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Frontier Production Function Models for Measuring Banking Efficiency

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Abstract: ***This paper makes an attempt to compare the inter-temporal business performance measured in terms of mean efficiency of total business and total income of Indian banking industry over three time periods 2005-2008, 2009-2012 and 2013-2016. Efficiency across various bank-groups also attempted to examine whether there exists any ownership structured effects in determining bank efficiency. To estimate efficiency of banks, a stochastic frontier production function model is adopted as an exclusive technique of analysis. The results suggested that Total business as a dependent variable, the overall mean efficiencies exhibited for three time periods are 82%, 80% and 84%. Similarly total income as a dependent variable the overall mean efficiencies are 99%, 99% and 87% over the time periods. Among the four ownership bank groups, SBI and its associates, nationalized banks are found quite efficient in the generating outputs, namely total business as well as total income compared to the other ownership groups i.e. private and foreign banks. In generating both the outputs viz. total business and total income, significant improvement in the labour efficiency is noticed as compared to capital efficiency during the three time periods. In the case of total business output variable, labour efficiency improved from 74% during 2005-2008 to 82% during the 2013-2016.In the case of total income labour efficiency increased 64% during 2005-2008 to 67% during 2013-2016.***

KEY WORDS: ***Stochastic Frontier Production Function Model (SFPFM); Scheduled Commercial Banks (SCBs); Public Sector Banks (PSBs); Measurement of mean efficiency; Total business; Total income; Capital and Employee Cost.***

I. GENERAL INTRODUCTION

Over the last two decades, operating environment of banks in India improved significantly due to Globalization, impact of deregulation, financial liberalisation, financial reforms and advance Information Technology etc. Policy makers have clearly recognised that inefficiency is the main factor contributing to the higher cost of banking services in India. Firstly, globalization is a complex process that is, best managed by public policies such as enhanced connectivity determined by three fundamental factors, viz., public policy, perception and technology. The main advantages of Globalization is the reduction barriers to the flow of goods, money, people across national, cultural and social boundaries, in large extent it helps that the banks to maximize benefits and minimize the cost. There has been a significant progress towards globalization in the recent past in Indian banking system.

The effect of deregulations is studied in the past by Verma and Saini (2008), which has found that liberal entry and expansion policy for banks have resulted in a strong competition, thus decreasing the mark-up and an increase in the overall efficiency in the process of intermediation by banks. Information technology has given upswing to new innovations and automation for the product designing and their delivery in the banking. The new sounds of money in banking system “tap”, “click” and “swipe”. Modern technology has brought changes in the activities of the banks such as replacing papers with computer files, bank tellers with automated teller machines (ATMs) and file cabinets with server racks. Current banking sector has come up with a lot of initiatives to provide a better customer services with the help of new technologies. Traditional products offered by the Indian Banks have neither comparable nor appreciated well by the customers compared to those offered by new generation private sector and foreign banks operating in India (Sharma and Singh et.al., 1993; Singh and Malhotra et.al., 1993). Customer services improvement is the most useful tool for better growth of the banks.

After financial liberalisation, the number of new private sector banks were allowed to operate with latest technology and fully automated systems akin to foreign banks. The public sector and the old private sector banks faced challenges in the form of competitive pressures, changing customer demands, both from foreign banks and new private sector banks. Most of the public sector and old private sector banks had their existence for more than a century with a number of legacy issues to tackle. While the new private sector banks adopted the best practices with latest technology in their operations, the foreign banks acquired the practices and technology akin to their host countries within the regulatory framework of India. In the financial liberalisation phase Banks

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were carryout reinforces regulatory and supervisory efforts, provide a strong incentive to banks for conducting their business in transparent manner and also to maintain adequate capital as a cushion against risk mitigation. RBI perspective, such a quality disclosures will help the early detection of problem with the banks by the financial market disruptions.

The financial reforms, in Indian banking sector namely as Narasimham committee–I (1991) report and the Narasimham committee-II (1998) report, were aimed to make the banking sector more competitive, versatile, efficient, productive to follow international standard and to free from the directions and control of Government. These recommendations not only helped the potential of banking in India and also recognised as a factor towards minimizing the impact of global financial crisis years, 1992 and 2007.

Financial crisis is one of the major impacts with banking business and also affected the real economy of the Banks in India. In India development needs to rely on the internal markets and not for the international trade. The rural market consumption trends followed by the rural Indians are considered to be the drivers of future growth of companies. These trends are visible across all the sectors Viz. IT, Banking, Poultry, Farmhouse and other allied areas etc. In India banking sectors shows interest of universal banking services to the customers under one roof, for example a bank offers investment in banking, credit card services, insurance policies, market instruments, the mutual funds schemes, POS (Post sells), Selling gold coins, postal services etc apart from their ordinary business. In the recent era, the main advantage of universal banking is that greater economic efficiency in the form of lower cost, higher output and better products. Finally many committees and reports by the Reserve Bank of India are in favour of universal banking.

