Are more productive banks always better?

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Abstract

In this paper we analyse the patterns, sources and beneficiaries of productivity gains in the Indian banking sector. We document the relative efficiency of different groups of banks by ownership. We quantify the magnitude of gains using the Data Envelopment Analysis and the Malmquist Index techniques for a sample of 37 commercial banks during the period 2002-2018. We find that the Indian banking sector experienced steady productivity growth till about 2010-11, and after that efficiency gains stagnated and even got reversed in the more recent years. The public sector banks stand out in particular. They experienced greater productivity growth compared to the private banks during 2002-2010, mostly benefitting from improved technology, and then a decline in efficiency from 2011 onwards, especially from 2015 to 2018. We conduct a detailed descriptive analysis to identify the beneficiaries of the gains and find that most of the gains may have accrued to the shareholders which for the public sector banks would mean the Government. We then make a series of observations about the period of rapid productivity growth in the Indian banking sector preceding a prolonged phase of balance sheet sress during which non-performing assets increased manifold. This raises important questions about how productivity in banking should be measured.

JEL classification: G21, G28, D24, D61

Keywords: Banking, Bank productivity, Data envelopment analysis, Indian commercial banks, Malmquist index,, Technical efficiency

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1 Introduction

An important source of economic growth is productivity growth. Productivity can be studied at the level of the entire economy and also for specific sectors. The banking sector is a significant pillar of the Indian economy and is the cornerstone of financial intermediation. Until the recent episode of banking crisis, banks contributed more than 90% of the economy's commercial credit. Total banking income accounts for roughly 6% of Indian GDP.[1] With a total asset size of Rs 163 trillion (US$2.2 trillion) it is also among the largest banking systems in the world. A comprehensive assessment of the productivity gains in the banking sector can therefore provide important insights into the overall productivity growth of the Indian economy.

In this paper, aim to study the productivity growth in Indian banking over the last couple of decades as well as across different ownership groups. India presents an interesting case to study efficiency of the banking sector.[2] After decades of financial repression and government control and ownership of almost 90% of the banking sector, India adopted a series of deregulation, liberalisation and privatisation reforms in early 1990s thereby forcing the erstwhile public sector banks to compete with private and foreign banks in a more open, and market-oriented environment.

Since then, Indian banking has witnessed many significant changes such as the rapid growth of privately owned banks, growth of foreign banks, growth along with expansion of reach of formal banking services, series of banking sector reforms to improve income recognition and asset classification, emergence of new forms of banks such as payment banks and small finance banks, gradual penetration of computers and information technology in all strata of banking, improved risk management practices, harmonisation of the regulatory regime with global standards and so on.

All these changes would have crucial and deep-rooted implications for the overall productivity of the banking sector. Specifically for the government owned, public sector banks that currently account for roughly 70% of the total banking sector assets, rapid adoption of technology since the 1990s may have resulted in significant productivity gains. Against this background it would be interesting to study the evolution of productivity gains in the banking sector over a long period of time and understand the sources of these gains.

One parameter that demonstrates these gains is employment in banking. Between 1991 and 2010, despite growing at over 15%, Indian banking did not add to net employment. It employed about the same number of people in 2010 as it did 1991. In fact, employment fell across both private and public sector banks between 2000 and 2009. Yet during this period, the banking sector balance sheet grew by 25%. Balance sheet per employee grew phenomenally between mid 1990s and 2010. This hints at dramatic improvements in productivity.

Another indicator of productivity growth is consistent reduction in costs. Preliminary data analysis shows that operating costs as percentage of total assets began declining from mid 1990s onwards, implying substantial productivity gains. Since 2010 however it appears that productivity growth in the overall banking sector has slowed down and may have even stalled. The data also reveals some convergence that has taken place between private and public sector banks in terms of productivity gains. We discuss this in greater detail in section 2 of the paper.

Our preliminary data analysis provides a high level view of how productivity may have evolved in the Indian banking sector over the last couple of decades. The story that emerges motivates

[1] Interest income and other non-interest income earned by scheduled commercial banks who account for over 95% of the assets of the banking system

[2] In this paper we use 'productivity' and 'efficiency' or 'technical efficiency' interchangably, to imply the same notion.

us to explore the evolution of productivity growth and analyse the sources of productivity gains for the entire banking sector as well as for banks in the two main ownership groups (public and private), using a rigorous empirical framework.

Accordingly, in this paper we attempt to measure productivity gains of the banking sector over the period 2002-2018, understand the sources of productivity gains, discern the patterns of these gains across various categories of banks based on ownership, and finally examine which stakeholders the productivity gains have accrued to, over the years and across bank groups. As the literature survey of Berger and Humphrey (1997) shows, that studies on bank efficiency can contribute to policy making, academic research as well as improving bank management.

In the extant literature there are two ways to measure bank productivity: the interrmediation approach and the production function approach. As described in Sanyal and Shankar (2011), the intermediation approach uses a combination of data envelopment analysis (DEA) and Malmquist Index (MI). Both these methods are non parametric in nature and are based on a linear input-output programming technique. They help estimate the efficiency of an organisation relative to a benchmark or a frontier. The production function method on the other hand is based on a stochastic frontier approach and uses a parametric translog cost function to estimate the efficiency frontier.

The disadvantage of the second method is that it assumes a specific form of the production function. The primary advantage of the DEA method on the other hand is that it is a non parametric approach and is not based on any particular functional form for the production frontier. Also it uses multiple inputs and outputs which is a good fit for the banking system because banks typically produce many financial services (outputs) using a given set of inputs. The drawback of the DEA method is that it does not distinguish between random error and inefficiency and assumes that all deviations from the estimated frontier represent inefficiency.

A large number of studies have been conducted using either of these two methods for the banking sectors of various countries, including India.[3] There exist a number of studies that analyse efficiency in the Indian banking sector in the post-1991 reform period using the DEA approach. Majority of these studies have explored the effect of the deregulation and liberalisation reforms of early 1990s on productivity growth in the banking sector.[4] Our study broadly fits into that literature, but in some sense it is broader in scope.

With this paper we contribute to the literature in three ways. To the best of our knowledge majority of the studies in the productivity literature on Indian banks are restricted to the immediate post-deregulation era with sample periods ending roughly in the mid 2000s. Since then many changes have taken place in the banking landscape which would impact productivity as alluded to earlier. The two most important phenomena being substantial expansion by private sector banks which would have changed the competitive dynamics of the entire banking sector and secondly, rapid penetration of technology into the system. These factors would significantly affect the evolution of productivity since late 1990s and the distribution of productivity gains across different ownership groups of banks. A study spanning a long time period is able to capture these nuances.

Secondly ours is the first attempt to investigate who have the productivity gains accrued to among the various stakeholders in the banking sector. The four main stakeholders who can benefit from productivity gains in banking are employees, depositors, borrowers, and shareholders. It is likely that parts of the gains accrued to all these classes of claimants. We try to assess how

[3]See for example Berger and Humphrey (1997), Kumbhakar et al. (2001), Canhoto and Dermine (2003), Das and Shanmugam (2004), Sensarma (2006), Casu et al. (2010), among others, and the references therein.

[4]See for example, Bhattacharyya et al. (1997), Sathye (2003), Das et al. (2005), Das and Ghosh (2006), Kumar and Gulati (2009), among others.

much each of these stakeholders benefitted from the gains. It is also likely that the beneficiaries and/or the extent of gains that accrued to them varied across types of banks. We attempt to examine this variation as well.

Finally, as far as we know, none of the studies in the context of Indian banking that has applied the DEA technique has also calculated the Malmquist Index values. The efficiency scores obtained from the DEA cannot be used to compare productivity gains accruing to banks over time. We fill this gap by reporting both DEA and MI results and hence are able to comment on the evolution of efficiency gains over a long period of time. Through this comprehensive analysis, we hope to shed light on policy actions that can drive continued productivity gains in the Indian banking sector in future.

Our results show that on average from 2002 to 2018, across a sample of 37 banks, there have been very small gains in efficiency. This is primarily because the sample period can be split into two halves, of which the first half (2003-2010) witnessed steady increase in productivity but the second half (2011-2018) was characterised by first a stagnation and then a decline in efficiency gains. This pattern is seen for both public and private sector banks. Public sector banks exhibited greater efficiency gains in the first half of the sample period compared to private banks and also experienced bigger decline in gains in the subsequent years. The results are robust irrespective of whether we use bank deposits as input or output in the estimations. The stagnation in productivity in recent times has resulted in a potential convergence between the private and public sector banks.

Regarding sources of productivity gains, we find that for the public sector banks, the frontier shift or technology change was more important whereas for the private sector banks, the efficiency change or catching up to the frontier played a bigger role. Foreign banks on the other hand experienced higher productivity gains during the 2011-2018 period and this was mostly due to technology change. Finally, preliminary data analysis reveals that most of the gains may have accrued to the shareholders which in case of the public sector banks would imply the Government.

Having conducted a comprehensive analysis of productivity growth in Indian banking, we end the paper by making a series of observations and raising questions about the desirability of bank productivity improvement as measured in the conventional sense if a period of strong efficiency gains is followed by a period of worsening asset quality. To the extent that the prevalent methods to quantify productivity growth in banking do not take into account the quality of credit extended by banks, the results from such an empirical approach have to be interpreted with caution. More importantly, a new methodology and a new set of metrics would be needed to understand productivity in banking so that the analysis can provide insights that are useful for policy making.

