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LIBERALISATION AND EFFICIENCY OF INDIAN COMMERCIAL BANKS: A STOCHASTIC FRONTIER ANALYSIS

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Abstract

The reforms introduced after 1992 are expected to have an impact on the performance of commercial banks. Thus the present study attempts to examine the efficiency level of Indian banks for the period 1985-2004. We employ the technique of stochastic frontier analysis to estimate bank specific cost, profit and advance efficiencies. Our results show that deregulation has significant impact on all three types of efficiency measures. Public sector banks rank first in two of the three efficiency measures showing that, as opposed to the general perception, these banks do not lag behind their private counter parts.

Introduction

The importance of financial systems for economic development is well recognized world wide [King and Levine, 1993; Levine, 1997; Levine and Zervos, 1998; Rajan and Zingales, 1998] as well as in India [RBI, 2000; Bhattacharya and Sivasubramanian, 2003]. Banks are the backbone of financial systems and play an important role in economic development. They act as intermediaries in channelising funds from surplus units to deficit units. An efficient banking system has significant positive externalities, which increases the efficiency of economic transaction in general. The Indian banking sector saw a major shift in the policy atmosphere after the introduction of financial sector reforms in 1992. These reforms are expected to have an impact on the operations of commercial banks. Also, one of the important objectives of financial sector reforms was to improve the efficiency of banking system (RBI, 2002).

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Thus it is essential to study the efficiency levels of Indian commercial banks to understand the impact of financial sector reforms on its performance.

The impact of deregulation on efficiency of different banking sectors has been found to be mixed across the globe. While in countries like Australia (Sturn and Williams, 2004) Spain (Vivas, 1997), Turkey (Isik and Hassan, 2003) and Norway (Berg *et al.,* 1992) financial liberalisation has positively affected the efficiency and productivity of commercial banks; in Italy (Boscia, 1999) and US (Bauer *et al.,* 1993) banking efficiency was relatively unchanged after deregulation. In Korea productivity has declined after deregulation (Mahadevan, 2004). A survey of 130 studies by Berger and Humphrey (2000) (which apply different frontier efficiency measurement techniques) of financial institutions in 21 countries shows that impact of deregulation on the efficiency of banks is mixed.

Most of the studies which look at the efficiency of Indian commercial banks use data related to either only pre-reform period [Bhattacharya, Lovell and Sahay, 1997; Keshari and Paul, 1994 or only post-reform period [Das, 1997; Shanmugam and Lakshmanasamy, 2001; Kumar and Verma, 2003; Mohan and Ray, 2004; Das *et al* 2005]. Furthermore many of them use data for a single time period which makes it difficult to compare the efficiency over two time periods. While few studies concentrate on the efficiency of only public sector banks, others look at the relationship between ownership and efficiency. Most of the studies use Data Envelopment Analysis (DEA) method as a technique of analysis.

Studies that cover both pre and post liberalisation periods mostly use parametric method of estimation [Kumbhakar and Sarkar, 2003; De, 2004; and Sensarma 2005]. In particular, while the main focus of Kumbhakar and Sarkar (2003) is to estimate the Total Factor Productivity; De (2004) estimates the efficiency levels of production outputs, and both these studies use data for the period 1985-1996. As reforms were

introduced only by 1992, studying their effect on the efficiency of banks in 1996 may not reveal the complete picture. Furthermore, since many reform measures have been introduced after 1996, there is a need to revisit the efficiency issue. Although the study by Sensarma (2005) uses data for the period 1985-2004, it looks at only cost and profit efficiency of commercial banks; whereas, it is observed that the objectives of commercial banks - which can be cost minimisation and/ or profit maximisation - are different from the objectives of the central bank of a country - which aims at the overall macroeconomic growth by making funds available for investment in the form of bank credit (Lightner and Lovell, 1998). Thus, besides the cost and profit efficiency, it is also essential to look at the impact of reforms on the ability of commercial banks to produce credit. Thus, the present study estimates three types of efficiency measures; cost, profit and advance (credit) efficiency, which measures the efficiency of banks in producing credit. Further, in the present study outputs are defined in a different way than in the study by Sensarma (2005)[1].

Given these objectives the paper is organized as follows. In the next section, a brief discussion about the Indian banking system and various reforms introduced after 1992 is given. The third section contains a brief discussion about the efficiency measurement technique. In the following section various approaches of output measurement in the banking sector are presented. While the penultimate section presents the data used for the study and the estimated results, the concluding section sums up the findings.

Indian Banking System and Policy Change

After independence the major development in the Indian banking sector was nationalisation of large commercial banks. In the post nationalisation period, there was a rapid expansion of banks in terms of coverage and deposit mobilisation. Large amount of credit was diverted for priority sector lending. In the post-nationalisation period, Government used the banking sector as an instrument to finance its

own deficit. This was done by high Cash Reserve Ratio (CRR) and Statutory Liquidity Ratio (SLR) (Sen and Vaidya, 1997). Along with high CRR and SLR, the operational freedom of the banks was curtailed with high priority sector lending norms (as high as 40% of the total lending in 1989-90). The Non Performing Assets (NPA) increased from 14% in 1969 to 35.4% in 1990. To keep the borrowing cost of the Government low, the interest rate on bank loan was fixed lower than market rates. This affected the profitability and efficiency of banks. Further, due to the dominance of the public sector banks there was no competition. In addition, due to the expansionary policy pursued by RBI, the number of loss making bank branches increased, especially in rural areas, which depleted resources of the banking industry.

