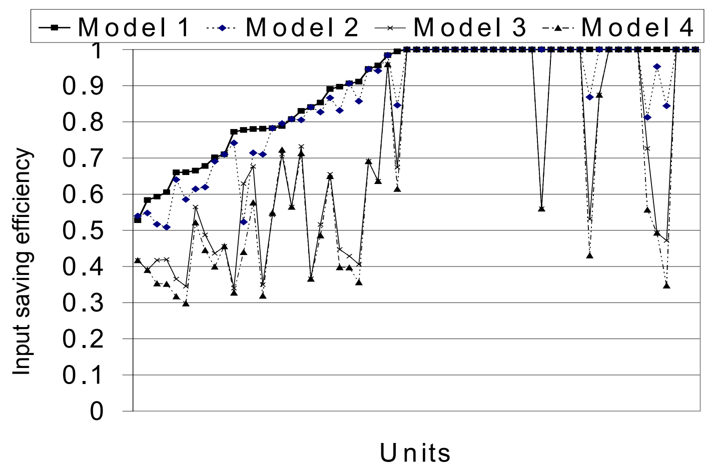

Figure 2. Input saving efficiency for Swedish banks 1996. Variable returns to scale.

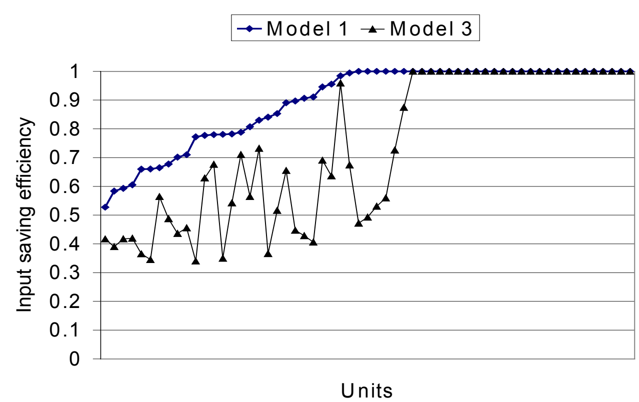

Figure 3. Efficiency distribution with and without net provisions as output variable. Variable returns to scale.

Three units, (Finn, Alingsås and Roslagen savings banks) show a deviation in efficiency scores that exceeds 0.50. Table 4 and 5 compare constant returns to scale (CRS) and variable returns to scale, among the four models. The Spearman rank correlation coefficients for the different models are significantly different from zero and range between (0.46 to 0.98) for CRS models and (0.38 to 0.99) for VRS models. The correlation coefficient reveals a high correlation for model 1 and 2 under both technological assumptions (Tables 4 and 5).

Labour use efficiency

`The extent of variation between the models is very large. In VRS, mean efficiency decreases from 0.79 in Model 1 to 0.45 in Model 4, and in CRS from 0.67 to 0.27. While all the comercial banks (except Östgöta Enskilda Bank) are on the frontier in Model 1 with VRS. Only Handelsbanken and JP Bank are on the frontier in all four models. In CRS, only Handelsbanken and JP Bank (together with Alingsås sparbank in Model 1 only) are on the frontier in all models, while SE-banken and Östgöta Enskilda Bank have efficiency scores of 0.75 and 0.62 respectively in Model 1.

