Efficiency of commercial banks in India after global financial crises

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Abstract. This study contributes to the bank efficiency literature by estimating the technical efficiency of banks in four different ownership groups in India during the post global financial crisis period, 2009-2018 utilizing the technical efficiency effects model for panel data. It finds that despite the consolidation of information technology efforts, the efficiency of Indian banking industry deteriorated during the post global financial crisis period. This may be due to the mounting pile of non-performing assets. Interestingly, the public banks seem to be more efficient than their private counterparts. The results also indicate that banks with larger capital adequacy ratio or older banks or banks with more branches are less inefficient in generating interest income. It is our hope that findings of this study would be useful to international agencies and other stakeholders in evaluating and improving the performance of Indian banks.

Keywords: stochastic frontier, technical efficiency effect, panel data, Indian banks, financial crisis.

JEL Classification: D24, G21, G34, G28.
1. Introduction

As the financial world has been increasingly interdependent, the global financial crisis has had a cascading effect on almost all economies and finances of countries. However, the Indian economy and its financial sector emerged relatively unaffected due to its stringent regulatory and prudent policies. Therefore, many appreciated the Indian financial system, particularly the banking system. But the scenario has changed after that. Two developments have happened in the Indian banking sector: (i) mounting pile of bad loans (i.e., non-performing assets) and (ii) consolidation of Information Technology (IT) based efforts.

Although India had the lowest non-performing assets (NPA) ratio among the G-20 nations in 2009, its NPA was the second highest, next only to Russia in 2018.\(^1\) According to the Reserve Bank of India (RBI) website, the NPA (Gross) of scheduled commercial banks in India increased from Rs. 699540 million (2.3 percent) in 2008-09 to Rs. 10396790 million (11.2 percent) in 2017-2018. 9 out of 10 most stressed banks were government banks. The RBI asked all banks before March 2017 to clean up their balance sheets which also required their lenders to set aside huge chunk of capital in the form of provisioning.\(^2\) The high degree of NPAs and the necessity of provisions could obviously affect the profitability and liquidity of banks.

Despite the NPA stress, Indian banks work towards creating a Digital India. While the internet banking grew faster in the 2000s because of the initiatives of Government of India and the RBI, the falling internet costs and increased awareness, in 2012-2013, Indian banks deployed technology-intensive solutions to increase their revenue, enhance customer experience, optimize cost structure and manage enterprise risks. However, wide variations exist in technology and implementation capabilities of different banks. In addition, these technological advancements have led to the emergence of new security risks like cybercrime, hacking, etc.

It is expected that the technological transformation through the digital revolution and mount of pressure due to NPA make the business milieu more uncertain as they bring positive as well as negative impacts. In such an environment, it is imperative to assess the performances of Indian banks after the global crisis and ensure the efficient functioning of banking sector which is vital for the overall economic development of the nation.

In the literature, two performance measures are used widely namely, productivity and efficiency. Although they are different, they are interrelated. Among them, the efficiency measure is more popular. The efficiency is measured as the ratio between the actual output of the bank and the benchmark or maximum or frontier output of the bank using the same amount of inputs. Broadly two alternative methodologies are employed in the literature to measure efficiency, namely the data envelopment analysis (DEA) and stochastic frontier approach (SFA). While each of them has its own advantages and limitations, the SFA is widely used for panel data.

There are four types of scheduled commercial banks in India. They are: i) the State Bank of India and its associates banks (SBIs), (ii) the nationalized banks (NBs), (iii) private
domestic banks (PBs), and (iv) private foreign banks (FBs). While a handful of studies emerged to measure the efficiency of Indian banks either using the DEA or SFA, they provide the estimates either before the global crisis period or initial year of the crisis. This study is an attempt to contribute to the banking efficiency literature by estimating the technical (in) efficiency of the Indian banking industry during the post global financial crisis period: 2009-2010 to 2017-2018. It employs the stochastic frontier methodology for panel data developed in Battese and Coelli (1995), which is called the Technical Efficiency Effects model. The main advantage of this method is that it allows us to estimate the frontier production function and inefficiency equation together. Thus, this paper provides and compares the efficiency variations across banking ownership groups and identifies the factors determining efficiency variations across banks.

The rest of this study proceeds as follows. Section 2 provides a short note on banking industry in India. Section 3 provides a brief review of the relevant literature. Section 4 explains the data, variables and the method used in this study, and section 5 presents and discusses the empirical results of the study. Finally, section 6 provides the summary and concluding remarks.

2. A Note on Indian banking industry

India has a bank dominated financial system. Its modern banking system has its roots in the late 18th century and primarily catered to needs of the British. After Independence, the nationalization of major private banks in 1969 was an important milestone in the banking system, which made banking accessible to the unbanked population of India. Another wave of nationalization happened in 1980. While the Indian banking industry comprises of SBIs, NBs, PBs and FBs, the public sector banks-SBIs and NBs have acquired a place of prominence in the financial intermediation process and made significant strides in expanding geographical coverage, mobilizing savings and providing funds for investments in agriculture and small-scale industry.