In 1991, Indian economy faced a major balance of payment crisis. The foreign exchange resources had almost disappeared. Fiscal deficit was high and the inflation rate reached double digits. To overcome this crisis India introduced many economic reforms, which included financial sector reforms. Since financial resources were required for growth of the private sector, there was a need to overhaul the financial system; thus financial sector reforms were introduced in 1992.

The financial sector reforms in India began as early as 1985 itself with the implementation of the recommendations of Chakravarti committee report (Report of the Committee to Review the Working of the Monetary System). But the real momentum was given to it in 1992 with the implementation of recommendations of the Committee on Financial System (CFS) (Narasimham, 1991). Almost all of the recommendations of the CFS have been implemented in a phased manner. In 1998 another committee, the committee on Banking Sector Reforms (BSR) (Narasimham, 1998) was constituted. The recommendations of the BSR committee have also been implemented in a phased manner. Following are the important financial sector reforms introduced after 1992.

Reduction in the statutory pre-emption:

This includes reduction in CRR and SLR. At one stage (in 1991) CRR applicable to incremental deposit was as high as 15% and SLR was 38.5% thus pre-empting 53.5% of incremental deposits. These ratios were reduced in a series of steps after 1992. The SLR was reduced to 25% and CRR to 4.5% of the total deposit by 2005.

Interest rate liberalisation:

Before 1991, interest rates, both on deposits and loans were controlled by RBI. But after liberalization these rates were freed in a series of steps. The RBI now directly controls only the interest rates charged on credit to exports, and also there is a ceiling of lending rate on small loans up to Rs 2 lakhs. On the deposit side, except the interest rate paid on savings deposits, all other interest rates have been deregulated.

Increased autonomy and competition:

Considerable operational autonomy has been provided to the banks by reducing the government's stake in banks. Competition has been infused by allowing new private sector banks and more liberal entry of foreign banks (at the end of march 2001, there were 8 new private sector banks, 23 old private sector banks and 42 foreign banks as against 23 foreign banks in 1991).

Regulatory Norms:

These were aimed at reducing the vulnerability of financial institutions in the face of fluctuations in the economic environment. Important among them is capital adequacy ratio. Following the CFS report, the capital adequacy ratio was fixed at 8%. It was increased to 9% following the BSR recommendation. Apart from this, various prudential norms related to income recognition, asset classification, provisioning for bad assets (NPAs) and assigning risk to various type of assets have been introduced.

These reforms are expected to have an impact on the operations of banks. With reduced statutory requirements banks will have more funds at their disposal for commercial lending. And interest rate

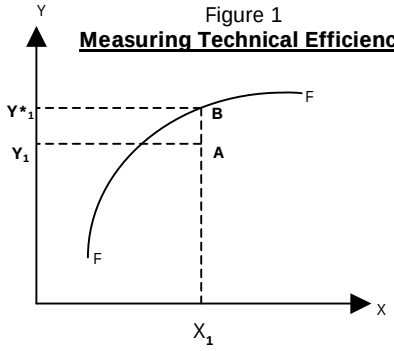
liberalisation is expected to bring flexibility and competition into the banking system. Competition is also infused by opening up banking sector for private and foreign banks. Along with these flexibilities certain regulatory reforms are also introduced, which are meant to make banks strong enough to face fluctuations in the economy. Overall, these reforms are aimed at improving the performance of banks. Thus it is important to see how far they have been successful in their objective. While performance of a bank can be measured in various ways, in the present study we use technical efficiency as a measure of the performance of Indian commercial banks. The concept and the method of measuring technical efficiency are discussed in the next section.

Measuring Efficiency

Efficiency has two components: one is purely technical or physical component which refers to the ability to avoid waste by producing as much output as input usage allows, or by using as little input as production allows. Thus the analysis of technical efficiency can have an output augmenting orientation or input conserving orientation. The other is the allocative or price component, which refers to the ability to combine inputs and outputs in optimal proportion in the light of prevailing prices (Lovell, 1993). Technical efficiency and Allocative efficiency together forms economic efficiency also called as X-efficiency. The basic assumption underlying the measurement of technical efficiency using frontier method is that a gap normally exists between a firm's actual and potential levels of technical performance (Kalirajan and Shand, 1999). The potential level of performance is given by the frontier which is locus of best performing firm(s) within the sample. Then, technical efficiency of a particular firm is measured as the ratio of actual performance to potential performance. This is shown in figure 1 where performance is measured in terms of output production.