The rest of the paper is organised as follows. In section 2 we provide a brief background of the Indian banking sector and conduct a preliminary data analysis to throw light on the trends and patterns of prroductivity growth for all commercial banks in India for the period 1991 to 2019. In sections 3 and 4 respectively, we present the empirical methodology and describe the data used in the study. In section 5 we discuss the results for all banks as well as for different groups of banks by ownership. We present a preliminary discussion of beneficiaries of the productivity gains in section 6. We ask some fundamental questions about the way productivity is conventionally measured in the banking sector in section 7. Finally we conclude in section 8.

2 Banking in India

Indian banking has undergone several structural changes over the last 50 years or so. Until 1969, banks in India were largely privately owned. The government brought much of the banking sector under its ownership and control through two rounds of nationalisation in 1969 and 1981. Between 1969 and 1995, government owned banks (called the public sector banks or PSBs) dominated the banking sector, with over 90% share of the business. A handful of foreign banks (Indian branches of international banks) and 'old private sector' banks - those that were considered too small to be nationalised, accounted for the remaining 10% of the banking business.

Throughout 1970s and 1980s, the PSBs grew rapidly, not in pursuit of commercial objectives (such as return on assets or return on equity) but primarily in line with the government policy. Pursuit of productivity and efficiency was not a priority of Indian banks in this era. The PSBs expanded their branch network in order to reach all segments of the population across the country. They also expanded their respective organisations through large scale recruitment. PSBs in this period, operated essentially as government departments. Competition in the banking business was muted and banks had to follow interest rate and pricing regulations.

In 1991, India embarked upon a policy of economic liberalisation with the objective to gradually transition into a capitalist, free market economy. A strong and stable banking system was critical to ensure economic growth. The policy changes made between 1993 and 1995, ushered in a dramatic shift in banking in India. New banking licenses were issued to private sector companies. These new private sector banks started operations in 1995 and 1996.

The new private sector banks introduced an element of competition in the Indian banking landscape. They started with superior technology platforms that helped them scale rapidly and efficiently. PSBs responded by adopting technology through efforts on implementing core banking solution, branch networking etc. They also downsized their overstaffed organisations by offering 'voluntary retirement schemes' (VRSs) to reduce headcount. The government also started the process of listing the shares of the banks it owned. Listing of shares brought the PSBs under scrutiny of the equity market participants who demanded greater focus on commercial objectives, including productivity.

2.1 Productivity gains in Indian banking

The structural changes in Indian banking in the early and mid 1990s got reflected in significant gains in productivity. An important metric for measuring productivity of the banking system is the cost of intermediation. Banks, as financial intermediaries between savers and borrowers, incur costs in transforming savings into credit. The cost of intermediation mainly consists of costs of operations of the banking system i.e. costs of manpower and establishment and other items such as information technology (IT) related costs. The cost of intermediation must come down for the system to enjoy productivity gains.

In we measure the cost of intermediation as the ratio of total operating costs to average total assets (or liabilities). We also present other related measures such as the ratio of total operating costs to average total income (sum of net interest income and other income) in figure 1.

The figure shows a secular decline in the cost of intermediation from 1992 until about 2010 after which it remains mostly constant before inching up in 2018 and 2019. Measured as a percentage of average total assets the cost of intermediation came down from around 3% to around 1.9% for the banking system as a whole i.e. a gain of 110 basis points. As a percentage of the total income, the cost of intermediation came down from around 60% in 1992 to roughly 45% by 2010 and remained at that level until 2018 before going up in 2019. On this metric, there is a

gain of around 15% over this period. This suggests that the Indian banking system witnessed productivity gains from 1992 until 2010 after which productivity appears to have stagnated.

As mentioned earlier, with the advent of the new private sector banks in mid 1990s, the PSBs faced acute competition.[5] They responded by aggressively adopting technology. In figure 2 we show the evolution of the cost of intermediation for four groups of banks over the period of 1992 to 2019. The four groups are, the State Bank of India (SBI) group, PSBs other than SBI, private banks including both old and new private banks, and foreign banks, which are branches of international banks operating in India.[6]

Figure 2 reveals an interesting pattern in productivity gains. Government owned banks including SBI group, the old private sector banks and foreign banks, all had similar levels of intermediation costs in early 1990s, at around 3% of total assets. The new private sector banks started in mid 1990s with structurally lower cost levels, largely due to their superior technology platforms. As these banks scaled up rapidly from late 1990s onwards, their operating costs came down sharply. The benefits ran their course by about mid 2000s and the operating cost levels remained flat for these banks since then.

Government owned banks, both the SBI group and other PSBs, witnessed steep gains in productivity, beginning mid 1990s. These gains appear greater than those made by private banks. By 2007, government owned banks had lower cost of intermediation than private or foreign banks.

All the four groups appear to have hit stagnation in productivity gains by 2010. Their cost of intermediation has stayed constant since then. There is also some convergence in the cost of intermediation across the four groups with PSBs' averaging around 1.65% in recent years, private banks at around 2.25% with foreign banks and the SBI group in between.

3 Methodology

We assess technical efficiency of the banks in our sample using a non-parametric programming method called the Data Envelopment Analysis (DEA). This method was developed by Charnes et al. (1978) and by now has been extensively used in the literature to assess productivity of various kinds of decision making units (DMUs), including banks. In this approach we define a non-parametric efficient production frontier which serves as a benchmark for the Debreu-Farrell measure of efficiency.[7] The benchmark is a linear combination of banks included in the sample. The efficiency scores thus obtained range from 0 to 1.

For example if a bank had an efficiency score of 0.7 in a particular year, this would indicate that had this bank been producing at the efficient frontier instead of at its current location in the production space, it would require only 70% of the current inputs to produce the same amount of output. This is also referred to as the input-oriented approach to efficiency measurement whereby the idea is to minimise the use of inputs to produce a certain level of output and hence lower cost to achieve efficiency.[8]

The DEA can be done both under constant returns to scale (CRS) and variable returns to scale (VRS) assumptions. Here we have reported only the CRS results for the sake of brevity.[9]

[5] Private banks, prior to 1995, comprised the so called 'old private sector banks' that were considered too small to be nationalised and hence continued with private ownership but had organisations and operations very similar to the government owned banks.

[6] The SBI group has several separate banks which were all subsidiaries of SBI until they merged into SBI in 2018.

[7] See Farrell (1957).

[8] See Canhoto and Dermine (2003) for details on the DEA method.

[9] We have also done the DEA under the VRS assumption and the results are similar. Details can be available

As discussed in Canhoto and Dermine (2003), the relative efficiency of two DMUs can be compared in two ways. If two banks are observed at time t, then using all the banks observed at time t as a reference technology or efficiency frontier, these two banks can be directly compared. Their efficiency will be calculated with respect to a common efficiency benchmark that is constructed using an identican sample of banks. However this same approach cannot be applied to compare two banks observed in different periods of time. If their efficiency scores are calculated using different benchmark samples of banks, these scores may not indicate the absolute improvement in efficiency between the time periods. At best these scores would show a relative change in the efficiency of a bank vis a vis other banks over time.

In order to analyse efficiency change over time, a more commonly used measure is the Malmquist Index (MI) which helps calculate absolute improvement over time in efficiency. Additionally the MI also gives insights into the sources of productivity gains by separating the efficiency change into a frontier or technology shift component and an efficiency gain or catching up component.

We first calculate the DEA scores for our sample of banks. Then we calculate the MI under the VRS assumption because that enables us to further dig deeper into the sources of efficiency change. Under VRS, the efficiency gain or catching up component is divided into two more sub-components viz: pure technical efficiency change and scale efficiency change.

The DEA and MI techniques are based on the concept of a production function and accordingly use inputs and outputs in order to calculate the efficiency scores. Depending on the choice of inputs and outputs, there can be various approaches to evaluate efficiency. In case of the banking sector, a critical decision while assessing productivity using the DEA method is whether deposits are to be treated as inputs or outputs. There is no consensus in the literature regarding this.

In our paper we use two alternative approaches: Intermediation approach and Value added approach. In the former, the inputs are deposits, employee expenses and operating expenses and output is loans and advances made by the banks. In the latter approach the inputs are interest expenses, employee expenses and operating expenses whereas the outputs are deposits and loans. We calculate the DEA score and MI values under both these approaches and compare results. The first approach evaluates the efficiency of converting deposits into loans whereas the second approach assesses the efficiency of gathering deposits over and above the efficiency of extending credit.

4 Data

We use data on 37 banks for our analysis with the composition being 19 PSBs, 11 private banks and 7 foreign banks, as shown in table 17. These banks together account for close to 90% of the total assets in the entire banking system and hence can be considered a highly representative sample. They were chosen based on their size. The data on individual banks is from the Prowess database of the Centre for Monitoring Indian Economy (CMIE) and the data used in the descriptive analyses on the entire banking sector (or bank groups) is from the Reserve Bank of India.

Our sample period is 2002 to 2018. This decision was motivated by the fact that calculation of the Malmquist Index requires a balanced panel and we wanted to include as many banks as possible. By 2002 most private banks that operate today had come into existence and hence this is a good starting point for the sample.[10]

from the authors upon request.

[10]Going forward we plan to estimate the models over a longer time period, from 1997 to 2019 in order to better capture the productivity gains of the private sector banks.

Tables 1 to 5 show the summary statistics of the variables used in the models as inputs and outputs, for the full sample period and all banks as well as for sub-periods and different groups of banks.