The highly regulatory environment with interest rates, credit allocation and entry being controlled by the RBI favoured tremendous achievements. However, most banks were plagued with poor profitability and under capitalization with a high proportion of non-performing assets and huge administrative expenditures during the late 1980s (Shanmugam and Das, 2004). Therefore, to review the functioning of the financial services industry in the country, the Government of India appointed the Narasimham Committee which submitted its recommendations in November 1991. Based on that, the RBI initiated various reform measures to improve the banking efficiency through entry deregulation, branch de-licensing and deregulation of interest rates, and to allow public sector banks to raise their equity in the capital market. Further, the reforms helped banks to improve their profitability through gradual reduction of cash reserve ratio, statutory liquidity ratio and relaxation of various quantitative restrictions on the composition of selected portfolios.
The economic liberalization in the early 1990s ushered in an era of privatization where many new private banks emerged. A few foreign banks commenced their India operations as well. All these banks were quick to leverage the emerging technology and were competitive in attracting customers. The increased competitive environment completely revitalized the banking operations in India. Indian banks adopted the international best practices. Several prudential and provisioning norms were introduced. These norms pressurize banks to improve their efficiency and trim down their Non-Performing Assets (NPAs) so as to improve the financial health of the banking system.

With their major role in credit intermediation process, payment and settlement system and monetary policy transmission, and additional responsibility of achieving the Government’s social agenda, the banking industry acts as a catalyst for the economic development of the country. In spite of various acts promulgated by the Government of India and guidelines passed by the RBI, the NPAs continued to increase in the Indian Banking sector. The state-run banks were on the verge of a crisis due to their high NPAs which constituted over 90 percent of the total bad loans of the industry. Many of them have reported losses on account of high NPAs. The RBI gave a deadline of March 2017 for all banks to clean up their balance sheets and set aside a huge chunk of capital in the form of provisioning.

On the technology front, the foremost breakthrough in the Indian banking industry started with the use of Advanced Ledger Posting Machines (ALPM) in 1980s. In the late 1980s, the Total Bank Automation (TBA) was introduced, followed by the establishment of mechanized cheque processing systems, using the Magnetic Ink Character Recognition (MICR) technology (Bansal, 2015). Internet banking grew faster in the 2000s because of the initiatives of Government of India and the RBI, the falling internet costs and increased awareness. Indian banks continuously invested on digital banking (DB). Key innovations in DB are: Digital-only/Virtual Banking, Biometric Technology, Artificial Intelligence (AI), Block Chain Technology, Bitcoin and Robotics. The digital-only bank provides end-to-end services through digital platforms like mobile phones, tablets and internet. It is paperless, branchless and signature-less banking offering 24/7 services to its customers. The biometric authentication provides simple and secure banking experience to its customers.

Consolidation of IT based efforts in banks happened in 2006-07. These efforts include the establishment of data centers, a shift towards centralized systems and large scale implementation of core banking systems across various branches of banks. The Payment and Settlement Systems (PSS) Act was also legislated in December 2007. The RBI has authorized the payment system operators of pre-paid payment instruments, card schemes, cross-border in-bound money transfers, ATM networks and centralized clearing arrangements. These efforts have resulted in deeper acceptance and penetration of non-cash payment modes in India. Thus, Indian banks deployed technology-intensive solutions to increase revenue, enhance customer experience, optimize cost structure and manage enterprise risks.
3. A brief review of literature

Farrell (1957) kick started the modern efficiency measurement concepts for any Decision Making Units (DMUs) like firms, farms, hospitals, banks etc. According to him, the economic efficiency (EE) of any DMU is the product of technical efficiency (TE) and allocative efficiency (AE). The AE is the ability of a DMU or bank to use inputs in optimal propositions, given their respective prices/costs, while the TE is the ability of a bank to obtain maximum possible output from a given set of inputs/technology. In a simpler term, the TE is the ratio between the actual output/outcome and the maximum possible or potential output. The major concern in technical efficiency is whether the actual outcome generated could be achieved with less inputs or whether the same inputs could produce better outcomes. Broadly, there are two approaches to estimate the (technical) efficiency: (i) mathematical approach or data envelopment analysis (DEA) and; (ii) econometric or stochastic frontier approach (SFA). The DEA include (i) the non-parametric deterministic model developed by Farrell (1957) later popularized by Charnes et al., 1978), (ii) the parametric deterministic model by Aigner and Chu (1968), (iii) the probabilistic model by Timmer (1971) and (iv) Corrected OLS. The deterministic model assumes that the actual output $Q$ is less than the potential output, $Q' (= f(.) )$, i.e., $Q \leq Q' = f(.)$. The output gap is: $u = Q' - Q$, and due to non-linear relationship the actual output is written as: $Q = f(.) e^u$. $u$ is also called the technical (in) efficiency term. The Linear Programming (LP) method is used to estimate the DEA model. The major limitation of the DEA is that it ignores the random factors which may influence the outputs of the production units.

Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) independently developed the SFA approach for cross section data to take in to account the random factors. According to them, the potential output is not deterministic, but stochastic due to random factors and so the actual output is: $Q = f(.) e^u$, where $v$ is regular stochastic error term and $\epsilon (= v - u)$ is the composite error term. For estimating this function using the maximum likelihood estimation (MLE) method, the one sided error term $u$ (is always positive) is assumed to follow one of the following four distributional assumptions, namely half normal, truncated normal, gamma and exponential. The individual specific efficiency can be computed using the Jondrow et al. (1982) procedure.

The SFA for cross section data suffers from three serious drawbacks.

First, the estimated inefficiency is not consistent. One can consistently estimate the (whole) error term for a given observation, but it contains statistical noise ($v$) as well as inefficiency term ($u$). The variance of the distribution of inefficiency term conditional on the composite error term does not vanish when the sample size increase (Jondrow et al., 1982).

