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Keywords: Banking, Bank productivity, Malmquist Index, Indian commercial banks, Technical efficiency, Non-performing asset

JEL Code: G21, G28, D24, D61

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Contents

1 Introduction

There has been a great deal of academic research to measure productivity growth in the banking sector across various countries. Conventional methods used in this extensive body of work mostly focus on a frontier efficiency analysis. This measures the deviation in productivity of a decision making unit from the efficient frontier defined by the most-productive units.

In the extant literature there are two types of methods that apply the efficient frontier concept to measure productivity: the parametric approach and the non-parametric approach. As described in Sanyal and Shankar (2011), the former is based on a stochastic frontier approach and uses a translog cost function to estimate the efficiency frontier.

On the other hand, non-parametric methods such as the Data Envelopment Analysis (DEA) and the Malmquist Index (MI) are not dependent on any particular functional form of the production frontier. They use a linear input-output programming technique. These models use 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 non-parametric method is that it does not distinguish between random error and inefficiency and assumes that all deviations from the estimated frontier represent inefficiency.

In our paper we focus on the non-parametric method, and in doing so, we highlight some measurement problems that may arise if the conventional input-output oriented methods are used to assess productivity growth of the banking sector in particular. We demonstrate these problems empirically using a specific case study, that of the banking sector of a large emerging economy, India. We raise questions as to whether productivity growth, measured using the conventional non-parametric methods is necessarily desirable.

As discussed in Canhoto and Dermine (2003), the relative efficiency of two decision making units (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 identical sample of banks. However this 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. The Malmquist Index helps calculate the absolute improvement over time in the efficiency of the DMUs studied.

The kind of measurement problems we are alluding to in our paper, become clearer when we analyse efficiency gains *over time*. Hence, in our analysis, we use the Malmquist Index (MI) method.

The MI method uses an input-output linear programming technique. As mentioned earlier, banks use multiple inputs to produce multiple outputs. Depending on the choice of inputs and outputs, there are two main approaches that use the MI method: the Intermediation approach, and the Value added approach.[1] In the Intermediation approach the banks are viewed as intermediators of financial services. The main distinction between these two approaches lies in the treatment of deposits accepted by the banks.

In the Intermediation (INT) approach, deposits are treated as inputs whereas the outputs considered are typically loans extended and investments made by the banks. On the other hand under the Value added (VA) approach, over and above loans and investments, deposits are also included as outputs. The common inputs across both these approaches are usually employee expenses, operating expenses, and interest expenses i.e. variables that capture the cost of resources (labour and capital) expended by a bank to produce the aforementioned outputs.

Both the INT and VA approaches use balance sheet variables as outputs of a bank. An alternative approach, called the Operations approach focuses instead on the income-expenditure statement of a bank and uses total income earned by a bank as the output. This can be split into interest income and non-interest income. The factors used as inputs in this model are the same as those in the INT and VA models.

A major problem with INT and VA approaches that employ the MI method is that they do not take into account the quality of loans extended, and hence the risk assumed by a bank. While applying the MI techniques of measuring productivity, a tacit assumption is made - that the quality of output remains constant over the period of time, or the cost of quality changes are incorporated in the input costs. This assumption does not hold true for banks when loans are included in the output vector. Banks can make bad loans that can imposes serious costs on them.

This intrinsic problem with the measurement of output in productivity studies of financial institutions such as banks, had been highlighted by relatively older studies in the literature such as Colwell and Davis (1992). In their insightful paper, they mention that one problem

[1]There is yet another approach called the Production approach in which banks are treated as firms which use capital and labour to produce different categories of deposit and loan accounts. Outputs are measured by the number of these accounts or the number of transactions carried out on each type of product, while total costs are all operating costs used to produce these outputs (Colwell and Davis (1992)). In recent years, the production approach has only been used by studies focusing on the relative efficiency of branches within a particular bank, rather than to study inter-bank productivity patterns. The biggest problem with this approach lies in the difficulties in collecting accurate data on the output measures.

of using loans as an output measure is that a bank may be able to boost output in terms of the balance sheet by increasing risk. But variations in risk are not taken into account in most output measures.

In this paper we empirically demonstrate this problem by applying the non-parametric MI method to the banking sector in India. 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.[2] With a total asset size of Rs 163 trillion (US$2.2 trillion) it is also among the largest banking systems in the world. We study the productivity growth in Indian banking over the last couple of decades as well as across different ownership groups.[3]

We calculate the efficiency scores of the 33 largest commercial banks in India, over the period 2002-2018, and apply the MI method across the three specific approaches discussed above-Intermediation, Value-added and Operations. We also report the results of our analysis separately for the government owned banks and private banks.

Our first finding is that our sample of banks exhibited efficiency gains during the first half of the period under review i.e. 2003-2010. This period of productivity growth (as seen from the INT and VA approaches) coincides with a period of high credit growth. This is almost inevitable by construction given that credit is an important output in both these approaches, especially in the INT approach.

A closer look suggests that this period of productivity growth in the Indian banking sector preceded a prolonged phase of balance sheet sress during which bad loans on the banks' books increased manifold. This was particularly the case for the government owned banks which also exhibited greater productivity growth in the preceding period compared to the private sector banks. This result holds across different model specifications of the MI method.

Secondly, we find some amount of moderation of the efficiency gains of banks when we use the VA approach compared to the INT approach. In the VA approach, deposits are also used as output over and above loans. In our sample of banks, deposits did not grow as rapidly as loans and hence inclusion of deposit in the output vector of the model suppresses productivity gains.

Finally, we find that the results of the INT and VA approaches that use balance sheet variables as outputs are different from that of the Operations approach that uses a bank's income as the output. In the Operations approach we are essentially capturing profitabil-

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

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

ity as a proxy for productivity and this exhibits a very different pattern of evolution over time. We find there has been a systematic decline in profitability in the banking sector during the same period when the productivity measures show an improvement in efficiency gains.

Our analytical findings highlight the fact that the conventional input-output approach based measures that use loans extended by banks as an output may convey a misleading picture of productivity growth. Banks may become more productive over time by extending more credit to their customers using the same amount of inputs or by minimising the utilisation of inputs to give out the same amount of loans. However the loans thus extended may turn bad after a few years if the borrowers default on them. In that case the health of the bank in question will deteriorate because its balance sheet now has all these stressed assets. In other words, a bank that has been exhibiting efficency gains over time may not necessaily be a healthy bank.

The main contribution of our paper is to demonstrate with empirical evidence this fundamental problem with the non-parametric methods typically used in the literature to measure productivity growth of the banking sector. By ignoring the *quality* of output produced by a bank and only focusing on the *quantity*, the conventional measures may not be the most accurate ways to estimate efficiency gains of the banking sector. They must be adjusted such that the riskiness of the loans extended by the banks is taken into consideration.

