COMPARATIVE ANALYSIS OF TOTAL FACTOR PRODUCTIVITY GROWTH AND ITS COMPONENTS OF INDIAN BANKS

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ABSTRACT

The purpose of this research paper is to measure and compare the Total Factor Productivity Growth and its decomposition of major public ownership banks and private ownership banks operating in India from the year 2007 to 2017. Total Factor Productivity (TFPCH) and its components, Efficiency Change and Technical Change are measured by applying Data Envelopment Analysis (DEA) through input and output orientations. Productivity of banks has also been computed through constant and variable returns to scales. The research paper measures the productivity growth scores under two alternative approaches of selecting inputs and outputs namely Intermediation Approach and Production Approach. The present research paper aims to measure and compare the Total Factor Productivity Change, Efficiency Change and Technical Efficiency Change of selected public ownership banks and private ownership banks operating in India. Productivity has been measured through input oriented and output oriented Malmquist Productivity Index using Data Envelopment Analysis technique. Productivity has also been computed through constant and variable returns to scale. Two models namely Intermediation Model and Production Model of the input and output combination have been used to measure the Total Factor Productivity of selected Indian public ownership banks and private ownership banks over the period of 2007-2017. The present research paper has established that the Efficiency Change and Technical Change of the banking sector operations have significant impact on its Total Factor Productivity Change (TFPCH). According to Intermediation Model, the averages of Efficiency Change, Technical Change and Total Factor Productivity Change scores are 1.025, 1.083 and 1.048 respectively. Under Production Model, the averages of Efficiency Change, Technical Change and Total Factor Productivity Change (TFPCH) scores are 1.016, 1.026 and 1.039 respectively. The productivity scores are more than one under both the models revealing productivity growth of banks. Average TFPCH

score of public ownership banks and private ownership banks are 1.109 and 0.988 respectively, depicting growth in the productivity of public ownership banks.

Keywords: Malmquist Productivity Index, Intermediation Model, Production Model.

INTRODUCTION

The Indian banking sector is an integral part of Indian economy. The growth of Indian economy significantly depends on the proper functioning of the banks in India. Indian banks operate under the umbrella of Reserve Bank of India which is a regulatory body. Banking Industry in India mainly includes Commercial Banks and Co-operative Banks. Commercial banks are of two types namely Scheduled Commercial Banks and Unscheduled Banks. Scheduled Commercial Banks constitute those banks which have been included in the Second Schedule of Reserve Bank of India (RBI) Act, 1934 and others are unscheduled. The Indian banks are also classified on the basis of ownership. The banks owned by the Government are called Public ownership banks and the banks which are owned by other bodies are called Private ownership banks. A majority stake (i.e. more than 50%) of Public ownership banks is held by a Government. At present, the number of banks owned by the Government is 21 alongside 1 state-owned Payments Bank in India. The private ownership banks in India are banks where the majority of the shares are owned by the private entities. Various foreign banks also entered the Indian Banking sector. Indian banks have been facing challenges with the entry of foreign players in the market.

Indian private ownership banks and public ownership banks need to cope up with the new technologies and the increased competition in the Indian banking industry. The health of a financial system of an economy depends on the health of the commercial banks operating within it. Performance of the commercial banks has to be paid attention for a healthy financial system and so for a healthy economy. Efficiency and productivity measurement are the major performance indicators of financial institutions and are also used to judge the performance of banks. Measuring the efficiency and productivity shows how well a bank is operating and how much it is contributing to the economy. Productivity can be measures as the ratio of actual output produced to input consumed. The output produced per unit of input is shown through

the production frontier which shows the relationship between output produced and input consumed. The productivity results help the managers to know the level of productivity of banks and the scope of improvement. Every firm uses a technology to produce its output and when a firm operates on the efficiency frontier, it is called a technically efficient firm. The firms operating below the production frontier are considered as technically inefficient firms. The technically inefficient firms are generally suggested to follow the technology adopted by the efficient firms. A firm yielding highest output per unit of input is called an efficient firm and the firms yielding less output per unit of input is considered as less efficient or inefficient firm.

There are different statistical techniques applied to measure the productivity growth of banks. Most appropriate technique is Malmquist Productivity Index (MPI) through the application of Data Envelopment Analysis (DEA). The important thing which has to be considered for measuring the productivity growth of banks through DEA is to decide the input and output variables. There are mainly four approaches used for the selection of input variables and output variables for measuring the efficiency and productivity namely Intermediation Approach, Production Approach, Value Added Approach and User-Cost Approach. In the present study, two models based on Intermediation and Production approach are used for the selection of input and output variables which have been employed in extant efficiency and productivity literature (Berger and Humphrey, 1992). According to the Intermediation Approach, the banks act as the intermediaries between depositors of funds and the customers who need funds. Under this approach, input variables include deposits and other lendable funds and output variables include loans and other assets that earn income. According to Production Approach, banks act as the service providers for the customers. Under this approach, input variables include labor, capital and resources consumed and output variables include loans, deposits and income from other services.

Value-Added Approach identifies input variables and output variables depending on the amount of value added by these to the financial statements of the banks. Input variables under this approach include purchased funds, number of staff members

and physical capital whereas output variables include advances and deposits. According to the User-Cost approach an asset is considered as an output variable if the profit earned from the same is more than the opportunity cost and a liability item is considered as an output variable if the cost incurred on the same is less than the opportunity costs. When neither condition is satisfied, the asset or liability is classified as an input (Berger and Humphrey, 1992).