Second, the estimation of the model and separation of inefficiency from the statistical noise require specific distributional assumptions on the inefficiency term. The choice of wrong assumption leads to biased estimates of efficiency. Finally, it may be incorrect to assume that the inefficiency term is independent of regressors included in the model.
Schmidt and Sickles (1984) introduced the stochastic frontier models for panel data, by taking account the individual effects. This approach assumes that efficiency is time-invariant and this panel data approach is free from above drawbacks. Assuming the Cobb-Douglas functional form (and lower cases indicate the logarithmic values) the model is specified as: 

\[ q_{it} = \alpha + \beta x_{it} + v_{it} - u_{i}, \]

where \( u_{i} \) to be independently and identically distributed (i.i.d.) with mean \( \mu \) and variance \( \sigma_{u}^2 \). Letting \( \alpha_i = \alpha - u_{i} \) the equation becomes: 

\[ q_{it} = \alpha_i + x_{it} \beta + v_{it}. \]

The \( \alpha_i \) is an individual specific effect and can be estimated using the fixed effects “within” method. \( \alpha^* = \max (\alpha_i) \) is the performance of the Most Efficient Unit and the relative efficiency of \( i \)th Unit can be measured as: 

\[ u_{i} = \alpha^* - \alpha_i. \]

Then, technical efficiency is computed as: 

\[ TE_i = \exp (-u_{i}). \]

Assuming that the individual specific effects are uncorrelated with the regressors, the random effects model treats them as random and merged with regular error term. The estimating equation in this case is: 

\[ q_{it} = \alpha + \beta x_{it} + \epsilon_{it}, \]

were \( \epsilon_{it} = v_{it} - u_{i} \) and feasible GLS method is used to estimate the equation. Then individual effect is obtained as: 

\[ \alpha_i = (1/T) \sum_{t} \epsilon_{it}; \quad i = 1, 2, \ldots, N, \]

and one can get \( \alpha^* \) and \( u_i = \alpha^* - \alpha_i. \) Then TE is calculated as above. Alternatively one can use MLE method to estimate the equation 

\[ q_{it} = \alpha + \beta x_{it} + v_{it} - u_{i}, \]

where \( u \) is assumed to follow either half normal or truncated normal distribution as in cross section model to calculate the time-invariant efficiency values.

For estimating the time-varying TE, there are three alternative models developed in the literature: (i) Cornwell et al. (1990) Model allows for both firm and time (t) effects (in efficiency is modelled as \( \alpha_{it} = \theta_{i1} + \theta_{i2} t + \theta_{i3} t^2 \)); (ii) Kumbhakar et al. (1990) model uses: 

\[ u_{it} = [1 + \exp \{b t + c t^2\}]^{-1} u_{i}, \]

where \( u_{i} \) follows a half normal distribution and \( b \) and \( c \) are unknown parameters to be estimated; and (iii) Battese and Coelli (1992) model specifies \( u \) as 

\[ u_{it} = u_{i} \eta_{it} = u_{i} \exp \{-\eta(t-T_{i})\}; \quad i = 1, \ldots, n; \quad t \in g(i); \]

where \( u_{i} \) are non-negative random variables that are assumed to be i.i.d. as truncated normal with mean \( \mu \) and variance \( \sigma_{u}^2 \). \( \eta \) is an unknown parameter to be estimated and \( g(i) \) represents the set of \( T_{i} \) time periods for which observations for state \( i \) are available. The MLE technique can be used to estimate the models. If \( \eta = 0 \), the model becomes time-invariant.

After estimating the efficiency in the first stage, then it is regressed on various factors to identify the major determinants of efficiency in the second stage. But the estimating the model in two stages is inconsistent in its assumptions regarding the independence of the inefficiency effects. To overcome this limitation, Batse and Coelli (1995) developed the Technical Efficiency Effects model which assumes the \( u_{it} \) to be i.i.d. with a truncated normal distribution and a time varying mean, i.e., \( u_{it} \sim N(m_{it}, \sigma_{u}^2) \). It is specified that the individual and time varying mean as \( m_{it} = Z_{it} \delta \), where \( Z \) is vector of variables explaining the efficiency. For a complete review of these models, see Aigner et al. (1977), Meeusen and Broeck (1977), Battese and Coelli (1992), Greene (1993), Kalirajan and Shand (1994) and Kumbhakar et al. (1997).

The above methodologies are widely used to measure efficiency in various fields. Some studies estimate the output function to measure the technical efficiency while many others estimate the cost or profit or revenue function to measure the cost efficiency or profit or
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revenue efficiency. The empirical studies on measuring efficiency of financial institutions are numerous and most of them concern with developed nations such as USA, Sweden, and Finland. After reviewing 130 studies on the efficiency of financial institutions/banks from 21 countries, Berger and Humphrey (1997) remarked that 116 studies were published during 1992-1997 and most of them analyzed the efficiency of US banks. They also found that the annual average technical efficiency ratios of these studies were around 77% (median 82%).

In the case of financial institutions particularly banks, the major issue is the selection of inputs and output sets. Past studies employ three approaches: the production (or also called service provision or value added) approach, the intermediation (or asset) approach and the modern approach (Hjalmarsson et al., 2000; Das and Ghosh, 2006). The first two approaches apply the microeconomic theory of producer’s behaviour to banking and differ only in the specification of banking activities.