Figure 1

Measuring Technical Efficiency



If a firm is operating at point 'A' using input 'X_1', its actual output is 'Y_1' and the corresponding potential output is 'Y^*_1' which is on the frontier 'FF', then the technical efficiency of the firm is given by the ratio Y_1/Y^*_1. The technical efficiency of a firm '*i*' can be given by the equation (Kumbhakar and Lovell, 2000),

$$TE_i = \frac{y_i}{f(x_i;\beta)} \qquad (1)$$

Where 'y_i' is the scalar output of producer '$i = 1,.....i$; 'x_i' is a vector of '*N*' inputs used by producer '*i* and [f (x_i;b)] is the production frontier (which is deterministic). The above model is the basic frontier model generally used for measuring technical efficiency. This basic model has been extended in a number of ways and various methods using different assumptions have been suggested in the literature to estimate frontier and thus the technical efficiency[2] . These methods can be broadly grouped under two major groups, namely, programming (deterministic) and statistical (stochastic) methods. In the programming (deterministic) approach efficiency levels of firms are estimated by using the linear programming method which does not take into account the statistical noise; but the advantage of this approach is that one need not impose a functional form. Alternatively, the statistical (stochastic) approach explicitly takes into account the random noise by including an error term in the specification, then the production frontier in the above model becomes

[$f(x_i;b)$. exp{v_i}] where 'v_i' is the statistical noise. But this approach has the danger of functional forms being specified wrongly. In the present study we use the approach used by Battese and Coelli (1995)[3]. Their model specification may be expressed as

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}) \qquad i = 1.....N; \quad t = 1.....T, \qquad (2)$$

Where 'Y_{it}' is the log of output of the i^{th} firm in t^{th} period, 'x_{it}' is a vector of input quantities, 'V_{it}' are random variables which are assumed to be iid, N (0, s_v^2) and independent of 'U_{it}'; 'U_{it}' are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the N(m_{it}, s_u^2) distribution; where $m_{it} = z_{it}d$; where; 'z_{it}' is a '1 x p' vector of variables which may influence the inefficiency of a firm and 'd' is a 'p x 1' vector of parameters to be estimated. The parameterization from Battese and Corra (1977) are used replacing s_v^2 and s_u^2 with $s^2 = s_v^2 + s_u^2$ and the parameters are estimated by Maximum Likelihood approach[4].

In the present study, we estimate a cost frontier a profit frontier and an advance (credit) frontier, which can be given as (cross-section and time subscripts are subsumed)

$$Cost = f(Y,W) + (V+U) \qquad (3)$$

$$Profit = f(Y,W) + (V-U) \qquad (4)$$

$$Advance = f(Y,W) + (V-U) \qquad (5)$$

Where 'Y' is the vector of outputs which includes advance and investment, and 'W' is the vector of input prices which includes price of capital, price of labour and price of deposits (definitions of these variables are given in section 4). The above frontier functions are estimated by using translog functional form[5]. In the case of profit efficiency the inefficient firms are expected to operate below the frontier, thus the term '$-U_i$' has a negative sign showing how far the firm operates below the profit frontier. Thus the profit efficiency is measured as the ratio

between actual profit and maximum possible profit that is achievable by the most efficient firm. Whereas, in the case of Cost frontier, inefficient firms are expected to operate above the frontier, thus the term 'U_i' has a positive sign showing how far the firm operates above the cost frontier. Thus the cost efficiency is measured as the ratio between minimum costs that is achievable by the most efficient firm to the actual cost. Advance efficiency is measured in the same way as profit efficiency, i.e., as the ratio of actual advance to the maximum possible advance produced by the best performing firm in the sample.

While advance and cost frontiers are specified in the standard manner as followed in the literature, profit frontier is specified in a slightly modified manner. In the literature there are two ways of specifying a profit frontier. One is the standard profit function (text book type), the other is the alternative profit function. Standard profit efficiency measures how close a firm is to earning the maximum possible profit, given a particular level of input prices and output prices. Alternative efficiency measures how close a firm is to earning maximum possible profit, given its output levels (rather than its output prices) and input prices (Berger and Mester, 2000). Thus standard profit function is defined as a function of output prices and input prices, whereas alternative profit function is defined as a function of output quantities and input prices. As in the case of Indian banking sector reliable data on output prices are not available for the entire study period, we chose to use alternative profit frontier.

Measurement of Variables

One of the most debated issues in the banking literature is output measurement. There is no consensus in defining bank outputs, as many of them are jointly produced. Various approaches of measuring output can be grouped into two broad categories: (a) Production approach and (b) Intermediation approach. The *production approach*, initiated by the work of Benston (1964) and Bell and Murphy (1968), describes banking activities as the production of services to depositors and borrowers. Under this approach output is measured by the number and type of transactions

or accounts[6] (both deposit and loan) and inputs used are only physical units such as labour and capital since only physical inputs are needed to provide financial services. Under *intermediation approach*, financial institutions are thought of as primarily intermediating funds between savers and investors. Under this approach, the inputs of the main branch are essentially financial capital (i.e., the deposits collected by local branches and the funds borrowed from financial markets and their interest cost), and outputs are measured by the volume of loans and investments outstanding. In addition to the above two, various alternative approaches have been used[7]. However, it has been suggested by various writers that the researcher can adopt any measure of output for the financial firm as long as the measure is consistent with the researcher's goal (Sealey and Lindley, 1977).