There are two approaches used for the application Malmquist Productivity Index of DEA: Input oriented approach where the fixed amount of output has to be produced by using the more or less inputs. Under this approach, input quantity is flexible. Output oriented approach is applied where the output is produced with the available input resources. Under this approach, the input remains fixed whereas output is flexible. In the present study, Efficiency Change, Technical Change and Total Factor Productivity of banks is measured through input oriented variable returns to scale, input oriented constant returns to scale and output oriented constant returns to scale approaches. The present research paper is divided in to five sections. Section II gives a brief account on the review of literature followed by a section on research methodology. Section IV makes the analysis of data collected whereas the last section portrays the conclusion of the study.

LITERATURE REVIEW

A number of research studies in the past have measured the efficiency and productivity of banks with different ownerships. A brief description of some of them is as follows:

Sathey (2001) measured the productivity of banks in India by using two models. Author suggested that thee banks might continue reducing non-performing assets and rationalizing the employees to obtain the efficiency gains. Abbott and Doucouliagas, C. (2001) investigated the efficiency and productivity of Australian colleges of advanced education. Authors noticed a growth in Technical Efficiency and Total Factor Productivity but reduction in growth of Technical Change and Scale Efficiency. Kumbhakar and Sarkar (2003) found that public ownership banks registered an overall Total Factor Productivity growth of 32 per cent over the period of study. Most of the growth in Total Factor Productivity had come from the scale component whereas contribution of Technical

Change component had been quite low. The estimates showed a secular decline in returns to scale since 1985. Krishnasamy *et. al.* (2004) investigated the change in the Total Factor Productivity of ten commercial banks in Malaysia. The authors found that almost all the banks have faced a growth in the Total Factor Productivity due to Technical Change rather than Technical Efficiency Change.

Althin and Behrenz (2004) focused on the efficiency and productivity of Swedish employment offices and found that average efficiency across offices was varying between 74 per cent and 78 per cent. The average TFPCH declined by 11 per cent during 1992-1993 and an increased by 7 per cent and 13 per cent during 1993-1994 and 1994-1995 respectively. Weber and Weber (2004) measured the efficiency and productivity in the US trucking and warehousing Industry and revealed low level of efficiency in the industries. Ram Mohan and Ray (2004) compared the efficiency and productivity of both public and private ownership banks. Authors found no significant difference in the performance of both. Zhao (2004) examined the effect of deregulation on the performance on Indian banking industry and concluded that average Technical Efficiency score was 0.78. Foreign banks had scored more as Technical Efficiency score than public and private ownership banks in first stage of deregulation but public ownership banks led in second stage.

Parimorac and Troskot (2005) compared the banks of Croatia and measured their productivity. Authors noted that eleven out of twenty six banks operated on the efficiency frontier. Stedbanka has been on the frontier and Zagrebacka had achieved full efficiency score among all the banks in Croatia banking industry during the study period. Reddy (2006) examined the Total Factor Productivity Changes in regional rural banks. Author used two models to calculate the same and found that mean efficiency was higher in service provision than in earning profits. Average Technical Efficiency and average efficiency had risen according to both the models. Isik (2007) analysed the productivity of banks in Turkey. Author noted that the development in the level of productivity for public ownership banks, private ownership banks and foreign banks was 1.2 per cent, 3.9 per cent and 14.2 per cent respectively. Wu and Ho (2007) evaluated the productivity and efficiency of

integrated circuit industry in Taiwan's and revealed that associated companies operating more and more inefficiently with the increase in asset size.

Mohindra and Kaur (2008) analysed the trends in Total Factor Productivity of regional rural banks in India. Authors revealed that the average Total Factor Productivity Change of banks was 1.3 per cent. Technical progress increased at 0.9 per cent whereas mean Technical Efficiency had increased 0.1 per cent and Scale Efficiency also increased by 0.3 per cent. Rezvanian *et. al.* (2008) examined the efficiency, efficiency change, and TFPCH growth and productivity growth of different ownerships. The banks operating outside India had higher efficiency scores when compared to other banks. Most of the Indian banks found to be operating below the standard level of efficiency. Sanyalm and Shankar (2008) calculated the Total Factor Productivity of banks and found that Indian private ownership banks had scored better efficiency and productivity scores than the public ownership banks and foreign banks both. Fiorentino, E. *et. al.* (2009) compared the productivity growth of banks operating in the Italy and Germany. Authors found growth of 32 per cent and 1.2 per cent in level of productivity of banks in Italy and Germany respectively. Bhandari (2010) measured Total Factor Productivity growth achieved by the commercial banks in India and revealed that public ownership banks were operating better than other ownerships. Author suggested the Government to approach liberalisation carefully.

Kumar *et. al*. (2010) checked the influence of Technical Change in the banking sector and found that Total Factor Productivity growth was the result of growth in the level of Technical Change. Kumar (2013) studied the estimated Total Factor Productivity for Indian banking sector covering public ownership banks, private ownership banks and foreign banks and noted that the annual average productivity growth rate in 2008-10 was 11 per cent, which was mainly due to 28 per cent TFPCH progress. Intermediation cost which was proxy of technology investment was also significant for increased productivity. Thayaparan and Pratheepn (2014) measured the level of growth in Total Factor Productivity its components of commercial banks operating in Sri Lanka and noticed that the development in the level of Total Factor Productivity was the result of Technical Change. Kaur and Gupta (2015) examined the

productivity of 56 Indian banks in relation to each other and noticed that productive efficiency had increased with time. Moses and ola (2015) measured the Technical Change and Efficiency Change of Nigerian banks and found that there has been an improvement in productivity.