The pioneer of the production approach, Benston (1965) considers banks as the providers of services to customers. He uses the number of deposits and loan accounts, as a surrogate for the level of services provided (i.e., outputs) and physical variables (like labour, material, space or information systems) or their associated cost as inputs. The intermediation approach proposed by Sealey and Lindley (1977) views banks as intermediating funds between depositors and creditors. Banks produce intermediation services through the collection of deposits and other liabilities and their application in interest-earning assets, such as loans, securities and other investments. Both operating and interest expenses are considered as inputs and loans and other major assets as outputs. The modern approach seeks to integrate some measures for risk, agency costs and quality of bank services. That is, it introduces the quality of bank assets and the probability of bank failure in the estimation of costs. This approach is best represented through the ratio-based CAMEL approach. This approach derives the individual components of CAMEL from the financial tables of the banks and uses them as variables in the performance analysis.

Most studies measuring efficiency of banks in developed nations employ the DEA approach. For instances, Elyasiani and Mehdian (1995) used the intermediation approach to measure the trends in efficiencies of small and large US commercial banks during 1979 to 1986 and found that although the efficiency declined over the years, small banks emerged as more efficient. Fecher and Pesteau (1993) found that the average efficiency estimates of financial services (banking and insurance) for 11 OECD countries during 1971 to 1986 to be 0.82 with a range of 0.67 (for Denmark) to 0.98 (for Japan). Maudos and Pastor (2001) estimated the cost and the profit efficiency for 14 countries of the European Union, as well as Japan and the US and found wide differences in the profit efficiency of these countries.

Efficiency studies on the Asian banking system are limited. Analyzing the operating efficiency in Taiwan’s banking industry during 1986-1989 to 1992-1995 Shyu (1998) found improvements in overall efficiency. Hao, Hunter and Yang (1999) employed the SFA and the data for 19 Korean banks during 1985 to 1995 and found that banks with faster growth rates, extensive branch network and those that made extensive use of deposits in
funding their assets were most efficient. On comparing the effect of deregulation on the productivity growth of banks in Indian sub-continent (including India, Pakistan and Bangladesh), Jaffry et al. (2007) showed that technical efficiency both increases and converges across the Indian sub-continent in response to reforms.

In the context of India, handful of studies emerged to measure the efficiency of banking industry. Most studies employ the DEA approach. Bhattacharya, Lovell and Sahay (1997) using the DEA approach found that the public sector banks were the best performing and they improved their efficiency in the deregulated environment during 1986-1991. Further, there was a temporal improvement in the performance of foreign banks and a temporal decline in the performance of Indian public sector banks. Mohan and Ray (2004) showed an improvement in the revenue efficiency of Indian banks and also the convergence in performance between public and private sector banks in the post-reform era.

Das et al. (2005) estimated the cost efficiency, the revenue efficiency, and the profit efficiency of Indian banks during 1997-2003 using DEA and showed that bank size, ownership, and stock exchange listing influenced the profit efficiency positively and to some extent, the revenue efficiency. Das and Ghosh (2006) utilizing three different approaches viz.: (1) intermediation approach; (2) value added approach; and (3) operating approach and DEA method showed that medium-sized public sector banks performed reasonably well, and banks with less NPAs were technically more efficient during 1992-2003. Gupta et al. (2008) using the DEA approach showed that the estimated the productive efficiency during 1999-2003 increased from 0.901 to 0.925. The SBI groups of banks had the highest efficiency, followed by private banks, and the other nationalized banks.

Ray and Das (2010) applied the DEA method to estimate the cost and the profit efficiency of Indian banks during the post reforms period and found that public sector banks were more efficient than their private counterparts, and small banks (with assets up to Rs.50 billion) were mostly operating below the efficiency frontier. Sunil and Gulati (2010) employed the DEA approach to measure and examine the convergence in cost, technical and allocative efficiencies 27 public sector banks during 1992-93 to 2007-08. They found that deregulation had a positive impact on the cost efficiency of Indian public banks over the years. While the technical efficiency of public sector banks exhibited an upward trend, the allocative efficiency exhibited a declining trend. The inefficient public sector banks were not only catching-up but also moving ahead than the efficient ones, confirming a strong β convergence in the efficiency levels of Indian public banks.

Dwivedi and Charyulu (2011) used DEA and showed that the estimated mean technical of all banks increased from 95.6 per cent in 2005 to 97.9 per cent in 2010. Other than SBIs, all remaining group banks improved their efficiency over the years. Jayaraman and Srinivasan (2014) considered four inputs (equity (capital plus reserves and surplus), borrowed funds (deposits and borrowing), number of employees and branches), two outputs (deployed funds including loans and investments and non-interest income) and one undesirable output (gross non-performing assets) to measure the profit efficiency of Indian
banks during 2005-2012. They found that the profit inefficiency of private sector bank group was close to 2.0 percent and that of public sector banks was 3.0 percent. The inefficiency was higher in big and large banks than in small and medium size banks.

Kaur and Gupta (2015) measured the efficiency of 57 banks (8 SBIs, 19 NBs and 30 PBs) during 2009-2013 using the DEA. They found that the mean efficiency score was 91 percent for all banks; 94.5 percent for SBIs; 92 percent for PBs; and 86.9 percent for NBs. Tandon et al. (2014) used DEA to measure efficiency of Indian banks (19 NBs, 15 PBs and 10 FBs) during 2009-2012. Seven out of 44 banks operated on the efficiency frontier. The efficiency scores did not vary much across three groups of banks. However, there was a scope for improving the scale efficiency of FBs.