We see from table 2 that during the period from 2002 to 2018, while loans and deposits of the banks grew phenomenally, employee expenses did not grow proportionately, thereby hinting at substantial productivity gains, as discussed in section 2. Similar patterns are observed for public, private and foreign banks.

5 Empirical results

In this section we analyse the empirical findings regarding the efficiency of banks in India. This discussion is divided into two parts. In the first part we describe the estimates of technical efficiency of the overall banking system under the two alternative approaches, namely, intermediation and value-added. For each of the approaches, we discuss the DEA results as well as the growth in productivity over time as seen from the Malmquist Index. In the second part, we compare the relative efficiency of PSBs, private banks and foreign banks. Once again we do this for both the intermediation and value-added approaches and for the static analysis of the DEA estimates as well as the dynamic analysis using the MI estimates.

5.0.1 Data envelopment analysis

The DEA approach consists of analysing each annual time series separately and calculating the relative efficiency of each bank within each time series. While this gives us an idea about the year-wise efficiency of banks, we cannot use this approach to compare these efficiency scores of over time since they have been calculated with respect to different efficiency frontiers.

The summary results of the technical efficiency estimates obtained from the DEA analysis under the CRS assumption are presented in Tables 6 and 7 for the intermediation approach and the value-added approach, respectively. The average technical efficiency estimate for every year represents the average of all values obtained from the DEA model for all banks in our sample for that particular year. For every year, efficiency scores are calculated using annual benchmarks, which in turn are obtained using the bank data for that year. In addition we also report the percentage of efficient banks for every year. The 'efficient banks' are those that lie on the frontier in that specific year, and hence have an efficiency score of 1.

Barring the years of 2012-2014, we find that the average efficiency scores are consistently higher under the value-added approach compared to the intermediation approach. This is consistent with the findings of Das and Ghosh (2006) who argue that the use of more number of outputs leads to higher DEA scores under the value-added approach. Another plausible argument is that during the period under review, the banks in our sample experienced remarkable growth in deposits which is considered as output under the value-added approach. This may have also contributed to the higher efficiency scores.

Under the intermediation approach, in 2002 the average efficiency of all banks was 43.9% and only 5.4% of the banks were on the efficiency frontier. In 2011, the corresponding numbers were 87.8% and 21.6% respectively. The numbers can be interpreted as follows. In 2002, if the average bank were producing on the frontier instead of at its actual location in the production space, only 43.9% of the inputs actually used would be necessary to produce the same output vector. This number gets doubled by 2011. Although we cannot compare the absolute scores over time

since the benchmarks are different for different years, this doubling can still be considered a big improvement in relative efficiency.

We also see that the percentage of efficient banks goes up over time especially till 2011 and after that it goes down. On average, 18% banks were on the efficiency frontier between 2003 and 2011 whereas between 2012 and 2018, this went down to 13%.[11]

While under the intermediation approach, 24.3% of the banks were on the efficiency frontier in 2009 (second highest), under the value-added approach, 37.8% banks were efficient in 2008 (highest). This roughly complements the observation we made in section 2 that the period 2003-2011 was one of high banking sector efficiency.

5.0.2 Malmquist Index

One drawback of the DEA method is that we cannot compare the efficiency scores over time and hence cannot use the findings to comment on growth in productivity in the Indian banking sector. Under the DEA method the efficiency frontier changes every year. The change in technical efficiency of a bank could be due to the fact that the bank is becoming more efficient and is moving closer to the frontier or due to the fact that the frontier technology itself is changing, or a combination of both. In order to compare efficiency over time and to find out the sources of efficiency change we estimate the Malmquist Index (or MI).

We calculate the MI under the assumption of variable returns to scale (VRS) in order to dig deeper into the sources of productivity gains. The MI consists of two components: technological change (TC) and efficiency change (EC). The former component refers to the effect of a frontier shift and throws light on the technical progress between two periods. The latter is a catching-up component that helps study whether a particular bank is moving closer or farther away from the own-period efficiency frontier.

In addition, when calculated under the VRS assumption, the EC component can be further split into pure technical efficiency change (PTEC) and scale efficiency change (SEC). PTEC is the part of 'catch-up' that can be attributed to technical efficiency whereas SEC is the contribution of scale improvement to the 'catch-up'.

In tables 8 and 9 we report the values of the MI and its components under the intermediation and value-added approaches, respectively. MI is calculated using the full sample panel data and we get the index values for each year and each bank. These values can then be used to calculate averages over the years.

In the tables, we report the average values for four equal sub-periods as opposed to showing values for every year, for ease of presentation. This also enables us to split the sample into two halves and look at the average values for these two periods viz: 2003-2010 and 2011-2018.[12] It turns out that 2010-2011 is sort of a turning point in the evolution of productivity gains of the banks, as highlighted in section 2. Hence, we analyse the results by comparing the estimates from these two periods. Finally, we also show the average values for the entire sample period.

- **2003-2010**: We see from table 8 that under the intermediation approach, the average value of MI for the first half of the sample is 1.034. This implies that between 2003 and 2010, our sample banks experienced an increase in efficiency of 3.4%. This finding is in line

[11] However the percentage of efficient banks was highest in 2017. This may have been a fall-out of the demonetisation episode that started in November, 2016 as a result of which commercial banks received huge amounts of deposits. The same is reflected in the value-added approach as well with 2017 showing a high average efficiency score as well as 32% of banks as efficient.

[12] The first sub-period starts from 2003 because information on the banks in 2002 is used to construct the efficiency frontier.

with our observation in section 2 that till 2010 banking sector in India witnessed steady productivity gains.
In terms of the components, the average TC value for the 2003-2010 was less than one indicating a negative impact of frontier-shift or technology change. The average EC on the other hand was 1.117, implying that the average efficiency indices increased by 11.7% between 2003 and 2010, relative to own period benchmark technology. Within the 'catching-up' component, pure technical efficiency change (PTEC) accounted for most of the gains in 2003-2010 (average growth of 10.2%) whereas SEC shows that efficiency due to scale improvement grew only by 1.9% on average.

- **2011-2018**: The average value of MI is 0.978 indicating that between 2011 and 2018, there was a decrease in average efficiency by 2.2%. While efficiency on average increased by 2.4% during 2011-2014, it declined by 5.4% during the 2015-2018 period. The gains due to both frontier shift and efficiency change slowed down with the latter exhibiting a small decrease. During this period, both PTEC and SEC declined. Productivity due to pure technical efficiency decreased by 1.4% whereas scale efficiency grew only by 0.1%.

- **2003-2018**: For the full sample period, the average efficiency improvement was only by 1% which indicates a productivity stagnation. This is because the sample period first witnessed efficiency gains followed by a consistent decline.

Results under the value-added approach are similar in terms of the productivity gains till 2010 and the stagnation/decline thereafter. Table 9 shows that during the sub-period 2003-2010, average efficiency grew by 4.3% and this was split almost equally between TC and EC and also between PTEC and SEC. On the other hand, during 2011-2018, average efficiency decreased by 2%.

The first part of the empirical analysis focused on the efficiency scores of the overall sample of banks and on the evolution of these efficiency scores over time. In the second part we compare the relative efficiency of the PSBs, private and foreign banks over the same period of time.

5.1 Relative efficiency of public, private and foreign banks

We apply a simillar methodology to compare the efficiency of the three groups of banks: public sector (PSBs), private and foreign banks. Primarily we are interested in the first two categories as they account for lion's share of banking business in India.

5.1.1 Data envelopment analysis

We report the yearwise average efficiency scores obtained from the DEA model for the three groups of banks in tables 10 and 11, for the intermediation and value-added approaches, respectively.

We find that in relative terms, under the intermediation approach, between 2008 and 2015, the average technical efficiency scores of the PSBs were higher than those of the private banks whereas from 2016 onwards the private banks score higher. However, the percentage of efficient banks is mostly higher for the private sector compared to the public sector for nearly all years. This implies that more private banks are closer to the benchmark frontier in any given year. The foreign banks on average score the lowest but the percentage of efficient banks is highest,

same as the private banks. For the full sample period, on average 35% of foreign banks and private banks are efficient as opposed to 28% of PSBs.

On the other hand under the value added approach, we find that from 2009 to 2018, the average efficiency scores of private banks are higher than that of the PSBs. The percentage of efficient banks is also higher for the private sector compared to the public sector and it is highest for the foreign banks. For the full sample period, on average 67% of foreign banks are on the efficiency frontier, compared to 55% of private banks and 32% of PSBs. This implies that private and foreign banks are significantly more efficient than PSBs in augmenting their respective deposit bases.

5.1.2 Malmquist Index

Tables 8 and 9 show the average MI values for the intermediation and value added approaches, respectively. We report the average values of the index along with its components for the same sub-periods as before for all three groups of banks.

- **2003-2010**: One consistent finding is that for the PSBs and private banks, the average MI values for this period are higher compared to the 2011-2018 period under both intermediation and value added approaches. Under the intermediation approach as shown in table 8, average efficiency of the PSBs improved by 5.9% till 2010 whereas for the private banks, average efficiency gain was much smaller (1.4%). Likewise under the value added approach, as shown in table 9, efficiency of PSBs and private banks improved by 4.8% and 1.1% respectively, during 2003-2010.

  When we look at the components of MI under the intermediation approach, we find from table 8 that for the PSBs, on average, the gains from frontier shift or technological change (4%) were greater than the gains from the catching up effect (1.8%) during this period. Within EC, the gains due to pure technical efficiency (PTEC) and scale efficiency (SEC) were more or less the same. On the other hand for the private banks, the 'catching up' component (EC) was above one indicating an increase in average efficiency by 12.5% relative to benchmark technology, whereas the frontier shift (TC) component was below one, implying a negative impact of technical change.