Addressing the issue about quality of loans in the model however poses different kind of challenges. The quality of loans is revealed over a period of time, in some cases several years after the loan is made. This issue is especially acute for banks in an emerging economy such as India. The loan books of Indian banks are dominated by the so called 'term loans'. These are long term loans whose payback period can be anywhere between 3 years to 10 years. This implies that even if data were available, say on the disclosed levels of non-performing assets (NPAs, i.e. bad loans) of the banks, it would be difficult to correctly assign them to the specific time period when the loans were originated, and hence adjust the credit growth for NPAs.

According to Colwell and Davis (1992), in order to account for the riskiness of loans given by a bank, "..it might be more appropriate to use some ex-post revenue measure, covering losses over the (loan) cycle, with provisions as negative output." Charnes et al. (1990) also suggested that provisions and actual loan losses could be counted as inputs. Banks make provisioning for credit losses that arise from bad loans. Conceptually, we could use such loan loss provisioning as another cost and include it in the input vector of the model. The level of provisioning at different stages of a loan is determined by the regulations governing the banks. Under Indian regulations, for example, banks start providing for

bad loans only after the default is more than 90 days old. Further, the provisioning is extended over a period of 3 to 4 years. This makes it difficult to relate the level of loan loss provisions in a year to the loans made in a specific year.

These issues highlight the challenges of adjusting bank credit growth for potential bad loans. Therefore, it is important to interpret the results obtained from the conventional input-output approach based measures of productivity with great care. Attention must be paid to the fact that periods of rapid credit growth in the banking sector would inevitably result in high productivity growth but this may also result in high credit losses in the subsequent periods.

The rest of the paper is organised as follows. In section 2, we present a comprehensive discussion of several studies that have applied the non-parametric method to the banking sector. In section 3 we provide a brief background of the Indian banking sector. In section 4 we present a detailed empirical analysis of productivity growth of Indian commercial banks and discuss the results for various model specifications. In section 5 we use our analytical findings from the Indian case study to ask some fundamental questions about the way productivity is conventionally measured in the banking sector. Finally we conclude in section 6.

2 Literature Review

Several studies exist in the literature that have used the Malmquist Index method to estimate efficiency gains over time in the banking sector.[4] Many of these studies have analysed the impact of deregulation on productivity growth in banking.

For instance, Berg, Forsund and Jansen (1992) study the productivity growth during the deregulation of the Norwegian banking industry. Using the DEA and MI methods they find that productivity increases rapidly post deregulation.

Some of the more recent studies include Canhoto and Dermine (2003) who quantify the magnitude of relative efficiency gains of banks in Portugal over the period 1990-1995. Their objective is to evaluate the impact of deregulation and granting of new licenses on the efficiency of the banking system. They find that in the post-deregulation period, overall efficiency of the banking sector improved and this was particularly the case for the new banks that were created at the time.

Mukherjee, Ray and Miller (2001) explore the productivity growth for a group of 201 large US commercial banks during the post-deregulation period from 1984 to 1990. They use the MI method and find that overall productivity grew at an average rate of 4.5%.

[4]For a detailed review of the literature on bank efficiency studies, see Berger and Humphrey (1997).

Majority of the studies that analyse efficiency gains in the Indian banking sector using the DEA and MI approach, are restricted to the immediate post-deregulation era with sample periods ending roughly in the mid 2000s. These studies have explored the effect of the deregulation and liberalisation reforms of early 1990s on productivity growth in the banking sector.

For instance, Das and Ghosh (2006) evaluate efficiency estimates of Indian banks using the non-parametric methods. Similar to our study, they also use the three approaches: Intermediation, Value added and Operations. They find that during the post-reform period of 1992-2002, medium-sized public sector banks exhibited higher levels of efficiency. However they do not estimate the MI model and hence their efficiency scores are not-comparable over time.

They do discuss the relationship between efficiency and soundness of banks. They find using correlation analysis and a multivariate Tobit model that more efficient banks are also those that have on average less non-performing loans and higher capital. However as discussed in the previous section, loans turn bad with a lag. Capital too gets eroded as and when loans turn non-performing, because that is when a bank has to dip into its capital to provide for the losses. Hence, a contemporaneous association between a bank's efficiency and soundness may not be the correct analysis.

Some of the other studies on Indian banking include Bhattacharyya et al. (1997), Sathye (2003), Das et al. (2005), Kumar and Gulati (2009), among others. However, none of these studies seems to have taken into account the possibility that productivity of the banking industry measured using the conventional methods may not convey the correct picture, owing to the intrinsic problems of measuring the output of a bank. Our study fills this gap in the literature by offering empirical evidence that efficiency gains in the banking sector, measured using the existing methods, might potentially lead to deterioration of bank balance sheets and hence must be interpreted with great care and caution.

3 Banking in India

Till the mid 1990s, the banking landscape in India was dominated by the government owned banks. 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. These reforms forced the erstwhile public sector banks (PSBs) to compete with new private and foreign banks in a more open, and market-oriented environment.

Since then, Indian banking has witnessed many significant changes such as rapid growth of the 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, 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. Given this background India provides an interesting case study to analyse the evolution of productivity gains in the banking sector and the distribution of productivity gains across different ownership groups of banks, over a long period of time.

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.

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. In this part of the descriptive analysis we use data on the entire commercial banking sector as obtained from the Reserve Bank of India database.

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

[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.

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.

Motivated by these preliminary findings, in the next section we dig deeper into the patterns of productivity growth of a sample of Indian commercial banks, using rigorous empirical methods, that are standard in the productivity literature.

4 Analysis of productivity growth in Indian banking

We assess technical efficiency of the banks in our sample using a non-parametric programming method called the Malmquist Index (MI). We calculate the efficiency scores for the 'input-oriented' model, under the constant returns to scale (CRS) assumption.[7]

The MI technique is 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 this method is

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

[7]The results remain the same if we assume variable returns to scale (VRS) or estimate an 'output-oriented' model. The VRS assumption is typically used in order to dig deeper into the various sources of productivity gains. Since that is not the objective of our paper, we stick to the CRS model. For details on the MI method, see Mukherjee, Ray and Miller (2001).

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 balance-sheet approaches: Intermediation approach (INT) and Value added (VA) approach. In the former, the inputs are deposits, employee expenses, and operating expenses and the 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. This is similar to the models estimated in Das and Ghosh (2006).