Utilizing Battese and Coelli’s (1992) SFA for panel data, Shanmugam and Das (2004) observed that during the deregulation period (1992-1999), the efficiency of raising noninterest income, investments and credits of Indian banks improved. Ataullah et al. (2004) reported that overall technical efficiency of the banking industry of India and Pakistan improved following the financial liberalization. Das et al. (2005) showed that the efficiency of Indian banks, in general, and of bigger banks, in particular, improved during the post-reform period. The findings of the study of Mahesh and Rajeev (2006) are completely similar to that of Shanmugam and Das (2004). Mahesh and Bhide (2008) found that deregulation has a significant positive impact on the cost and the profit efficiencies of commercial banks. Das and Ghosh (2009) also found that the liberalization of the banking sector in India generally produced positive results in terms of improving the cost and profit efficiencies of banks.

Using hedonic aggregator function, Das and Kumbhakar (2012) observed that the efficiency of public sector banks has surpassed the efficiency of private sector banks during the post reform period 1996-2005. Bhattacharya and Pal (2013) estimated the technical efficiency of 103 commercial banks during 1989-2009 using a multiple-output generalized stochastic production frontier and intermediary approach. They showed that the mean efficiency of Indian commercial banks was 64 percent during the study period. Public sector banks were more efficient than private and foreign banks. The review indicates that the efficiency studies on the Indian banks after post financial crisis period are non-existent.

4. Model, data and estimation

This study utilizes the model for TE effects in a stochastic frontier production function for panel data developed in Battese and Coelli (1995). Consider the actual production ($Y_{it}$) function of a bank $i$ for period $t$ as:

$$Y_{it} = f(x_{it}; \beta) \exp(v_{it} - u_{it})$$

where $f(.)$ is the frontier output that can be produced by the bank with a given level of inputs and technology; $x_{it}$ is a vector of inputs while $\beta$ is a vector of parameters, describing the transformation process; $v_{it}$ is stochastic error term (i.i.d. normal with mean 0 and...
variance $\sigma^2_v$) and $u_{it}$ (TE effect) is a one-sided (non-negative) residual term, assumed to be independently distributed such that $u_{it}$ is obtained by truncation at zero of the normal distribution with mean $Z_{it}\delta$ and variance $\sigma^2$. $Z_{it}$ is a vector of determinants of technical inefficiency of production function of banks over time and $\delta$ is a vector of unknown parameters associated with $Z$ variables. Thus, the technical inefficiency effect $u_{it}$ in equation (1) can be specified as:

$$u_{it} = Z_{it}\delta + w_{it}$$ (2)

where the random variable $w_{it}$ is a truncated normal variable with mean 0 and variance $\sigma^2$, such that the point of truncation is $-Z_{it}\delta$, i.e., $w_{it} \geq -Z_{it}\delta$.

The method of maximum likelihood (ML) can be used for simultaneous estimation of the coefficients of the stochastic frontier and the technical inefficiency effects model. The TE of bank $i$ for period $t$ is:

$$TE_{it} = \exp(-u_{it}) = \exp(-Z_{it}\delta - w_{it})$$ (3)

Regarding the selection of inputs and outputs, this study uses the operating (or income based) approach. This approach defines bank’s output as the total revenue and input as the total expenses including interest and operating expenses. The stochastic frontier production function to be estimated is specified as:

$$\ln Y_{it} = \beta_0 + \beta_1 \ln \text{Interest Expenses}_{it} + \beta_2 \ln \text{Employee Expenses}_{it} +$$

$$+ \beta_3 \ln \text{Capital Related Operating Expenses}_{it} + \nu_{it} - u_{it}$$ (4)

where $\ln$ denotes the natural logarithm and the technical inefficiency effects are assumed to be defined as:

$$u_{it} = \delta_0 + \delta_1 \text{Capital Adequacy Ratio}_{it} + \delta_2 \text{Age}_{it} + \delta_3 \text{Bank Branches}_{it} +$$

$$+ \delta_4 \text{Dummy for SBI Group}_{it} + \delta_5 \text{Dummy for Nationalized Bank}_{it} +$$

$$+ \delta_6 \text{Dummy for Private Bank}_{it} + w_{it}.$$ (5)

As total revenue includes interest income and non-interest income, the $Y_{it}$ (total revenue) in equation (4) is replaced with interest income and non-interest income in alternative specifications of the model. Thus the study considers total revenue, interest income and non interest income as outputs in alternate specification of equation (4). The data on inputs, and outputs and $Z$ variables of commercial banks in India from 2009-2010 to 2017-2018 have been compiled from the Statistical Tables relating to Banks in India published by the RBI. Appropriate deflators are used to convert all monetary values into 2011-2012 prices. Due to the missing data, 99 banks belonging to four ownership groups are included in the estimation. The final data set is an unbalanced panel of observations (a total of 754) on inputs, outputs and $Z$ variables. Table 1 presents the descriptive statistics of the study variables.
5. Empirical results