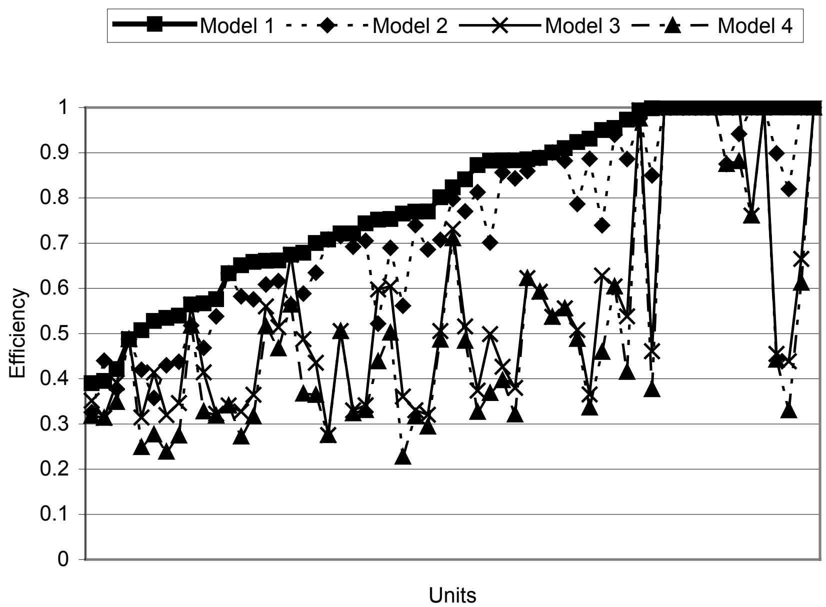

Figure 4. distribution for Swedish banks 1996. Constant Returns to Scale (CRS).

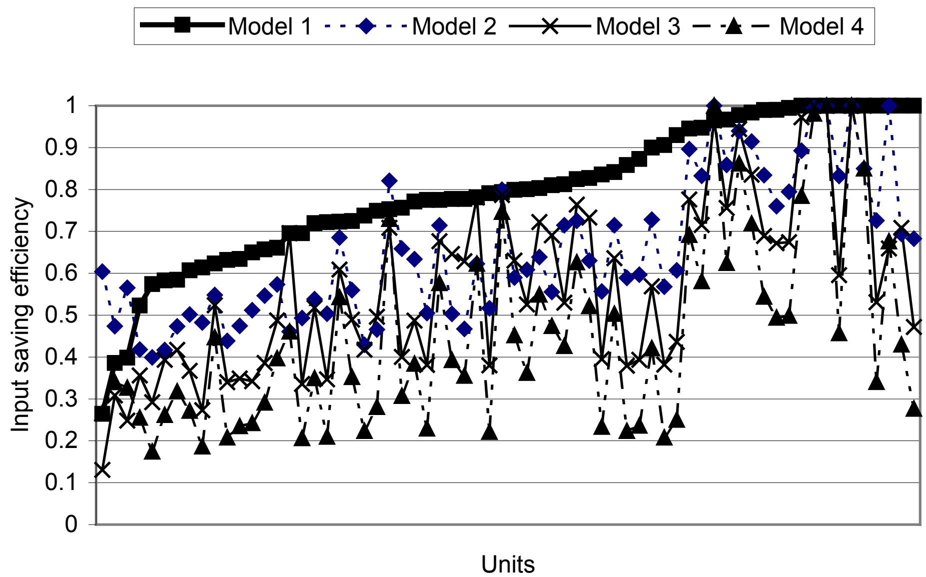

Figure 5. Labour use efficiency for Swedish banks 1996. Variable returns to scale.

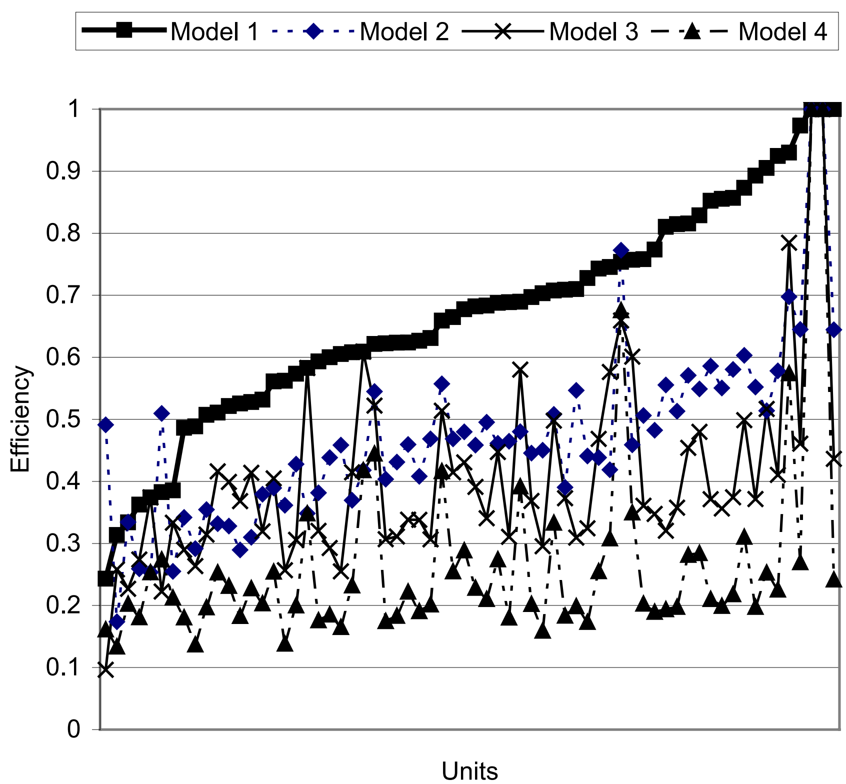

Figure 6. Labour use efficiency for Swedish banks 1996. Constant returns to scale.