We also estimate a third approach called the Operations (OP) approach where we consider a bank's interest income and non-interest income as outputs and the inputs are the same as in the Value-added approach, i.e. interest expenses, employee expended and operating expenses. This approach takes a purely operational view of the banks, focusing on income as an output and costs as inputs. It does not consider the balance sheet factors as relevant for productivity but only the factors included in the income statement.

Among the first two approaches that use balance sheet variables as outputs, the INT approach evaluates the efficiency of converting deposits into loans whereas the VA approach assesses the efficiency of gathering deposits over and above the efficiency of extending credit.[8]

We use data on 33 scheduled commercial banks for our analysis with the composition being 19 PSBs, 9 private banks and 5 foreign banks, as shown in table 12. 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).

Our sample period is 2002 to 2018. This decision was motivated by the fact that calculation of the Malmquist Index works best on 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. From 2018 onwards several public sector banks got merged and this would affect our data. That is why we end our sample in March 2018.[9]

Table 1 shows the summary statistics of all the output and input measures used in the

[8]In several studies, investment by banks is also included as an output. As a part of the Statutory Liquidity Reserve (SLR) requirements, Indian banks are mandated by regulation to invest a certain fraction of their total liabilities in government securities. Since this investment is related to the level of liabilities, it does not require the use of much resources. Non-SLR investments which are discretionary are a very small fraction of the balance sheets of most banks in our sample. Hence we do not consider investment as an output. In any case even when we do, the results of the paper remain the same.

[9]We have estimated our models for a longer time period as well, from 1995 to 2018 and the results of the paper remain the same.

various models in our paper, for the full sample period, 2002-2018. We show this for all banks as well as for the public and private sector banks.

We next discuss the growth in productivity over time as seen from the Malmquist Index values, for all banks as well as for the public and private sector banks in our sample.[10]

We report the raw values of the Malmquist Index for the INT, VA and OP approaches in the Appendix in tables 8, 9 and 10 respectively, for all banks as well as for the public and private sector banks. These tables show the average index values for each year in our sample.

For the ease of interpretation, we calculate the compounded annual growth rates (CAGR) of productivity of the banks based on the MI values as obtained from our model estimation. In order to demonstrate the dynamic evolution of efficiency gains over time, we report the growth rates of productivity for four equal sub-periods as opposed to showing the values for every year.

We also split the sample into two halves and look at the CAGR values for these two periods viz: 2003-2010 and 2011-2018.[11] 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 3. Hence, we analyse the results by comparing the estimates from these two periods. Finally, we also show the CAGR values for the entire sample period. These are shown in tables 2, 3 and 4 for the INT, VA and OP approaches respectively.

4.1 Intermediation and Value-added approaches

- **2003-2010**: We see from table 2 that under the INT approach, the compounded annual growth rate of productivity of all banks in the first half of the sample period was 3.64%. The efficiency gains were unevenly distributed during this period, with the years 2003-2006 witnessing a productivity growth of 4.64% whereas productivity growth came down to 1.87% in 2007-2010. This finding is in line with our observation in section 3 that till about 2010, the banking sector in India witnessed steady productivity gains.

  The pattern of productivity growth is similar for both public (PSBs) and private sector banks, though the magnitude of the efficiency gains is much higher for the PSBs. While their productivity grew by 7.22% till 2010, the private banks reported much smaller efficiency gain (1.8%) during this period. The PSBs experienced pos-

[10] Although our sample of banks includes 5 foreign banks we do not separately analyse their productivity gains. Primarily we are interested in the public and private bank categories as they account for lion's share of banking business in India.

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

itive productivity growth throughout the first half of our sample period, including a staggering 9.27% growth in the years 2003-2006.

The private sector banks on the other hand witnessed a decline in productivity growth in 2007-2010. This echoes our observations in section 3 that by the mid-2000s the private banks in India had run the course of efficiency improvements whereas the PSBs were catching up to them throughout this period by adopting modern technology etc.

- **2011-2018**: The CAGR of productivity growth for all banks in our sample during this period is -2.13% indicating that between 2011 and 2018, there was a decline in productivity. While efficiency on a compounded basis increased by 2.63% during 2011-2014, it declined by 7.04% during the 2015-2018 period.

  The decline in productivity was evidently led by the PSBs whose productivity during this period grew at a CAGR of -2.86%, whereas the private sector banks exhibited a new stagnation of productivity growth (0.48%). Both these groups of banks gained efficiency in the years 2011-2014 but there was a marked decline in efficiency in the subsequent years, especially for the PSBs (-7.84%).

For the full sample period (2003-2018), the efficiency improvement was only by 1.01% which indicates a productivity stagnation. This is because the sample period first witnessed efficiency gains followed by an almost equivalent decline in productivity.

The results of the sub-periods mask year-wise differences in productivity which are shown more clearly in table 8 in the Appendix. The pattern that seems to emerge from this analysis is that when we consider loans and advances as the sole output of the banking sector, there is evidence of productivity growth in the first half of our sample period, during the years 2003-2010 followed by a stagnation or a decline in efficiency gains, particularly during the latter part of our sample period, 2015-2018. The patterns are more pronounced for the PSBs.

Results under the VA approach are similar in terms of the productivity gains till 2010 and the stagnation/decline thereafter. Table 3 shows that during the sub-period 2003-2010, compounded growth rate of productivity for all banks was 4.12%. On the other hand, during 2011-2018, efficiency decreased by 2.62%. Likewise the efficiency of PSBs and private banks improved on a compounded basis by 4.97% and 1.56% respectively, during 2003-2010, whereas in the second half, both groups of banks experienced a decline in productivity growth, the PSBs more than the private banks. These patterns perhaps hint at some kind of a mean reversion after a period of steady efficiency gains.

The difference in the results of the two approaches is that in the VA approach i.e. when both deposits and loans are considered as outputs, the productivity growth of the 2007-

2010 period is more muted (0.98%) compared to the INT approach (1.87%). This is consistent across both PSBs and private banks.

In fact in the subsequent period (2011-2014), the VA approach (table 3) shows a decline in productivity for all groups of banks, especially for the private banks (-5.11%), whereas the INT approach (table 2) continues to show positive efficiency gains. This is presumably because the inclusion of deposits in the output vector suppresses productivity. The deposits of these banks did not grow as rapidly as loans during the period under review. That is why we see from tables 8 and 9, that for the years 2005-2009, when credit growth was at its peak, the raw MI values for the INT approach are higher than those under the Value added approach. In fact in the 2015-2018 period both credit and deposit growth slowed down which gets reflected in productivity declines in both the INT and VA approaches.

This further highlights the measurement problem we are alluding to in our paper, that using the quantity of loans in the output vector may convey a misleading picture of productivity gains of the banking sector.

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. Our empirical analysis shows that 2003-2010 was a period of steady productivity gains in the banking sector in India which stagnated or got reversed in the subsequent years. We get similar patterns from studying both the Intermediation and Value-added approaches.