The present study adopts intermediation approach to specify outputs and inputs of commercial banks. Accordingly advances and investment are defined as the two outputs of commercial banks which are produced by using inputs like labour, capital, funds (which is mainly deposits) and material. Thus the dependent variable of the cost frontier function is the 'total cost' which includes total operating cost and total interest expenditure. Explanatory variables include two output variables- (i) advances and (ii) investments; and three input prices (i) price of capital (ii) price of labour and (iii) price of deposits[8] (measurement of these variables is explained in the next section). The profit frontier function is specified in the same way as cost function with one change, that is, the dependent variable in the profit function is net profit[9]. Finally, the dependent variable in the advance frontiers is the total advance and the explanatory variables included are labour, capital (fixed), funds and material. All nominal values are converted into real values by deflating with GDP deflator and all values are in their natural logarithms.

After finding the efficiency scores (which are obtained by estimating frontier equation), we try to examine determinants of efficiency by taking into account the effect of some variables (This is done by

regressing the inefficiency estimates over a set of variables which can explain the inefficiency of banks). The variables included in the inefficiency equation for advance, which are determinants of the inefficiency of a firm, are (a) total asset (proxy for the bank size) (b) Herfindahl index[10] (a measure of competition in the market) (c) a trend variable (d) dummy for deregulation (which has the value 1 for 1993 and thereafter) and three bank group specific dummies[11]. Variables included in the inefficiency equation for cost and profit frontiers are the same as those included in advance investment frontiers, except Herfindahl index.

Data set

Data collected are for the period 1985-2004. However, as many private and foreign banks were established after 1995 and few were closed during the study period, data are not available consistently for all banks for all years. Thus we have an unbalanced panel of 94 banks for 20 years (total observation used being 1597). Banks are devided into four groups[12] (i) State Bank of India and Associates (SB & A) (ii) Nationalised Banks (NB) (iii) Private Banks (PB) and (iv) Foreign Banks (FB). Data on the number of employees are collected from the *Performance Highlights of Banks* published by Indian Banks' Association, and data on the rest of the variables included in the advance frontier are collected from *Annual Accounts of Scheduled Commercial Banks* published by Reserve Bank of India. Advances are measured as total advances. Fixed capital (or capital stock) is the sum of premises, furniture and other fixed assets[13]. These data are collected from the balance sheets of respective banks. The number of employees is measured as the total number of employees which include officers, sub-ordinates and clerks. Material is measured as the sum of expenditure on printing & stationeries, postage and telegrams & telephones etc.

Apart from the variables mentioned above, data on cost, profit and other variables included in cost and profit frontiers are obtained from earning and expenditure statements of respective banks. Price

of labour (employees) is obtained by dividing the total expenditure on employees by the total number of employees and the price of capital is obtained by = (total operating cost – total expenses on labour)/ total fixed assets[14]. Price of deposits is obtained by dividing the total interest expenditure on deposits by total deposits.

Empirical Results

In any analysis using frontier technique, in order to obtain the efficiency estimates, it is essential to first estimate the value of the frontier coefficients. The estimated coefficients of all three frontiers (Cost, Profit and Advance) are reported in the Appendix. We observe that the Likelihood Ratio (LR) exceeds the critical value suggesting that gamma is significant in all cases. This validates the use of Frontier specification instead of average response function. The value of gamma in all five frontier cases shows that majority of residual variation is due to the inefficiency effect[15]. The bank-specific efficiency estimates obtained from frontier estimates are averaged across bank-group in each year and are presented here.

Cost Efficiency Results

After estimating the cost frontier (equation 3), cost efficiency of bank '*i*' at time '*t* ' is estimated as the ratio between minimum cost (cost of the best performing bank in the sample) and the actual cost (cost of bank '*i*' at time '*t*'). These cost efficiency estimates are presented in

Table 1: Cost Efficiency Estimates

Year	SB & A	NB	PB	FB	Total
1985	0.958	0.966	0.861	0.855	0.899
1986	0.950	0.971	0.855	0.876	0.904
1987	0.945	0.967	0.859	0.823	0.888
1988	0.944	0.968	0.852	0.838	0.890
1989	0.942	0.968	0.861	0.841	0.894
1990	0.944	0.956	0.843	0.868	0.892
1991	0.945	0.969	0.841	0.864	0.893
1992	0.946	0.954	0.817	0.805	0.863
1993	0.953	0.960	0.823	0.847	0.881
1994	0.957	0.969	0.845	0.899	0.906
1995	0.955	0.963	0.841	0.837	0.881
1996	0.948	0.961	0.841	0.837	0.876
1997	0.960	0.969	0.885	0.847	0.895
1998	0.959	0.971	0.890	0.847	0.897
1999	0.961	0.972	0.907	0.856	0.907
2000	0.964	0.971	0.909	0.844	0.904
2001	0.961	0.968	0.902	0.833	0.897
2002	0.958	0.967	0.893	0.839	0.897
2003	0.957	0.961	0.888	0.805	0.882
2004	0.902	0.957	0.874	0.766	0.858
Average	**0.950**	**0.965**	**0.864**	**0.841**	**0.890**

The average cost efficiency estimate of 0.89 for total banking industry suggests that on average banks are 89 percent efficient in optimally incurring input costs compared to the best practising bank operating in the same environment[16]. Public sector banks (SB&A and NB) are more efficient than private and foreign banks. The reason for private and foreign banks being less cost efficient is that they incur high establishment expenditure. Their capital expenditure is higher than public sector banks and they pay high salaries for their employees. It is also noticed that large part of the funds mobilized by foreign banks are in the form of borrowing, for which they have to pay high interest. While the temporal behaviour of cost efficiency of public sector banks (SB&A and NB) is almost stable, in the case of private sector banks and foreign banks the trends are opposite to each other. The cost efficiency of private banks shows an increasing trend all through the study period, for foreign banks it increases till 1994 and then declines. This may be due to the entry of new foreign banks around 1995 with huge establishment expenditure which raised the cost level.

