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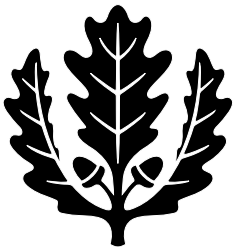

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Abstract

This paper empirically estimates and analyzes various efficiency scores of Indian banks during 1997-2003 using data envelopment analysis (DEA). During the 1990s Indias financial sector underwent a process of gradual liberalization aimed at strengthening and improving the operational efficiency of the financial system. It is observed, none the less, that Indian banks are still not much differentiated in terms of input or output oriented technical efficiency and cost efficiency. However, they differ sharply in respect of revenue and profit efficiencies. The results provide interesting insight into the empirical correlates of efficiency scores of Indian banks. Bank size, ownership, and the fact of its being listed on the stock exchange are some of the factors that are found to have positive impact on the average profit efficiency and to some extent revenue efficiency scores are. Finally, we observe that the median efficiency scores of Indian banks in general and of bigger banks in particular have improved considerably during the post-reform period.

LIBERALIZATION, OWNERSHIP, AND EFFICIENCY IN INDIAN BANKING: A NONPARAMETRIC ANALYSIS

I. Introduction

Measurement of efficiency of banking institutions serves two important purposes. It helps to benchmark the relative efficiency of an individual bank against the 'best practice' bank(s) and secondly, it helps to evaluate the impact of various policy measures on the efficiency and performance of these institutions. As the banking system provides transaction services and payment system, an efficient banking system has significant positive externalities, which increases the efficiency of economic transactions in general. In the Indian context, we have seen unfolding of a slew of financial sector reform measures since the early 1990s. An important objective of these measures is to increase the operational efficiency of the banking sector as a whole as well as of individual institutions. In fact, policy makers have clearly recognized that inefficiency is an important factor contributing to the high level of cost of banking services in India.[1]

However, efficiency measurement in this sector is not straightforward because it is difficult to define and measure either inputs or outputs of a bank. Further, banks may not be homogeneous with respect to the types of outputs actually produced. There is also the question of various concepts of efficiency that can be employed to compute relative efficiency scores of individual banks. We also need to reckon with the fact that there exist a number of possible approaches to estimate a given measure of efficiency. Once the efficiency scores are worked out, the next question arises with regard to its empirical correlates, which can throw light on the sources of observed in-efficiency. Appropriate policies designed to enhance efficiency can be designed if the dimensions along which performers get clearly demarcated from non-performers are suitably identified. In this paper we measure efficiency scores of all major Indian commercial banks having a minimum level of retail presence in the country, using a variety of efficiency measures computed by the nonparametric method of Data

[1] This is quite apparent from the following statement by Bimal Jalan, the Governor of Reserve Bank of India:

"Inefficiency in the use of resources, tolerance of waste and slothfulness also contributes to low productivity as often reflected in high spreads. The important challenge of managing transformation would, for the banking sector, mean moving from high cost, low productivity and high spread to being more efficient, productive and competitive" (Jalan 2002).

Envelopment Analysis (DEA). We then attempt to find out the possible sources of observed inefficiency.

An important consequence of liberalization is that a bank is now able to go to the stock market to raise equity and thereby absorb a greater degree of risk than before. A concomitant degree of market discipline infuses greater accountability and transparency in the day-to-day operations of the bank and fosters efficiency. Banks of different ownership types, however, vary in the extent to which they are exposed to the stock market. Our objective is to examine whether liberalization has, in deed, enhanced efficiency and if so whether there are systematic differences in the effects of liberalization across ownership categories. Because public and private sector banks may have different objectives and may face different constraints in respect of the variables that they can choose, we use alternative measures of efficiency to compare their performance.

The rest of the paper unfolds as follows. Section II includes a brief review of the relevant literature. Section III provides a bird's eye view of the Indian banking system as it has evolved in the recent past and puts the question of efficiency, the main theme of this paper, in its proper perspective. Section IV outlines the non-parametric DEA methodology and discusses various measures of efficiency that we have used. The data sources along with identification of inputs and outputs are reported in Section V. Section VI discusses the findings from the empirical analysis. Section VII concludes.

II. Review of Literature

The literature on the efficiency of financial institutions is by now quite large despite its relatively recent origin. Numerous attempts have been made to study the efficiency of banks in developed countries. By contrast, studies analysing the efficiency of banks in developing countries, especially in India, are far fewer.

Of the 130 studies of financial institution efficiency considered by Berger and Humphrey (1997), 116 were published between 1992 and 1997. They find that, overall, depository financial institutions/banks operate at an annual average technical efficiency level of around 77 percent (median 82 percent). Frontier inefficiency, sometimes called X-inefficiency, at financial institutions account for a considerable portion of the total costs, are a much greater source of performance problems than

either scale or product mix inefficiencies, and have a strong empirical association with higher probabilities of failures [Bauer *et al.* (1998)].