Bhatia and Megha (2016) evaluated the productivity of rural bank branches with deposit per rural branch, credit per rural branch and business per rural branch as the variables. Authors revealed that productivity of rural branches of banks noticed a growth in all the three productivity standards. Isik *et. al.* (2016) measured the productivity development of banks. Authors observed that under production model overall Technical Efficiency was 81 per cent, 76 per cent and 79 per cent for commercial banks, investment banks and for Islamic banks respectively. Under Intermediation Model, Technical Efficiency was 98 per cent, 86 per cent and 87 per cent for commercial banks, investment banks and Islamic banks respectively. Majumdar and Asgari (2017) examined the Total Factor Productivity of twenty seven firms operating in the United Arab Emirates and found that food and beverages, telecommunication and pharmaceuticals industries were operating efficiently in post crisis period in contrary to services, real estate, construction and cements industries.

Balcerzak *et. al.* (2017) measured the efficiency and productivity of banks operating in the Europe and noticed the differences between the level of efficiency of banks operating in EU member countries and of banks operating outside the Euro-zone. Libena *et. al.* (2017) examined the comparative productivity of banks operating in four Central European States and studied the Technical Efficiency as well as the Total Factor Productivity Changes. Authors found that efficiency for Czech, Polish and Slovak banks increased and Hungarian banks noticed a reduction in the level of efficiency. Authors also revealed stability in the level of productivity across all countries. Oteng-Abayie (2017) measured the change in the level of Technical Efficiency and Total Factor Productivity of RCBs in Ghana through the application of Stochastic Frontier Analysis (SFA) and observed that RCBs may achieve higher scores of Technical Efficiency and Total Factor Productivity.

Total Factor Productivity Change was observed to be the result of the change in Technical Efficiency.

Osuagwu (2018) estimated Total Factor Productivity difference for the Nigerian banks and revealed that Total Factor Productivity difference in DEA decreases due to the increment in the income generated through fees. Aisyah and Hosen (2018) measured the productivity and efficiency and factors which affect the level of efficiency. Authors revealed that only six of the eleven banks that have a good productivity levels. Wang *et. al.* (2020) estimated the productivity of the world"s top twenty automakers through the application of Malmquist Productivity Index (MPI). Authors evaluated the Technical Efficiency and the Total Factor Productivity difference.

The present research paper contributes significantly to the existing literature of Total Factor Productivity evaluation of Indian commercial banks. The literature on productivity of Indian banking sector includes most of the studies which have evaluated the productivity of banks during the pre and post-reforms periods using either Intermediation Model or Production Model. It is immensely important to evaluate the Total Factor Productivity of Indian banking sector from time to time and decompose the Total Factor Productivity into Efficiency Change and Technical Change using both the models simultaneously. This research paper fills the gap and makes an effort to measure and compare the Total Factor Productivity and its decomposition of top ten public and private ownership banks using Intermediation Model and Production Models.

RESEARCH METHODOLOGY

This research paper deals with the measurement and comparison of Total Factor Productivity Change (TFPCH), Efficiency Change and Technical Change of major public and private ownership banks operating in India, applying Intermediation and Production Models. This section explains the sample, period, variables, database and statistical tools used in research paper.

Research Design

The research paper is descriptive as well as well as exploratory in nature. The period of the study under consideration is from April 1, 2007 to March 31, 2018. Moving average of three years has been calculated after which the study period is 2009-10 to 2017-18.

Sample Size

The sample size of the research paper is twenty banks which consist of top ten public ownership banks and top ten private ownership banks in India based on market capitalization as depicted by the RBI reports as on January 1, 2016.

Source of Data

The present research paper is totally based on the secondary data. The research data is collected from Reserve Bank of India (RBI), Indian Bank"s Association (IBA), Prowess database of CMIE and websites of the selected banks.

Statistical Models and Techniques

There are mainly two approaches of complex econometric models which may be applied to measure the efficiency and productivity of Decision Making Units (DMUs) which are parametric (Econometric Approach) and non-parametric (Linear Programming Approach). In the present study, Data Envelopment Analysis (DEA) which is a non- parametric technique is applied to measure the Total Factor Productivity growth of the banking institutions under reference. DEA is a linear programming methodology to measure the productivity growth of multiple DMUs with multiple inputs and output variables. DEA is extensively used as a technique for measuring and improving the level of efficiency and productivity of DMUs functioning in the areas of banking, education, retail, sports, health care and other service industries. DEA was extended by Charnes, Cooper, and Rhodes as a mathematical programming model applied to the selected DMUs with multiple inputs and outputs. Later Banker, Charnes and Cooper (BCC) model was introduced to measure the Pure Technical Efficiency Change (managerial efficiency Change) and Scale Efficiency Change of the DMUs having more than one inputs and output variables. In the present research paper, Input oriented Charnes, Cooper and Rhodes (CCR) model and Banker, Charnes and Cooper (BCC) models of DEA are applied for measuring the productivity and its decomposition of Indian public and private ownership banks. A bank is considered as productive if it operates on the efficiency frontier. The measurement of the productivity growth under constant returns to scale is considered as Total Factor Productivity Change (TFPCH) and under BCC, it is termed as TFPCH

having two components namely Pure Technical Efficiency (PTE) Change and Scale Efficiency (SE) Change. The PTE Change is the growth in the level of productivity under variable returns of scale and reports the managerial efficiency Change. The SE Change is derived by the division of OTE Change to PTE Change and reveals the capability of the management to have the proper allocation of input resources in order to achieve the maximum production level.