  Within EC, pure technical efficiency grew by 6.1% and scale efficiency improved by 4.6% on average. The findings for the components are similar under the value added approach with frontier shift or technology change impacting efficiency of PSBs in a positive way in 2003-2010 whereas efficiency change or catching up being more important for private banks during the same period.

- **2011-2018**: Under the intermediation approach as shown in table 8, average efficiency of the PSBs declined by 2.3% during this period and for the private banks, it was stagnant at 0.2%. Similarly, under the value added approach, as shown in table 9, the decrease in efficiency for PSBs during this period was 1.9% and for the private banks, productivity was stagnant. Foreign banks on the other hand experienced higher efficiency gains during this period under both the approaches. In terms of the components, for the PSBs, the decline in technological change was higher than in the catching up.

- **2003-2018**: The average MI index for the PSBs is larger than that of the private banks, for the full sample period under both intermediation and value added approaches, indicating superior improvement in efficiency over time.

Thus the result for the bank groups is consistent with the finding for the full sample of banks and also with earlier observations about evolution of productivity gains based on preliminary data analysis. It is apparent that 2003-2010 was a period of steady productivity gains in the banking sector which stagnated or got reversed in the subsequent years.

It is interesting to note that during the 2003-2010 period, PSBs exhibited higher productivity growth than private banks. This could be because private sector banks started at higher levels of productivity. While they may have been more efficient at factor utilisation especially with regard to labour, they also paid higher salaries (10). This could have slowed down further productivity gains even as the public sector banks were rapidly adopting new technology. Tables 14-16 list the banks who experienced the highest productivity growth during the period 2002-2018.

6 Beneficiaries of productivity gains

The above discussion implies that in the post-reform period, the Indian banking system experienced significant productivity gains until roughly 2010. In this section we attempt to understand who benefitted from these gains. In the absence of a plausible empirical framework to assess this issue, for now we resort to descriptive analysis of the data, and reserve a more rigorous investigation for the future.

There are four possible stakeholders in the banking business that can benefit from the productivity gains âĂŞ owners (i.e. shareholders), depositors, borrowers, and employees. It is likely that the some part of the productivity gains would accrue to each of these four classes of stakeholders. In the following sections we analyse each of these four stakeholders and attempt to assess their share of the productivity gains.

6.1 Depositors

Indian banks offer three types of deposits - demand deposits (commonly known as current accounts and are similar to checking accounts in the US), savings account deposits and term deposits (also known as fixed deposits). Of these, demand deposits do not carry any interest. Savings account interest rate was regulated until 2012 at 4% and even after deregulation most banks adhere to the old levels of 4%. Only the term deposits are priced based on market conditions and their pricing reflects prevailing interest rates and competitive dynamics in the deposit business.

This implies that if the depositors benefitted from productivity gains, we would expect the term deposit pricing to improve over time. Accoridngly, we plot the average interest rate on term deposits and the 5 year government security yield from 1997 to 2019 in figure 3.[13][14]

We find that there has been no appreciable improvement in the term deposit pricing relative to the reference rate suggesting that depositors may not have received any part of the prroductivity gains. Average term deposit has been priced during this period at a discount of around 50 to 71 basis points and the discount has stayed in the same range. Only exception was the period between 2001 to 2004 when the deposits were priced at premium to the reference yield.[15]

[13] Average maturity of term deposits in Indian banks is around 2.6 years (ranges between 2.5 to 2.8 years), and hence 5 year government security is the closest reference yield with reliable data. The pattern of relative pricing and hence the conclusions do not change if we use the 10 year yield or the 1 year yield.

[14] The reason for using data from 1997 is that reliable data on government security yields prior to 1997 is not available.

[15] This could be attributed to the intense competition and hence higher pricing of term deposits due to the merger of a large Development Finance Institution (DFI) into a commercial bank which compelled the bank to

If we look at the same data across the bank groups, we see no perceptible differences in deposit pricing except for foreign banks which appear to be pricing deposits at even higher discount to the reference rate. Figure 4 presents the relative deposit pricing for the four (government owned banks split into PSBs and SBI as in section 2) bank groups.

6.2 Borrowers

Bank borrowers are important stakeholders in the banking business and rightful claimants to productivity gains. As in the case of the depositors, any sharing of productivity gains by the borrowers should reflect in the pricing of the loans. Loan prices should decline relative to an appropriate reference rate. In figure 5 we plot the average yield on loans and the 10 year government security yield for the period of 1997 to 2019.[16]

The figure shows that the loan pricing premium over the reference rate has been more or less constant from 2005 onwards suggesting that like depositors, borrowers too may not have received any share of the productivity gains.

6.3 Employees

The next stakeholders that we consider are employees. Employee costs (wages and salaries) are a component of the overall cost of intermediation. Hence productivity growth measured as a reduction in the cost of intermediation would imply that employee costs would come down but the important question is, by how much on a relative scale. In figure 6 we plot the employee costs for the banking system as a percentage of average total assets, total income, and total operating costs.

We find that employee costs have secularly come down from about 2% of average total assets to around 1%. As a percentage of total income, they have come down from around 40% to roughly 30%. It is worth noting that the share of employee costs in the total operating costs also came down from around 70% to 50%.

Employee costs have come down largely because the number employees declined between 1991 and 2010. To evaluate the possible share of employees in productivity gains, in figure 7 we plot the real per employee wage cost relative to the growth in real balance sheet of the entire banking sector from 1992 to 2019.[17] Our hypothesis is that if the employees had shared some productivity gains, the total wage bill would come down but the per employee real (or nominal) wages would improve by at least as much as the growth in banking income or assets, if not by more.

The figure shows that during 1992-2019, the growth in real per employee wages has lagged behind the growth in banking sector balance sheet. The compounded annual growth rate (CAGR) of real per employee compensation was 3.6% whereas the growth in real balance sheet of the banking system was 7.7%. The CAGR in real wages was faster from 1992 to 2007 at 5.9% when the real balance sheet grew at 9.4%. From 2007 to 2019 the real per employee wages have been almost stagnant, growing at only 0.7% annually when the real balance sheet grew at 4.9%.

This suggests that employees do not appear to have benefitted from the productivity gains given that wage growth has been consistently lower than the growth in banking business and has been almost stagnant for the past 12 years or so.

raise very large amount of deposits to meets its reserve requirements (merger of erstwhile ICICI Ltd into ICICI Bank).

[16]The pattern does not change if we use the 5 year G-Sec yield instead.

[17]The real parameters were computed by deflating the nominal numbers with the consumer price index.

6.4 Shareholders

The last stakeholders we consider are shareholders of the banks. For the PSBs, the majority owner is the government which, by law, has to maintain at least 51% ownership in these banks. For private banks, the ownerships tends to be widely distributed as the current regulations limit any individual or entity to a 5% ownership (which can go upto 10% with special approval of the regulator). Most foreign banks operate in India as branches of the parent international banks.

Figure 8 depicts the pre-provisioning operating profits (PPOP) of the banking system and the cost of intermediation. The evolution of these two parameters suggests that the cost of intermediation saved by the banks went directly into the PPOP implying that it accrued to the shareholders. As discussed above, it seems that other stakeholders in banks- depositors, borrowers, and employees did not receive much of the productivity gains.

Among other uses, increases in PPOP are potentially utilised to make provision for the credit losses that banks incur. After providing for these losses, paying taxes, and paying dividend to shareholders (if any), the residual profits add to the capital base of the bank. In order to understand the pattern of use of the productivity gains towards credit loss provisioning, ideally we would like to look at the data on credit loss provisioning over the same time period. Unfortunately this data in not available. Hence, we look the level of non performing assets (NPAs) of the banks which would be a crucial determinant of the credit loss provisioning needed. For this we analyse three separate groups of banks: government owned banks (PSBs and SBI group together), private banks and foreign banks.

Figure 9 shows the three variables- cost of intermediation, PPOP and gross NPAs of government owned banks as a group over the period of 1997 to 2018. The figure can be interpreted as follows. The level of PPOP increased with the productivity gains. During 1997-2005, part of the increased PPOP was presumably used to bring down the level of high gross NPAs built in the mid 1990s. This would imply that the productivity gains effectively went to the defaulting borrowers via PPOP and NPA provisioning. With the stagnation in productivity from 2010 onwards, the growth in PPOP also stopped. When the current NPA buildup started around 2014, there were not enough productivity gains to address the rise in gross NPAs. Consequently, these banks had to raise large amounts of external capital from the government as the internally generated capital was not enough to deal with the NPAs.

In figures 10 and 11 we look at the same parameters for private banks and foreign banks, respectively. Productivity gains for the private banks through lower cost of intermediation were mostly during the period 1997-2005 and even then, were not as substantial as those for PSBs. As discussed in section 5, their productivity gains were lower than the PSBs during 2002-2010 and stagnated from 2010 onwards. Their NPA levels have also been historically lower than PSBs (Sengupta and Vardhan (2017)), hence the issue of productivity gains going to defaulting borrowers is less relevant for them.

The patterns of productivity gain, PPOP, and NPAs appear to be different for the foreign banks as also found in 5. They did not gain much in terms of productivity in the mid 1990s-2008 period, compared to the PSBs and private banks. They saw substantial productivity gains in the subsequent years during which their PPOP also went up. They also had much smaller NPA levels.