Most bank efficiency studies based on DEA focus on the US or other developed countries. Among the few bank efficiency studies so far that have used East Asian banking data are the papers by Leightner and Lovell (1998), Gilbert and Wilson (1998), Shyu (1998) and Hao *et al.*(2001). As regards Indian banks, Bhattacharya *et al.* (1997) used DEA methodology to study the impact of policy of liberalizing measures taken in 1980s on the performance of various categories of banks. They worked out a grand frontier using data of 70 banks for the period 1986-91. As the banking sector was overwhelmingly dominated by the Indian public sector banks, with new private sector banks yet to emerge fully in the Indian banking scenario, it is no surprise that they found that the Indian public sector banks were best performing banks. A few other authors have also used DEA methodology to study the efficiency and performance of Indian banks. For example, Rammohan and Ray (2004) compared the revenue maximizing efficiency of three categories of banks- public, Indian private and foreign banks, using physical quantities of inputs and outputs during 1992-2000. They used loans, investments and other income as outputs and deposits and operating costs as inputs. All the outputs and inputs were deflated by price index to obtain real quantities. They found that public sector banks were significantly better than private sector banks on revenue maximization efficiency but between public sector banks and foreign banks the difference in efficiency was not significant.

In another group of studies, bank efficiency is measured by a number of financial indicators and compared over various categories of banks. For example Sarkar *et al*. (1998) considered three bank groups- public, Indian private and foreign- for comparison purpose. After controlling for effects of some concomitant variables, they conducted regression analysis to find the effect of ownership type on different efficiency measures. Rammohan (2002, 2003) also used financial measures for comparing operational performance of different categories of banks over a period of time.

III. An Overview of the Indian Banking System

The banking system in India comprises commercial and co-operative banks, of which the former account for around 98 per cent of banking system assets. Based on the ownership pattern, the commercial banks can be in grouped into three types- State owned or public sector banks (PSBs), private banks under Indian ownership, and foreign banks. The 27 PSBs dominate the commercial banking system of India, accounting for a little more than 80 per cent of commercial banking assets.[2]

The macroeconomic, regulatory and supervisory frameworks under which banks in India operate have undergone a major structural change since 1991 when the Indian reform process began. It may be noted here that in the 1950s, the financial system in India was fairly liberal with limited control on interest rates and low statutory pre-emption of fund. The disconcerting findings of the All-India Rural Credit Survey Committee (RBI, 1954) of the inequitable distribution of bank credit raised misgivings about the ability of markets to efficiently allocate resources.[3] In response, the Government tightened its control over the credit allocation process to ensure adequate flow of credit into genuinely productive activities in conformity with the Plan priorities. Towards this end, controls on lending rates were introduced, liquidity requirements were raised, and a system of development banks, catering to various segments of industry and agriculture were established. The process culminated with the nationalization of 14 largest commercial banks in 1969 and subsequently of other 6 major commercial banks[4] in 1980.

Over the decade following nationalization, there was an unparalleled policy driven expansion in the branch network of the PSBs. Such expansion of banking facilities was designed not only to mop up potential savings, but also to meet the credit gaps in agriculture, retail trade and small scale industries, thereby bringing large stretches of economic activity within the ambit of organized banking system. In this context, scheduled commercial banks are required to lend as much as 40 per cent of its credit portfolio to the preferred or 'priority' sector.

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[2] The entire segment is referred to as Scheduled Commercial Banks, since they are included in the Second Schedule of the RBI Act, 1934.

[3] The All-India Rural Survey Committee observed that out of the total borrowings of Rs.750 crore (i.e,75 billions)f or the cultivators in 1951-52, agriculturalist money lenders and professional money lenders accounted for 24.9 per cent and 44.8 per cent, respectively.

[4] The number has since fallen to 19 with the merger of two banks in 1993.

In addition, several other quantitative and functional restrictions were imposed. During 1991, cash reserve ratio (CRR) of commercial banks was at the statutory maximum of 15 per cent, while investment in government debt instruments in the form statutory liquidity ratio (SLR) was highest around 38.5 per cent[5]. Banks had very limited access to financial markets. Interest rates on both sides of the balance sheet were highly regulated. Finally, competition was limited due to strict entry barrier of new private banks.

A process of liberalization of the financial sector was initiated in 1991-92, which aimed at creating a more diversified, profitable, efficient and resilient banking system (Government of India, 1991). The underlying philosophy was to make the banking system more market-oriented and to that end, engendered a shift in the role of the RBI from micro-management of banks operations to macro governance. While these reforms were being implemented, the world economy also witnessed significant changes, 'coinciding with the movement towards global integration of financial services' (Government of India, 1998). Against this backdrop, a second Government-appointed Committee on banking sector reforms provided the blueprint for the current reform process (Narasimham Committee II, Government of India, 1998). The noteworthy developments in the financial system over the period were as follows (Bhide *et al*, 2001):

(a) financial repression through statutory pre-emptions have been lowered. Illustratively, at end-March 2003, the CRR stood at 4.75 per cent (legal minimum is 3 per cent) and SLR at 25 per cent (legal minimum).

(b) The administered interest rate regime has been dismantled, allowing banks the freedom to choose their deposit and lending rates based on the prevailing market condition.

(c) Competition has been infused by allowing more liberal entry of foreign banks and permitting functioning of new private banks.

(d) A set of micro-prudential measures (capital adequacy requirements, income recognition, asset classification and provisioning norms for loans, exposure norms, accounting norms) has been stipulated.

[5] The statutory maximum is 40 per cent.

Until 1991-92, all PSBs were fully owned by the Government. Since the onset of reforms, several relevant acts were amended to enable the state-owned banks to raise capital up to 49 per cent from the public. As many as 12 state-owned banks accessed the capital market and raised up to around Rs.65 billion till end-March 2002. A hallmark of the reform process in India has been its 'gradualism', which was the outcome of India's democratic and highly pluralistic polity in which reforms could be implemented only if based on a popular consensus (Ahluwalia, 2002).