5. Summary and conclusion

This paper has reviewed existing literature on banking efficiency and productivity and has found out that many studies define inputs and outputs differently, depending on the availability of data and the objective of the study. Some of these definitions, however, are inconsistent with the neo-classical theory of the firm.

With reference to the existing studies it is possible to draw the following conclusions: (a) Under the *production approach,* inputs are defined in terms of labour, machines and materials. This is due to the fact that positive costs are attributable to the following outputs: (i) supplying demand and deposit services (ii) short-term and long-term services (iii) brokerage and other services (iv) property management and (v) the provision of safe deposit boxes. (b) Under the *asset or intermediation approach,* inputs are defined as labour, machines, deposits, materials and other costs. Deposits are considered as inputs because they are used in income generating activities such as loan provision etc. Outputs are the profits and revenues generated after the provision of bank services. See Table 2 for summary.

The efficiency analysis conducted among Swedish banks in 1996, illustrates the sensitivity of the results with respect to the choice of variables. On the one hand, the choice between labour costs and labour hours has only a minor impact on the efficiency distribution. On the other hand, the results are very sensitive to the inclusion or exclusion of net provisions as an output variable. While the results are robust for the commercial banks – which are all (with one exception) fully efficient, the differences between models are striking for some savings banks.

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Table 1. Summary of Inputs and Outputs in banking industry

Authors (Date)	Method	Study	Inputs	Outputs
Bhattacharyya, Bhattacharrya & Kumbhakar (1996)	SFA	TFP (India)	Labour and Physical capital	Loans and advances, fixed deposits, current deposits and investments.
Parson, Gotlieb & Denny (1993)	SFA	Productivity (Canada)	Labour and capital	Index of quantities of each service provided i.e. checks debit and credit loans, deposits.
Henry Tulkens (1993)	FDH	Efficiency (Belgium)	Labour, windows, automatic teller machines.	Deposits, Automatic teller machine operations, international operations (transactions on foreign exchange and on travellers checks), stocks and bonds, credit operations, opening of new accounts, special services.
Berger, Hancock, & Humphrey (1993)	DFA	Efficiency (USA)	Labour capital deposits, physical capital.	Business loans, consumer loans.
English,Grosskopf, Hayes & Yaisawarng (1993)	DEA	Efficiency (USA)	Labour, capital deposits, borrowing.	Investment income, real estate loans, consumer loans and commercial loans.
Berg, Førsund, Hjalmarsson & Suominen (1993)	DEA	Efficiency & Productivity (Nordic)	Labour ,capital (book value of machinery and equipments).	Loans, deposits and number of branches.
Lang and Welzel (1996)	DFA	Efficiency & Technical Progress. (Germany)	Total cost, price of labour, price of capital, price of deposits, volume of labour, volume of deposits.	Short term loans to nonbanks, loans to banks, bonds, cash, real estate, investments, fees, and commissions, revenue from sales and number of offices.
Chaffai M.E (1997)	SFA	Input-specific technical inefficiency (Tunisia)	Labour, capital (book value) Time deposits.	Total loans Interest and fees on loans,
Brockett, Charnes, Cooper, Huang & Sun (1997).	DEA	Performance (USA)	Interest expenses on deposits, expenses for federal funds purchased and repurchased in domestic offices Salaries, buildings, furniture, and equipment. Total deposits.	Income on federal funds sold and repurchases in domestic offices. Allowances for loan losses, loans, net of unearned income.
DeYoung Robert (1997)	DFA	Efficiency (USA)	Price of labour, borrowed funds, and Physical capital.	Total loans, transactions deposits and fee-based income.
Mester Loreta (1997)	SFA	Efficiency (USA)	Labour, Physical capital, funding	Real estate loans, commercial and industrial loans, lease financing receivable, agricultural loans, other loans, private loans to individuals.
Humphrey David (1993)	SFA	Technical Change (USA)	Labour, physical capital, interest on deposits, interest on purchased funds.	Value of demand deposits, small time and saving deposits, real estate loans, installment loans, commercial and industrial loans.