New banking trends in India are the application creation for the financial technology to solve financial problems and also exploiting financial opportunities like, E-banking, Internet banking, mobile & SMS banking, type of ATMs, RTGS and NEFT etc. Currently India is the 13th largest Non-cash payment systems market in the world with a high potential to grow significantly as POS terminals and accept the card payments (according to Frost and Sullivan).

The study estimated efficiency of banks by fitting Stochastic Frontier Production Function Model (SFPFM) by taking two output variables; total business and total income, and two input variables; capital and employee cost. The model have been widely used in various studies to measure the efficiency of banks in India as well as in other countries. The paper is organised in five sections. Section 2 presents an overview and growth of ATMs of Indian banking sector. Section 3 provides a survey of literature. Section 4 deals with data and methodology. Finally the study concludes in section 5, where all findings and concluding observations are presented.

II. OVERVIEW OF THE INDIAN COMMERCIAL BANKING SECTOR

The Indian commercial banking sector has broadly three major ownership groups, namely: (a) the PSBs, further divided into the state bank and its five subsidiaries operating with 23742 branches and the Nationalised banks which are 21 in number operating with 66500 branches,(b) private sector banks which are further divided into old generation banks and new generation banks, a total of 21 in number operating with 23315 branches and (c) finally the 45 foreign banks which are overseas branches of their parent company established abroad, many of which operates with a single representative branch with a total of 317 branches.

In addition to the above, there are 56 Regional Rural Banks(RRBs) established to cater for the financial needs mainly of the rural population and operate with a network of 20877 branches and 70 non-scheduled banks which are very small in size. The last two groups (RRBs, non-scheduled banks) are not included in the study as their size of business is very small compared to the scheduled commercial banks. Indian banking industry has recently witnessed the roll out of innovative banking model like payment banks and small finance banks. The Reserve Bank of India granted in principle approval to 11 payment banks and 10 small finance banks in the financial year 2015-2016. With the threat of competition from the foreign and new private sector banks, the PSBs have employed a number of measures to improve their operational efficiency, meeting customer expectations and reduction of operating costs. These include going for fully automated systems Core Banking Solution (CBS) preceded with Business Process Reengineering (BPR), training and retraining of staff, lateral recruitment of specialists, emphasis on marketing, advertising, customer relationship management and improving brand image, diversification of activities, introduction of electronic-based multiple service delivery channels, setting up of back offices and front offices, creation of the centralised data centres and business process outsourcing etc. Some of these banks have undergone restructuring exercise with the involvement of international consulting agencies to adopt best international practices and remove bottlenecks in their operations.

A. Growth in Automated Teller Machines (ATMs) in Indian banking systems

Over the years, the Reserve Bank has laid special emphasis on technology infusion in the day to day operations of banks. Technology, apart from increasing the efficiency of banking services, increase in the number of off-site ATMs in various locations

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as well as use of mobile phones for delivering banking technology has further facilitated banking outreach in remote areas. The Automated Teller Machine (ATM) has been hailed as one of the most innovative and revolutionary technological developments in the history of banking. The Channel, which was initially a medium for disbursal of cash to customers at bank branches, has now developed into a touch-point for delivery of a wide variety of banking services at branches and convenient off-site locations. Though banks initially owned and deployed their own ATMs, over time this has undergone a broad change, with banks now preferring outsourcing all or many of the activities associated with ATM operations- starting from deployment, maintenance, cash loading and technology upgrading. This has helped to reduce their operational costs and stay more focused on their core business.

Internationally, in addition to bank-owned and deployed ATMs, independent ATM Deployers (IADs) and Independent service organization (ISOs) are engaged in the ATM business. Such ATMs are called White-label ATMs (WLAs).In the year 2011-2012, the Reserve Bank of India has permitted white-Label ATMs in the country to supplement the existing ATM schemes operated by banks. Under the policy guidelines, non-bank entities incorporated in India under Companies Act, 2013 would be authorized to set up, own and operate ATMs in India, which will provide banking services to the customers of the banks in India, based on the cards(debit/credit/pre-paid) issued by banks. Finally model envisages that cash management and customer redressal would continue to be the responsibility of the sponsor's banks. The scheme offers scope for large volumes especially in unbanked/under-banker areas. Table (1) and Chart (1) presents the bank group wise number of ATM branches of banks in India for a period of five years i.e. 2011-2016. The growth of the ATMs are upward trends for all the banks, especially for the nationalised banks, the no of branches are 83771 and SBI group a total of 58688 branches as on March 31,2016.