Table 1: Summary of the Banking Industry: 1990-91 to 2002-03

(Amount in Rs. billion)

Year/Bank Group	1990-91			1995-96			2002-03		
	PSB	Pvt.	Forgn.	PSB	Pvt.	Forgn.	PSB	Pvt.	Forgn.
No. of Banks	28	25	23	27	35	29	27	29	38
Total Deposit	2087	94	85	3908	361	306	10794	2069	693
Total credit	1306	50	51	2075	219	225	5493	1377	522
Credit-deposit ratio	0.63	0.52	0.60	0.53	0.61	0.75	0.51	0.67	0.75
Share (in per cent) of									
Total Deposits	92	4	4	85	8	7	77	15	5
Total Credit	93	4	3	82	9	9	72	18	7
Total Income	240	104	15	539	72	75	1285	316	121
Total Profit	5	0.3	2	3	5	7	122	29	18

PSB. Public Sector Banks; Pvt. Private Sector Banks; Forgn: Foreign Banks.
Source: RBI

Table 2: Some Select Banking Indicators: 1992-03

Year	Cost of deposits	Return on advances	Net interest margin	CRR	SLR	Bank rate
1992	6.5	14.7	3.8	15.0	38.5	12.00
1993	7.4	14.2	3.0	14.5	37.8	12.00
1994	6.7	13.1	3.2	14.5	34.8	12.00
1995	5.8	10.9	3.2	15.0	31.5	12.00
1996	7.0	12.9	3.4	13.5	25.0	12.00
1997	7.8	14.6	3.3	10.0	25.0	11.00
1998	7.6	13.0	3.0	10.3	25.0	9.00
1999	8.0	12.7	2.7	10.5	25.0	7.00
2000	7.4	11.5	2.8	8.5	25.0	8.00
2001	7.2	11.1	2.8	8.0	25.0	7.00
2002	7.0	10.5	2.6	5.5	25.0	6.50
2003	6.4	9.9	2.7	4.75	25.0	6.25

Evidence of competitive pressures on the Indian banking industry can be found in the decline of the 'five-bank asset concentration ratio' from 0.51 in 1991-92 to 0.44 in 1995-96 and thereafter to 0.41 in 2001-02 and the presence of increasing number of private and foreign banks (Table 1). Deregulation of the interest rate structure, lowering reserve ratios, increased competition, *etc.,* have facilitated lowering of

interest rates on both sides of balance sheet and interest spread in line with international standards (Table 2). In general, deregulation has introduced significant operational freedom in the working of Indian banks. In this context, efficiency assumes critical importance against the background of competitive viability and improved performance in the future.

IV. The Nonparametric Methodology

In econometric applications one specifies some explicit form of the production, cost, or profit function to represent the benchmark technology for efficiency measurement. The validity of the derived measures of efficiency, however, does critically depend on the appropriateness of the functional specification. In the nonparametric alternative, one makes a number of fairly general assumptions about the technology but leaves the functional form unspecified. Typically, it is assumed that the production possibility set is convex and both inputs and outputs are freely disposable.

Consider an industry producing m outputs from n inputs. An input-output bundle *(x, y)* is considered feasible when the output bundle *y* can be produced from the input bundle *x*. The technology faced by the firms in the industry can be described by the production possibility set

$$T = \{(x, y): y \text{ can be produced from } x\}. \qquad (1)$$

In the single output case, one can conceptualize the production function

$$f(x) = \max y: (x, y) \in T. \qquad (2)$$

In the multiple output case, frontier of the production possibility set is the production correspondence

$$F(x, y) = 1. \qquad (3)$$

The method of Data Envelopment Analysis introduced by Charnes, Cooper, and Rhodes (CCR)(1978) and further extended to non-constant returns technologies by Banker, Charnes, and Cooper (BCC)(1984) provides a way to construct the production possibility set from an observed data set of input-output bundles.

Suppose that (x^j, y^j) is the input-output bundle observed for firm j $(j = 1,2,\ldots, N)$. Clearly, these input-output bundles are all feasible. Then the smallest production possibility set satisfying the assumptions of convexity and free disposability that includes these observed bundles is

$$S = \{(x, y) : x \geq \sum_{j=1}^{N} \lambda_j x^j ; y \leq \sum_{j=1}^{N} \lambda_j y^j ; \sum_{j=1}^{N} \lambda_j = 1; \lambda_j \geq 0; (j = 1,2,..., N)\}. \quad (3)$$

The set *S* is also known as the free disposal convex hull of the observed input-output bundles. One can obtain various measures of efficiency of a firm using the set *S* as the reference technology. In the following paragraphs we describe how the efficiency of a firm can be measured under alternative assumptions about what its choice variables are.