Table 2 shows the ML estimates of the parameters of the stochastic frontier and technical efficiency models for Indian banks using FRONTIER 4.1 software. Column (1) of the table presents the results of total revenue (interest plus non-interest income) equation 4. All three inputs have positive and statistically significant effects at 1 percent level. The capital related expenses is a dominant factor in determining the total income of Indian banks as its parameter is the largest (0.37), followed by employee expenses (with 0.33). Both $\sigma^2$ and $\gamma$ terms are positive and statistically significant at 1 percent level, indicating that the observed level of total income significantly differs from the frontier level due to factors which are within the control of banks. The estimated value of $\gamma$ of 0.94 indicates that 94 percent of the difference between actual and frontier output is due to technically inefficient performance of banks.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total Revenue</th>
<th>Interest Income</th>
<th>Non-Interest Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Stochastic Frontier Model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>3.2213 (47.369)</td>
<td>2.5448 (55.649)</td>
<td>2.4993 (15.761)</td>
</tr>
<tr>
<td>Ln Interest Expenses</td>
<td>0.2151 (21.935)</td>
<td>0.2797 (44.169)</td>
<td>-0.1399 (-5.512)</td>
</tr>
<tr>
<td>Ln Employee Expense</td>
<td>0.3317 (14.314)</td>
<td>0.3626 (18.009)</td>
<td>0.3371 (5.658)</td>
</tr>
<tr>
<td>Ln Capital Related Expenses</td>
<td>0.3698 (15.340)</td>
<td>0.3089 (15.403)</td>
<td>0.6903 (11.447)</td>
</tr>
<tr>
<td>Technical In-Efficiency Model</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.1969 (1.692)</td>
<td>-0.2366 (-2.092)</td>
<td>-0.4271 (-2.074)</td>
</tr>
<tr>
<td>Capital Adequacy Ratio</td>
<td>0.0030 (6.869)</td>
<td>-0.0073 (-3.526)</td>
<td>0.0181 (18.041)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0004 (-0.905)</td>
<td>-0.0024 (-2.091)</td>
<td>-0.0011 (-0.764)</td>
</tr>
<tr>
<td>Number of Branches</td>
<td>-0.0002 (-1.087)</td>
<td>-0.0002 (-7.573)</td>
<td>-0.0005 (-3.218)</td>
</tr>
<tr>
<td>Dummy for SBI Group</td>
<td>-0.8596 (-3.985)</td>
<td>-3.6857 (12.032)</td>
<td>-0.0565 (-1.310)</td>
</tr>
<tr>
<td>Dummy for Nationalized</td>
<td>-1.7045 (-4.151)</td>
<td>-5.3758 (-17.485)</td>
<td>-0.9814 (-2.809)</td>
</tr>
<tr>
<td>Dummy for Private</td>
<td>-0.3741 (-4.449)</td>
<td>-2.5342 (-13.649)</td>
<td>-0.2341 (-1.099)</td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>0.3112 (7.439)</td>
<td>0.7925 (6.873)</td>
<td>1.412 (13.992)</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.9384 (85.957)</td>
<td>0.9640 (136.713)</td>
<td>0.8674 (37.652)</td>
</tr>
<tr>
<td>Log-Likelihood</td>
<td>-129.8715</td>
<td>-130.0228</td>
<td>-804.6371</td>
</tr>
<tr>
<td>LR test of one-sided error</td>
<td>188.7411</td>
<td>356.0795</td>
<td>270.2594</td>
</tr>
<tr>
<td>Mean TE (%)</td>
<td>72.47</td>
<td>77.32</td>
<td>57.57</td>
</tr>
<tr>
<td>N (Sample)</td>
<td>754</td>
<td>754</td>
<td>754</td>
</tr>
</tbody>
</table>

t-values are in the parentheses.
The estimated coefficients in the inefficiency model in Column (1) of Table 2 indicates that the capital adequacy ratio has a positive and significant (at 1 percent level) coefficient, which indicates that the banks with higher capital adequacy ratio are more inefficient than banks with less capital adequacy ratio. The negative and significant (at 1 percent level) parameter of number of bank branches implies that banks with larger number of branches tend to be less inefficient. The Age coefficient is negative, which indicates that the older banks are less inefficient than the younger ones. However, this relationship is very weak because this relation is not supported by t value. As the parameters associated with all three dummies for SBIs and NBs and PBs are negative and statistically significant at 1 percent level, the three groups of banks are less inefficient then the base category, namely the foreign banks.

Column (2) of Table 2 presents the estimation results of interest income. As in Column (1), all input parameters are positive and statistically significant at 1 percent level. The employee expenses variable is the dominant factor in determining the interest income, followed by capital related expenses and interest expenses. $\sigma^2$ and $\gamma$ terms are positive and statistically significant at 1 percent level. The estimated value of $\gamma$ indicates that 96 percent of the difference between actual and frontier output is due to technically inefficient performance of banks. In technical inefficiency model, capital adequate ratio, age and branch variables have negative and significant impact at 5 percent level, indicating that banks with larger capital adequacy ratio/older banks/banks with more branches are less efficient in generating interest income. Like in Column (1), all dummy coefficients are negative and statistically significant at 1 percent level, indicating that the SBI group, nationalized and private banks are less inefficient in generating interest income than foreign banks.

Column (3) of Table 2 shows the estimation results for non-interest income. Both capital related expenses and employee expenses are having positive and statistically significant impact at 1 percent level on non-interest income of banks. Of these, the former is the dominant factor as it has the larger coefficient (0.69). The interest expense has negative and significant parameter. Both $\sigma^2$ and $\gamma$ terms have positive and statistically significant coefficients. The estimated value of $\gamma$ indicates that about 87 percent of the difference between actual and potential output is due to technically inefficient performance of banks.