7 How to interpret productivity gains in banking?

The descriptive discussion of section 2 as well as the analytical exposition of section 5 reveal a consistent finding, that the Indian banking sector witnessed significant productivity gains from early 2000s till about 2010-11. Thereafter the productivity growth stagnated and in the recent years productivity has been on the decline. These results are based on conventional mathematical methods of measuring productivity that are generally applied to all kinds of decision making units in the economy, including non-financial firms and financial service providers such as banks. In this section we ask deeper questions about interpreting these results in the context of the banking sector, in particular the Indian banking sector.

The empirical methods prevalent in the productivity literature use an input-output framework. In case of the banking sector, an important output is credit extended or loans and advances. In the design of the conventional methods, if for example, using the same number of employees, a bank gives out a higher volume of loans, then this shows up as a rise in productivity. This is irrespective of the quality of credit extended by the bank. It is therefore plausible that a bank that is considered highly productive based on the conventional measures could in effect be giving out loans that are of dubious quality i.e. lending to risky or less credit worthy borrowers.

One can also argue that when a bank uses roughly the same number of employees to extend significantly greater amount of credit, then the lending standards are likely to get compromised due to the sheer increase in workload on the existing employees, thereby resulting in more risky loans being made. The consequences of such a bank increasing its loan book and presumably experiencing efficiency gains would be seen a few years later when much of the loans extended by the bank are defaulted upon, resulting in a steady deterioration of asset quality on the bank's books.

Therefore, when banking output is measured in terms of the volume of credit, periods of rapid credit growth will always show strong productivity gains but these could well be periods where credit quality goes down. Hence the conventional measure of productivity growth could be misleading. We now revisit the results we have obtained so far, from this perspective.

- **2002-2010**: Indian economy witnessed a remarkable credit boom roughly from 2003 to 2009 during which bank credit to commercial sector increased dramatically. This was especially so for PSBs that made huge amounts of loans to the infrastructure sector. Between 2003 and 2010, the total banking sector credit grew 4.7 times suggesting a CAGR of almost 25% which was an unprecedented growth in bank credit. As our analysis in the previous sections shows, this was also the period of steady productivity growth in the banking system, particularly for the PSBs.

  In the post 2010 period, non-performing assets (NPAs) in the banking sector began rising. Gross NPAs as a share of total advances of the banking system went up from 2.5% in 2010 to 4.3% in 2015. For the PSBs the gross NPAs during the same period mode than doubled, going up from 2.3% to 5%. NPAs peaked in 2018 at 11.1% for the banking system and 14.6% for the PSBs.

  Private sector banks which experienced relatively mild productivity gains from 2002 to 2010, (see tables 12 and 13) did not experience as severe a rise in NPAs as the PSBs, in the subsequent period.

  Thus, a period of rapid productivity improvement in Indian banking coincided with a period of high credit growth. As mentioned earlier, this is obvious as the output parameter in the measures of productivity is the volume of loans. This period was subsequently followed by a prolonged phase of stress in the balance sheet of banks and slowdown in

credit growth. This pattern raises important questions about how we measure productivity and how we interpret the results. Specifically, what is the meaning of productivity growth in banking sector when the prevalent methods do not account for the quality of outputs produced?

- **2011-2018**: Our results show that productivity growth in the banking sector stagnated from 2011 onwards, and there was a decline in efficiency gains roughly from 2015 onwards, especially for PSBs. Taken on face value this may appear to be a negative outcome. In reality, between 2010 and 2015, credit growth in the Indian banking sector slowed down to a CAGR of roughly 14.5%. This was partly because of decline in private corporate investment which depressed the demand for credit and partly because NPA-saddled banks themselves became wary of lending. This shows as a slowdown in productivity but if as a result of the balance sheet stress, banks became tightened their lending standards, that may not be such a negative outcome after all.

The above discussion implies that productivity measures that can be applied to non-financial firrms for example may not necessarily be suitable for banks. A comprehensive measure of productivity for the banking sector must take into account the issues and nuances outlined in this section.

8 Conclusion

Our descriptive analysis from 1992 to 2019 reveals that banking sector in India experienced substantial productivity gains till about 2010 after which there seems to have been a stagnation in productivity and even a decline in recent years. Among the bank groups, private sector banks which primarily began operating from 1994-95 onwards in the post-liberalisation era, witnessed sharp reductions in their operating costs even as their balance sheets expanded rapidly, indicating steady productivity improvement. These banks started on superior technology platforms which may have contributed to the steep efficiency gains. However the benefits ran their course by about mid 2000s. On the other hand, public sector banks witnessed significant productivity gains from mid to late 1990s onwards till about 2010, and their gains even surpassed that of the private banks.

Empirical investigation using the data envelopment analysis and the Malmquist Index technique over the period from 2002 to 2018 for a sample of 37 banks confirms the findings of our descriptive analysis. We find that the Indian banking sector experienced steady productivity growth, the public sector banks (PSBs) substantially more than the private banks, during the period 2002-2010. Among the sources of efficiency gains, technology change or frontier shift was more important for the PSBs whereas private banks seem to have benefitted from faster efficiency change or catching up to the frontier. From 2011 onwards productivity growth of the banking sector slowed down dramatically and the system witnessed a decline in productivity from 2015 onwards, led primarily by the public sector banks.

Taken on face value, one policy implication of our analysis would be that policymakers need to look at the various sources of efficiency gains and take steps to restore the productivity growth of the Indian banking sector going forward. However, our analysis also raises some important questions about how to measure productivity in the banking sector and how to interpret the results.

To the extent that the prevalent methods to quantify productivity growth in banking do not take into account the quality of credit extended by banks, the results from such an approach have to be interpreted with great care. More importantly, a new set of metrics that factor in

the unique nature of business conducted by banks would be needed to understand productivity in banking in a more meaningful manner.

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9 Figures and tables

Figure 1 Cost of intermediation of the Indian banking system, 1991-2019

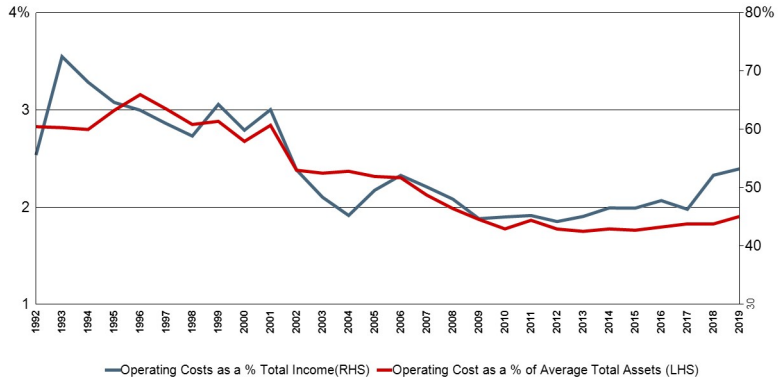

Figure 2 Cost of intermediation for various groups of banks, 1991-2019

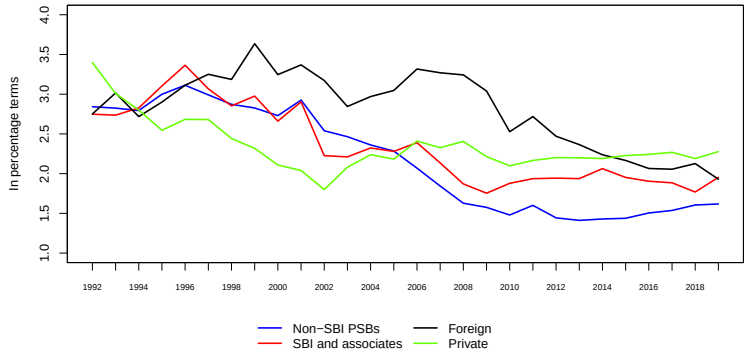

Figure 3 Term Deposit Pricing Relative to Risk Free Government Security Yield

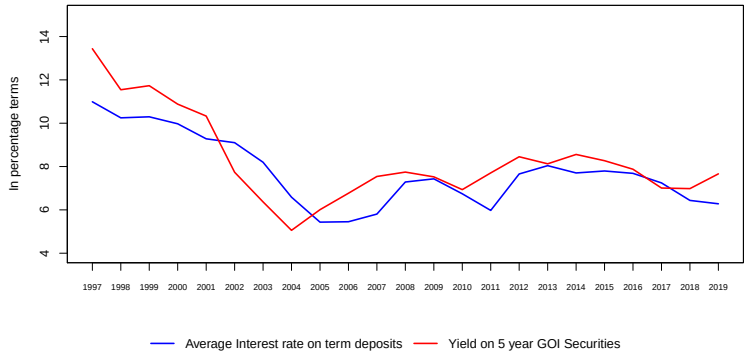

Figure 4 Term Deposit Pricing Relative to Risk Free Government Security Yield across Bank Groups