Output-oriented Technical efficiency:

When the input bundle of a firm is treated as exogenously determined, its technical efficiency is to be measured by comparing its actual output with what is maximally producible from its observed input bundle. The output-oriented efficiency of a firm producing the output bundle y^0 from the input bundle x^0 is

$$\tau_y = \min \tau : (x^0, \tfrac{1}{\tau} y^0) \in T. \quad (4)$$

The DEA measure of output-oriented technical efficiency using the set *S* as the benchmark is

$$\tau_y (x^0, y^0) = \tfrac{1}{\phi^*} \quad (5)$$

where

$$\phi^* = \max \phi$$

s.t.
$$\sum_{j=1}^{N} \lambda_j y^j \geq \phi y^0;$$

$$\sum_{j=1}^{N} \lambda_j x^j \leq x^0; \quad (6)$$

$$\sum_{j=1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,..., N).$$

Input-oriented Technical Efficiency:

In a different situation, the output-bundle of the firm may be treated as an assigned task and the efficiency of the firm is judged by the maximum equi-proportionate reduction in all of its inputs without compromising the feasibility of the target output. The input-oriented technical efficiency of the firm is measured as

$$\tau_x = \min \theta$$

$$\text{s.t.} \quad \sum_{j=1}^{N} \lambda_j y^j \geq y^0;$$

$$\sum_{j=1}^{N} \lambda_j x^j \leq \theta x^0; \qquad (7)$$

$$\sum_{j=1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,...,N).$$

Cost Efficiency:

In measuring input-oriented technical efficiency all inputs are treated equally and the objective is to reduce all inputs by the same proportion to the extent possible. Thus, once any one input becomes binding no further possible reduction in any other input is considered. But when input prices are available, reducing the more costly input assumes a greater priority than reducing the less costly ones. In this case, efficiency lies in producing the target output bundle y^0 at the minimum cost.

Suppose that the input price vector faced by the firm is w. Then its actual cost is $C^0 = w'x^0$. The minimum cost of producing the target output is

$$C(w, y^0) = \min w'x : (x, y^0) \in T. \qquad (8)$$

With reference to the estimated production possibility set S, the minimum cost is obtained as

$$C^* = \min w'x$$

$$\text{s.t.} \quad \sum_{j=1}^{N} \lambda_j y^j \geq y^0;$$

$$\sum_{j=1}^{N} \lambda_j x^j \leq x; \qquad (9)$$

$$\sum_{j=1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,...,N).$$

The cost efficiency of the firm is then measured as

$$\gamma = \frac{C^*}{C^0} \leq 1. \qquad (10)$$

Revenue Efficiency:

In the measurement of output-oriented efficiency, the objective is to achieve the maximum rate of increase that would be feasible for all outputs. But, as in the case of

inputs, some outputs are more valuable than others. When output prices are available, a firm attains efficiency by producing the output bundle that results in the highest revenue at the applicable output prices. Thus, the criterion of efficiency in this case is revenue maximization. Assume that the output price vector faced by the firm is p. Then the revenue from its observed output bundle would be $R^0 = p'y^0$. The maximum attainable revenue, on the other hand, will be

$$R(p, x^0) = \max p'y : (x^0, y) \in T. \qquad (11)$$

Again, in an empirical application, the maximum revenue achievable from the input bundle x^0 is

$$R^* = \max p'y$$

$$\text{s.t.} \quad \sum_{j=1}^{N} \lambda_j y^j \geq y;$$

$$\sum_{j=1}^{N} \lambda_j x^j \leq x^0; \qquad (12)$$

$$\sum_{j=1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,...,N).$$

The revenue efficiency of the firm is measured as

$$\rho = \frac{R^0}{R^*} \leq 1. \qquad (13)$$

<u>Profit Efficiency</u>:

In all of the oriented models, either inputs or outputs were treated as exogenously given. For a commercial firm, however, both inputs and outputs will be choice variables and the only constraint would be the feasibility of the input-output bundle chosen. For such a firm, the criterion of efficiency is profit maximization. At input and output prices w and p, respectively, the actual profit of the firm producing the output bundle y^0 from the input bundle x^0 is $\Pi^0 = p'y^0 - w'x^0$. The maximum profit feasible for the firm at the se process is

$$\Pi(w, p) = \max p'y - w'x : (x, y) \in T. \qquad (14)$$

In any empirical application, the maximum profit may be obtained as

$$\Pi^* = \max p'y - w'x$$

$$\text{s.t.} \quad \sum_{j=1}^{N} \lambda_j y^j \geq y;$$

$$\sum_{j=1}^{N} \lambda_j x^j \leq x;$$

$$\sum_{j=1}^{N} \lambda_j = 1; \qquad (15)$$

$$\lambda_j \geq 0; (j = 1,2,...,N).$$

The profit efficiency of the firm is measured as

$$\delta = \frac{\Pi^0}{\Pi^*}. \qquad (16)$$

This measure is also bounded between 0 and 1 except in the case where the actual profit is negative while the maximum profit is positive. In that case δ is less than 0. If the maximum profit is negative as well, δ exceeds unity.

<u>Quasi-fixed Inputs and Efficiency in the Short Run</u>:

In all of the models above where inputs are treated as choice variables, we have implicitly assumed that the firm can vary all of the inputs to achieve efficiency. This is true for the models that measure input-oriented technical, cost, and profit efficiency. This clearly corresponds to a long run analysis. It is possible, however, that one or more input is quasi-fixed and only the other inputs are subject to variation at the discretion of the firm. One needs to modify the relevant efficiency measure in order to take explicit account of the quasi-fixed inputs. It may be noted that presence of quasi-fixed inputs would not alter the measures of either output-oriented technical efficiency or revenue efficiency.

Suppose that the input vector x can be partitioned as $x = \{v, K\}$, where v is an n_1 element vector of variable inputs, while K is an n_2 element vector of quasi-fixed inputs. Then the variable input-oriented technical efficiency of the firm using v^0 in conjunction with K^0 to produce the output y^0 is

$$\tau_v = \min \theta_v : (\theta_v v^0, K^0, y^0) \in T. \qquad (17)$$

The revised DEA model for measuring input-oriented technical efficiency in the short run is

$$\tau_v = \min \theta_v$$

s.t. $$\sum_{j=1}^{N} \lambda_j y^j \geq y^0;$$

$$\sum_{j=1}^{N} \lambda_j v^j \leq \theta v^0; \qquad (18)$$

$$\sum_{j=1}^{N} \lambda_j K^j \leq K^0;$$

$$\sum_{j=1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,..., N).$$

Note that in this case, the scale down factor θ_v applies only to the variable inputs but not to the quasi-fixed inputs.

