

The Analysis of Productivity of Scheduled Commercial Banks in India after Global Financial Crisis-An Application of Data Envelopment Analysis using Malmquist Index of Productivity

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Abstract

This study investigates the change in efficiency and productivity of banking industry during 2009 to 2016. This study analyses the effects of various indicators on the efficiency of 6 State Bank group banks, 20 each Nationalised, Private and Foreign banks depending on availability of data during the period of study. Malmquist index is used to measure efficiency and productivity of 66 selected commercial banks of India. The components of Malmquist productivity index used in the performance measurement are changes in technical efficiency, technological change, change in scale efficiency and the change in total factor productivity. As a whole, results show that the productivity change of commercial banks in India has improved over the sample period just following the period of global financial crisis in the year 2007-08. However, the improvement in the financial performance of different banks was unbalanced, because some of them were declining in terms of the total factor productivity. Moreover, decomposition of the DEA based Malmquist Index shows that the bulk of the improvement in total factor productivity of commercial banks in India has been attained through the rapid technological improvement in banking sector which is partially offset through a reduction in the technical efficiency change. So, from the study, it can be said that as far as the Indian banking industry is concerned, although, the banks in India are not as technologically advanced as their counterparts in the developed world; they are following the majority of international trends in the IT domain. To conclude, we can say that, the banking industry in India is rapidly progressing with increased customer base and due to newly improved and innovative facilities offered by the technology and should have to focus on improving managerial efficiency of the banking sector.

JEL Classification Codes: C14, C61, C67, D24, G21, O16.

The globalization of financial markets and banking industry has affected the actions of many nations especially up-and-coming countries. Banking industry plays a vital role in stability of financial system through efficient mobilization of savings and transforming them to investment. Investment plays a key role in promoting economic growth of any country. In India, banking sector plays the pivotal role in financial sector in terms of contribution of credit to accumulate investment. So, measuring efficiency and productivity of banking sector is crucial to foster economic growth of India.

Theoretical Background of the Study:

In 1988, RBI set up a committee on computerization of banks and in 1991, Narasimham Committee came up with set of recommendations for reforming Indian Banking system. In 1998, Narasimham Committee –II report came up with second set of recommendations aiming at stronger banking sector. Vimal Jalan, the then RBI Governor gave 3 to 4 years to banks to implement the Narasimham Committee Report-II. In 2007, Global financial crisis began all over the world. In 2008, intensity of global financial crisis was diluted to some extent. This paper studies the change in productivity of commercial banks in India as a whole from the year 2009 to 2016 using panel data in the post global financial crisis era. As Banking Sector Reforms have been implemented since 1991 and in 1998, Narasimham Committee Report-II has come into force. After 10 years of Narasimham Committee Report-II which can be referred as finishing touch in structural change in banking sector, we can assess the impact of financial sector reforms on productivity of Indian Banking Sector.

Review of Literature:

In 1953, Sten Malmquist, a Swedish economist and statistician first derived a quantity index for use in consumption analysis in *Trabajos de Estadística* (Malmquist, 1953). Later Caves et al. (1982) adapted Malmquist's idea for production analysis and they named the productivity changes index after Sten Malmquist. The application of data envelopment analysis based on Malmquist total factor productivity index is widely used in the comparison of countries and aggregate comparisons of productivity between countries (Fare et al. 1994; Yörük & Zaim, 2005) as well as various economic sectors such as agriculture (Tauer, 1998), airlines (Barros & Weber, 2008), telecommunications industry (Calabrese et al. 2001) etc. Berg et al. (1992) presented the first application of the Malmquist index to measure productivity growth in the Norwegian banking system in the pre and post deregulation era (1980-89), using the value added approach. Their analysis showed that the productivity exhibited a lackluster performance in the pre-deregulation era, however, the productivity increased remarkably in the post-deregulation era suggesting that deregulation led to more competitive environment, especially for larger banks. Likewise, using a generalized Malmquist productivity index, Grifell-Tatje & Lowell (1997) analyzed the sources of