We next try to look at the determinants of cost inefficiency. This is done by regressing the inefficiency estimates over a set of variables which can explain the inefficiency of banks. The estimated coefficients are presented in Table 2. Size variable (measured by total assets) has a negative relation with inefficiency which means larger banks are less (more) cost inefficient (efficient). Thus there appears to be economies of scale in the Indian banking sector. Deregulation dummy is significant showing that it has an impact on the cost efficiency. The negative sign of deregulation dummy shows that the average cost inefficiency of the total banking sector (efficiency) has declined (increased) in the deregulation period. This may be because of the reduction in the wage bill of many public sector banks after they cut down the number of employees through schemes like Voluntary Retirement Scheme.

Table 2: Determinants of Cost Inefficiency

	Coefficient	Standard Error	t-ratio
Constant	2.1065*	0.0838	25.1463
Total Asset	-0.8992*	0.0279	-32.2661
Time	0.0245*	0.0024	10.3013
DEREG	-0.0632***	0.0318	-1.9888
NB	-0.5393*	0.0313	-17.2260
PB	-0.1511*	0.0453	-3.3366
FB	-0.2084*	0.0483	-4.3147

*- Significant at 1%, *** - Significant at 10%

Cost efficiency only tells us how best a firm is incurring costs but it does not reveal anything about the earnings side (Berger et al, 2000). As we will see in the next section, a firm which is more cost efficient need not be more profit efficient. For example, a firm that spends Re 2 to raise revenue of Re 5 (may be due to better technology), would be measured as more profit efficient but would be measured as less cost efficient in comparison with a firm which spends Re 1 to raise a revenue of Re 2. Thus profit efficiency issue is taken up in the next section.

Profit Efficiency Results

Like cost efficiency estimates, here too we obtain the profit efficiency estimates after estimating the profit frontier presented in equation 4. But, unlike cost efficiency, profit efficiency is estimated as the ratio between actual profit (profit of bank '*i*') and the maximum possible profit (profit of the best performing bank in the sample). The average profit efficiency of the total banking sector (presented in table 3) is around 89.6 percent, which suggests that on an average 10.4 percent profit is lost, relative to the bank with best practice, due to technical inefficiency.

Unlike in the case of cost efficiency, here private bank group ranks first with a profit efficiency level of 97 percent. Public sector banks rank second and foreign banks are the least efficient. The reason for private banks being most efficient is that their non-interest income is higher than public sector and foreign banks, which is mainly because they focus more on providing fee based services than conventional banking activities. The temporal behaviour of the profit efficiency estimate of total banking sector shows a varying trend. At the bank group level, the profit efficiency of SB&A, NB and PB are almost stable. Whereas, the profit efficiency of foreign banks declines from 1995 to 1999 and increases thereafter. As mentioned above, many foreign banks entered Indian banking sector after 1995. In the initial stage due to their high establishment expenses their profit level will be low but after a period of time their profit level may show a different trend.

Table 3: Profit Efficiency Estimates

Year	SB & A	NB	PB	FB	Total
1985	0.958	0.967	0.967	0.695	0.891
1986	0.963	0.972	0.973	0.695	0.895
1987	0.965	0.971	0.972	0.725	0.900
1988	0.953	0.963	0.967	0.728	0.896
1989	0.943	0.954	0.953	0.740	0.891
1990	0.968	0.968	0.976	0.754	0.907
1991	0.966	0.968	0.975	0.756	0.903
1992	0.969	0.971	0.978	0.800	0.919
1993	0.963	0.926	0.977	0.764	0.895
1994	0.966	0.922	0.979	0.832	0.916
1995	0.967	0.972	0.983	0.814	0.927
1996	0.949	0.943	0.970	0.730	0.887
1997	0.956	0.967	0.972	0.738	0.887
1998	0.963	0.970	0.970	0.729	0.882
1999	0.955	0.960	0.969	0.690	0.866
2000	0.958	0.961	0.973	0.709	0.877
2001	0.946	0.946	0.970	0.735	0.879
2002	0.960	0.959	0.973	0.747	0.891
2003	0.967	0.968	0.972	0.754	0.895
2004	0.944	0.977	0.977	0.831	0.924
Average	**0.959**	**0.960**	**0.972**	**0.748**	**0.896**

We next look at the determinants of Profit inefficiency. Estimated coefficients of bank group specific determinants of profit inefficiency are presented in Table 4. Bank size does not seem to have any impact on the profit (in)efficiency of commercial banks. Coefficient of time variable shows that, on average, profit inefficiency of total banking sector is declining over time; in other words, profit efficiency is increasing. The coefficient of deregulation shows that the average inefficiency of total banking sector has increased over time, which means the average efficiency has declined after deregulation.