Next consider cost efficiency in the short run. Suppose that the input price vectors are q and r for the variable and fixed inputs, respectively. The actual variable cost of the firm is $VC^0 = q'v^0$ while its fixed cost is $FC^0 = r'K^0$. Note that the fixed cost is a constant in the short run and plays no role in its cost-minimization. Hence, the appropriate criterion of efficiency in this context is variable cost minimization. The minimum variable cost of the firm is

$$VC(q, y, K^0) = \min q'v : (v, K^0, y^0) \in T. \qquad (19)$$

The revised DEA problem to be solved for variable cost minimization is

$$VC^* = \min q'v$$

s.t.
$$\sum_{j=1}^{N} \lambda_j y^j \geq y^0;$$

$$\sum_{j=1}^{N} \lambda_j v^j \leq v; \qquad (20)$$

$$\sum_{j=1}^{N} \lambda_j K^j \leq K^0;$$

$$\sum_{j=1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,..., N).$$

The variable cost efficiency of the firm is

$$\gamma_v = \frac{VC^*}{VC^0}. \qquad (21)$$

Finally, consider the firm's profit-maximization problem in the short run. This time the firm can only maximize its producer's surplus or variable profit- the difference between the total revenue and variable costs. The actual variable profit of the firm is

$$\Pi_v^0 = p'y^0 - q'v^0. \qquad (22)$$

The maximum variable profit is

$$\Pi_v (p, q, K^0) = \max p'y - q'v : (q, K^0, y) \in T. \qquad (23)$$

The revised DEA problem for variable profit maximization is

$$\Pi_v^* = \max p'y - q'v$$

s.t.
$$\sum_{j=1}^{N} \lambda_j y^j \geq y;$$

$$\sum_{j=1}^{N} \lambda_j v^j \leq v;$$

$$\sum_{j=1}^{N} \lambda_j K^j \leq K^0; \qquad (24)$$

$$\sum_{j=1}^{N} \lambda_j = 1;$$

$$\lambda_j \geq 0; (j = 1,2,..., N).$$

The variable profit efficiency of the firm is

$$\delta_v = \frac{\Pi_v^0}{\Pi_v^*}. \qquad (25)$$

We conclude this section with a few general observations. In any given context, the correct measure of efficiency can be obtained only if the choice variables of the firm are correctly identified. When there is some ambiguity about what variables the firm can freely choose and what are exogenous variables, one should consider alternative scenarios and compute alternative measures of efficiency. This is what we do in the present study. When the efficiency measures are robust across models, they become more reliable.

V. Data and Choice of Inputs and Outputs

For estimation of efficiency frontier by DEA methodology we need measures of inputs and outputs and also that of efficiency. Regarding the former, there is no consensus in the literature about what constitutes inputs and outputs for a banking firm. There are two broad approaches to this measurement issue. In the production approach, banks are considered to be producing various types of accounts maintained with them- loan accounts and deposit accounts. It is the number of accounts of various types that are taken as measures of output, produced by use of capital and labour. Berger and Humphrey (1992) describe this approach as value added approach. Under the alternative intermediation approach or asset approach, a bank is treated as a

producer of intermediation services- by transforming risk and maturity profile of funds received from depositors, to investment or loan portfolio of a different risk and maturity profile, by using labour and capital. But banks also produce services for which specific charges are levied- for example, custodial services, and safe deposit services for valuables, payment services and others. Thus according to this approach, money value of loans and non-interest income are taken as outputs, while inputs are labour and capital. The treatment of money value of deposits, however, remains ambiguous. In the literature it was treated as input by some authors while others categorized it as output.

It is to be noted here that for national income estimation purpose, the output of banks comprise two components- direct charges paid by customers on services rendered by banks like commissions, fees, etc., and financial services indirectly measured or FISIM. Calculation of FISIM is problematical as it should ideally depend on an unobserved market reference interest rate and the excess interest paid by borrowers of bank fund over the reference rate. For depositors, the implicit service charges paid by them amount to the shortfall in interest as compared to the reference rate. This definition of bank output is also consistent with corresponding output concept for other producing sectors in the sense that output as measured by FISIM is in the nature of flow, whereas number of loan accounts or loan amount are in the nature of stocks. The difficulty in using FISIM, as a measure of output is that associated price for this output cannot be easily calculated.

For large US banks, Mukherjee *et al*. (2001), following the intermediation approach, considered four outputs- consumer loans, real estate loans, investments and total non-interest income and five input measures- demand deposits, time deposits, equity, staff expenses and remaining non-interest expenses. In the Indian context, Rammohan and Ray (2004) considered loans, investments and other non-interest income as outputs and deposits and operating costs as inputs. To arrive at the corresponding physical quantities, they deflated both output and input by a single price index. Das (1997) analysed overall efficiency – technical, allocative and scale, of Indian public sector banks using net interest margin and other operating income as outputs and deposits, borrowing and staff as inputs.