III. REVIEW OF LITERATURE

There are number of banking studies investigating the efficiency of commercial banks. This section review various empirical studies which uses SFA to estimate the efficiency of banking sector. Farrell was the first to study empirical measurement of productive efficiency in terms of deviation from ideal frontier and also decomposition of economic efficiency into two efficiency measures Viz. technical and allocative efficiency. Aiger, D.J., Lovell, C.A.K., and Schmidt, P. (1977) et.al. An attempt made for formulation and estimation of stochastic frontier production function models. Battese, G.E., and Coelli, T.J. (1988),(1992),(1993) and (1995) a series of studies on panel data for Stochastic frontier production function technical efficiency with application of paddy farmers in India and also Prediction of Firm Level technical efficiencies. Kumbhakar and Saubal and Subrata Sarkar et.al. (2003) made an attempt through variety investigation the ownership, liberalization and efficiency issues of the Indian banking industry using panel data set for the period 1985-1996 for measuring time invariant technical efficiency using Stochastic frontier production function incorporating the Cobb-Douglas technology with four input and two alternative outputs. The results shows that the efficiency of the banking industry has not improved after financial liberalisation and the foreign owned banks as a group has the highest efficiency regardless of the choice of output. In addition that banks time-Invariant technical efficiency has more than 70 percent holds in this period. De (2004) made an attempt to estimate the technical efficiency of public, private and foreign banks in the pre-reforms as well as post-reforms period. An SFA with Cobb-Douglas production function was used to estimate the efficiency. The study used panel data of 64 banks from 1985-1986 to 1995-1996 and also finds that the foreign banks achieved the highest average efficiency compared to public and private sector banks. Sensarma (2006) made an attempt with stochastic frontier analysis to compare the performance of foreign banks operating in India with the domestic banks for the period 1986-2000. The results indicates that the foreign banks have been the poor performers throughout the period as compared with state owned and private domestic banks and there is no significant difference were found in the performance of public sector banks and domestic private banks.

Kumar and Gulati (2008) analysed and examined the trends of cost efficiency and the issue of convergence in cost, technical and allocative efficiency levels across Indian public sector banks for the period 1992-1993 to 2007-2008. He finds that deregulation has a positive impact on the cost efficiency levels of Indian public sector banks. Technical efficiency of Indian public sector banks followed an upward trend, while allocative efficiency followed a path of deceleration. Finally the convergence analysis reveals that the inefficiency of public sector banks are not only catching-up but also moving ahead than the efficient ones in the post reform period. Sreeramulu M and Sharat Kumar (2010) et.al. made an attempt to compare the efficiency of Indian banks over two time periods, 1999-2003 and 2004-2008.The study also compare the ownership effects in determining the efficiency of Indian banks between the two time periods using stochastic production frontier with Cobb-Douglas production functional model. The study make use of balanced panel data for 67 Indian banks (8 SBI and its associates,19 nationalised banks,20 domestic private banks and 20 foreign banks), with 670 total observations for the ten-years' time period from 1999-2008 collected from statistical tables related to banks in India published by the RBI (1999-2008). The study concludes that improvements in the operating efficiency of banks in

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India are upward during the comparative periods and the empirical results indicates that domestic private sector banks are efficient in generating output as compared with the other ownership groups.

Rajan (2011) attempted to examine technical efficiency and productivity performance of Indian scheduled commercial banks for the period 1979-2008 using stochastic frontier analysis model with multiple output/multiple input technology production frontier using semi-parametric estimation methods. The results shows that the PSBs are more efficient compared to domestic private banks and foreign banks. Foreign banks are considerably less efficient than PSBs possibly of their relative smaller scale. However, the foreign banks have higher efficiency compared to the domestic private banks due to their specialized activities. Majority of the studies have the positive feedback for deregulation and other reforms in last eras on the efficiency and productivity of Indian banks across the different ownership groups.

Ke Wang and Altubas (2014) made an attempt with DEA approach to disaggregate, evaluate and test the efficiency of 16 major Chinese commercial banks during the reforms period. Conclusion of the study is that foreign banks exhibit a higher level of efficiency than domestic banks, while big banks revealed scores of efficiency lower than the small banks. Bhagat Gayal and V H Bajaj (2015) in their study employed efficient frontier methods of Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) to estimate efficiency of Indian commercial banks, a sample of 19 nationalized Indian banks has been analysed for effectiveness using DEA and SFA. Conclusion of the study DEA and SFA efficiency estimates are significant.