In the technical inefficiency model, the results of almost all variables are more or less the same with variations in the magnitude of the impact of these variables.

Technical efficiency estimates

Table 2 shows that on an average the sample banks realized only 72.5 percent of their technical abilities in raising total income and 77.3 percent in raising interest income and 57.4 percent of their technical abilities in raising non-interest income. Table 3 shows the time varying mean TE values by banks groups. The overall results indicate that the nationalized banks have the largest mean efficiency values in raising total income, interest income and non-interest income followed by SBI group banks, private banks and foreign banks. The overall mean TE value of banks in raising total revenue (income) increased from 71.5 percent in 2009-2010 to 76.7 percent in 2011-2012. After that it started declining to reach 68.2 percent in 2017-2018. The overall efficiency of raising interest income
Efficiency of commercial banks in India after global financial crises

increased from 74.9 percent in 2009-2010 to 80.2 percent in 2012-2013 and then declined to 74.4 percent in 2017-2018. During 2009-2019 to 2017-2018, the overall mean efficiency of generating non-interest income declined from 61.3 percent to 54.1 percent.

During 2009-2010 to 2017-2018, the mean efficiency of raising total revenue of SBI group of banks declined from 85.6 percent to 84.2 percent. For nationalized banks, although the mean efficiency value increased initially and then declined, in 2017-2018 their mean efficiency was the same as in 2009-2010. For private banks, the mean efficiency increased from 68.6 percent to 75.2 percent. For foreign banks the mean efficiency declined from about 60 percent to 57 percent. During 2009-2010 to 2017-2018, the mean efficiency of raising interest income of SBI group banks declined marginally from 88.8 percent to 87.4 percent while the mean efficiency of nationalized banks declined from 89.1 percent to 88.5 percent. At the same time, the mean efficiency of private banks increased from 77.4 percent to 82.7 percent and the mean efficiency of foreign banks also increased from 59.9 percent to 63.9 percent. It is noticed that the mean efficiency values of raising non-interest income of SBI group, nationalized and private banks increased over the years and only for the foreign banks the mean efficiency value declined over the years.

Table 3. Time varying mean efficiency values by banks groups

<table>
<thead>
<tr>
<th>Year</th>
<th>SBI Group</th>
<th>Nationalized Banks</th>
<th>Private Banks</th>
<th>Foreign Banks</th>
<th>All Banks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td></td>
<td>Total Revenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009-10</td>
<td>85.57</td>
<td>86.29</td>
<td>68.61</td>
<td>59.99</td>
<td>71.54</td>
</tr>
<tr>
<td>2010-11</td>
<td>83.76</td>
<td>87.76</td>
<td>67.91</td>
<td>59.95</td>
<td>70.9</td>
</tr>
<tr>
<td>2011-12</td>
<td>87.85</td>
<td>91.68</td>
<td>74.07</td>
<td>67.23</td>
<td>76.66</td>
</tr>
<tr>
<td>2012-13</td>
<td>88.54</td>
<td>92.56</td>
<td>76.07</td>
<td>62.25</td>
<td>74.16</td>
</tr>
<tr>
<td>2013-14</td>
<td>85.22</td>
<td>91.59</td>
<td>75.17</td>
<td>59.75</td>
<td>72.37</td>
</tr>
<tr>
<td>2014-15</td>
<td>86.12</td>
<td>89.18</td>
<td>75.14</td>
<td>62.57</td>
<td>73.47</td>
</tr>
<tr>
<td>2015-16</td>
<td>85.06</td>
<td>86.88</td>
<td>74.62</td>
<td>62.21</td>
<td>72.45</td>
</tr>
<tr>
<td>2016-17</td>
<td>89.4</td>
<td>86.36</td>
<td>75.94</td>
<td>62.21</td>
<td>72.38</td>
</tr>
<tr>
<td>2017-18</td>
<td>84.15</td>
<td>86.29</td>
<td>75.24</td>
<td>56.53</td>
<td>68.18</td>
</tr>
<tr>
<td>overall</td>
<td>85.29</td>
<td>88.71</td>
<td>73.64</td>
<td>61.32</td>
<td>72.47</td>
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<td>Interest Income</td>
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<tr>
<td>2009-10</td>
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<td>77.44</td>
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<tr>
<td>2010-11</td>
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<td>90.59</td>
<td>77.12</td>
<td>61.96</td>
<td>75.15</td>
</tr>
<tr>
<td>2011-12</td>
<td>90.69</td>
<td>92.87</td>
<td>82.19</td>
<td>67.76</td>
<td>79.48</td>
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<td>2012-13</td>
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<td>93.25</td>
<td>84.01</td>
<td>70.34</td>
<td>80.15</td>
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<td>2013-14</td>
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<td>83.47</td>
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<td>2014-15</td>
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<td>82.81</td>
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<td>83.00</td>
<td>67.89</td>
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<td>88.36</td>
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<tr>
<td>2017-18</td>
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<td>88.49</td>
<td>82.73</td>
<td>63.93</td>
<td>74.37</td>
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<tr>
<td>Overall</td>
<td>88.8</td>
<td>90.71</td>
<td>81.73</td>
<td>66.17</td>
<td>77.32</td>
</tr>
<tr>
<td></td>
<td>Non-Interest Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009-10</td>
<td>72.47</td>
<td>72.78</td>
<td>58.92</td>
<td>52.43</td>
<td>61.34</td>
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<tr>
<td>2010-11</td>
<td>69.16</td>
<td>68.80</td>
<td>54.80</td>
<td>52.56</td>
<td>58.58</td>
</tr>
<tr>
<td>2011-12</td>
<td>67.77</td>
<td>70.80</td>
<td>57.35</td>
<td>54.26</td>
<td>60.17</td>
</tr>
<tr>
<td>2012-13</td>
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<td>72.17</td>
<td>58.88</td>
<td>44.25</td>
<td>55.56</td>
</tr>
<tr>
<td>2013-14</td>
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<td>68.80</td>
<td>57.31</td>
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<td>54.73</td>
</tr>
<tr>
<td>2014-15</td>
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<td>60.70</td>
<td>49.09</td>
<td>56.64</td>
</tr>
<tr>
<td>2015-16</td>
<td>68.97</td>
<td>67.57</td>
<td>57.19</td>
<td>47.97</td>
<td>56.19</td>
</tr>
<tr>
<td>2016-17</td>
<td>72.74</td>
<td>74.15</td>
<td>63.26</td>
<td>48.82</td>
<td>59.89</td>
</tr>
<tr>
<td>2017-18</td>
<td>75.46</td>
<td>74.51</td>
<td>60.99</td>
<td>41.33</td>
<td>54.07</td>
</tr>
<tr>
<td>Overall</td>
<td>69.26</td>
<td>70.96</td>
<td>58.82</td>
<td>47.61</td>
<td>57.37</td>
</tr>
</tbody>
</table>
6. Summary and conclusion