The Malmquist Productivity Index

In the present study, input and output oriented Malmquist Productivity Index is used to measure the Total Factor Productivity growth of the selected public and private ownership banks from 2007-2017. Malmquist Productivity Index is a DEA based programming method introduced by Fare et al. (1994) and it depends on the constant returns to scale and output based approach. However, a Malmquist Index measured under the assumption of constant returns to scale implies that the results of the output oriented approach and input oriented approach have no significant difference. (Coelli, 1996; Thanassoulis, 2001). In the present study, the input oriented and output oriented Malmquist Productivity Index is used for measuring the productivity change of banks over time. It measures the TFPCH for a specified time series measures the ratio of the distances of each data relative to a common TFPCH process. The output-oriented Productivity Index stick to the Fare et al. (1994) method under the constant return to scale and can be demonstrated as follows:

$$M_0 = \left[\frac{d_0^t(u_0^t, v_0^t)}{d_0^t(u_0^{t+1}, v_0^{t+1})} \frac{d_0^{t+1}(u_0^t, v_0^t)}{d_0^{t+1}(u_0^{t+1}, v_0^{t+1})} \right]^{\frac{1}{2}}$$

Equation (1)

M_0 in equation (1) measures the productivity of production points (u^{t+1}, v^{t+1}) relative to production points (u^t, v^t). Technology used by the index in current period is denoted t and the technology used in the next period is t+1. The productivity index is calculated by using the Technical Efficiency score of these two mixed periods. The Malmquist Productivity Index uses the distance functions to measure the productivity change which may further be decomposed into Technical Change and Technical Efficiency Change. This is demonstrated as follows:

$$M_0 = \frac{d_0^t(u_0^t, v_0^t)}{d_0^{t+1}(u_0^{t+1}, v_0^{t+1})}$$

$$\left[\frac{d_0^{t+1}(u_0^{t+1}, v_0^{t+1})}{d_0^t(u_0^{t+1}, v_0^{t+1})} \times \frac{d_0^{t+1}(u_0^t, v_0^t)}{d_0^t(u_0^t, v_0^t)} \right]^{\frac{1}{2}}$$

Equation (2)

In equation (2), the ratio outside the brackets calculates the output oriented Technical Efficiency for the period t to t+1 which is introduced by Farrell et al. The equation (2) is explained by separating the two terms below:

$$\text{Efficiency Change} = \frac{d_0^t(u_0^t, v_0^t)}{d_0^{t+1}(u_0^{t+1}, v_0^{t+1})}$$

Equation (3)

and Technical Change =

$$\left[\frac{d_0^{t+1}(u_0^{t+1}, v_0^{t+1})}{d_0^t(u_0^{t+1}, v_0^{t+1})} \times \frac{d_0^{t+1}(u_0^t, v_0^t)}{d_0^t(u_0^t, v_0^t)} \right]^{\frac{1}{2}}$$

Equation (4)

Equation (3) and (4) indicate the ratio of measuring Technical Efficiency Change and Technical Change in productivity. When the Technical Efficiency Change is multiplied by the Technical Change, Total Factor Productivity Change is measured. Similarly, Technical Efficiency Change is the multiplication of Pure Technical Efficiency Change (VRS assumption) and Scale Efficiency Change.

Table 1 shows the indication of Malmquist Productivity Index. When Malmquist index score is more than one, it shows a constructive change in the level of productivity, improvement from t to t+1. On the other hand if the productivity score is below one, it demonstrates a reduction in the level of productivity, while when the score is equal to one, it clearly shows that there is no change in the productivity level during the specified period.

Table 1: Productivity Index

Malmquist Productivity Index	Productivity state
M>1	Growth in Productivity
M=1	No difference in Productivity
M<1	Decline in Productivity

Selection of Inputs and Outputs

The selection of input and output variables is an important task for measuring the productivity

growth of Decision Making Units (DMUs) through the application of DEA. Production Approach and Intermediation Approach are extensively used for the choosing the variables. Labor and capital are the inputs used by the banks to generate outputs called loans and deposits. Under Intermediation Approach, bank is termed as an intermediary, collecting money from the surplus holders and providing loans to the investor for the financial gain.

Table 2: Description of Input and Output Variables used in Intermediation and Production Models

Sr. No.	Input / Output	Description of variables
1.	Deposits (I)	Demand Deposits + Term Deposits + Savings Deposits
2.	Interest expenses (I)	Interest on deposits + RBI borrowings + Interbank borrowings and others
3.	Operating Expenses (I)	Demand Deposits + Term Deposits + Savings Deposits
4.	Investments (O)	Investments in shares, debentures, Government Securities and other approved securities in India and Outside India
5.	Interest income (O)	Interest /Discount on Advances/bills + Income on Investments + Interest on Balance with RBI + Others
6.	Loans and advances (O)	Term Loans + Cash Credit , Overdraft + Bills purchased and discounted etc.
7.	Interest income (O)	Interest /Discount on Advances/bills + Income on Investments + Interest on Balance with RBI + Others

Table 2 portrays the description of input and output variables used in both the models. In the present study, two models namely Intermediation Model and Production Model have been used to measure the productivity of selected public and private ownership banks.