For our study, we adopted the intermediation approach and considered four inputs – borrowed funds (deposits and other borrowings), number of employees, fixed assets and equity. The borrowing component in total liability is fairly small, especially for Indian banks. However, foreign banks operating in India historically maintain relatively sizeable borrowing portfolio. The prices associated with the first three inputs are respectively- cost of borrowed funds measured by average interest paid per rupee of borrowed funds, average staff cost and cost of fixed assets measured by non-labour operational cost per rupee amount of fixed asset. The equity is considered as quasi-input without any associated price. Thus, our measures of input-oriented technical, cost, and profit efficiency are all short run measures as explained above. We have used three output measures- investments, performing loan assets and other non-interest fee based incomes. The use of earning asset as an output measure is a novel attempt in the Indian context, although similar measure has been used in the context of USA (Barr *et al.*, 2000). As a measure of output, this is a better measure because only the earning asset contributes to the revenue of a bank and not its entire loan asset. The associated price indicator for the first two output measures are respectively- average interest earned on per rupee unit of investment and average interest earned on per rupee unit of performing loan asset. For non-interest income, the total amount itself is taken as an output in value term.

As regards efficiency measures, we have decided to adopt a holistic approach. Instead of measuring a single measure of efficiency, we have used multiple measures- two measures of technical efficiency, cost efficiency, revenue efficiency and profit efficiency. Rammohan and Ray (2004) first used revenue efficiency in the Indian context. In their study, they used ratio of interest spread and interest spread net of provisions to total assets as measures of revenue. They argued against use of profit efficiency because of lack of freedom on the part of Indian banks to choose optimum amount of labour or fixed capital (for not having the option to close branches). But on a closer examination this argument does not seem to be valid. First of all, despite having the stated constraints, there is considerable variation in profitability even among state owned banks, implying thereby that profitability indicator can be used to differentiate performers from non-performers. Secondly, many public sector banks raised equity capital from stock market through partial disinvestments by state in the 1990s and it would be wrong to say that maximization of shareholders value did not

figure in the management's objective function. We do recognize, however, that compared to the other inputs, the level of equity is much more difficult to alter – especially in the short run. For this reason, we treat equity as quasi-fixed in our measurement of (variable) cost or profit efficiency.

Our study period covers seven years beginning with financial year 1996-97.[6] We also decided to include in our observation set only those banks, which had at least three branches during the entire study period. This was done to remove many small foreign banks, which were operating mainly to service their clients of their parent banks abroad and may be choosing their input and output mix on considerations totally different from all other banks having a significant retail presence in the country. We also decided to exclude the Regional Rural Banks, which are also scheduled commercial banks in the state sector from our scope of study. These banks are local banks with their domain of operations restricted to one or two contiguous districts and mostly provide credit to farmers and small enterprises. Since these banks have been formed to meet some social objectives of providing credit to a specific target group, inclusion of them in our data set may lead to misleading results. Based on this criterion, we have 71 banks selected in the year 1996-97 and 68 banks in the terminal year of our study. We have calculated different efficiency scores for each year separately. The data for inputs, outputs and prices are culled out from various issues of *Statistical Tables Relating to Banks in India*, Reserve Bank of India.

VI. Results

Table 3 presents the year-wise distribution of different efficiency scores. It is obvious that on the ground of technical efficiency (either the input- and the output-oriented measures) there is not much to differentiate between various banks. The results vary little over years. In terms of cost-efficiency also most of the banks fall in the highest efficiency range with around five to six banks falling in the next lower range. Although there is some yearly variation in the distribution of this efficiency measure, it cannot be considered very significant or showing any trend. However, for remaining two measures of efficiency that take into account both input cost as well as output realized, the banks appear to be more differentiated, particularly in respect of profit

efficiency. For the latter measure, there are a significant number of banks in the lowest range. It is also interesting to note that over the years there has been a noticeable improvement in the profit profile of the banks, particularly after 1999-2000.

It is not difficult to understand why profit efficiency or revenue efficiency measures are better differentiator of performers from non-performers in the Indian context, as compared to technical or cost efficiency measures. In a policy environment where banks have little leeway to choose its input mix and output prices, the inter bank variation in input or output bundle are small but for scale effect. But at the same time there is considerable room for improvement in productivity and profitability by efficient management of credit and investment portfolio, and better resource management in day-to-day operations. That is why we observe a much wider variation in terms of profit and to some extent in revenue efficiency.

Table 3: Median Efficiency Scores of Indian Banks: 1997-2003

Year	Technical Efficiency (Input)	Technical Efficiency (Output)	Cost Efficiency	Revenue Efficiency	Profit Efficiency
1997	0.999	0.997	0.910	0.851	0.410
1998	0.990	0.992	0.977	0.939	0.550
1999	0.980	0.985	0.918	0.924	0.400
2000	0.999	0.999	0.958	0.953	0.560
2001	0.977	0.980	0.912	0.918	0.490
2002	0.987	0.989	0.931	0.933	0.580
2003	0.998	0.999	0.953	0.959	0.650

In order to study the effect of different classificatory attributes on the banks' efficiency scores, we look at median efficiency scores of various categories of banks defined along the dimension of these attributes. As the difference in technical and cost efficiency scores are not perceptibly large, we restrict our observations only to revenue efficiency and profit efficiency scores. The following conclusions are easily drawn:

[6] Data from earlier years could not be included due to a lack of separate information on non-performing loans.