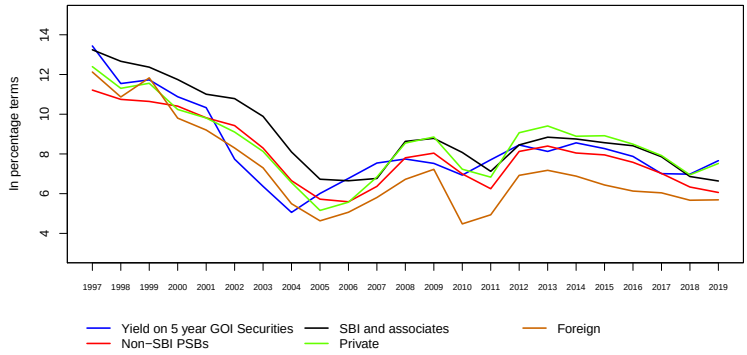

Figure 5 Loan Pricing relative to Risk Free Government Security Yield

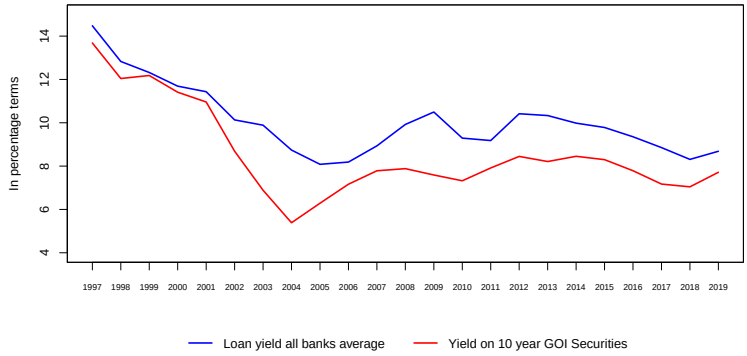

Figure 6 Employee Costs as a Percentage of Total Assets and Income

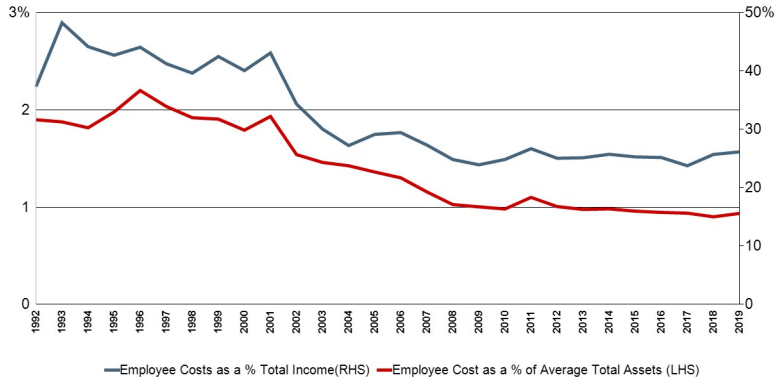

Figure 7 Real Per Employee Compensation and Total Balance Sheet of the Banking System

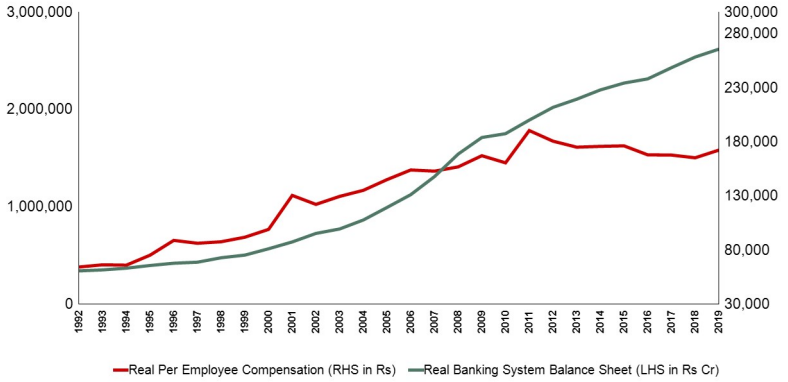

Figure 8 Operating cost and Pre Provisioning Operating Profits(PPOP) of Indian Banking, 1991-2019

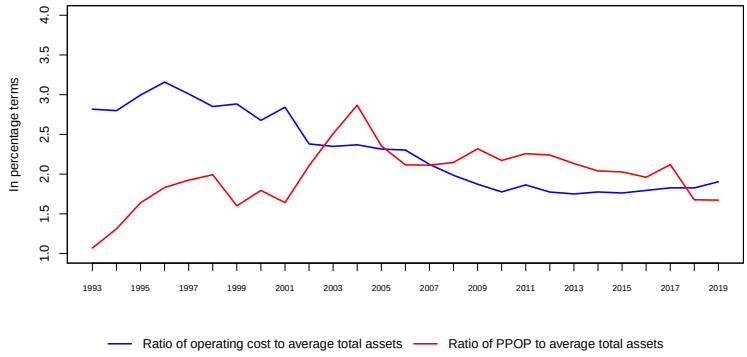

Figure 9 Cost of Intermediation, Pre-provisioning Operating Profits and Gross NPAs of PSBs, 1997 - 2018

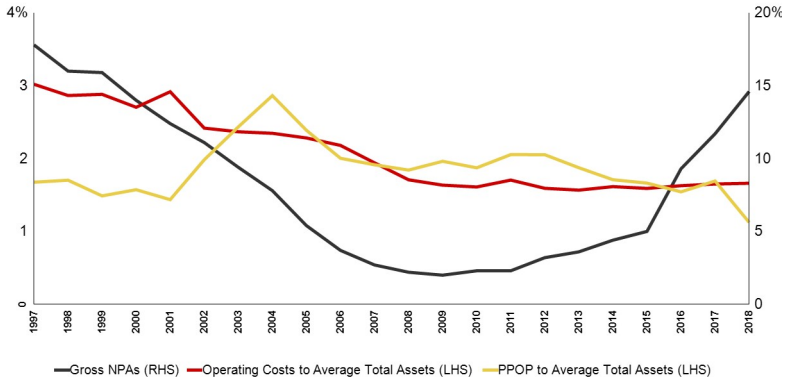

Figure 10 Cost of Intermediation, Pre-provisioning Operating Profits and Gross NPAs of Private banks, 1997 - 2018

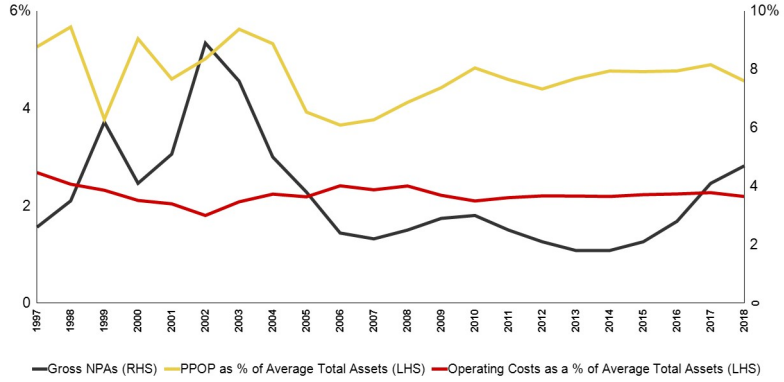

Figure 11 Cost of Intermediation, Pre-provisioning Operating Profits and Gross NPAs of Foreign banks, 1997 - 2018

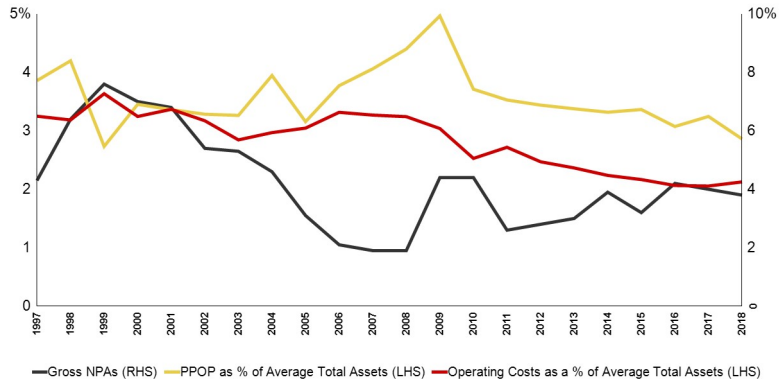

Figure 12 Real Wages Per Employee and Real Balance Sheet Growth of PSBs, 1992-2019

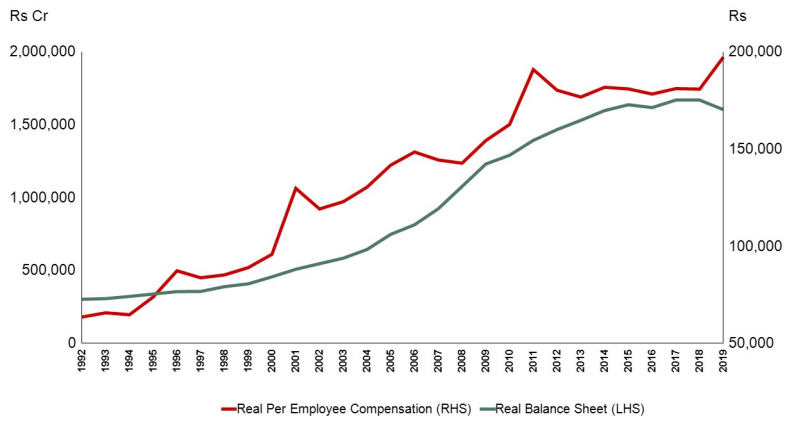

Figure 13 Real Wages Per Employee and Real Balance Sheet Growth of Private Banks, 1992-2019

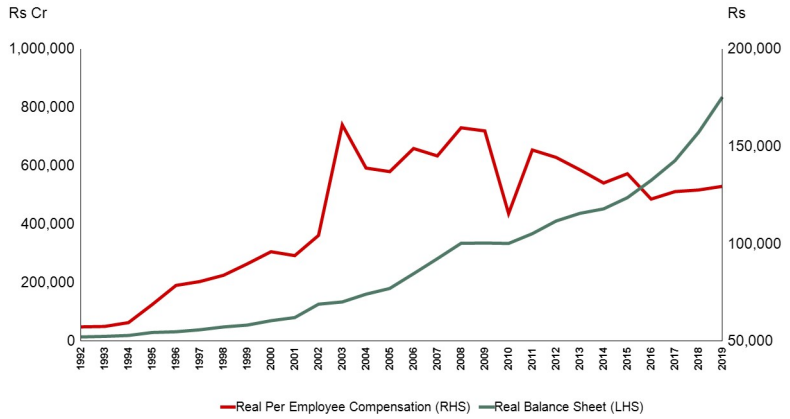

Table 1 Summary Statistics

Average values(2002-2018)	All banks	Private	PSBs	Foreign
Loans	972.6	743.8	1405.5	157.7
Deposits	1291.5	865.1	1935.2	214.4
Employee expenses	15.6	9.6	23.5	3.6
Interest expenses	78.2	57.0	115.6	10.5
Operating expenses	38.0	33.0	50.0	13.3

Note: All figures are in Rs billion. PSBs are public sector banks.