productivity change in Spanish banking over the period 1986-1993 and found that the commercial banks had a lower rate of productivity growth compared to saving banks, but a higher rate of potential productivity growth. Drake (2001) studied efficiency and productivity changes in the main UK banks over the period 1984 to 1995 and suggested that bank scale inefficiencies were a more severe problem than X-efficiencies. Drake's Malmquist productivity indices suggested that, on the whole, UK banks exhibited positive productivity growth over the period. Sathye (2002) also used Malmquist index to analyze productivity changes from 1995-1999 in a panel of 17 Australian banks to assess the effects of deregulation and the reforms introduced by the Wallis report of 1997. Sathye (2002) found a decline of 3.1 per cent in technical efficiency over the period and of 3.5 per cent in the total factor productivity index, although annual productivity grew by 1.3 per cent. Likewise, Neal (2004) measured X-efficiency and productivity change of Australian banks for the period of 1995-1999. The findings displayed that overall efficiency had a declining trend until 1997 but rose in 1998 as well as 1999, and allocative efficiency of banks was higher than technical efficiency. Handful of research has also been devoted to investigate the efficiency of banks in Asian countries. Bhattacharyya et al. (1997) examined the productive efficiency of Indian commercial banks during 1986-1991 and found a marginal increase in overall average performance after 1987 and the average efficiency of publicly owned banks is much higher than in the privately owned or foreign owned banks. Galagedera & Edirisuriya (2005) used data envelopment analysis and Malmquist Index in a sample of Indian commercial banks over the period of 1995-2002 and found no significant growth in productivity during the sample period. He found that there has been no growth in productivity in private sector banks where as the public sector banks appeared to demonstrate a modest positive change through 1995-2002. Sinha & Chatterjee (2008) tried to make a comparison of fund based operating performance and total factor productivity growth of selected Indian commercial banks for the five year period 2000-01 to 2004-05 using data envelopment analysis and Malmquist total factor productivity index. The findings displayed that the mean technical efficiency of the in-sample private and foreign banks is somewhat higher than the in-sample public sector banks. However, in-sample public sector commercial banks exhibited higher Malmquist index than the in-sample private sector banks. Likewise, Rezvanian et al. (2008) also used Malmquist index to examine the effects of the ownership on efficiency, efficiency change, technological progress, and productivity growth of the Indian banking industry over the period of 1998-2003. They found that foreign banks were operating significantly more efficient than privately owned and publicly owned banks.

Biwesh Neupane analyzes the effects of various indicators on the efficiency of the twenty two commercial banks in Nepal. He used as to measure the efficiency and productivity where as Tobit regression used as

to analyze the determinants of efficiency. Results showed that the productivity change of commercial banks in Nepal had improved over the sample period and that the increase in productivity change in Nepalese commercial banks was due to the technical progress rather than efficiency components. It also reported that the decline in efficiency change was due to decline in both pure efficiency change and scale efficiency change analyzed the effects of various indicators on the efficiency of the twenty two commercial banks in Nepal.

Research Methodology:

We have used Data Envelopment Analysis to judge efficiency and productivity of selected 66 scheduled commercial banks for year 2009 to 2016. Data is collected from “Statistical Tables Relating to Banks in India” obtained from RBI website www.rbi.org.in. The technique DEA with its multiple input-output nature and non linear relationship between inputs and outputs, defines an efficiency measure of a production unit by its position relative to the frontier of the best performance represents the efficiency of production units which attain 100% efficiency.

Malmquist Productivity Index is used to measure the total factor productivity and its corresponding changes in its components between 2009 and 2016. Among the alternative measures of productivity changes using the DEA, the Malmquist Index, suggested by Fare, et al (1994), has the advantages over the other measures, the Fisher Index and Tornquist Index. The advantages of the Malmquist Index are-it neither require the profit maximization assumption nor the cost minimization assumption, it does not require the information about the prices of inputs and outputs and moreover, in case of panel data, this approach allows the decomposition of productivity change into technical efficiency change or, catching up and technological change. But in this approach, it is necessary to compute the distance function. There are two types of distance functions-the input distance functions and the output distance functions based on input oriented and output oriented measures of change in productivity. In this study, we use the output oriented Malmquist index where the output oriented distance functions consider the maximum proportional expansion of output with a given set of inputs.

The Malmquist index measures the change in total factor productivity of a firm over a time period, by calculating the ratio of the distance functions in respect to a common technology. For the Malmquist index, we assume that for each period of time, production technology $S_t=(x^t, y^t)$ where x^t produces y^t .