1) The profit efficiency has a clear positive relationship with size class[7] of banks, with size being measured by total assets (Table 4A). More importantly, the profit efficiency score has improved considerably for all size classes, but more significantly for the largest size class. For the latter size class, the median score has almost doubled during the seven years studied. Despite this considerable improvement, the efficiency score of average firm in all size classes for the terminal year of our study period indicates presence of a large degree of inefficiency in the Indian banking sector. It may be said that the banks in India can increase their profit performance, on the average, at least by 30-40 per cent, only by adopting the best practices obtaining within their peer size group.

Table 4A: Profit Efficiency (Median) of Indian Banks Classified by Size: 1997-2003

Year/Size	I	II	III	IV
1997	0.370	0.440	0.470	0.360
1998	0.440	0.620	0.660	0.460
1999	0.300	0.370	0.460	0.460
2000	0.430	0.630	0.650	0.520
2001	0.360	0.590	0.480	0.530
2002	0.400	0.580	0.620	0.730
2003	0.510	0.630	0.750	0.730

Table 4B: Revenue Efficiency (Median) of Indian Banks Classified by Size: 1997-2003

Year/Size	I	II	III	IV
1997	0.805	0.842	0.913	0.844
1998	0.902	0.979	0.974	0.900
1999	0.869	0.900	0.936	0.990
2000	0.915	0.970	0.974	0.952
2001	0.872	0.928	0.944	0.928
2002	0.910	0.930	0.945	0.949
2003	0.906	1.000	0.956	0.975

I: Assets up to Rs.5000 crore, II: Assets between Rs.5000 crore to Rs.10000 crore, III: Assets between Rs.10000 crore to Rs.20000 crore, IV: Assets above Rs.20000 crore.

2) The differences in revenue efficiency scores across different size classes are of much lower magnitude as compared to profit efficiency scores (Table 4B). The

[7] Based on total assets, four size classes have been considered. These are: I: Assets up to Rs.5000 crore, II: Assets between Rs.5000 crore to Rs.10000 crore, III: Assets between Rs.10000 crore to Rs.20000 crore, IV: Assets above Rs.20000 crore.

improvement in revenue efficiency scores over years has also been much less pronounced, primarily because the inefficiency in terms of this score was much less to begin with.

3) The standard classification of banks in terms of ownership type has been threefold- Public or state owned banks, Indian private banks and foreign banks. However, the classification adopted by the supervisory authority is more refined and sharp. For peer group performance study a six-fold classification is adopted, giving due weights to the vintage of banks apart from its ownership type and size (Table 5). Thus we have old private banks along with new private banks, old foreign banks as well as new foreign banks. The other two peer groups are small state owned banks and large state owned banks. The peer group-wise comparison of median efficiency scores suggests that there is considerable year-to-year variation in profit efficiency scores for all peer groups. The old Indian private banks have fared badly for all the years and have never been able to achieve even 55 percentile score on the average. New Indian private banks, new foreign banks and large state owned banks have improved their profit efficiency dramatically in the last two years of study; new foreign banks having recorded the highest improvement. It cannot be said the size has been a positive factor in determine efficiency within the state owned banks- the median performance being comparable between these two peer groups. The vintage of a bank is an important factor in determining profit efficiency score for Indian banks but not so for foreign banks. Since the new Indian private banks have uniformly adopted latest technology as compared to their older counterparts, it is obvious that technology has played a positive role in this regard. But foreign banks, both old and new have moved ahead on the technology front because of their exposure to international competition and technologically these two peer groups could be considered on par. In fact, but for the last year old foreign banks have performed uniformly better than their recent counterparts.

4) For any bank, a key (and frequently used) performance indicators representing managerial efficiency is its operating expenses per unit of assets in value terms. Based on this indicator, the banks are grouped into three categories – high, average and low level of managerial efficiency (Table 6). The average profit efficiency scores for these three groups show that there seems to exist a clear positive association between good management practices and profit efficiency, not a surprise by any means. Similarly it

is also observed that banks with higher labour productivity[8], on the average, register better profit efficiency score (Table 7). These two observations together validate the conventional wisdom that factor productivity and profit efficiency are positively associated.

Table 5: Profit Efficiency (Median) of Indian Banks Classified by Peer Groups: 1997-2003

Year/Peer Groups	I	II	III	IV	V	VI
1997	0.333	0.530	0.611	0.384	0.446	0.394
1998	0.617	0.945	0.609	0.514	0.559	0.388
1999	0.476	0.492	0.588	0.356	0.462	0.379
2000	0.636	0.505	0.724	0.459	0.581	0.497
2001	0.541	0.577	0.773	0.361	0.487	0.391
2002	0.557	0.521	0.620	0.512	0.589	0.625
2003	0.742	0.930	0.579	0.528	0.711	0.710

I - New Private Banks', II-Mostly New Foreign Banks, III - Old Foreign Banks,
IV= Mostly Old Private Banks, V= Mostly Small Public Sector Banks,
VI - Mostly Large Public Sector Banks

Table 6: Revenue/Profit Efficiency (Median) of Indian Banks Classified by Operating Expenses: 1997-2003

Year	Revenue Efficiency			Profit Efficiency		
	Op. Exp≤1%	1%<Op. Exp ≤2%	Op. Exp ≥2%	Op. Exp≤1%	1%<Op. Exp≤2%	Op. Exp ≥2%
1997	0.721	0.875	0.904	0.530	0.439	0.321
1998	1.000	0.927	0.842	0.822	0.550	0.247
1999	1.000	0.897	0.956	0.523	0.411	0.349
2000	0.958	0.933	0.968	0.650	0.538	0.348
2001	0.992	0.915	0.919	0.599	0.438	0.358
2002	0.973	0.925	0.905	0.611	0.575	0.386
2003	0.976	0.941	1.000	0.579	0.698	0.541