Table 1. Continued……

Berg, Førsund, Jansen (1991)	DEA	Technical Efficiency. (Norway)	Labour, Machine, Material, Material, Buildings.	Demand deposits, Time deposits, Short-term loans, Long-term loans, Other services.
Bukh, Førsund, & Berg (1995)	DEA	Efficiency (Nordic)	Capital (as a book value of machinery and equipment),	Total deposits, total loans, number of branches, guarantees given to customers,
Kumbhakar, Hjalmarsson, & Heshimati (1998)	SFA	Adjustment	Labour (man-hour), materials (non-labour, non-capital operating expenses) Labour, Capital	Deposits, Public loans, Guarantees, & Number of branches.

Table 2. Definition of inputs and outputs based on the approach used.

Potential Outputs	Production Approach	Asset Approach
Loan	Yes	Yes
Deposits	Yes	No
Cheques	Yes	No
Stocks and bonds	Yes	Yes
Investment income	Yes	Yes
Branches	Maybe	No
Interests and fees on loans	Yes	Yes
Interest and fees on deposits	Yes	Yes
Guarantees	Yes	Yes

Potential Inputs	Production Approach	Asset Approach
Labour	Yes	Yes
Capital	Yes	Yes
Deposits	No	Yes
Interest and fees on deposits	No	No
Material and Machines	Yes	Yes

Table 3. The difference between the models applied.

Variable	Net provisions	Labour cost	Labour hours	Number of output	Number of input
Model 1	Yes	Yes		4	5
Model 2	Yes		Yes	4	5
Model 3		Yes		3	5
Model 4			Yes	3	5

Table 4. Spearman rank correlation coefficients for constant returns to scale (CRS) models.

	Model 1	Model2	Model 3	Model 4
Model 1	1.00000			
	0.00000			
Model 2	0.97741	1.00000		
	0.00010	0.00000		
Model 3	0.57507	0.58636	1.00000	
	0.00010	0.00010	0.00000	
Model 4	0.49680	0.47527	0.46048	1.00000
	0.00010	0.00010	0.00020	0.00000

Table 5. Spearman rank correlation coefficients variable returns to scale (VRS) models.

	Model 1	Model 2	Model 3	Model 4
Model 1	1.00000			
	0.00000			
Model 2	0.98883	1.00000		
	0.00010	0.00000		
Model 3	0.77158	0.77052	1.00000	
	0.00010	0.00010	0.00000	
Model 4	0.42140	0.38205	0.42050	1.00000
	0.00070	0.00240	0.00070	0.00000

APPENDIX

Computation of efficiency scores by DEA

The computation of the input saving measure under the variable returns to scale is carried out by solving the linear programming problem (LP-problem) [(1) to (1d)]. This must be done for each production unit i.

$$\min_{\lambda_i} E_{1i} \qquad (1)$$

subject to:

$$y_{ki} \leq \sum_{j}^{N} \lambda_{ij} y_{kj}, \quad k=1,...,m \qquad (1a)$$

$$E_{1i} x_{ri} \geq \sum_{j}^{N} \lambda_{ij} x_{rj}, \quad r=1,...,n \qquad (1b)$$

$$\sum_{j}^{N} \lambda_{ij} = 1 \qquad (1c)$$

$$\lambda_{ij} \geq 0 \quad j=1,...,N \qquad (1d)$$

where E_{1i} is the input-saving efficiency measure for bank *i*, N is number of banks, y_k is outputs, x_r is inputs, λ_{ij} is a vector containing the non-negative weights, *m* is the number of outputs, and *n* is the number of inputs. Restriction (1a) implies that the reference unit must produce as much as unit *k*, while (1b) implies that the efficiency adjusted volume of input used by unit *k* must amount to the input volume used by the reference unit. (1c) implies variable returns to scale. If this restriction is omitted, constant returns to scale (CRS) is implied. For further details and derivation of the model see Farell (1957) and Charnes et el. (1978).