According to Fare et al (1994), the output oriented Malmquist index for changes in total factor productivity of a particular DMU_i at time (t+1) and t is:

$$M_i = \left[\left\{ \frac{D_i^t(x^{t+1}, y^{t+1})}{D_i^t(x^t, y^t)} \right\} \left\{ \frac{D_i^{t+1}(x^{t+1}, y^{t+1})}{D_i^t(x^{t+1}, y^{t+1})} \right\} \right]^{1/2} \dots 1$$

The above output based Malmquist productivity index can be decomposed according to Fare et al (1992, 1989) as:

$$M_i(x^{t+1}, y^{t+1}, x^t, y^t) = \{D_i^{t+1}(x^{t+1}, y^{t+1}) / D_i^t(x^t, y^t)\} [\{D_i^t(x^{t+1}, y^{t+1}) / D_i^{t+1}(x^{t+1}, y^{t+1})\} \{ D_i^t(x^t, y^t) / D_i^{t+1}(x^t, y^t)\}]^{1/2}$$

Where M_i = Malmquist productivity index,

D_i = output distance function, x & y represent inputs and outputs respectively over the time period t to $t+1$.

The ratios inside the brackets is geometric mean of productivity indexes representing the changes in production technology (TECHCH) between two time periods t and $t+1$ whereas the ratio outside the brackets measures the change in technical efficiency (EFFCH) between the time periods t and $t+1$, capturing changes in efficiency over time, that is whether production become closer or more distant from the efficient frontier. Therefore, the Malmquist index or the total factor productivity change is the product of the two components the technical efficiency change (EFFCH) and technological change (TECHCH).

Fare (1994) also decomposed the Malmquist index by decomposing the technical efficiency change (EFFCH) into pure technical efficiency change (PECH) and scale efficiency change (SECH). The pure efficiency change measures the managerial ability to convert inputs into outputs while the scale efficiency change measures how much the operators can take advantage of returns to scale by altering its size towards optimal size. All the components of Malmquist total factor productivity greater than one indicates improvement or progression, on the other hand, the values less than one indicates deterioration or regression, while the values equal to one implicate that there is neither improvement nor deterioration has been occurred.

In order to select the variables (i.e. inputs and outputs) in performance analysis of banks using the DEA technique we mostly depend on the definition of a bank's function. In the banking literature there are mainly two approaches which discuss the activities of banks –the production approach and intermediation approach. The intermediation approach views banks as the intermediary of financial services whereas the production approach defines the banks' activity as production of services. In this paper, we use the intermediation approach for identification of inputs and outputs. The intermediation approach transforms the money borrowed from depositors into the money lent to borrowers.

In this study, the output variables taken are advances, other earning assets, interest income and non-interest income. Input variables taken here are deposits, fixed assets, interest expenses, non-interest expenses and capital reserves.

As per definition of RBI, advances equal to Bills purchased and discounted plus cash credits, overdrafts and loans plus term loans secured by tangible assets plus term loans covered by bank/government guarantees plus unsecured loans plus Advances in India (Priority sector as defined by RBI, public sector, banks and others) plus Advances outside India. Other earning assets are assets other than advances which generate income such as rental property, interest on dividend earning accounts, certificate of deposits etc. Interest income consist of interest earned on advances, income on bills' discounting, income on investments, interest on balances with RBI and other interbank funds etc. Non-interest income includes deposit & transaction fees, insufficient funds fees (NSF), annual fees like fees on out of network ATM transaction, fees for issuing cheques, loan-servicing fees, monthly fees like fees for extending brokerage service, account service charge etc.

Deposits of banks consist of demand deposits from banks & others, savings bank deposits, term deposits from banks & others, deposits of branches both in and outside India. Fixed assets comprise of premises, fixed assets under construction & other fixed assets. Interest expenses of banks include interest on deposits, interest on RBI/ other banks' borrowing etc. Non-interest expenses constitute of payments to and provisions for employees, rent, taxes & lighting, printing and stationary, advertisement & publicity, depreciation on bank's property, directors' fees, allowances & expenses, auditors' fees & expenses, legal charges, postage, telegrams, telephone etc. charges, repairs & maintenance cost, insurance and other expenditure. Capital reserves for banks is set up to meet regulatory requirements and acts as buffer during financial repression and they also absorb the adverse impact of a drop in asset values of banks or, anticipated losses on their loan books.