Table 3: Input and Output Variables of Intermediation Model and Production Model

Sr. No.	Intermediation Model	Production Model
1.	Deposits (I)	Operating Expenses (I)
2.	Interest expenses (I)	Interest expenses (I)
3.	Loans and advances (O)	Loans and advances (O)
4.	Investments (O)	Investments (O)
5.	Interest income (O)	Operating income (O)

Table 3 describes the variables used in Intermediation and Production Models. Intermediation Model includes two input variables namely Deposits (I) and Interest Expenses (I) and three output variables namely Loans and advances (O), Investments (O) and Interest Income (O). In Production Model Deposits are replaced by Operating expenses in the input variables and in the output variables, Interest income is replaced by operating income.

RESULTS AND DISCUSSION

In this section, the results of Malmquist Productivity Index have been discussed and results have been achieved through the application of DEA technique. The results include the Total Factor Productivity Change, Technical Efficiency Change and TFPCH of selected banks for the period.

Descriptive Statistics

Descriptive statistics of input and output variables are mentioned in table 4. There are three inputs namely deposits, operating expenses and interest expenses and four outputs namely loans and advances, investments, operating income and interest income of both the models (Intermediation Model and Production Model). Mean, standard deviation, minimum and maximum have been calculated using MS-Excel for all the variables. As shown in table 4, the mean and standard deviation of public ownership banks is almost double of private ownership banks. This means that the public ownership banks have grown faster than the private ownership banks during the period under reference.

Table 4: Descriptive Statistics of Input and Output Variables used in both the Models of Commercial Banks from 2007 to 2017.
(Rupees in crore)

Variable	Private O and B Capital	Mean	Std.	Min	Max	Public O and B Capital	Mean	Std.	Min	Max
Deposits (I)	10	131159	138217	10634	359658	10	411511	467386	125735	169729
Operating Expenses (I)	10	7126	10920	377	35969	10	10100	17221	2062	58737
Interest expenses (I)	10	9071	9398	734	28250	10	25567	28054	8203	103169
Loans and advances (O)	10	119557	129504	8603	364782	10	301790	374424	94396	134396
Investments (O)	10	60235	77085	3493	248423	10	134228	161558	38790	610872
Interest income (O)	10	15357	16218	1144	45482	10	36806	44464	1214	160831
Operating Income (O)	10	6224	10705	165	35458	10	6918	12172	1478	41331

Empirical Results

Empirical results of Malmquist Productivity Index under Intermediation and Production Models of selected public and private ownership banks from 2007-2017 have been discussed in this section. The Malmquist Productivity Index results have achieved through the application of Data Envelopment Analysis technique. DEA is applied through Input and Output orientations. Productivity analysis of banks is done through variable and constant returns to scales.

Table 5 summarizes and compares the Efficiency Change, Technical Change and Total Factor Productivity scores of public and private ownership banks. Table 5 describes the Total Factor Productivity Change (TFPCH) scores of public and private ownership banks. TFPCH is decomposed into Efficiency Change and Technical Change to reveal the reason behind the changes in the TFP. Average TFPCH of public ownership banks for the period 2007-17 is 1.109 which indicates constructive difference in the productivity level of the public ownership banks. Average Efficiency Change of public ownership banks for the same

period is 1.018 while average Technical Change score is 1.134 which is more than the growth in efficiency. Minimum TFPCH score of public ownership banks is 1.011 which is scored by Bank of India Thus the growth in TFPCH of public ownership banks is attributed to the technological progress. Maximum TFPCH score of public ownership banks is 1.307 which is scored by IDBI. All the public ownership banks have constructive change in the level of productivity.

As depicted in table 5, four out of ten private ownership banks noticed productivity score higher than one which are ICICI, Indusind, Yes bank and Karur Vysya bank. Six banks have scored TFPCH less than one which includes HDFC Bank, Kotak Mahindra Bank, Axis Bank, Federal Bank, City Union Bank and DCB. TFPCH score of these private ownership banks is less due to technological digression. Average Efficiency Change score of private ownership banks is 1.018 which is higher than one revealing an improvement in the Technical Efficiency.