Table 4: Determinants of Profit Inefficiency

	Coefficient	Standard Error	t-ratio
Constant	-1.0467*	0.0842	-12.4301
Total Asset	0.0003	0.0114	0.0262
Time	-0.0137*	0.0022	-6.1807
DEREG	0.0617*	0.0235	2.6322
NB	-0.0273	0.0418	-0.6537
PB	-0.6307*	0.0703	-8.9683
FB	1.3715*	0.0798	17.1928

*- Significant at 1%

The reason for the declining profit efficiency of commercial banks in the post-liberalisation period is the squeeze in net profit faced by many commercial banks due to various reasons, one of them being the declining interest income in the post-liberalisation period due to the declining interest rate margin[17].

As mentioned earlier, given the different objectives of banks themselves (which can be cost minimisation and/or profit maximisation) and that of the central bank (overall economic growth by making funds

available for investment in the form of bank credit), apart from the cost and profit efficiency it is also essential to look at the impact of reforms on the advance efficiency. Thus in the next section we look at the advance efficiency of Indian commercial banks[18].

Advance efficiency results

Advance efficiency is measured as the ratio between actual advance (of bank '*i*') and the maximum possible advance (of the best performing bank in the sample) and is presented in Table 5. On average Indian banks are 88.7 percent efficient in producing advances relative to the best practicing bank during the study period. Public sector banks (SB&A and NB) are more efficient in producing advances compared to private and foreign banks. The temporal behaviour of advance efficiency shows that it is declining over time, across bank groups. This decline is more in the case of foreign banks, particularly after liberalisation, compared to other bank groups. The declining advance efficiency of commercial banks could be attributed to the reason that commercial banks are diverting more of their funds towards investment rather than lending[19].

Table 5: Advance Efficiency Estimates

Year	SB&A	NB	PB	FB	Total
1985	0.965	0.956	0.928	0.874	0.925
1986	0.964	0.955	0.919	0.880	0.923
1987	0.956	0.939	0.895	0.865	0.905
1988	0.965	0.950	0.900	0.860	0.910
1989	0.971	0.958	0.906	0.855	0.913
1990	0.971	0.958	0.916	0.854	0.915
1991	0.974	0.960	0.911	0.800	0.895
1992	0.981	0.964	0.902	0.820	0.901
1993	0.980	0.959	0.898	0.803	0.893
1994	0.967	0.930	0.884	0.821	0.885
1995	0.973	0.939	0.892	0.836	0.895
1996	0.972	0.943	0.919	0.880	0.917
1997	0.974	0.931	0.899	0.849	0.894
1998	0.974	0.932	0.882	0.820	0.877
1999	0.962	0.931	0.873	0.758	0.851
2000	0.962	0.934	0.875	0.763	0.855
2001	0.962	0.939	0.871	0.750	0.851
2002	0.962	0.950	0.880	0.747	0.857
2003	0.958	0.951	0.886	0.724	0.851
2004	0.927	0.950	0.878	0.672	0.828
Average	**0.966**	**0.946**	**0.896**	**0.811**	**0.887**

We now deal with the determinants of advance inefficiency. The estimated coefficients of bank specific variables which explain the differences in the advance inefficiency across banks are presented in Table 6. Coefficient of bank size has a negative influence on advance inefficiency, which means, larger banks are less inefficient (more efficient) than small banks in producing loans. Similar results were observed for cost inefficiency also. This indicates that there may be economies of scale operating in Indian banking sector. Herfindahl index has a negative relation with advance inefficiency indicating that when competition is increasing efficiency is increasing. Time variable shows a positive influence on inefficiency which means advance efficiency is decreasing over time. Deregulation variable becoming significant shows that deregulation have an impact on advance efficiency.

Table 6: Determinants of Advance Inefficiency

	Advance	Standard Error	t-ratio
Constant	1.7009*	0.2037	8.3504
Total Assets	-0.6782*	0.0463	-14.6447
Herfindahl Index	-11.5906*	1.4849	-7.8059
Time	0.0323*	0.0033	9.8373
DEREG	0.1243**	0.0542	2.2950
NB	-0.1011	0.1489	-0.6792
PB	0.2101***	0.1074	1.9564
FB	0.6215*	0.1009	6.1623

*- Significant at 1%, ** - Significant at 5 %, *** - Significant at 10%

Conclusion

Indian banking sector changed significantly with respect to the policy environment after financial sector reforms were introduced in 1992. These reforms are expected to affect the operations of commercial banks. The present study attempts to measure the efficiency of Indian commercial banks for the period 1985-2004. For this purpose we have estimated cost efficiency, profit efficiency and advance efficiency estimates using Battese and Coelli (1995) approach. Our results show that deregulation has significant impact on all three types of efficiency measures[20]. While advance efficiency has not shown much improvement after deregulation, cost and profit efficiency shows varying trends. Though the efficiency estimates cannot be strictly compared across different frontiers, we notice that the efficiency ranking of bank groups differs in each frontier. While NBs rank first in cost efficiency estimates, PBs rank first in profit efficiency and SB&A rank first in advance efficiency estimate. This suggests that using a single frontier to measure efficiency might lead to misleading results, thus validating our approach of estimating three different frontiers.