Ombir and Sanjeev Bansal (2015) compared the performance of public, private and foreign banks in India in the post reform period by computing overall, pure and scale efficiency under the three different approaches viz. Production, intermediation and value added of input and output specification of banks using Data Envelopment Analysis. The results indicate that nationalized banks and foreign banks show 100% technical efficiency under the CRS and VRS assumption regardless of the choice the inputs and outputs. New private sector banks show 100% overall technical efficiency under the production and intermediate approach. The value added approach results shows that the presence of some inefficiency partly due to the scale factors and partly due to their failure in augmenting their deposits in the post crisis period. Old private sector banks receive 100% pure technical efficiency score under the all three approaches during the entire study period, but their overall technical efficiency scores are less than 100%. SBI group banks appear 100% efficient under the intermediate and value added approach. Foreign banks are significantly better than public sector banks under the production approach, but as per intermediate and value added approach no significance difference is found. Foreign banks are performing significantly better than the domestic private sector banks only under intermediate approach. Finally the results indicate that positive impact of the financial sector reforms on the efficiency of Indian banking industry. The study mainly compares the inter-temporal business performance measured in terms of mean efficiency of total business and total income of Indian banking industry over three time periods 2005-2008, 2009-2012 and 2013-2016 using a Stochastic Frontier Analysis. The reason for dividing the twelve years into three time periods 2005-2008, 2009-2012 and 2013-2016. Therefore selected 2005-2008 as pre-global crisis period, 2009-2012 as during the crisis and 2013-2016 as post-global crisis. We have used capital and employee cost as input variables, total business and total income as output variable for estimating the stochastic frontier production function model. The definition of variables are given below.

Description of data items		
S. No	Data items*	Description
1	Capital	Capital+ Reserves and Surplus
2	Total business	Sum of advances and deposits
3	Total Income	Sum of interest and non-interest income
4	Employee Cost	Payment to and provisions for employees

*Capital and total business are balance sheet items while total income and employee cost are earnings and expenses items.

IV. DATA AND METHODOLOGY

The necessary data was extracted from "Statistical Tables relating to Banks in India", published by Reserve Bank of India 2005-2016.The study made balanced panel data for 71 Indian banks (6 SBI and its associates, 20 nationalised banks, 19 private sector

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banks and 26 foreign banks) for three time periods 2005-2008, 2009-2012 and 2013-2016 with 852 total observations. The model employed in the study is estimated by the frontier 4.1 version developed by Coelli (1995).

A. Model Specification

We adopted the approach proposed by the Battese and Coelli (1995), the Stochastic Frontier Production Function model for panel data with an error term with two components, one to the account for random effect and the other for technical inefficiencies, are as follows:

$$Y_{it} = f\left(x_{it};\beta\right) + v_{it} - u_{it}, i = 1,2,....N; t = 1,2,.....T \quad (1)$$

Where Y_{it} is the output of i^{th} bank in t^{th} period

x_{it} is the vector of input for i^{th} bank in t^{th} period.

β is the vector of unknown parameters to be estimated

v_{it} is the symmetric random error term which are assumed to be i.i.d., $N\left(0,\sigma_v^{\,2}\right)$

u_{it} is the non-negative random variable which are assumed to account of technical inefficiency in output and to be independently distributed as truncated at zero of the $u_{it} \overset{iid}{\sim} N\left(\mu,\sigma_u^{\,2}\right)$ distribution.

The technical inefficiency effects u_{it} in the stochastic frontier model is specified as follows:

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

Where Z_{it} is a $\left(1\times p\right)$ vector of variable which may influence the inefficiency of the Banks

$\delta = \left(p\times 1\right)$ Vector of parameters to be estimated.

W_{it} the random variable follows truncated normal distribution with mean zero and variance σ^2

The parameters of the stochastic frontier given by the above equation (1) and inefficiency model given by the equation (2) are estimated by using Maximum likelihood estimation method for technical efficiency of the i^{th} bank in t^{th} period.

Similarly, technical efficiency is defined as the capacity and willingness of economic unit to produce the maximum possible output from a given bundle of inputs. Under given firm's production curve, the technical efficiency of a firm can be measured by observing how close a firm actual production possibility frontier for a given quantities of inputs. If a firm actual production point lies on the frontier, it is perfectly technically efficient. If it lies below the frontier, then it is technically inefficient. Therefore, technical efficiency is the relationship between the observed and actual outputs. The technical efficiency can be obtained by the following expressions for equations (1) and (2)

$$TE_{it} = \frac{Y_{it}}{f\left(x_{it};\beta\right)} \quad (3)$$

$$TE_{it} = \frac{u_{it}}{f\left(z_{it},\delta\right)} \quad (4)$$

Finally, if the variables are logged, then the technical inefficiency of the function is

$$TE_{it} = exp\left(-u_{it}\right) \quad (5)$$

Estimation of the stochastic production frontier requires a particular functional form of production function. It would be either Cobb-Douglas production function or CES production function or translog production function. In this study, we have adopted the stochastic frontier production function model with capital $\left(C_{it}\right)$, employee cost $\left(E_{it}\right)$ as inputs and total business $\left(y_{1t}\right)$ and total income $\left(y_{2t}\right)$ as two individual outputs for the production function models

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$$\ln y_{it} = b_0 + b_1 \ln C_{it} + b_2 \ln E_{it} + v_{it} - u_{it} \quad (6)$$

$$\ln y_{1t} = b_0 + b_1 \ln C_{1t} + b_2 \ln E_{1t} + v_{1t} - u_{1t} \quad (7)$$

$$\ln y_{2t} = b_0 + b_1 \ln C_{2t} + b_2 \ln E_{2t} + v_{2t} - u_{2t} \quad (8)$$

Where y_{it} is the output of i^{th} bank in t^{th} period, $i = 1 \& 2, t =$ Representing the three time periods 2005-2008, 2009-2012 and 2013-2016

C_{it} is the capital of the bank i at time period t,

E_{it} is the employee cost of bank i at time period t

v_{it} is the symmetric random error term which are assumed to be i.i.d., $N\left(0, \sigma_v^{\ 2}\right)$

u_{it} is the non-negative random variable which are assumed to account of technical inefficiency in output and $u_{it} \overset{iid}{\sim} N\left(\mu, \sigma_u^{\ 2}\right)$.