Table 7: Revenue/Profit Efficiency (Median) of Indian Banks Classified by Labour Productivity: 1997-2003

(Labour productivity is measured in Rs. crore)

	Revenue Efficiency			Profit Efficiency		
Year	labour≤100	100<labour≤200	labour>200	labour≤100	100<labour≤200	labour>200
1997	0.886	0.843	0.721	0.404	0.403	0.494
1998	0.948	0.906	0.978	0.386	0.550	0.641
1999	0.947	0.915	0.927	0.311	0.413	0.497
2000	0.968	0.919	0.971	0.107	0.525	0.628
2001	0.715	0.928	0.978	-0.038*	0.416	0.531
2002		0.955	0.915		0.536	0.578
2003		0.903	0.980		0.523	0.698

[8] Labour productivity is measured as business (i.e., deposits + advances) per employee.

*: Negative profit efficiency for this class was due to very poor performance of a particular Indian private bank. Indeed that bank has been subsequently merged with a public sector bank.

5) We have also examined whether the fact of being listed on a stock exchange has an impact on the efficiency score of a bank (Table 8). It is expected that listed firms would make a greater effort to enhance shareholders value and, therefore, score higher in terms of profit efficiency. The results are on the expected lines and it is also observed that the differences between listed and non-listed banks in terms of efficiency scores is most pronounced in respect of profit efficiency.

Table 8: Revenue/Profit Efficiency (Median) of Listed vis-à-vis Non-Listed Indian Banks: 1997-2003

	Revenue Efficiency		Profit Efficiency	
YEAR	Non-Listed	Listed	Non-Listed	Listed
1997	0.872	0.876	0.285	0.391
1998	0.873	0.948	0.405	0.606
1999	0.896	0.942	0.311	0.435
2000	0.919	0.936	0.396	0.553
2001	0.910	0.877	0.370	0.468
2002	0.935	0.910	0.469	0.578
2003	0.921	0.955	0.599	0.717

Table 9: Bank Group-wise Profit Efficiency (Median) of Indian Banks: 1997-2003

Year	SBI & its Associates	Nationalized Banks	Indian Private Banks	Foreign Banks
1997	0.665	0.343	0.363	0.596
1998	0.835	0.316	0.514	0.677
1999	0.628	0.355	0.382	0.588
2000	0.680	0.510	0.488	0.650
2001	0.667	0.384	0.423	0.773
2002	0.715	0.513	0.541	0.620
2003	0.982	0.698	0.582	0.603

6) We compared the efficiency scores across conventionally defined banks groups. It is seen that the State Bank and its associates score much higher than all other groups in terms of profit efficiency (Table 9). As before, the other efficiency measures do not differentiate the bank groups so sharply as the profit efficiency measures. Over the years nationalized banks have been able to improve their profit efficiency scores considerably. By contrast, although average profit efficiency of foreign banks has

been much higher than that of nationalized banks in all but the last year in this study period, there is no clear evidence of improvement over time. The average efficiency scores of Indian private banks have moved erratically over the years but their performance has been more or less comparable to that of nationalized banks. Thus on the basis of measured efficiency scores it may be difficult to claim that privatization per se leads to greater efficiency, but at the same time it is also to be emphasized that greater managerial freedom enjoyed by a state owned bank that is listed in the stock market does help in boosting efficiency.

7) Finally, we computed Spearman rank correlations across various efficiency measures. Technical efficiency measures, input and output oriented, recorded very high correlation. Profit efficiency registered highest correlation with revenue efficiency, followed by cost efficiency. Apparently, revenue, rather than the cost, played a dominant role in determining profit efficiency of Indian banks.

VII. Conclusions

Separation of performers from non-performers is an avowed objective of efficiency studies based on variants of frontier methodologies. Using the nonparametric method of DEA as the analytical format, this paper empirically estimates the efficiency scores of banking firms of India - an emerging market economy that has witnessed the unfolding of a reform process in the recent past. In the pre-reform period the banks were subject to rigorous control over input and output prices and to some extent in the output mix as well. As the edifice of this control measures is slowly but steadily being dismantled, sharp differentiation between firms based on efficiency scores is expected to emerge**.**

Taking its study period as latest seven years of the post reform, the empirical analysis, however, finds that Indian banks are still not much differentiated in terms of input oriented or output oriented technical efficiency and cost efficiency. This is not unexpected because input prices and output prices and to some extent output mix are yet to be determined by the free play of market forces of demand and supply. However, most interestingly, the Indian banks are becoming sharply differentiated in terms of revenue efficiency and profit efficiency. This would imply that even within an environment subject to restriction on input or output mixes and its prices, a firm

can improve its profitability significantly, by adopting the best practices observed within the sector.

The paper also examines the average efficiency scores of the Indian banks classified into different groups based on a number of attributes. The results of this exercise provide interesting insight into the empirical correlates of efficiency scores of Indian banks. Some of the factors that are found to have positive impact on the average profit efficiency (and to some extent revenue efficiency) scores are asset size, ownership structure, and the fact of being listed on the stock exchange. Finally, we observe that the median efficiency scores of Indian banks in general and of bigger banks in particular have improved considerably during the course of our study period. This sends out a very positive signal about the effect of the reform process on the performance of the Indian banking sector.

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