Table 5: Comparative Analysis of Malmquist Productivity Index (Intermediation Model) of Public and Private Ownership banks operating in India (2007-08 to 2017-18)

Public O and B Capital				Private O and B Capital			
Bank	Efficiency Change	Technical Change	TFPCH	Bank	Efficiency Change	Technical Change	TFPCH
SBI	1.018	1.156	1.139	HDFC	1.002	0.901	0.903
IDBI	1.115	1.320	1.307	Kotak	0.983	0.977	0.965
PNB	1.054	1.090	1.047	ICICI	1.030	1.068	1.095
Canara	1.014	1.071	1.075	AXIS	1.017	0.932	0.956
BOI	1.006	1.006	1.011	Federal	1.024	0.953	0.932
Centeral	0.976	1.211	1.020	Indus Ind	1.062	0.990	1.044
Indian	0.950	1.072	1.051	Yes	1.019	1.012	1.063
Corporation	1.006	1.197	1.205	City Union	0.964	0.962	0.888
Andhra	1.025	1.120	1.097	Karur	1.009	1.025	1.031
BOB	1.017	1.098	1.134	DCB	1.005	0.998	0.998
Mean	1.018	1.134	1.109	Mean	1.011	0.982	0.988
St. Dev.	0.044	0.090	0.092	St. Dev.	0.027	0.048	0.070
Minimum	0.950	1.006	1.011	Minimum	0.964	0.901	0.888
Maximum	1.115	1.320	1.307	Maximum	1.062	1.068	1.095

Average Technical Change score of private ownership banks are 0.982 which is less than one indicating technological digression. Minimum TFPCH score of private ownership banks is 0.888 which is scored by City Union bank. Maximum TFPCH score of private ownership banks is 1.095 which is scored by ICICI bank. TFPCH scores of public ownership banks as compared with that of private ownership banks, it is suggested that latter should focus more on its technological operations. Total Factor Productivity Index of public and private ownership banks is measured through input oriented variable returns to scale. The productivity of both the ownerships have been measured and compared. It is imperative to measure the overall productivity of all the banks applying both the models (Intermediation Model and Production Model). Input oriented variable returns to scale under Intermediation Model are depicted in table 6 below.

Table 6: Malmquist Productivity Index (Input Oriented Variable Returns to Scale) of Commercial Banks Operating in India from 2007 to 2017 (Intermediation Model)

Banks	Efficiency Change	Technical Change	TFPCH
HDFC	0.987	0.941	0.912
Kotak	0.972	0.983	0.964
ICICI	1.020	1.066	1.057
AXIS	0.983	0.945	0.937
Federal	1.010	1.072	1.035
Indus Ind	1.070	0.969	1.026
YES	1.004	1.010	1.029
City Union	0.970	0.990	0.900
Karur	0.976	0.927	0.881
DCB	1.007	1.024	1.015
SBI	1.014	1.194	1.204
BOB	1.008	0.950	0.948
IDBI	1.106	1.128	1.095
PNB	1.023	0.993	0.995
Canara	1.005	0.943	0.955
BOI	1.003	0.923	0.920
Centeral	0.984	1.127	1.010
Indian	0.982	0.968	0.953
Corporation	1.012	1.024	1.031
Andhra	1.020	1.024	1.069
Mean	1.008	1.010	0.997
St. Dev.	0.032	0.074	0.077
Minimum	0.970	0.923	0.881
Maximum	1.106	1.194	1.204

Table 6 depicts Malmquist Productivity Index of Indian public and private ownership banks applying input oriented variables returns to scale for the period 2007-2017. HDFC Bank has

achieved TFPCH score equal to 0.912 which is less than one indicating reduction in the productivity level. Efficiency Change and Technical Change score of the same is 0.987 and 0.941 respectively. Reduction in Technical Change is more than the reduction in Efficiency Change. It means that the bank should focus more on its technological progress in order to reduce its inputs. TFPCH score of Kotak Mahindra Bank is 0.964 which indicates that the bank is not utilizing its inputs efficiently. Efficiency Change and Technical Change score of the same is 0.972 and 0.983 respectively. Efficiency Change score is decreased more than the Technical Change score. Reduction in the Efficiency Change score could be the result of Pure Technical Efficiency Change or Scale Efficiency Change. ICICI Bank has scored TFPCH equal to 1.057 which indicates improvement in the productivity level. It means that the bank is utilizing its resources efficiently. Axis Bank has achieved the TFPCH score equal to 0.937 which is less than one revealing reduction in the productivity level. Efficiency Change and Technical Change is score is 0.983 and 0.945 respectively. It is revealed from Technical Change score that there is a need for Axis Bank to focus on the technological advancements. Federal Bank, Indus Ind Bank and Yes Bank have score TFPCH score equal to 1.035, 1.026 and 1.029 respectively. These banks have up gradation in their productivity level. City Union Bank has its TFPCH score equal to 0.900. Efficiency Change and Technical Change score of the same is 0.970 and 0.990 respectively. Reduced TFPCH score of City Union Bank is the result of reduced Efficiency Change score. Karur Vysya Bank has scored 0.881 as its TFPCH score which is the lowest of all the banks. Technical Change score of the same bank is lower than the Efficiency Change score which indicates that the bank should focus more on technological progress. DCB and State Bank of India have their TFPCH score more than one. State Bank of India has achieved the maximum TFPCH score (0.204) among all the banks. Bank of Baroda has TFPCH score equal to 0.948.

Efficiency Change and Technical Change score are 1.008 and 0.950 which indicates that reduction in the TFPCH score of Bank of Baroda is due to technical deterioration. TFPCH score of IDBI Bank is 1.095 designating development in productivity level. Punjab National Bank, Canara Bank, Indian Bank and Bank of India have their TFPCH score lower than one, revealing degradation of productivity level. Corporation Bank and Andhra

Bank have their TFPCH score higher than one indicating up gradation in their productivity level. Average TFPCH of all the banks is 0.997 which is less than one revealing the reduction in the level of productivity of all the banks. The reduction in the productivity level is attributed to reduction in the Efficiency Change of many banks which could be the result of Pure Technical Efficiency Change or Scale Efficiency Change. Average Efficiency Change of all the banks is 1.008 and average Technical Change is 1.010. TFPCH score of all the banks varies from the low of 0.881 to a high of 1.204. The banks which have scored TFPCH more than one comprise of 50% of the total banks.