If $\mu = 0$ and restricted then the model (6) is estimated by using the Maximum Likelihood Method of estimation.

If μ is not restricted, then u_{it} follows truncated normal distribution.

The value of gamma term is equal to $\frac{\sigma_u^2}{\sigma^2}$, where $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and gamma value lies between 0 and 1.

If $u_{it} = 0$, indicating full technical efficiency, then gamma=0. Therefore, the deviations from the production frontier are entirely due to noise v_{it}.

If gamma=1, then all the deviations from the production frontier are due to technical inefficiency then the model (6) is estimated using production function option in Frontier 4.1 program developed by Coelli (1995).

B. Likelihood ratio test

The likelihood ratio test is an imperative feature and helps to determine whether the suggested stochastic frontier production function model is appropriate. The likelihood ratio test is used to test the null hypothesis that, there is no technical inefficiency in the model and is given by

$$\lambda_{LR} = -2\left\{\ln\left[L(H_0)\right] - \ln\left[L(H_1)\right]\right\} \quad (9)$$

Where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null and alternative hypothesis. The test statistic follows mixed chi-square distribution. The null hypothesis is rejected when $\lambda_{LR} > \chi_c^2$

The following are null hypotheses for the statistics:

1) $H_0 : b_1 = b_2 = 0$, the null hypothesis stated that, the coefficients of stochastic frontier production function model are zero.

2) $H_0 : \gamma = 0$, the null hypothesis specifies that the technical inefficiency effects in stochastic frontier production function model.

Here γ is the variance ratio, explaining the total variation in output from the frontier level of output attributed to technical efficiency and defined by

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} \quad (10)$$

The calculation of the maximum likelihood estimates for the parameters of the stochastic frontier models are obtained computer programme frontier 4.1 developed by Coelli (1995).

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IV. CONCLUSION

In this paper an attempt is made to compare the efficiency of total business and total income of Indian banking industry over three time periods 2005-2008, 2009-2012 and 2013-2016. The study also compares the ownership structured effects in determining the mean efficiency of Indian banks for the three time periods 2005-2008, 2009-2012 and 2013-2016. To fulfil the above two objectives, a stochastic frontier production function model is fitted to estimate the bank mean technical efficiency scores. We have used capital and employee cost as input variables, total business and total income as output variables for the stochastic frontier production function. The study make use of balanced panel data for 71 Indian banks (6 SBI and its associates,20 nationalised banks,19 private sector banks and 26 foreign banks) for three time periods 2005-2008, 2009-2012 and 2013-2016 collected from statistical tables relating to banks in India published by the Reserve Bank of India.

It appears from the data that competition has affected the Indian Banking sectors whose share in total deposits and advances in banking industry for three time period 2005-2008, 2009-2012 and 2013-2016.Desscriptive analysis suggest that the Indian Public sector banks whose share in total deposits and advances in the banking industry marginally declined from 89.09% to 87.09% in the period 2005-2008 and 87.11% to 85.42%, in the period 2013-2016.The gainers are the SBI and its associates and Private sector banks. To infer this the business and income for the bank-group wise SBI and its associates and Private sector banks are better than the nationalized banks, foreign banks.

By examining the balance sheet trends, it was found that the share of loans and advances in total assets of all bank groups has increased trend for three time periods, while the share of investment of PSBs, Private banks are declined, other bank group i.e. foreign banks has increased. In the period 2013-2016, the deposits occupied around 80% share of total assets in case of PSBs, 70% in case of private sector banks and 56% in case of foreign banks branches operating in India. On the income and expenditure side, the share of other income increased across all bank groups in the three time periods. As far as P & L account is concerned, the share of total income is high in the case of foreign banks as compared with public Sector Banks and Private Banks. The share of wage bill in total expenditure in case of PSBs declined significantly for three time periods. Credit to deposit ratio is 90% in case of private banks during the period 2013-2016 as compared to PSBs and Foreign banks.

The empirical results indicate that there is an overall improvement in operating efficiency of Indian banks over three time periods 2005-2008, 2009-2012 and 2013-2016. Stochastic frontier production function model with total business as a dependent variable (output variable), the overall mean efficiencies exhibited for three time periods are 82%, 80% and 84%. Similarly total income as a dependent variable the overall mean efficiencies are 99%, 99% and 87% over the time periods. Improvement in the operating efficiency in both cases, the banks in India are mainly attributed globalisation, liberalisation, introducing various market products and advance information technology. All these factors appears to significantly contribute to shift the production frontier on Indian banks in upward direction.