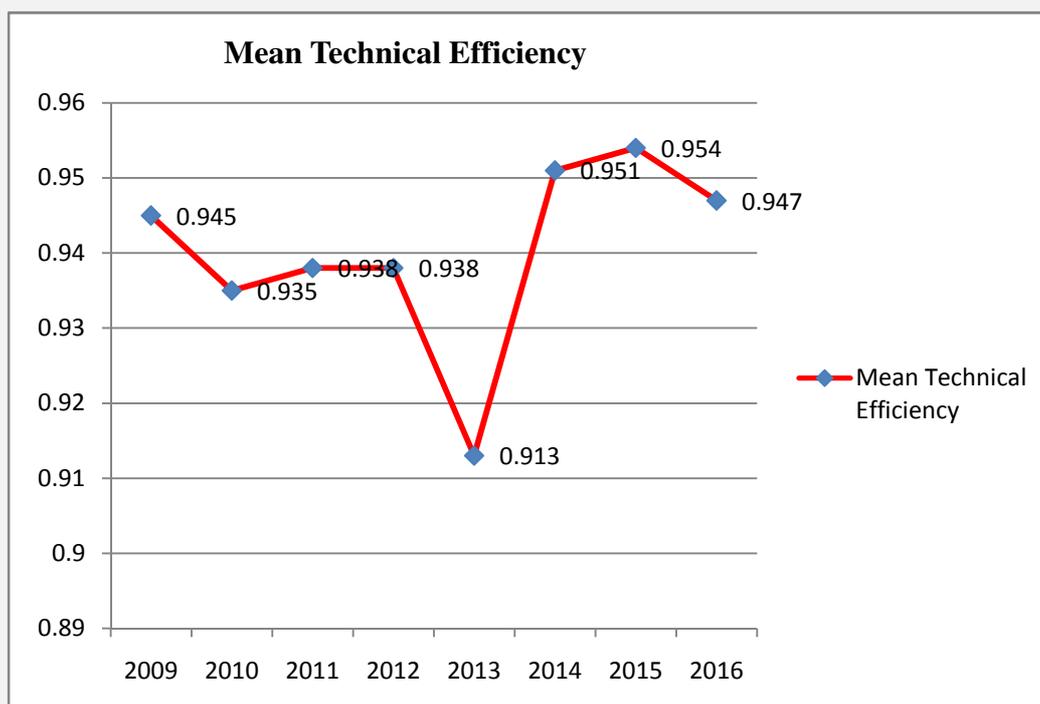
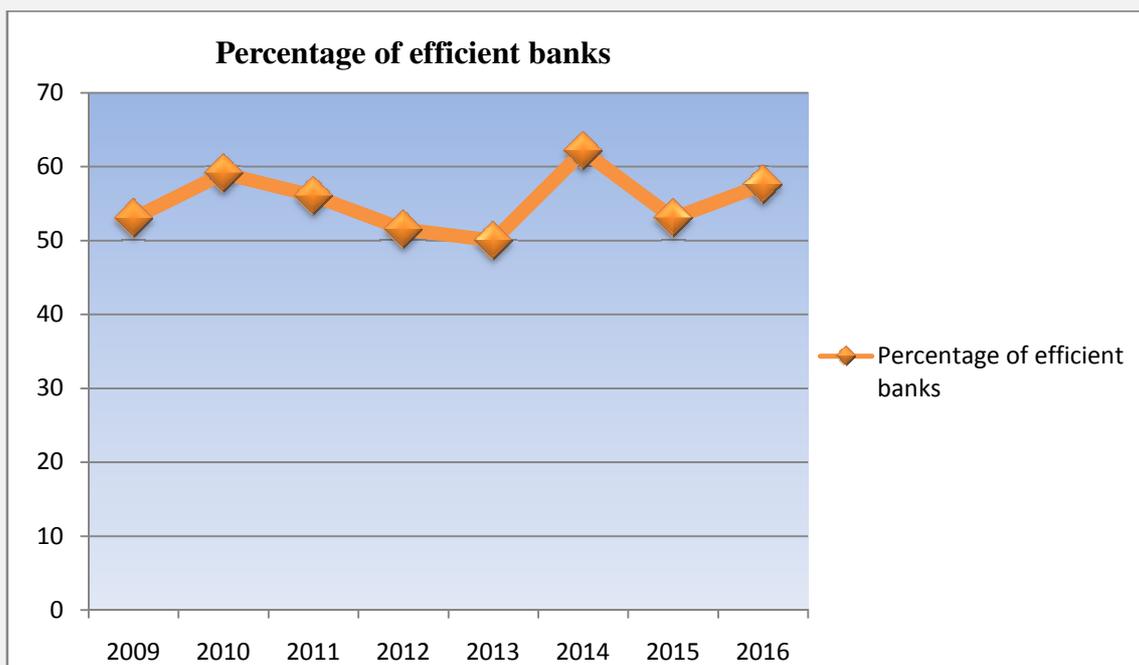
We have employed panel data with about 528 observations that appears in 8 years of our empirical study. The components of Malmquist productivity index used in the performance measurement are changes in technical efficiency, technological change, change in scale efficiency and the change in total factor productivity. Among 66 banks, 20 private, 20 foreign and 26 public sector banks have been studied.