We also conduct robustness checks wherein we add capital as an input in both the models, following studies such as Mukherjee, Ray and Miller (2001). The results presented in tables 5, and 6 for the INT and VA approaches respectively, are similar to those discussed above. There is a clear pattern of productivity growth till about 2010 after which productivity seems to have declined. The patterns as before, are more acute for the PSBs compared to the private sector banks. The corresponding graphs for the cumulative productivity growth rates are presented in the Appendix.

4.2 Operations approach

The results from the third approach i.e. the OP approach are quite different from those of the first two approaches. As shown in table 4, under this approach, the banks in our sample experienced a decline in productivity till about 2006 (-2.61%); after which till 2010, there were some efficiency gains which again turned negative in 2011-2014 (-1.66%).

As a result during the first half of our sample, the OP approach shows that the banks in our sample hardly experienced any productivity growth (0.07%). This is the same for the

PSBs. The private sector banks infact witnessed a decline in productivity growth during this period (-1.93%). These numbers are in stark contrast of our findings in the first two approaches.

What is consistent across all the three approaches is that productivity declined from 2011 onwards, and the decline is more evident during the years 2015-2018.

In case of the OP approach, incorporating capital in the model shows a decline in productivity growth even during the 2003-2010 period (see table 7). In both the models with and without capital, we find that this approach shows a negative productivity growth for the full period, for all banks as well as for the two bank groups.

In this approach the output vector includes a bank's income whereas the input vector consists of the bank's expenses. In other words, this approach may be regarded as capturing a bank's profitability. Our results are showing that during the period when the balance-sheet centric methods show clear evidence of efficiency gains of the banks, the profitability of the same banks was either negligible or declining. This is more so for the model incorporating capital as an input (see table 7) because when capital is accounted for, profitability further goes down.

In table 7 we find that the decline in productivity was more acute for the private sector banks in nearly all sub-periods. When the private banks were small in size relative to the banking industry, they could run higher profitability businesses. However, as they started becoming larger relative to the system, competitive pressures forced them to revert to the industry average profitability.

We graphically depict our findings in figures 3 to 5. We plot the cumulative productivity growth of all banks, public and private sector banks for all the years in our sample, for the three approaches, respectively. We take the annual productivity gains or losses estimated from the model and using the year 2002 as the basis, we plot the cumulative effect of these annual changes in productivity. Alternatively, in figure 6 we plot the cumulative productivity for all the three approaches together for all the banks in our sample in order to be able to compare the results.

Whichever way to plot it, the result is consistent - productivity gain from 2004 until about 2011 and a stagnation or decline thereafter. The INT approach that uses only loans in the output vector, clearly shows much greater variation compared to the VA approach where deposits as output moderate the overall productivity gains. Both these approaches converge by 2018 when deposit and loan growth slows down to similar levels of around 10%. Productivity under the OP approach peaks in 2010. Since we have kept the scale of the axis same across all the figures we can see that the efficiency gains under this approach are significantly more muted compared to the other two.

5 How to interpret productivity gains in banking?

The descriptive discussion of section 3 as well as the analytical exposition of section 4 reveal a consistent finding, that the Indian banking sector witnessed significant productivity gains from early 2000s till about 2010-11, especially when we use balance sheet variables as outputs in the Intermediation and Value-added approaches. Thereafter the productivity growth stagnated and in the recent years, roughly from 2015 onwards, 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, using the Indian banking sector as a case-study.

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, or minimises the use of inputs to extend the same amount of total credit, 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. The same logic applies to minimising the use of resources to extend the same amount of credit as before which too can lead to a compromise in credit quality.

Therefore, when banking output is measured in terms of the volume of credit, periods of rapid credit growth are likely to coincide with period of 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.

- **2003-2010**: The 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 public sector banks 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. Figure 7 shows the year on year growth in credit for all the banks in our sample. The period of credit boom from roughly 2004 to 2008 is evident here as well. This was particularly so for the public sector banks as shown in figure 8. As our analysis in the previous sections shows, this was also the period of steady productivity growth in the banking system, and especially for the PSBs.

In the post 2010 period, non-performing assets (NPAs) in the banking sector began rising steadily especially from 2015 onwards. 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. The rise in NPAs for our sample of banks is shown in figure 7 and for the PSBs specifically in figure 8.

Private sector banks which experienced relatively mild productivity gains from 2003 to 2010, (see tables 2 and 3) did not experience as severe a rise in NPAs as the public sector banks, in the subsequent period.

Table 11 show the top 10 banks by values of the MI index, under all three approaches, for the first half of our sample period. In the post-2015 period, the Reserve Bank of India (RBI) had initiated a Prompt Corrective Action framework in order to address the balance sheet problems of several stressed banks that had reported high levels of non-performing assets. It is interesting to note that 5 out of the top 10 banks as per the INT approach, for the period 2003-2010 eventually came under the RBI's PCA framework in the post-2015 period.

Thus, a period of rapid productivity improvement in Indian banking coincided with a period of high credit growth. As mentioned earlier, this might just be the outcome of the manner in which the productivity measures are designed. The output parameter in the measures of bank 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 the public sector banks. Between 2010 and 2015,

credit growth in the Indian banking sector slowed down to a CAGR of roughly 14.5%. Credit growth fell further in the post-2015 period.

This was partly because of a decline in private corporate investment which depressed the demand for credit and partly because NPA-saddled banks themselves became wary of lending. This shows up as a slowdown in productivity but if as a result of the balance sheet stress, banks tightened their lending standards, a decline in productivity measured using the conventional methods might be a desirable outcome.

The above discussion implies that productivity measures that can be applied to non-financial firms 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.

We also find that the results of our analysis crucially depend on which variables are used as outputs. While we find evidence of productivity growth when loans and deposits are treated as outputs of a bank, we find entirely different results when we use income earned by a bank as output.

6 Conclusion

Our empirical investigation using the Malmquist Index technique over the period from 2002 to 2018 for a sample of 33 banks reveals 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. 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.

Our analysis raises some important questions about how to measure productivity in the banking sector and how to interpret the results. The desirability of improvement in bank productivity measured using the conventional methods is doubtful, especially 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 that factor in the unique nature of business conducted by banks would be needed to understand productivity in banking, so that the analysis can provide insights that are useful for policy making.

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7 Figures and Tables

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

This figure shows the evolution over time of two measures of productivity in Indian banking: ratio of operating costs to total income and ratio of operating costs to average total assets of all commercial banks.