Based on sample results, the four ownership bank groups, namely SBI and its associates, nationalised banks, private sectors banks and foreign banks. The mean efficiency of SBI and its associates is better than the remaining bank groups and also SBI and its associates, nationalized banks are found quite efficient in the generating outputs, namely total business as well as total income, compared to the other ownership groups i.e. private and foreign banks.

In generating both the outputs viz. total business and total income employee cost is the dominant factor as compared to capital input. In between capital and labour cost, significant improvement in the labour efficiency is noticed as compared to capital efficiency during the three time periods considered in the study. In the case of total business output variable, labour efficiency improved from 74% during 2005-2008 to 82% during the 2013-2016.In the case of total income labour efficiency increased 64% during 2005-2008 to 67% during 2013-2016.

TABLE (1) :DISTRIBUITION OF ATM BRANCHES :BANK-GROUP WISE FROM THE YEAR 2011 TO 2016

YEAR	2011		2012		2013		2014		2015		2016	
Bank group	On site	Off site	On site	Off site	On site	Off site	On site	Off site	On site	Off site	On site	Off site
Nationalised Banks	15926	9407	18277	12773	21533	15528	37350	21946	47267	27422	53629	30142
State Bank Group	14275	10625	15735	11408	18708	13883	28570	22558	22635	31487	26770	31918
Private Sector Banks	2662	1510	3342	2429	4054	3512	4727	4657	5270	5366	5578	5404
Old Private Sector Banks	8117	11746	9907	20401	11182	24353	12472	26611	13627	27227	15712	28887
Foreign Banks in India	286	1089	284	1130	283	978	260	904	262	835	261	798
Grand Total	**41266**	**34377**	**47545**	**48141**	**55760**	**58254**	**83379**	**76676**	**89061**	**92337**	**101950**	**97149**

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TABLE (2): TOTAL DEPOSITS AND ADAVANCES OF SCHEDULED COMMERCIAL BANKS OVER THREE TIME PERIODs 2005- 2008, 2009-2012 & 2013- 2016.

(Figures in. Percent)

	2005-2008*		2009-2012*		2013-2016*	
Bank Group	**Deposits**	**Advances**	**Deposits**	**Advances**	**Deposits**	**Advances**
Nationalised banks	25.33	24.74	25.3	24.3	25.99	23.71
SBI and its associates	13.76	12.37	11.65	11.99	11.1	11.71
Public sector banks	89.09	87.11	86.96	86.28	87.09	85.42
Private banks	8.56	9.61	10.17	10.46	10.64	12.28
Foreign banks	2.35	3.27	2.88	3.25	2.27	2.3
All banks	100	100	100	100	100	100

TABLE (3): TOTAL BUSINESS OF SCHEDULED COMMERCIAL BANKS OVER THREE TIME PERIOD 2005- 2008, 2009- 2012 & 2013- 2016.

Balance sheet items	PUBLIC SECTOR BANKS			DOMESTIC PRIVATE BANKS			FOREIGN BANKS		
	2005-2008	2009-2012	2013-2016	2005-2008	2009-2012	2013-2016	2005-2008	2009-2012	2013-2016
	(Figures In. Millions)								
Capital	414321.352	530283.526	1083852.96	33644.875	46132.554	105689.162	70129.37	222857.7	594286.2
Reserve and Surplus	2080710.81	4372449.53	14255847.7	273703.107	867574.345	3185106.126	119684.1	270461.1	782660
Deposits	32740999.3	57739293	175788293	3146297.362	6750328.769	21476733	863891.6	191161 1	4588000
Borrowings	2614962.66	4589865.99	19673594.9	443597.048	879573.284	4753107.654	308471.6	583149.2	1242575.5
Total liabilities	412949052.3	734808963.3	220213097	4278916.988	9401438.443	30832404.8	153636 3	364098 6	8146228.8
Cash and balances with RBI	2080677.9	5526509.62	9823457.04	213241.645	712815.221	1216323.107	67590.11	220112.6	237553.25
Investment	155594977.7	197717095.3	532702893.3	1406666.481	2785780.677	7397986.077	428576.1	989101.9	2812256.7
Loans and advances	200505098.8	427433681.1	134900438	2213032.969	5184024.176	19393394.26	753182.5	161132 8	3635507.8
Fixed assets	364923.5	711909.3	1962473.	77267.56	96284.746	227066.41	18827.2	39686.8	52454.6