Empirical Results:

The results show mean variable return to scale (VRS) technical efficiency from 2009 to 2016, reflecting the development of efficiency of Indian commercial banks. The table below shows the mean variable returns to scale (VRS) technical efficiency from 2009 to 2016.

Year	Mean Technical Efficiency	Percentage of efficient banks
2009	0.945	53.03
2010	0.935	59.09
2011	0.938	56.06

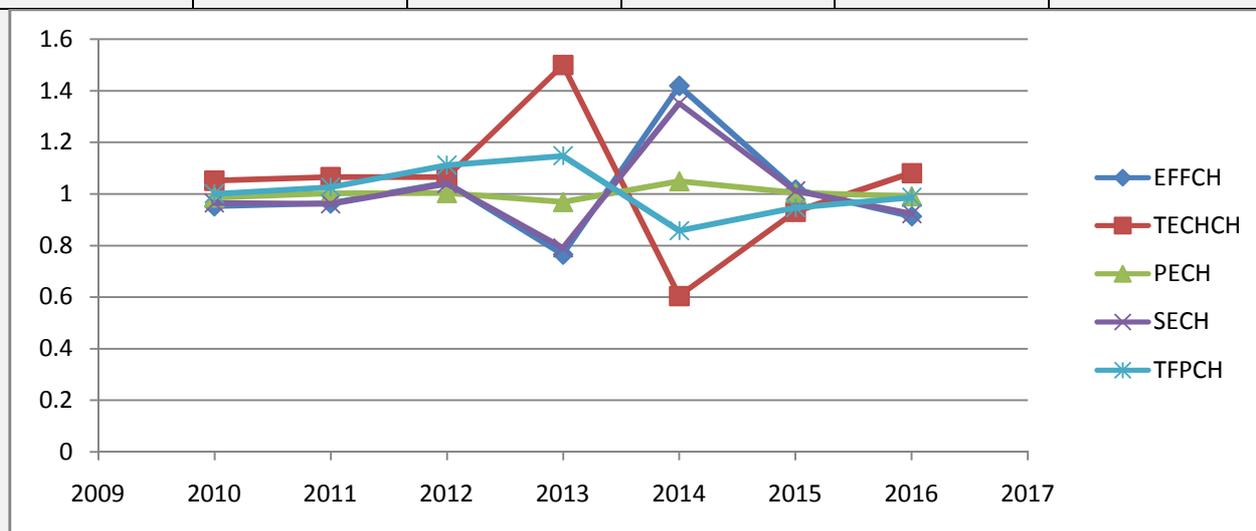
2012	0.938	51.52
2013	0.913	50
2014	0.951	62.12
2015	0.954	53.05
2016	0.947	57.58



Efficiency begins to fall abruptly in the year 2009 to 2010 just after the global financial crisis from 0.945 to 0.935 but it revives in the next year increasing to 0.938. Again in 2012 to 2013, efficiency falls rapidly than before from 0.938 to 0.913. After that, technical efficiency of banks gradually improved. From 2009 to 2010, percentage of efficient banks increased from 53.03% to 59.09% but it begins to fall from 2010 to 2013 when percentage of efficient banks falls to 50%. Percentage of efficient banks attain maximum in the year 2014 with 62.12%. The results obtained from Data Envelopment Analysis, regarding components of Malmquist productivity index used in the performance measurement are as follows:

Table-Malmquist index summary of annual means

YEAR	EFFCH	TECHCH	PECH	SECH	TFPCH
2010	0.952	1.051	0.986	0.965	1.000
2011	0.963	1.065	1.002	0.961	1.026
2012	1.043	1.065	1.003	1.039	1.111
2013	0.765	1.499	0.968	0.790	1.147
2014	1.418	0.604	1.049	1.351	0.857
2015	1.016	0.931	1.004	1.012	0.946
2016	0.913	1.080	0.990	0.922	0.986
Mean	0.994	1.012	1.000	0.994	1.006



Percentage analysis of table mentioned above is:

$effch < 1 = 4 = 57\%$ $techch < 1 = 2 = 29\%$ $pech < 1 = 3 = 43\%$ $sech < 1 = 4 = 57\%$
 $tfpch < 1 = 3 = 43\%$
 $effch > 1 = 3 = 43\%$ $techch > 1 = 5 = 71\%$ $pech > 1 = 4 = 57\%$ $sech > 1 = 3 = 43\%$
 $tfpch > 1 = 3 = 43\%$

effch = 1 = 0 = 0% techch = 1 = 0 = 0% pech = 1 = 0 = 0% sech = 1 = 0 = 0%
 tfpch = 1 = 1 = 14%

The components of Malmquist productivity index used in performance measurement are changes in technical efficiency, technological change, change in scale efficiency and the change in total factor productivity.