This study has analyzed the efficiency and its determinants of commercial banks in India during post global financial period 2009-2010 to 2017-2018. The data set is an unbalanced panel of 99 banks (a total of 754 observations) belonging to four ownership groups. Based on operating approach, it has considered the total revenue (interest income plus non-interest income) as output and the total expenses including interest, employee and capital related expenses as inputs. It has utilized the technical efficiency effects model for panel data.

The results indicate the dominants of capital related expenses in producing the total income and also the non-interest income and the dominants of employee expenses in generating interest income. The observed outputs are less than their respective frontier outputs due to technical inefficiency of Indian banks. The overall mean efficiency of banks is 72.5 percent in raising total income, 77.3 percent in raising interest income and 57.4 percent in raising non-interest income. In terms of mean TE value of raising all three variants of outputs, the nationalized group ranks first, the SBI group the second, the private banks the third and the foreign group obtains the last rank. For almost all groups, the overall mean efficiency initially increased from 2009-10 to two or three years and after that all mean efficiency values declined. This is a clear indication that despite the consolidation of IT efforts, the banking performance in India deteriorated during the post global financial crisis period. It seems that Indian banks are still learning the new technology to reap the maximum possible outputs. Further, the mounting pile of non-performing assets would have caused the declining performance of all groups of banks.

The results also indicate that banks with larger capital adequacy ratio or older banks or banks with more branches are less inefficient in generating interest income. Banks with more branches seem to be less inefficient in generating non-interest income and total income, but banks with larger capital adequacy ratio are more inefficient in generating non-interest income as well as total income. It is our hope that this study would be useful to international agencies, and stakeholders in evaluating and improving the performance of banking sector in India.

Notes

(1) As per data on world indicators available in: https://data.worldbank.org/indicator.
(2) In his monetary policy speech, Mr. Raghuram Rajan, then Governor of RBI suggested to sell NPAs to asset reconstruction companies to clean up their balance sheets to keep moving forward.
(3) Commercial banks improve allocation of resources by lending money to priority sectors of the economy. They also provide finance to the infrastructure and support the economic growth.
(4) Finance Ministry’s 2015-16 Annual Report reveals that Gross NPAs of banks could soar to 6.9 percent by March 2017 in a severe stress scenario.
(5) If a DMU knows its inefficiency, then it will affect its choice on resource base (inputs).
(6) The production approach focuses on operating cost and ignores interest expenses while the intermediation approach considers both. Elyasiani and Mehdian (1990) argue that the intermediation approach is preferred to other approaches. Due to the controversy on whether deposits to be treated as input or output, three variants of intermediation models emerged: the asset, user cost and value added approaches. The asset approach uses deposits and other liabilities, together with labour and capital as inputs, and the output set includes only bank assets such as loans (Sealy and Lindley, 1977). In the user cost approach if the financial returns on an asset exceed the opportunity cost of the funds, they are considered as outputs; otherwise, they are considered as inputs (Hancock, 1985). The value-added approach identifies those balance sheet categories (assets or liabilities) as outputs that contribute to the bank value added (Berger et al., 1987).

(7) The operating approach (or income-based approach) views banks as business units with the final objective of generating revenue from the total cost incurred for running the business (Leightner and Lovell, 1998). Accordingly, it defines banks’ output as the total revenue (interest and non-interest) and inputs as the total expenses (interest and operating expenses).

(8) As the empirical studies on measuring banking efficiency are larger, we discuss about only a few, but selective studies in India and other countries.

(9) The likelihood function and its partial derivatives are given in Battese and Coelli (1993).

(10) The capital related operating expenses include rent, taxes, lighting, printing and stationary expenses, depreciation on bank property, repairs, and maintenance and insurance.

(11) Someone may argue that the technology process used for generating the interest income and the non-interest income may be different and so adding them and used as a dependent variable in the production function may be biased.

References


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