Table 2 All banks' average values by sub-periods

Periods	Deposits	Loans	Employee expenses	Interest expenses	Operating expenses
2002-2004	316.0	171.7	5.5	20.4	8.6
2005-2007	513.4	350.5	7.6	25.2	13.8
2008-2010	929.8	687.6	11.0	55.8	23.0
2011-2013	1513.3	1186.0	17.9	94.2	37.1
2014-2018	2427.6	1869.7	27.8	148.8	79.6

Note: All figures are in Rs billion.

Table 3 Public sector banks' average values by sub-periods

Note:

Periods	Deposits	Loans	Employee expenses	Interest expenses	Operating expenses
2002-2004	516.8	263.8	9.8	32.3	12.7
2005-2007	775.3	509.8	12.6	37	17.9
2008-2010	1402	1018.7	16.5	81.3	25.5
2011-2013	2319.2	1790.8	26.5	141.4	48.6
2014-2018	3571.7	2628.8	40.6	217.8	107.2

Note: All figures are in Rs billion.

Table 4 Private banks' average values by sub-periods

Note:

Periods	Deposits	Loans	Employee expenses	Interest expenses	Operating expenses
2002-2004	136.7	99.8	1.1	10.6	4.8
2005-2007	321.2	246.5	2.7	17.8	10.8
2008-2010	583.4	468.1	6.3	41.5	22.9
2011-2013	936.5	779.3	11.4	65.0	30.8
2014-2018	1750.2	1568.8	19.8	112.5	70.3

Note: All figures are in Rs billion.

Table 5 Foreign banks' average values by sub-periods

Note:

Periods	Deposits	Loans	Employee expenses	Interest expenses	Operating expenses
2002-2004	52.5	34.4	0.8	3.5	3.6
2005-2007	93.1	71.9	1.7	4	6.9
2008-2010	192.5	134	3.8	8.9	16.2
2011-2013	231.9	183.1	4.7	12.2	16.1
2014-2018	386.9	282.3	5.5	18.5	19.3

Note: All figures are in Rs billion.

Table 6 Average technical efficiency of all banks: Intermediation Approach

Years	Average efficiency	Percentage of efficient banks
2002	0.439	5.4
2003	0.678	13.5
2004	0.673	13.5
2005	0.727	10.8
2006	0.808	21.6
2007	0.881	24.3
2008	0.894	18.9
2009	0.872	24.3
2010	0.885	13.5
2011	0.878	21.6
2012	0.897	10.8
2013	0.871	10.8
2014	0.841	10.8
2015	0.788	8.1
2016	0.785	8.1
2017	0.886	29.7
2018	0.792	13.5

Note: The table reports the average DEA scores for every year for all 37 banks in the sample, under the intermediation approach in which deposits are treated as inputs. Percentage of efficient banks for any given year is the proportion of banks that are on the efficiency frontier in that year with a DEA score of 1.

Table 7 Average technical efficiency of all banks: Value added approach

Years	Average efficiency	Percentage of efficient banks
2002	0.778	13.5
2003	0.892	29.7
2004	0.840	27
2005	0.775	18.9
2006	0.903	35.1
2007	0.919	29.7
2008	0.934	37.8
2009	0.904	27
2010	0.901	21.6
2011	0.890	24.3
2012	0.856	21.6
2013	0.820	16.2
2014	0.805	16.2
2015	0.846	18.9
2016	0.952	37.8
2017	0.916	32.4
2018	0.901	29.7

Note: The table reports the average DEA scores for every year for all 37 banks in the sample, under the value added approach in which deposits are treated as outputs. Percentage of efficient banks for any given year is the proportion of banks that are on the efficiency frontier in that year with a DEA score of 1.

Table 8 Average efficiency gains over time for all banks: Intermediation approach

Periods	MI	TC	PTEC	SEC	EC
2003-2006	1.014	0.892	1.190	0.998	1.177
2007-2010	1.054	1.001	1.014	1.040	1.056
2011-2014	1.024	1.038	0.988	1.000	0.987
2015-2018	0.946	0.969	0.984	1.002	0.987
2003-2010	1.034	0.946	1.102	1.019	1.117
2011-2018	0.985	1.003	0.986	1.001	0.987
2002-2018	1.010	0.975	1.044	1.010	1.052

Note: The table reports the average values of the Malmquist Index and its components and sub-components for the periods mentioned, for all 37 banks in the sample under the intermediation approach in which deposits are treated as inputs. TC: Technology change (frontier shift), EC: Efficiency change (catching up), PTEC: pure technical efficiency change and SEC: scale efficiency change.

Table 9 Average efficiency gains over time for all banks: Value added approach

Periods	MI	TC	PTEC	SEC	EC
2003-2006	1.074	1.045	1.029	1.020	1.053
2007-2010	1.013	1.010	0.999	1.003	1.003
2011-2014	0.966	0.995	0.970	1.001	0.971
2015-2018	0.994	0.967	1.028	1.003	1.032
2003-2010	1.043	1.028	1.014	1.012	1.028
2011-2018	0.980	0.981	0.999	1.002	1.002
2002-2018	1.012	1.004	1.007	1.007	1.015

Note: The table reports the average values of the Malmquist Index and its components and sub-components for the periods mentioned, for all 37 banks in the sample under the value added approach in which deposits are treated as outputs. TC: Technology change (frontier shift), EC: Efficiency change (catching up), PTEC: pure technical efficiency change and SEC: scale efficiency change.

Table 10 Average efficiency scores for bank groups: Intermediation Approach

Years	PSB	Percentage of efficient banks	Private	Percentage of efficient banks	Foreign	Percentage of efficient banks
2002	0.833	15.8	0.51	18.2	0.702	42.9
2003	0.858	21.1	0.852	36.4	0.479	14.3
2004	0.831	26.3	0.787	27.3	0.497	14.3
2005	0.844	26.3	0.875	27.3	0.713	42.9
2006	0.904	31.6	0.921	36.4	0.69	42.9
2007	0.935	31.6	0.954	45.5	0.798	42.9
2008	0.955	31.6	0.921	36.4	0.923	57.1
2009	0.962	36.8	0.928	36.4	0.936	57.1
2010	0.949	21.1	0.943	27.3	0.903	42.9
2011	0.958	42.1	0.918	45.5	0.751	28.6
2012	0.972	36.8	0.919	36.4	0.819	28.6
2013	0.95	31.6	0.929	27.3	0.914	42.9
2014	0.935	26.3	0.918	27.3	0.835	28.6
2015	0.936	21.1	0.932	27.3	0.76	14.3
2016	0.929	26.3	0.949	36.4	0.753	14.3
2017	0.911	31.6	0.954	63.6	0.884	42.9
2018	0.885	21.1	0.947	36.4	0.895	42.9

Note: The table reports the average DEA scores for every year for the three groups of banks, under the intermediate approach in which deposits are treated as inputs. PSB denotes public sector banks. Percentage of efficient banks for any given year is the proportion of banks that are on the efficiency frontier in that year with a DEA score of 1.

Table 11 Average efficiency scores for bank groups: Value Added Approach

Years	PSU	Percentage of efficient banks	Private	Percentage of efficient banks	Foreign	Percentage of efficient banks
2002	0.962	47.4	0.841	27.3	0.877	57.1
2003	0.955	36.8	0.952	54.5	0.822	42.9
2004	0.924	36.8	0.923	54.5	0.849	71.4
2005	0.945	26.3	0.944	54.5	0.795	42.9
2006	0.944	36.8	0.993	72.7	0.839	71.4
2007	0.971	42.1	0.959	45.5	0.870	42.9
2008	0.961	42.1	0.961	63.6	0.969	71.4
2009	0.951	42.1	0.989	63.6	0.956	57.1
2010	0.911	15.8	0.954	63.6	0.942	71.4
2011	0.914	21.1	0.945	45.5	0.945	85.7
2012	0.887	21.1	0.948	45.5	0.894	57.1
2013	0.884	31.6	0.964	63.6	0.973	57.1
2014	0.837	26.3	0.934	45.5	0.951	71.4
2015	0.859	21.1	0.965	45.5	0.992	71.4
2016	0.958	36.8	0.977	72.7	0.990	85.7
2017	0.917	36.8	0.972	36.4	0.988	85.7
2018	0.899	15.8	0.958	72.7	1	100.0

Note: The table reports the average DEA scores for every year for the three groups of banks, under the value added approach in which deposits are treated as outputs. PSB denotes public sector banks. Percentage of efficient banks for any given year is the proportion of banks that are on the efficiency frontier in that year with a DEA score of 1.