Summary of annual means of Malmquist index shows that most of the years due to revolutionary up gradation of technology in banking, technological change are more than 1 in all the years except 2014 & 2015. Pure efficiency showing change in managerial efficiency shows mean 1 with 2011, 2012, 2014 & 2015 showing more than one value. Scale efficiency change is highest in 2014 balancing the adverse effect of technology change to some extent. Total factor productivity change shows 0.6% increase despite decline in technical efficiency by 0.6% because of 0.6% decline in scale efficiency during the study period. This is owing to 1.2% increase due to technology change.

The above table indicates that commercial banks have shown improvement in technical efficiency by 43% of the study period, technical change by 71% of the study period, pure technical change improvement by 57% of the study period and scale efficiency change by 43% of the study period. The annual means of the Malmquist index show that the scale efficiency change deteriorates by 0.6%, efficiency change deteriorates by 0.6%, technological change improves by 1.2%, and total factor productivity change improves by 0.6%, whereas pure technical efficiency change neither deteriorates nor improves.

The year 2012 recorded improvement in technical efficiency change by 4.3% and the improvement in efficiency change by 6.5% resulting in an improvement in commercial banks' total factor productivity change by 11%. In the year 2013, the technological change recorded highest improvement by 49.9% but the technical efficiency change recorded deterioration by 23.5% leading to total factor productivity change of commercial banks to be 14.7% which is highest improvement in the whole study period. This improvement owes to huge improvement in technological efficiency.

Table: Malmquist index summary of bank means:

BANKS	EFFCH	TECHCH	PECH	SECH	TFPCH
STATE BANK OF BIKANER & JAIPUR	1.000	1.020	1.000	1.000	1.020
STATE BANK OF HYDERABAD	0.983	1.007	1.000	0.983	0.989
STATE BANK OF INDIA	0.998	1.025	1.000	0.998	1.024
STATE BANK OF MYSORE	0.992	1.000	0.992	0.999	0.992

STATE BANK OF PATIALA	0.971	1.002	1.000	0.971	0.973
STATE BANK OF TRAVANCORE	0.989	0.998	1.000	0.989	0.987
ALLAHABAD BANK	1.004	0.999	1.005	0.999	1.003
ANDHRA BANK	1.018	0.998	1.002	1.015	1.016
BANK OF BARODA	0.988	1.015	1.000	0.988	1.003
BANK OF INDIA	0.985	0.996	0.991	0.994	0.981
BANK OF MAHARASHTRA	1.015	1.014	1.011	1.004	1.029
CANARA BANK	1.005	0.987	1.000	1.005	0.992
CENTRAL BANK OF INDIA	0.976	1.017	0.988	0.988	0.992
CORPORATION BANK	1.019	1.003	1.000	1.019	1.021
DENA BANK	0.998	0.992	0.996	1.002	0.990
IDBI BANK LIMITED	0.994	0.985	1.000	0.994	0.980
INDIAN BANK	1.003	1.000	0.997	1.006	1.003
INDIAN OVERSEAS BANK	0.991	0.988	0.994	0.996	0.978
ORIENTAL BANK OF COMMERCE	1.002	0.992	0.999	1.003	0.994
PUNJAB AND SIND BANK	1.024	0.994	1.008	1.015	1.017
PUNJAB NATIONAL BANK	1.001	1.005	1.000	1.001	1.006
SYNDICATE BANK	0.995	1.007	1.000	0.995	1.002
UCO BANK	1.027	0.988	1.004	1.022	1.014
UNION BANK OF INDIA	0.996	0.999	1.000	0.996	0.996
UNITED BANK OF INDIA	1.007	0.985	1.003	1.005	0.992
VIJAYA BANK	1.009	0.990	1.003	1.006	0.998
AXIS BANK	1.004	1.038	1.008	0.996	1.042
CATHOLIC SYRIAN BANK LTD	0.995	1.011	0.997	0.999	1.006
CITY UNION BANK LIMITED	0.995	0.994	1.000	0.995	0.989
DCB BANK LIMITED	0.967	1.036	1.005	0.963	1.003
DHANLAXMI BANK	0.972	1.059	0.990	0.982	1.029
FEDERAL BANK	0.965	0.999	0.983	0.982	0.964
HDFC BANK	0.977	1.042	1.000	0.977	1.017
ICICI BANK	1.003	0.991	1.000	1.003	0.995