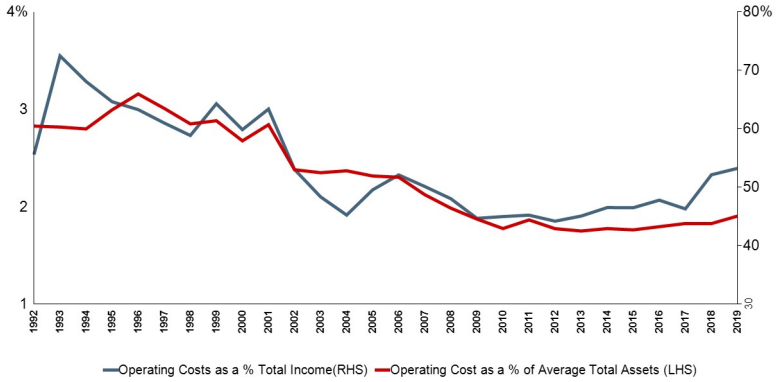

Figure 2 Cost of intermediation for various groups of banks, 1991-2019

This figure shows the evolution over time and across groups of banks of the ratio of operating costs to average total assets. The four bank groups are private sector banks which include the old and the new private banks, foreign banks, State Bank of India and its associates and the non-SBI public sector banks.

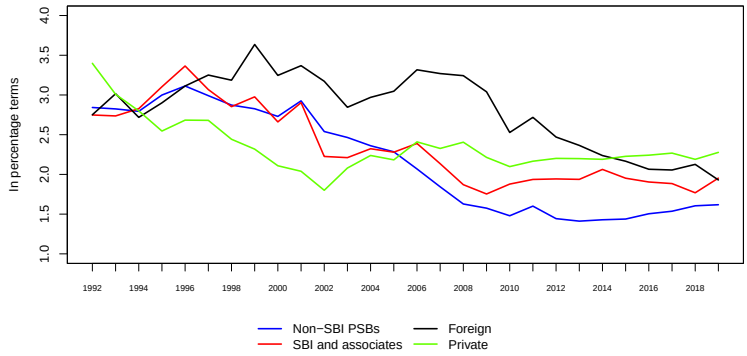

Figure 3 Cumulative Productivity Growth: Intermediation Approach

This figure shows the evolution over time in the efficiency scores obtained from the Intermediation approach, for all the 33 banks in our sample as well as separately for the public and private sector banks.

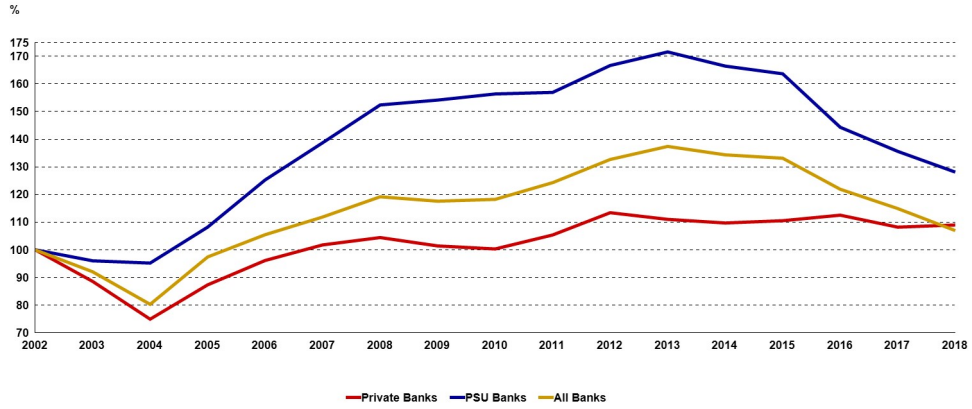

Figure 4 Cumulative Productivity Growth: Value-added Approach

This figure shows the evolution over time in the efficiency scores obtained from the Value added approach, for all the 33 banks in our sample as well as separately for the public and private sector banks.

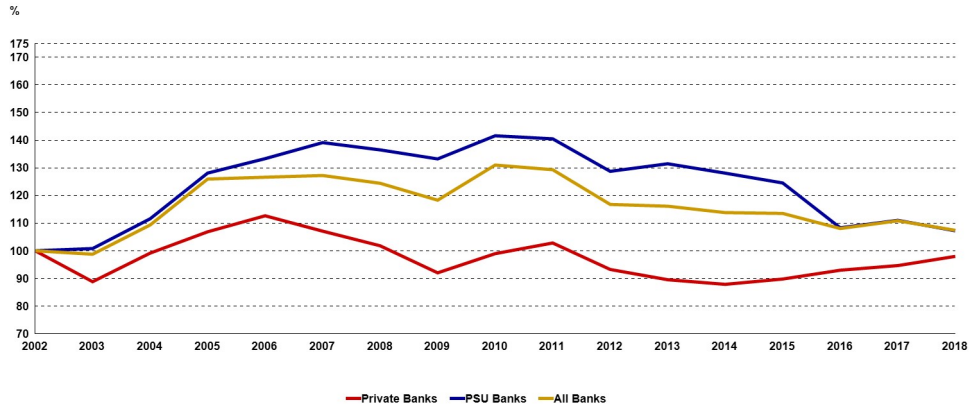

Figure 5 Cumulative Productivity Growth: Operations Approach

This figure shows the evolution over time in the efficiency scores obtained from the Operations approach, for all the 33 banks in our sample as well as separately for the public and private sector banks.

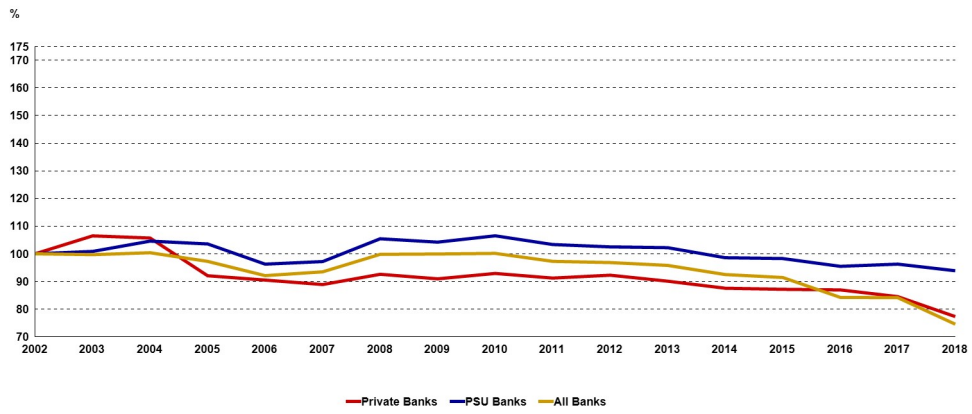

Figure 6 Cumulative Productivity Growth: All 3 approaches

This figure shows the evolution over time in the efficiency scores of all the banks in our sample separately for the three approaches, namely, Intermediation, Value added and Operations.