Table 12 Efficiency gains over time for bank groups: Intermediation approach

Periods	**Public Sector Banks**				
	MI	TC	PTEC	SEC	EC
2003-2006	1.061	1.037	1.011	1.011	1.022
2007-2010	1.057	1.043	1.003	1.010	1.013
2011-2014	1.005	1.009	1.000	0.996	0.996
2015-2018	0.949	0.963	0.992	0.993	0.985
2003-2010	1.059	1.040	1.007	1.010	1.018
2011-2018	0.977	0.986	0.996	0.994	0.991
2002-2018	1.018	1.013	1.002	1.002	1.004
	Private Banks				
2003-2006	1.019	0.885	1.110	1.096	1.242
2007-2010	1.009	1.002	1.011	0.996	1.007
2011-2014	1.007	1.014	0.996	0.997	0.993
2015-2018	0.996	0.989	1.007	1.001	1.008
2003-2010	1.014	0.943	1.061	1.046	1.125
2011-2018	1.002	1.001	1.002	0.999	1.000
2002-2018	1.008	0.972	1.031	1.023	1.062
	Foreign Banks				
2003-2006	1.008	0.968	1.006	1.079	1.086
2007-2010	1.023	0.907	1.018	1.169	1.202
2011-2014	1.148	1.169	1.009	0.992	1.002
2015-2018	1.032	1.062	1.009	0.986	0.994
2003-2010	1.016	0.937	1.012	1.124	1.144
2011-2018	1.090	1.115	1.009	0.989	0.998
2002-2018	1.056	1.030	1.011	1.055	1.070

Note: The table reports the average values of the Malmquist Index and its components and sub-components for the periods mentioned, for the three groups of banks in the sample under the intermediate in which deposits are treated as inputs. TC: Technology change (frontier shift), EC: Efficiency change (catching up), PTEC: pure technical efficiency change and SEC: scale efficiency change.

Table 13 Efficiency gains over time for bank groups: Value added approach

Periods	**Public Sector Banks**				
	MI	TC	PTEC	SEC	EC
2003-2006	1.087	1.094	1.000	0.994	0.994
2007-2010	1.010	1.008	0.998	1.004	1.002
2011-2014	0.997	1.017	0.991	0.990	0.981
2015-2018	0.965	0.961	1.010	1.000	1.011
2003-2010	1.048	1.051	0.999	0.999	0.998
2011-2018	0.981	0.989	1.001	0.995	0.996
2002-2018	1.010	1.015	1.000	0.997	0.997
	Private Banks				
2003-2006	1.058	1.023	1.017	1.027	1.045
2007-2010	0.965	0.952	1.006	1.006	1.013
2011-2014	0.995	1.004	0.996	0.997	0.993
2015-2018	1.005	1.003	1.002	1.001	1.002
2003-2010	1.011	0.988	1.012	1.016	1.029
2011-2018	1.000	1.003	0.999	0.999	0.998
2002-2018	1.002	0.994	1.004	1.006	1.011
	Foreign Banks				
2003-2006	1.131	1.219	0.991	0.943	0.932
2007-2010	0.941	0.861	1.016	1.078	1.093
2011-2014	1.050	1.042	0.999	1.009	1.007
2015-2018	1.060	1.055	1.003	1.002	1.004
2003-2010	1.036	1.040	1.004	1.010	1.012
2011-2018	1.055	1.049	1.001	1.005	1.006
2002-2018	1.040	1.033	1.003	1.012	1.014

Note: The table reports the average values of the Malmquist Index and its components and sub-components for the periods mentioned, for all the three groups of banks in the sample under the value added approach in which deposits are treated as outputs. TC: Technology change (frontier shift), EC: Efficiency change (catching up), PTEC: pure technical efficiency change and SEC: scale efficiency change.

Appendices

Table 14 Top 10 banks according to the average MI values for 2002-2018

Bank name	**Intermediation Approach**				
	MI	TC	PTEC	SEC	EC
Barclays Bank Plc (F)	1.206	0.966	1.014	1.230	1.248
H D F C Bank Ltd.	1.045	0.958	1.090	1.001	1.091
Deutsche Bank A G (F)	1.039	0.964	1.078	1.000	1.078
Federal Bank Ltd. (P)	1.031	0.970	1.062	1.001	1.063
Axis Bank Ltd. (P)	1.030	0.960	1.065	1.008	1.073
Karnataka Bank Ltd. (P)	1.027	0.958	1.070	1.002	1.072
South Indian Bank Ltd. (P)	1.023	0.962	1.056	1.007	1.063
Jammu & Kashmir Bank Ltd. (P)	1.022	0.971	1.051	1.001	1.052
Indian Bank	1.020	0.968	1.054	0.999	1.053
Allahabad Bank	1.019	0.970	1.049	1.002	1.051
	Value Added Approach				
Barclays Bank Plc (F)	1.112	1.027	1.004	1.079	1.083
Citibank N A (F)	1.054	1.028	1.024	1.001	1.025
Hongkong & Shanghai Banking Corpn. Ltd. (F)	1.049	1.017	1.031	1.001	1.032
Deutsche Bank A G (F)	1.047	1.004	1.034	1.008	1.042
Bank Of America N A (F)	1.039	0.967	1.064	1.010	1.074
Allahabad Bank	1.034	1.031	1.003	1.000	1.003
Federal Bank Ltd. (P)	1.028	1.001	1.026	1.001	1.027
Canara Bank	1.020	1.020	0.994	1.005	1.000
Jammu & Kashmir Bank Ltd. (P)	1.019	1.013	1.002	1.003	1.005
Oriental Bank Of Commerce	1.018	1.009	1.009	1.000	1.009

Note: The table shows the top 10 banks according to the values of the Malmquist Index (MI) and also the average values of MI and its components for each of the banks over the period 2002 to 2018, under the intermediation and value added approaches. 'F' next to a bank's name denotes foreign banks andd 'P' denotes private bank; all other banks are public sector banks.

Table 15 Top 5 Public Sector Banks

Bank name	**Intermediation Approach**				
	MI	TC	PTEC	SEC	EC
Allahabad Bank	1.044	1.027	1.009	1.008	1.017
Canara Bank	1.034	1.026	1.010	0.998	1.008
Oriental Bank Of Commerce	1.031	1.034	0.996	1.001	0.997
State Bank Of India	1.023	1.008	1.000	1.015	1.015
Indian Bank	1.023	1.007	1.009	1.006	1.016
	Value Added Approach				
Allahabad Bank	1.036	1.040	0.998	0.999	0.996
Canara Bank	1.020	1.026	0.993	1.001	0.994
Punjab National Bank	1.014	1.015	0.998	1.001	0.999
Uco Bank	1.010	1.019	0.997	0.994	0.991
State Bank Of India	1.010	1.012	1.000	0.998	0.998

Note: The table shows the top 5 public sector banks banks according to the values of the Malmquist Index (MI) and also the average values of MI and its components for each of the banks over the period 2002 to 2018, under the intermediation and value added approaches.

Table 16 Top 5 Private Sector Banks

Note:

Bank name	**Intermediate Approach**				
	MI	TC	PTEC	SEC	EC
H D F C Bank Ltd.	1.052	0.965	1.082	1.008	1.091
Karnataka Bank Ltd.	1.041	0.971	1.043	1.028	1.072
Federal Bank Ltd.	1.030	0.969	1.052	1.011	1.063
Axis Bank Ltd.	1.029	0.958	1.051	1.021	1.073
South Indian Bank Ltd.	1.027	0.966	1.024	1.038	1.063
	Value Added Approach				
Federal Bank Ltd.	1.032	1.009	1.020	1.003	1.022
Karnataka Bank Ltd.	1.031	1.017	1.011	1.004	1.015
Jammu & Kashmir Bank Ltd.	1.023	1.023	1.000	1.000	1.000
South Indian Bank Ltd.	1.017	1.011	1.001	1.005	1.006
H D F C Bank Ltd.	1.016	1.001	1.012	1.002	1.014

Note: The table shows the top 5 private sector banks banks according to the values of the Malmquist Index (MI) and also the average values of MI and its components for each of the banks over the period 2002 to 2018, under the intermediation and value added approaches.

Table 17 Banks in the sample

Private banks	**Foreign banks**	**Public sector banks**
Axis Bank Ltd.	Bank Of America N A	Allahabad Bank
Federal Bank Ltd.	Barclays Bank Plc	Andhra Bank
H D F C Bank Ltd.	Citibank N A	Bank Of Baroda
I C I C I Bank Ltd.	Credit Agricole Corporate & Invst. Bank	Bank Of India
Indusind Bank Ltd.	D B S Bank Ltd.	Bank Of Maharashtra
Jammu & Kashmir Bank Ltd.	Deutsche Bank A G	Canara Bank
Karnataka Bank Ltd.	Hongkong & Shanghai Banking Corpn. Ltd.	Central Bank Of India
Karur Vysya Bank Ltd.		Corporation Bank
Kotak Mahindra Bank Ltd.		Dena Bank
Lakshmi Vilas Bank Ltd.		Indian Bank
South Indian Bank Ltd.		Indian Overseas Bank
		Oriental Bank Of Commerce
		Punjab National Bank
		State Bank Of India
		Syndicate Bank
		Uco Bank
		Union Bank Of India
		United Bank Of India
		Vijaya Bank