INDUSIND BANK	1.067	1.081	1.025	1.041	1.153
ING VYSYA BANK	1.010	1.027	1.037	0.974	1.037
JAMMU & KASHMIR BANK LTD	0.983	0.985	0.998	0.985	0.967
KARNATAKA BANK LTD	0.992	0.983	1.001	0.991	0.976
KARUR VYSYA BANK	0.983	0.989	1.001	0.982	0.972
KOTAK MAHINDRA BANK LTD	0.918	1.001	1.000	0.918	0.919
LAKSHMI VILAS BANK	1.010	0.994	1.004	1.006	1.004
NAINITAL BANK	0.965	1.008	0.970	0.995	0.973
SOUTH INDIAN BANK	0.970	0.990	0.995	0.975	0.961
TAMILNAD MERCANTILE BANK LTD	0.993	1.000	0.999	0.994	0.992
THE RATNAKAR BANK LIMITED	1.001	1.052	1.024	0.978	1.054
YES BANK LTD.	1.003	0.967	1.007	0.996	0.970
AB BANK LIMITED	1.000	1.080	1.000	1.000	1.080
ABU DHABI COMMERCIAL BANK	1.026	1.062	1.003	1.022	1.089
BANK OF AMERICA N.A.	1.000	0.994	1.000	1.000	0.994
BANK OF BAHRAIN & KUWAIT B.S.C.	0.991	1.055	0.989	1.002	1.045
BANK OF CEYLON	1.000	0.977	1.000	1.000	0.977
BANK OF NOVA SCOTIA	1.000	0.984	1.000	1.000	0.984
BANK OF TOKYO-MITSUBISHI UFJ LTD	1.000	0.988	1.000	1.000	0.987
BNP PARIBAS	1.000	1.077	1.000	1.000	1.077
CITIBANK N.A.	0.965	0.950	1.000	0.965	0.917
DBS BANK LTD.	1.000	1.090	1.000	1.000	1.090
DEUTSCHE BANK AG	1.004	0.986	1.000	1.004	0.990
HONGKONG AND SHANGHAI BANKING CORPN.LTD.	0.975	0.942	0.985	0.990	0.918
JP MORGAN CHASE BANK N.A.	1.000	1.165	1.000	1.000	1.165
KRUNG THAI BANK PUBLIC COMPANY LIMITED	1.058	1.101	1.043	1.014	1.164
MASHREQ BANK PSC	1.000	1.060	1.000	1.000	1.060
MIZUHO BANK LTD	1.000	1.105	1.000	1.000	1.105
SHINHAN BANK	1.000	1.031	1.000	1.000	1.031

SOCIETE GENERALE	0.935	1.038	0.956	0.978	0.971
SONALI BANK	0.935	0.967	1.000	0.935	0.903
STANDARD CHARTERED BANK	0.997	0.933	1.000	0.997	0.930
Mean	0.994	1.012	1.000	0.994	1.006

Summary of bank means of Malmquist index of selected commercial banks show improvement in pure efficiency occurred in following Public Sector Banks such as Bank of Maharashtra (by 1.1%), Allahabad Bank (by 0.5%), UCO (by 0.4%), Andhra (by 0.2%), Punjab & Sind Bank (by 0.8%), UBI & Vijaya Bank (each by 0.3%). Technology change effect is somewhat lower in case of these banks. Among private banks, INDUSIND bank performed the best in this study period with total factor productivity growth showing 15.3% increase owing to 8.1% technological change and the rest in technical efficiency consisting of 2.5% increase in pure efficiency signifying improvement of managerial efficiency. Among other private sector banks, AXIS (TFPCH 1.042), Catholic Syrian (1.006), DCB (1.003), Dhanlaxmi Bank (1.029), Lakshmi Bilas Bank (1.004) and The Ratnakar Bank Limited (1.054) revealed positive total factor productivity arising out of improvement in technological change. This means that rapid change in banking technology plays the key role in maintaining positive total factor productivity. Among foreign banks, best performing banks in terms of total factor productivity are JP Morgan Chase Bank N.A. (1.165) & Krung Thai Bank Public Company Ltd. (1.164). The later one Krung Thai Bank and Abu Dhabi Commercial Bank shows improvement in managerial efficiency that is pure efficiency PECH value 1.043 and 1.003 respectively. Otherwise, like private sector banks show improvement in technology mostly.