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	49	95	78			6	6	7	42
Total assets	41294905.2	73480896.3	22021309 7	4278916.988	9401438.443	30832404.8	153636 3	364098 6	8146228.8
INCOME AND EXPENDITURE ITEMS									
Income									
Interest income	2761660.85	5215568.48	16804492.4	262654.454	709911.871	2476890.872	91704.63	244165.4	523175.19
Other income	586195.605	931881.225	2283228.38	63671.567	170063.093	496326.274	38656.96	105876.2	125149.58
Expenditure									
interest expenditure	1578436.07	3569032.62	11576211.5	162732.51	484950.922	1495543.78	40414.47	106038.8	241011.19
Operating expenditure	871791.883	1239453.11	3687517.35	86748.541	202671.332	637463.25	44174.12	103528.6	162050.75
Wage bill	533840.452	645787.976	3662440.3	41511.062	97133.626	427073.133	25949.29	74351.77	136987.98
Operating profit	897628.503	1338963.98	3823991.95	76844.97	192352.71	840210.116	45773.01	140474.2	245262.83
Credit-Deposit ratio	61.24	74.03	76.74	70.34	76.80	90.30	87.18	84.29	79.24
Cash balance-deposit ratio	6.35	9.57	5.59	6.78	10.56	5.66	7.82	11.51	5.18
Investment/Deposit ratio	47.52	34.24	30.30	44.71	41.27	34.45	49.61	51.74	61.30
Operating profits to total assets	2.17	1.82	1.74	1.80	2.05	2.73	2.98	3.86	3.01
Net interest income to total assets	6.69	7.10	7.63	6.14	7.55	8.03	5.97	6.71	6.42

Ratios in Percentage

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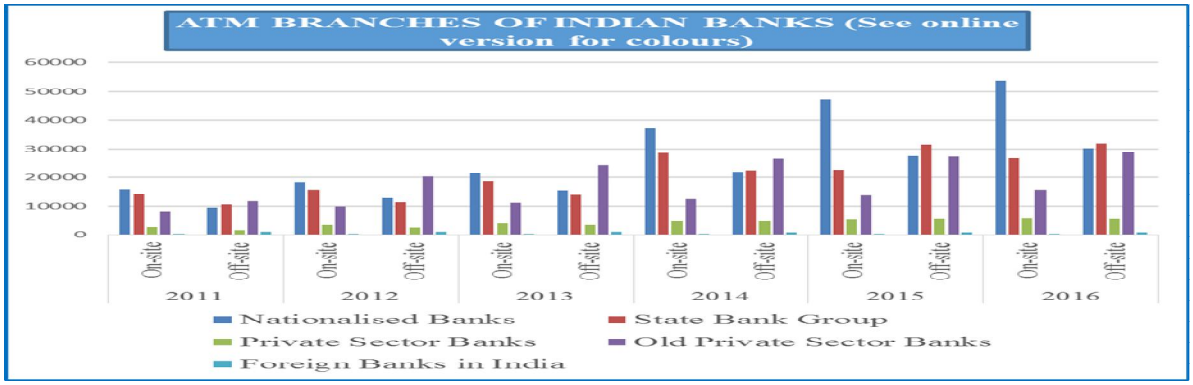
TABLE (4) : SUMMARY -MEAN EFFICIENCIES OF BANKS IN INDIA				
YEAR	NO OF BANKS	2005-2008	2009-2012	2013-2016
MEASURES		MEAN EFFICIENCY	MEAN EFFICIENCY	MEAN EFFICIENCY
TOTAL BUSINESS AS A DEPENDENT VARIABLE				
State Bank Group	6	0.999919	0.971928	0.979875
Nationalised Banks	20	0.915611	0.956295	0.977014
Private Sector Banks	19	0.877597	0.873335	0.899100
Foreign Banks	26	0.999279	0.901661	0.998833
ALL BANKS	71	0.823293	0.798501	0.842067
TOTAL INCOME AS A DEPENDENT VARIABLE				
State Bank Group	6	0.999918	0.964895	0.976306
Nationalised Banks	20	0.933140	0.965641	0.945513
Private Sector Banks	19	0.939244	0.892217	0.911086
Foreign Banks	26	0.999598	0.999535	0.857606
ALL BANKS	71	0.999456	0.998813	0.879853