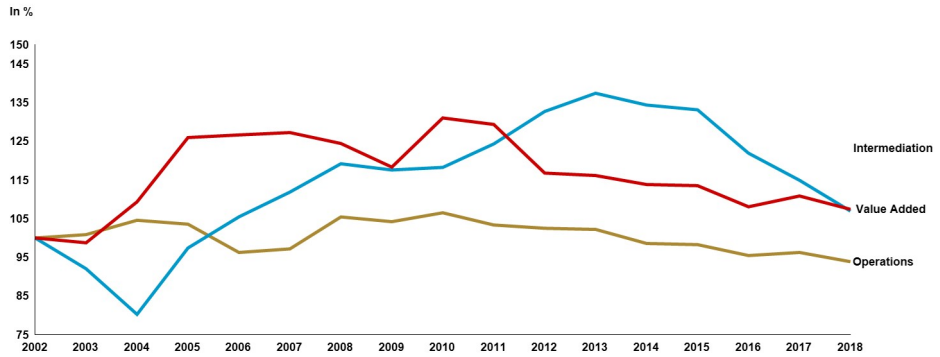

Figure 7 Growth of Credit and NPAs for public sector banks

This figure shows the year on year growth of loans and non-performing assets (NPA) of all the 33 banks in our sample for the years 2002 to 2018. Net NPA refers to gross NPA less provisioning.

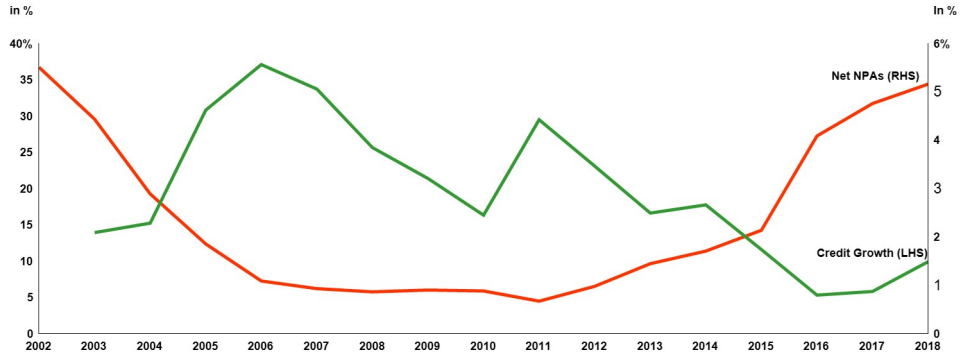

Figure 8 Growth of Credit and NPAs for all banks

This figure shows the year on year growth of loans and non-performing assets (NPA) of the public sector banks in our sample for the years 2002 to 2018. Net NPA refers to gross NPA less provisioning.

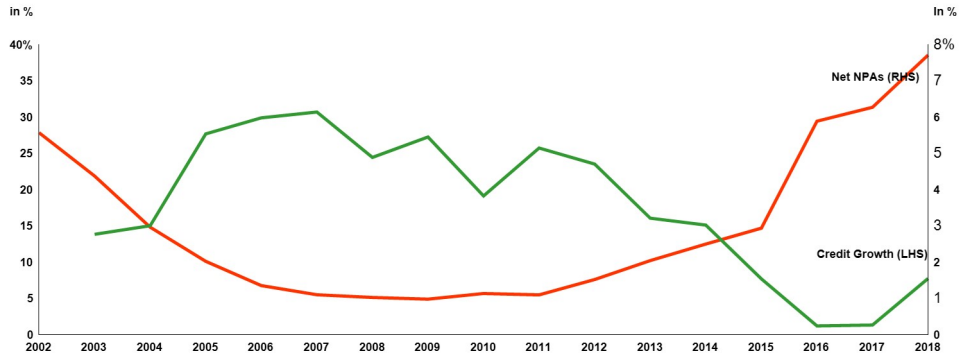

Table 1 Summary Statistics: Average output and input measures

Variables	All banks	Public sector banks	Private sector banks
Loans	1102.70	1450.60	860.46
Deposits	1424.31	1935.23	978.21
Interest income	131.57	169.64	106.89
Non-interest income	24.74	27.85	25.44
Employee expense	17.18	23.49	10.87
Operating expense	41.86	50.01	38.51
Interest expense	86.25	115.57	64.8
Capital & Reserves	126.04	133.01	144.26

Note: This table reports the average values of all the output and input measures used in our productivity models, for the full sample period, from 2002 to 2018. All figures are in Rs billion. All banks include private sector, public sector and foreign banks.

Table 2 Average efficiency gains over time for banks: Intermediation approach

Periods	All banks	Public sector banks	Private banks
2003-2006	4.64%	9.27%	2.77%
2007-2010	1.87%	4.07%	-0.48%
2011-2014	2.63%	1.98%	1.35%
2015-2018	-7.04%	-7.84%	-0.47%
2003-2010	3.64%	7.22%	1.80%
2011-2018	-2.13%	-2.86%	0.48%
2003-2018	1.01%	1.94%	1.39%

The table reports the compounded annual growth rates (CAGR) of productivity of all the 33 banks in the sample, for various sub-periods. It also shows the productivity growth of the public and private sector banks. The productivity has been measured using the Malmquist Index method and following the Intermediation Approach, where loans are the output and the inputs are deposits, employee expenses, and operating expenses.

Table 3 Average efficiency gains over time for banks: Value added approach

Periods	All banks	Public sector banks	Private banks
2003-2006	8.64%	9.77%	8.25%
2007-2010	0.98%	0.59%	-2.60%
2011-2014	-4.17%	-3.04%	-5.11%
2015-2018	-1.83%	-4.86%	2.96%
2003-2010	4.12%	4.97%	1.56%
2011-2018	-2.62%	-3.79%	-0.69%
2003-2018	0.56%	0.41%	0.66%

The table reports the compounded annual growth rates (CAGR) of productivity of all the 33 banks in the sample, for various sub-periods. It also shows the productivity growth of the public and private sector banks. The productivity has been measured using the Malmquist Index method and following the Value-added Approach, where loans and deposits are the outputs and the inputs are employee expenses, interest expenses and operating expenses.