Total Factor Productivity Index according to variable returns to scale is measured under Intermediation Model. It is imperative to analyze the Malmquist Productivity Index results according to input oriented constant returns to scale under the same model. Table 7 narrates Malmquist Productivity Index of public and private ownership banks operating in India applying input oriented constant returns to scale for the period 2007-2017. HDFC Bank has achieved TFPCH score equal to 0.891 which is less than one meaning thereby decline in the level of productivity. Efficiency Change and Technical Change score is 0.980 and 0.959 respectively which indicates TFPCH score may be affected by the technical deterioration. Kotak Mahindra Bank has also noticed a decrease in TFPCH which may be due to Pure Technical Efficiency Change or Scale Efficiency Change. Technical Change score of the same is 1.039 indicating technological progress. ICICI Bank is having its TFPCH score more than one revealing improvement in its efficiency and technology. Federal Bank has TFPCH score equal to 0.983 indicating decline in productivity level. Indus Ind Bank and Yes Bank have achieved improved TFPCH score depicting efficiency and technical development. TFPCH score of City Union Bank is 0.910 portraying a decline in the level of productivity. Decline in the productivity level may be due to Efficiency Change or Technical Change. Karur Vysya Bank, DCB, State Bank of India, Bank of Baroda, IDBI, Punjab National Bank, Canara Bank, Bank of India, Indian Bank, Corporation Bank and Andhra Bank have scored TFPCH score more than one showing an increase in the level of productivity.

The improvement in their productivity level may be the result of their managerial efficiency or technological advancements. Central Bank has scored 0.969 as its TFPCH indicating declined productivity level and it may be due to managerial inefficiency. TFPCH score of all the banks fluctuates between a low of 0.891 to a high of 1.228. HDFC bank has scored 0.891 lowest TFPCH score among all the banks and IDBI has scored highest TFPCH score of among all the banks. Average TFPCH of all the banks is 1.048 which is more than one which indicates high level of productivity of most of the banks. TFPCH is decomposed into Efficiency Change and Technical Change. Average Efficiency Change of all the banks is 1.025 which indicates that most of banks have their Pure Technical Efficiency Change and Scale Efficiency Change score more than 1. Average Technical Change score of all the banks is 1.083 which indicates technological progress of most of the banks. Fourteen out of twenty banks are having their productivity score more than one including ICICI bank, Indusind bank, Yes bank, Karur Vysya bank, DCB, SBI, Bank of Baroda, IDBI, PNB, Canara bank, Bank of India, Indian bank, Corporation Bank and Andhra bank. Banks scoring TFPCH less than one are HDFC, Kotak Mahindra Bank.

Table 7: Malmquist Productivity Index (Input Oriented Constant Returns to Scale) of Public and Private Ownership banks Operating in India from 2007 to 2017 (Intermediation Model)

Banks	Efficiency Change	Technical Change	TFPCH
HDFC	0.980	0.959	0.891
Kotak	0.983	1.039	0.966
ICICI	1.052	1.099	1.066
AXIS	0.986	0.966	0.960
Federal	1.102	1.112	0.983
Indus Ind	1.051	1.082	1.051
YES	1.018	1.050	1.116
City Union	1.038	1.057	0.910
Karur	0.987	1.127	1.033
DCB	1.025	1.084	1.030
SBI	1.028	1.158	1.155
BOB	1.019	1.134	1.116
IDBI	1.119	1.245	1.228
PNB	1.039	1.088	1.086
Canara	1.020	1.042	1.047
BOI	1.010	1.017	1.019
Centeral	1.024	1.118	0.969
Indian	0.975	1.060	1.065
Corporation	1.015	1.146	1.160
Andhra	1.022	1.070	1.117
Mean	1.025	1.083	1.048
St. Dev.	0.037	0.066	0.087
Minimum	0.975	0.959	0.891
Maximum	1.119	1.245	1.228

Input oriented Malmquist Productivty Index under Intermediation Model has been analysed. It is necessary to analyse the output oriented approach of Malmquist Productivity Index of all the banks under reference. Table 8 represents the results of output oriented variable returns to scale under Intermediation Approach Model. Table 8 depicts Malmquist Productivity Index of public and private ownership banks operating in India from 2007-2017 by applying output oriented variable returns to scale. Input and output variables have been selected considering Intermediation Model. TFPCH score of all the banks varies between a low of 0.898 to a high of 1.328. Average TFPCH score of all the banks is 1.094 which is more than one depicting an overall productivity growth of banks. Efficiency Change score of the banks vary from a low of 0.967 to a high of 1.064. Average Efficiency Change score of all the banks is 1.011, depicting improvement in Pure Technical Efficiency and Scale Efficiency. Technical Change score of all the banks vary form a minimum of 0.946 to a maximum of 1.495. Average Technical Change score of all the banks is 1.125, indicating overall technical growth among the banks. HDFC Bank has achieved TFPCH score equal to 0.898 which is less than one revealing decrease in the level of productivity. Productivity level of HDFC Bank has declined due to technological downturn and managerial inefficiency. Axis Bank scored TFPCH equal to 0.970, indicating reduction in the efficiency and technical advancement of the bank. TFPCH score of Indus Ind Bank is 0.992. Efficiency Change and Technical Change scores are 1.064 and 0.975 respectively. It is clear that the reduction in TFPCH score of Indus Ind Bank may be due to decrease in technological advancements. City Union Bank has TFPCH score equal to 0.948 depicting reduction in the level of productivity. Efficiency Change and Technical Change scores of the same are 1.017 and 1.075 respectively. Managerial inefficiency could be the reason behind the reduced TFPCH score of the bank. TFPCH score of sixteen out of twenty banks is more than one including Kotak Mahindra Bank, ICICI Bank, Federal Bank, Yes Bank, Karur Vysya Bank, DCB, State Bank of India, Bank of Baroda, IDBI, Punjab National Bank, Canara Bank, Bank of India, Central Bank Indian Bank, Corporation Bank and Andhra Bank. It is noticed from the table 9 that all the public ownership banks have scored their TFPCH more than one. It indicates that public