One of the reasons for public sector banks being less profit efficient compared to private banks is that, Public Sector Banks (PSB) (SB&A and NB) spend around 15 percent of their total income on salaries, whereas PBs spend around 8 percent of their income on salaries. This shows that the income generated per employee is higher in the case of PB compared to PSBs. Thus, if PSBs are given autonomy to decide on their employment level and wage bill, it will help them to achieve higher profit which will in turn lead to higher profit efficiency.

Our results show that Foreign Banks (FB) are the least efficient in all three efficiency measures. This might be because of their small scale of operation as they are regulated in many respects. However in the post-reform period many of these regulations are being relaxed (for example FB are allowed to have Wholly Owned Subsidiaries, they are allowed to open more branches, acquire domestic private banks up to 74

percent etc.)[21]. If foreign banks take this opportunity and expand their operations then it will help them to improve their efficiency level[22].

It is important to observe that, though PSB were the most controlled banks during the pre-liberalisation period and still continue to be controlled to some extent, they are the most efficient in two of the three efficiency estimates. Even in the profit efficiency measure, the difference between private and public sector banks is minute. This shows that, as opposed to the general perception, public sector banks are not lagging behind their private counterparts[23].

While studying the determinants of inefficiencies we found that bank size (measured by asset) is positively related to efficiency level of banks. Large banks are more efficient than smaller ones, which shows that there seems to be economies of scale working in Indian banking sector. This suggests that merging smaller banks would lead to greater efficiency. Competition (measured by Herfindahl index) also seems to have a positive impact on the efficiency of commercial banks[24]. So, apart from mergers efficiency can also be increased by increased competition.

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Appendix

Table 7: Cost Frontier Estimates

	Coefficient	Standard-Error	t-ratio
Constant	0.2775**	0.1341	2.0699
Adv	0.0866	0.1096	0.7895
Inv	1.2447*	0.1005	12.3867
W	0.3143*	0.0965	3.2565
D	0.5324*	0.0786	6.7707
T	-0.0440*	0.0082	-5.3499
Adv^2	0.1026*	0.0203	5.0605
Inv^2	0.0973*	0.0231	4.2214
W^2	-0.0215	0.0205	-1.0471
D^2	0.1336*	0.0173	7.7432
T^2	0.0004*	0.0002	2.3617
Adv*Inv	-0.2407	0.0407	-5.9104
Adv*W	0.1899*	0.0415	4.5790
Adv*D	-0.0429	0.0399	-1.0773
Adv*T	0.0175*	0.0039	4.4720
Inv*W	-0.2569*	0.0385	-6.6667
Inv*D	0.1556*	0.0386	4.0347
Inv*T	-0.0165*	0.0037	-4.4998
W*D	-0.0530***	0.0299	-1.7759
W*T	-0.0002	0.0031	-0.0708
D*T	-0.0085**	0.0029	-2.9151
sigma-squared	0.0812*	0.0065	12.5788
gamma	0.9582*	0.0033	288.2143
Log Likelihood Ratio = 1320.4137			
LR test of the one-sided error = 1180.6713			

Note: Adv-Advances; Inv-Investments; W-Wage to Capital price ratio; D-Deposit price to capital price ratio; T- time trend

* - Significant at 1%, ** - Significant at 5 %, *** - Significant at 10%

Table 8: Profit Frontier Estimates

	Coefficient	Standard-Error	t-ratio
Constant	0.2775**	0.1341	2.0699
Adv	0.0866	0.1096	0.7895
Inv	1.2447*	0.1005	12.3867
W	0.3143*	0.0965	3.2565
D	0.5324*	0.0786	6.7707
T	-0.0440*	0.0082	-5.3499
Adv^2	0.1026*	0.0203	5.0605
Inv^2	0.0973*	0.0231	4.2214
W^2	-0.0215	0.0205	-1.0471
D^2	0.1336*	0.0173	7.7432
T^2	0.0004*	0.0002	2.3617
Adv*Inv	-0.2407	0.0407	-5.9104
Adv*W	0.1899*	0.0415	4.5790
Adv*D	-0.0429	0.0399	-1.0773
Adv*T	0.0175*	0.0039	4.4720
Inv*W	-0.2569*	0.0385	-6.6667
Inv*D	0.1556*	0.0386	4.0347
Inv*T	-0.0165*	0.0037	-4.4998
W*D	-0.0530***	0.0299	-1.7759
W*T	-0.0002	0.0031	-0.0708
D*T	-0.0085**	0.0029	-2.9151
sigma-squared	0.0812*	0.0065	12.5788
gamma	0.9582*	0.0033	288.2143
Log Likelihood Ratio = 1320.4137			
LR test of the one-sided error = 1180.6713			

Note: Adv-Advances; Inv-Investments; W-Wage to Capital price ratio; D-Deposit price to capital price ratio; T- time trend