Table 4 Average efficiency gains over time for banks: Operations approach

Periods	All banks	Public sector banks	Private banks
2003-2006	-2.61%	-1.55%	-5.28%
2007-2010	2.33%	3.10%	1.48%
2011-2014	-1.66%	-1.56%	-1.36%
2015-2018	-6.58%	-1.52%	-3.93%
2003-2010	0.07%	0.78%	-1.93%
2011-2018	-3.73%	-1.37%	-2.34%
2003-2018	-1.92%	-0.48%	-2.11%

The table reports the compounded annual growth rates (CAGR) of productivity of all the 33 banks in the sample, for various sub-periods. It also shows the productivity growth of the public and private sector banks. The productivity has been measured using the Malmquist Index method and following the Operations Approach, where interest income and non-interest income are the outputs and the inputs are employee expenses, interest expenses and operating expenses.

Table 5 Average efficiency gains over time for banks: Intermediation approach, with capital

Periods	All banks	Public sector banks	Private banks
2003-2006	3.51%	7.15%	0.31%
2007-2010	1.38%	3.73%	-1.52%
2011-2014	2.85%	2.15%	1.88%
2015-2018	-4.35%	-7.20%	0.07%
2003-2010	2.92%	6.31%	0.31%
2011-2018	-0.87%	-2.58%	0.60%
2003-2018	1.27%	1.66%	0.69%

The table reports the compounded annual growth rates (CAGR) of productivity of all the 33 banks in the sample, for various sub-periods. It also shows the productivity growth of the public and private sector banks. The productivity has been measured using the Malmquist Index method and following the Intermediation Approach, where loans are the output and the inputs are deposits, employee expenses, operating expenses and capital.

Table 6 Average efficiency gains over time for banks: Value Added approach, with capital

Periods	All banks	Public sector banks	Private banks
2003-2006	6.85%	6.14%	6.30%
2007-2010	0.76%	0.50%	-2.33%
2011-2014	-2.64%	-0.84%	-3.84%
2015-2018	-0.28%	-3.44%	3.80%
2003-2010	3.32%	3.53%	1.04%
2011-2018	-1.38%	-2.23%	0.81%
2003-2018	0.81%	0.56%	0.64%

The table reports the compounded annual growth rates (CAGR) of productivity of all the 33 banks in the sample, for various sub-periods. It also shows the productivity growth of the public and private sector banks. The productivity has been measured using the Malmquist Index method and following the Value-added Approach, where loans and deposits are the outputs and the inputs are employee expenses, interest expenses, operating expenses and capital.

Table 7 Average efficiency gains over time for banks: Operations approach, with capital

Periods	All banks	Public sector banks	Private banks
2003-2006	-5.24%	-5.30%	-6.52%
2007-2010	1.30%	2.31%	0.05%
2011-2014	-0.81%	0.02%	-0.25%
2015-2018	-2.54%	-1.96%	-1.67%
2003-2010	-1.61%	-1.0%	-2.89%
2011-2018	-1.61%	-0.97%	-1.14%
2003-2018	-1.80%	-1.17%	-2.15%

The table reports the compounded annual growth rates (CAGR) of productivity of all the 33 banks in the sample, for various sub-periods. It also shows the productivity growth of the public and private sector banks. The productivity has been measured using the Malmquist Index method and following the Operations Approach, where interest income and non-interest income are the outputs and the inputs are employee expenses, interest expenses, operating expenses and capital.

Appendix

Figure 9 Cumulative Productivity Growth: Intermediation Approach with capital

This figure shows the evolution over time the efficiency gains obtained from the Intermediation approach with capital as an input, for all the 33 banks in our sample as well as separately for the public and private sector banks.

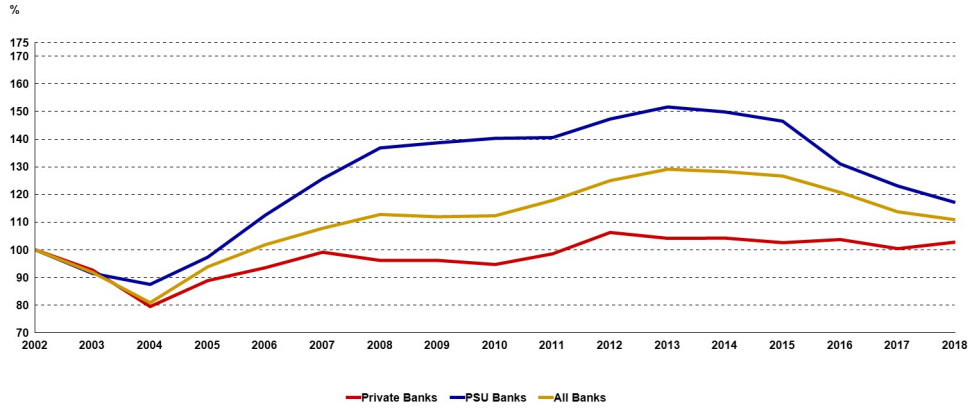

Figure 10 Cumulative Productivity Growth: Value-added Approach with capital

This figure shows the evolution over time the efficiency gains obtained from the Value added approach, with capital as an input, for all the 33 banks in our sample as well as separately for the public and private sector banks..

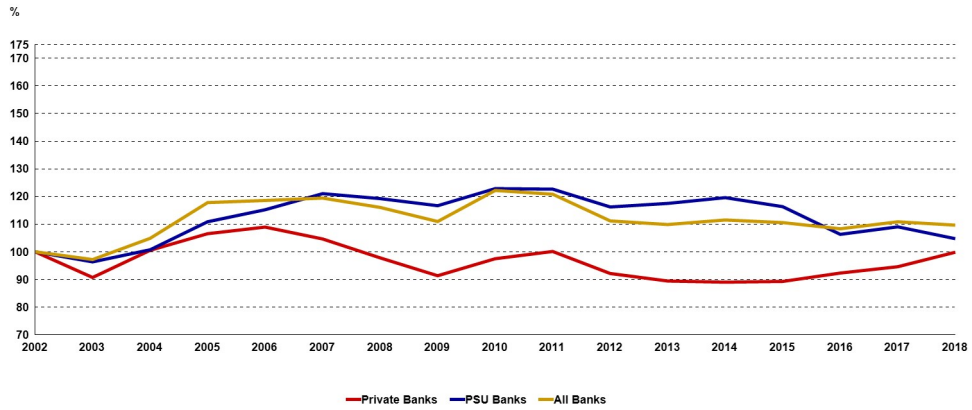

Figure 11 Cumulative Productivity Growth: Operations Approach with capital

This figure shows the evolution over time the efficiency gains obtained from the Operations approach, with capital as an input, for all the 33 banks in our sample as well as separately for the public and private sector banks.