Bank group wise analysis of Malmquist summary of bank means show the following results:

Bank Group	EFFCH	TECHCH	PECH	SECH	TFPCH
Public Sector	0.999615	1.000231	0.999731	0.999731	0.999692
Private Sector	0.98865	1.01235	1.0022	0.9866	1.00115
Foreign	0.9943	1.02925	0.9988	0.99535	1.02385

This group-wise means shows that on an average private sector banks improved a bit in terms of PECH that is managerial efficiency. Otherwise, more than one TECHCH signify rapid improvement in banking technology in this study period contributed to improvement in total factor productivity change (TFPCH).

All Malmquist index averages are geometric means.

effch < 1 = 32 = 48.5%	techch < 1 = 32 = 48.5%	pech < 1 = 17 = 25.7%	sech < 1 = 4 = 57%
tfpch < 1 = 35 = 53%			
effch > 1 = 22 = 33.3%	techch > 1 = 31 = 47%	pech > 1 = 18 = 27.3%	sech > 1 = 19 = 28.8%
tfpch > 1 = 31 = 47%			
effch = 1 = 12 = 18.2%	techch = 1 = 3 = 4.5%	pech = 1 = 31 = 47%	sech = 1 = 12 = 18.2%
tfpch = 1 = 0 = 0%			

The above table shows that the total factor productivity of commercial banks recorded an improvement by 0.6% and the technological change recorded an improvement by 0.6% and the technological change recorded an improvement by 1.2%. There is deterioration in both the change in technical efficiency and change in scale efficiency by the same amount by 0.6% but there is no change in pure technical efficiency change.

The table indicates that 48.5% of commercial banks recorded deterioration in efficiency changes while 33.3% of commercial banks indicated improvement in efficiency change and 18.2% of commercial banks recorded no improvement in efficiency change. In case of technological progress, 48.5% of commercial banks recorded deterioration in technical change, 47% of commercial banks recorded improvement in technological change and only 4.5% commercial banks did not show any change in technological progress. With regard to pure efficiency change of commercial banks, 25.7% shows deterioration, 27% shows improvement and 47% shows no change.

Among the selected commercial banks in India, the JP Morgan Chase Bank N.A. bank recorded the highest improvement in total factor productivity change by 16.5% during the study period. The only component of such total factor productivity improvement was change in the technological efficiency by 16.5%, since change in efficiency remains the same.

The bank Krung Thai Public limited Company Bank obtained the second largest improvement in total factor productivity during the study period. It is observed that its increase of 16.4% in total factor productivity is predominantly due to technological change, which incurred an increase of 10.1%. However, the component of efficiency change did not suffer deterioration, but an improvement of 5.8%. The change in efficiency occurred mainly due to improvement in pure efficiency by 4.3% while the change in scale efficiency recorded an increase of 1.4% of input usage relative to the best practice bank. That is, banks on average could have produced the same amount of output with 0.06% fewer input resources. There is relatively less waste of valuable resources in the Indian banking industry over the study period. The decomposition of overall technical efficiency into pure technical efficiency and scale efficiency shows that the average value of pure technical efficiency and scale efficiency are 0.994 and

1.000 respectively. This suggests that the overall technical inefficiency was due to pure technical inefficiency which can be attributed to managerial errors such as selecting incorrect input combinations.

From the table, we see that the commercial banks of India exhibit a mean overall efficiency score of 0.994, signifying a high level of efficiency. This suggests that banks in India wasted 0.06% of inputs.

Conclusion:

Using output-oriented DEA based Malmquist productivity index, we have assessed the changes in financial performance of the commercial banks of India eight years after global financial crisis in 2007-08 based on their total productivity. The analysis finds that there was a progress in performance of commercial banks of India during the study period. However, the improvement in the financial performance of different banks was unbalanced, because some of them were declining in terms of the total factor productivity. Moreover, decomposition of the DEA based Malmquist Index shows that the bulk of the improvement in total factor productivity of commercial banks in India has been attained through the rapid technological improvement in banking sector which is partially offset through a reduction in the technical efficiency change. So, from the study, it can be said that as far as the Indian banking industry is concerned, although, the banks in India are not as technologically advanced as their counterparts in the developed world; they are following the majority of international trends in the IT domain. To conclude, we can say that, the banking industry in India is rapidly progressing with increased customer base and due to newly improved and innovative facilities offered by the technology and should have to focus on improving managerial efficiency of the banking sector.

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