* - Significant at 1%, ** - Significant at 5 %, *** - Significant at 10%

Table 9: Advance Frontier Estimates

	Coefficient	Standard-Error	t-ratio
Constant	1.0464*	0.0862	12.1328
F	0.1315***	0.0659	1.9969
C	0.3108*	0.0651	4.7763
E	-0.0377	0.0474	-0.7958
M	6.7922*	1.4980	4.5341
T	0.0145**	0.0049	2.9439
F2	0.1652*	0.0211	7.8361
C2	-0.0095	0.0191	-0.4971
E2	-0.0254	0.0164	-1.5508
M2	2.5692	1.9674	1.3059
T2	0.0002***	0.0001	1.7295
F*C	-0.1729*	0.0379	-4.5649
F*E	0.0269	0.0322	0.8350
F*M	-2.4425*	0.7910	-3.0878
F*T	-0.0018	0.0030	-0.6084
C*E	0.0648*	0.0201	3.2298
C*M	1.8708*	0.5984	3.1263
C*T	0.0036	0.0021	1.7070
E*M	-0.1748	0.3541	-0.4935
E*T	-0.0051**	0.0019	-2.7125
T*M	-0.0207	0.0276	-0.7502
sigma-squared	0.1120*	0.0084	13.2946
gamma	0.9826*	0.0019	521.4478
log likelihood function = 1408.72			
LR test of the one-sided error = 1512.815			

Note: F-Funds; C-Capital; E-Employment; M- Material, T- Time trend

* - Significant at 1%, ** - Significant at 5 %, *** - Significant at 10%

End Notes

[1] While Sensarma (2005) defines deposits as outputs, we define them as inputs.

[2] See Lovell (1993) and Coelli *et al* (1998) for a review of various methods of measuring technical efficiency.

[3] They use Stochastic Frontier Analysis which explicitly account for statistical noise.

[4] The log-likelihood function is given in Battese and Coelli (1993)

[5]Translog is more flexible than Cobb-Douglas as it does not impose restrictive assumptions like fixed Returns to Scale and an elasticity of substitution equal to unity.

[6] However, the usual approach is to use the dollar amounts, which are more readily available.

[7] See Berger and Humphrey (2000) for a brief review on this.

[8] In the final estimation the ratio of labour price to capital price and of deposit price to capital price are included in the function.

[9] The dependent variable for the profit function is measured as $[\pi + |\pi|^{min} + 1]$, where $|\pi|^{min}$ is the absolute of the minimum value of net profit (π) over all banks. Since the net profit of most banks are negative the constant $[|\pi|^{min} + 1]$ is added to every firm's net profit so that the natural logarithm is taken of a positive number.

[10] Hefindahl Index = $\sum Si^2$, where Si is the output share of each firm in the output of total industry

[11] We do not consider the State Bank of India and Associates (SB&A) dummy to avoid dummy variable trap. Therefore, the specified dummy variables should be interpreted in comparison to the SB&A which serves as the base.

[12]This grouping is done following the standard classification of RBI

[13] Capital stock is converted into its present value using perpetual inventory method

[14] Similar method is used by Kumbhakar and Sarkar (2003)

[15] A value zero for gamma indicates that the deviations from the frontier are due entirely to noise, whereas a value of one would indicate that all deviations are due to technical inefficiency. Gamma is estimated as; $\gamma = \sigma^2/\sigma_s^2$, where σ^2 is the variance of u_i (inefficiency term), and σ_s^2 is total variance (variance of v_i plus variance of u_i).

[16] Alternatively, around 11 percent of the costs are wasted, on average, relative to the best-practice firm due to technical inefficiency.

[17] The interest income as percent of total assets of the total banking sector declined from around 10.26 percent in 1992 to around 7.29 percent in 2004

[18] Ideally one should look at efficiency estimates of advance as well as investment as these are the two ouputs produced by commercial banks. While we have looked at the efficiency estimates of both advances and investments, in this paper we present only the results of advance efficiency as providing credit is the most important activity of a commercial bank.

[19] This is evident from the fact that Credit to Deposit ratio is declining (it was around 60% in 1991-92 which has declined to around 53 % in 2002-03) where as investment to deposit ratio is increasing over time (it was around 37% in 1991-92 which has increased to around 42 % in 2002-03).

[20] While Sensarma (2005) has found that the deregulation does not have any impact on cost efficiency, but has significant impact on profit efficiency, De (2004) has found that for more than two third of the banks in the sample, efficiency (measured in terms of gross income and total earnings) is stable throughout the study period.

[21] See Karunagaran (2006) for more discussion on the development of foreign banks in India.

[22] Our results show that size has a positive impact on efficiency level.

[23] Similar results are obtained by Sensarma (2005) and Mohan and Ray (2004). However, Das *et al* (2005) has found that there is no difference among bank groups. Results of Keshari and Paul (1994) show that, though there is not much difference among bank groups in terms of efficiency, public sector banks are around 1 percent more efficient than other bank groups.

[24] Kumbhakar and Sarkar (2003) too have found that competition has positive impact on the productivity of Indian commercial banks.