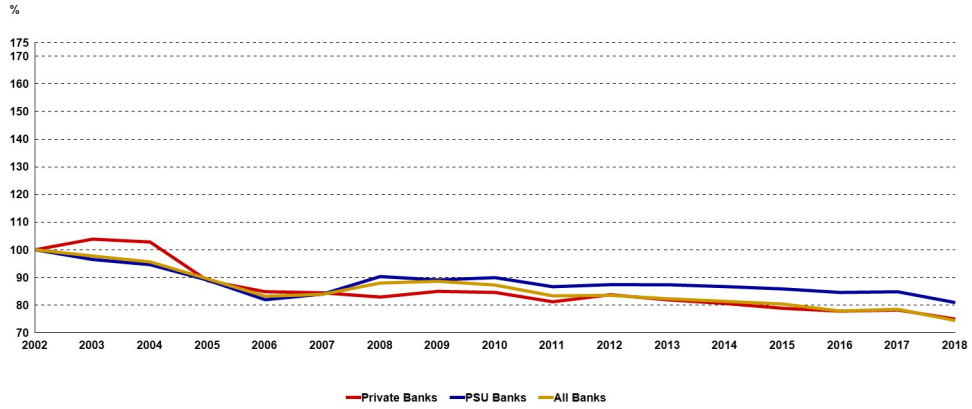

Table 8 Average efficiency gains over time for all banks: Intermediation approach

Years	All banks	Public sector banks	Private banks
2003	0.920	0.960	0.886
2004	0.872	0.991	0.846
2005	1.214	1.137	1.166
2006	1.083	1.158	1.101
2007	1.061	1.107	1.059
2008	1.065	1.099	1.026
2009	0.987	1.012	0.971
2010	1.006	1.014	0.989
2011	1.051	1.004	1.050
2012	1.067	1.062	1.076
2013	1.036	1.029	0.979
2014	0.978	0.970	0.988
2015	0.991	0.983	1.008
2016	0.916	0.882	1.018
2017	0.943	0.940	0.961
2018	0.931	0.945	1.007

Note: The table reports the average values of the Malmquist Index for all years, for all 33 banks in the sample under the intermediation approach in which deposits are treated as inputs. These are the results from the baseline model where capital is not included as an input. MI value of 1.065 for all banks in 2008 implies that our sample banks experienced an increase in efficiency of 6.5% on average relative to the efficiency frontier of 2007. Likewise a value of 0.916 for all banks in 2016 implies that our sample banks experienced a decline in productivity by 8.4% relative to 2015.

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

Years	All banks	Public sector banks	Private banks
2003	0.988	1.008	0.888
2004	1.107	1.107	1.116
2005	1.152	1.148	1.078
2006	1.005	1.041	1.054
2007	1.005	1.044	0.951
2008	0.978	0.981	0.951
2009	0.951	0.976	0.904
2010	1.107	1.063	1.075
2011	0.987	0.992	1.039
2012	0.903	0.916	0.907
2013	0.995	1.021	0.960
2014	0.980	0.974	0.981
2015	0.997	0.972	1.022
2016	0.952	0.870	1.036
2017	1.026	1.025	1.018
2018	0.969	0.966	1.035

Note: The table reports the average values of the Malmquist Index for all years, for all 33 banks in the sample under the value-added approach in which deposits are treated as outputs. These are the results from the baseline model where capital is not included as an input. MI value of 1.107 for all banks in 2004 implies that our sample banks experienced an increase in efficiency of 10.7% on average relative to the efficiency frontier of 2007. Likewise a value of 0.980 for all banks in 2014 implies that our sample banks experienced a decline in productivity by 2% relative to 2013.

Table 10 Average efficiency gains over time for all banks: Operations approach

Years	All banks	Public sector banks	Private banks
2003	0.997	1.009	1.065
2004	1.007	1.037	0.993
2005	0.969	0.990	0.871
2006	0.947	0.929	0.983
2007	1.015	1.010	0.982
2008	1.068	1.085	1.042
2009	1.001	0.988	0.982
2010	1.002	1.022	1.021
2011	0.971	0.970	0.982
2012	0.996	0.992	1.011
2013	0.989	0.997	0.976
2014	0.966	0.964	0.972
2015	0.988	0.997	0.995
2016	0.921	0.971	0.998
2017	0.999	1.008	0.972
2018	0.886	0.975	0.914

Note: The table reports the average values of the Malmquist Index for all years, for all 33 banks in the sample under the operations approach in which the outputs are interest and non-interest income. These are the results from the baseline model where capital is not included as an input. MI value of 1.068 for all banks in 2008 implies that our sample banks experienced an increase in efficiency of 6.8% on average relative to the efficiency frontier of 2007. Likewise a value of 0.921 for all banks in 2016 implies that our sample banks experienced a decline in productivity by 7.9% relative to 2015.

Table 11 Top 10 banks according to the average MI values for 2003-2010

Intermediation	**Value-Added**	**Operations**
Oriental Bank of Commerce*	Allahabad Bank*	UCO Bank*
UCO Bank*	UCO Bank*	Dena Bank*
Dena Bank*	Oriental Bank of Commerce*	Allahabad Bank*
Central Bank of India*	Canara Bank	Canara Bank
Allahabad Bank*	Dena Bank*	Central Bank of India*
Lakshmi Vilas Bank Ltd. (P)	Syndicate Bank	Oriental Bank of Commerce*
Canara Bank	Lakshmi Vilas Bank Ltd. (P)	Vijaya Bank
South Indian Bank Ltd. (P)	Punjab National Bank	Bank of Baroda
HDFC Bank Ltd. (P)	Union Bank of India	South Indian Bank Ltd. (P)
Federal Bank Ltd. (P)	Federal Bank Ltd. (P)	Union Bank of India

Note: The table shows the top 10 banks according to the values of the Malmquist Index (MI) over the period 2002 to 2018, under the intermediation, value added approaches and operations approaches. 'P' next to a bank's name denotes private bank; all other banks are public sector banks. We have not considered the foreign banks while doing this ranking. '*' next to a bank's name denotes the fact that this particular bank was put on the Prompt Corrective Action program by the Reserve Bank of India in the post-2015 period.

Table 12 Banks in the sample

Private banks	**Foreign banks**	**Public sector banks**
Axis Bank Ltd.	Bank Of America N A	Allahabad Bank
Federal Bank Ltd.	Citibank N A	Andhra Bank
H D F C Bank Ltd.	D B S Bank Ltd.	Bank Of Baroda
I C I C I Bank Ltd.	Deutsche Bank A G	Bank Of India
Indusind Bank Ltd.	Hongkong & Shanghai Banking Corpn. Ltd.	Bank Of Maharashtra
Karur Vysya Bank Ltd.		Canara Bank
Kotak Mahindra Bank Ltd.		Central Bank Of India
Lakshmi Vilas Bank Ltd.		Corporation Bank
South Indian Bank Ltd.		Dena Bank
		Indian Bank
		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