TABLE (5): MAXIMUM LIKELIHOOD ESTIMATION OF STOCHASTIC FRONTIER PRODUCTION FUNCTION						
YEAR	2005-2008		2009-2012		2013-2016	
ESTIMATED VALUES	COEFFICIENT	T-CAL	COEFFICIENT	T-CAL	COEFFICIENT	T-CAL
TOTAL BUSINESS (Y_{1t})						
CONSTANT(b_0)	1.538406	9.7834335*	1.448240	6.7141759*	1.730179	10.500096*
CAPITAL(C_{1t})	0.379523	4.7519616*	0.412816	3.6902117*	0.263372	3.4686105*
EMPLOYEE COST(E_{1t})	0.740176	11.535482*	0.727907	8.4024147*	0.824040	13.907777*
SIGMA SQUARE	0.078993	3.968885	0.101351	4.437565	0.058838	4.401371
GAMMA	0.870380	10.158696	0.946663	22.453905	0.917882	16.585193
LOG LIKELIHOOD RATIO	5.305203		8.610925		8.097163	
TOTAL INCOME (Y_{2t})						
CONSTANT(b_0)	0.335910	1.371886	0.33115	1.00383	0.57488	4.14443
CAPITAL(C_{2t})	0.412376	8.1469421*	0.36766	6.9567089*	0.36950	6.289911*
EMPLOYEE COST(E_{2t})	0.649021	17.159908*	0.71019	17.246756*	0.67925	13.174735*
SIGMA SQUARE	0.014272	6.010411	0.01511	6.03753	0.03300	2.90375
GAMMA	0.000033	0.001168	0.00015	0.00182	0.85431	5.49686
LOG LIKELIHOOD RATIO	Not exists		Not exists		2.65938	

Notes: * Significant at 5% level of significance.

Chart (1): atm branches (on-site & off-site) growth of indian banks for the period 2011-2016.



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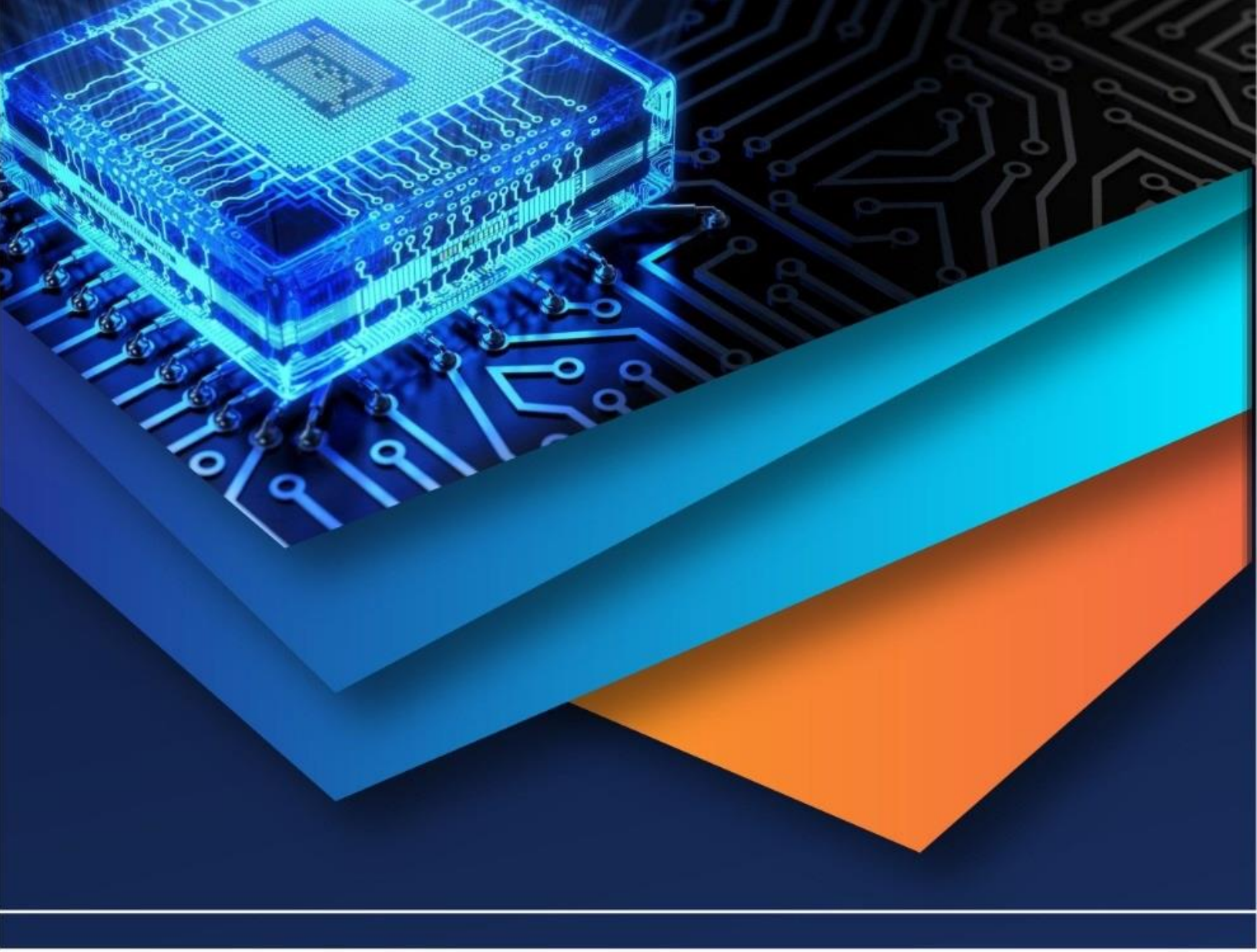

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