ownership banks have utilized their inputs efficiently and achieved desired level of output. The credit may also be given to the technological advancements which have resulted in improved TFPCH scores of public ownership banks.

Table 8: Malmquist Productivity Index (Output Oriented Variable Returns to Scale) of Public and Private Ownership banks Operating in India from 2007 to 2017(Intermediation Model)

Banks	Efficiency Change	Technical Change	TFPCH
HDFC	0.987	0.946	0.898
Kotak	0.971	1.056	1.034
ICICI	1.017	1.072	1.053
AXIS	0.988	0.982	0.970
Federal	1.041	1.136	1.032
Indus Ind	1.064	0.975	0.992
YES	1.008	1.115	1.155
City Union	1.017	1.075	0.948
Karur	0.987	1.174	1.112
DCB	1.021	1.048	1.025
SBI	1.015	1.183	1.193
BOB	1.011	1.143	1.121
IDBI	1.043	1.495	1.328
PNB	1.024	1.168	1.161
Canara	1.005	1.095	1.097
BOI	1.002	1.078	1.076
Centeral	1.019	1.198	1.040
Indian	0.967	1.175	1.170
Corporation	1.010	1.275	1.293
Andhra	1.023	1.109	1.172
Mean	1.011	1.125	1.094
St. Dev.	0.024	0.119	0.109
Minimum	0.967	0.946	0.898
Maximum	1.064	1.495	1.328

Table 9: Analysis of Malmquist Productivity Index (Input Oriented Variable Returns to Scale) of Public and Private Ownership banks Operating in India from 2007 to 2017 (Production Model)

Banks	Efficiency Change	Technical Change	TFPCH
HDFC	0.978	0.939	0.917
Kotak	1.008	0.991	1.014
ICICI	1.036	1.073	1.093
AXIS	1.021	0.968	0.996
Federal	0.951	1.076	1.001
Indus Ind	1.033	1.007	1.061
YES	1.016	1.237	1.254
City Union	1.047	1.097	1.087
Karur	1.003	0.914	0.914
DCB	1.002	0.990	0.977
SBI	1.031	1.043	1.048
BOB	1.075	0.948	0.985
IDBI	1.004	1.127	1.150

PNB	1.135	1.088	1.202
Canara	1.077	0.952	1.062
BOI	1.033	0.983	1.030
Centeral	0.917	1.044	0.962
Indian	0.964	0.981	0.978
Corporation	0.999	1.050	1.055
Andhra	0.985	1.015	0.987
Average	1.016	1.026	1.039
Min	0.917	0.914	0.914
Max	1.135	1.237	1.254
SD	0.048	0.077	0.087

Malmquist Productivity Index of all the banks have been analysed under Intermediation Model and it is revealed that the productivity of banks has improved throughout. To have more detailed understanding of productivity of banks under reference, it is needed to analyse the results of Malmquist Productivity Index under Production Model. Table 9 describes Malmquist Productivity Index of public and private ownership banks operating in India for the period 2007-2017 by applying input oriented variable returns to scale. Input and output variables have been selected considering Production Model. TFPCH score of the banks varies from a low of 0.914 to a high of 1.254. Average TFPCH score of all the banks is 1.039 which is more than one revealing an overall productivity growth of banks. Efficiency Change score of all the banks vary from a low of 0.917 to a high of 1.135. Average Efficiency Change score of all the banks is 1.016, depicting improvement in Pure Technical Efficiency and Scale Efficiency. Technical Change score of all the banks vary form a minimum of 0.914 to a maximum of 1.237. Average Technical Change score of all the banks is 1.026, indicating overall technological growth among the banks. Eight out twenty banks have scored TFPCH below one including HDFC Bank (0.917), Axis Bank (0.996), Karur Vysya Bank (0.914), DCB (0.977), Bank of Baroda (0.985), Central Bank (0.962), Indian Bank (0.978) and Andhra Bank (0.987). Technical Change scores of HDFC Bank, Axis Bank, Karur Vysya Bank, DCB and Bank of Baroda are less than the Efficiency Change score which indicates that reduction in TFPCH score of the same may be due to technological digression. Efficiency Change scores of Central Bank, Indian Bank and Andhra Bank are less than the Technical Change score indicating digression in their Pure Technical Efficiency and Scale Efficiency resulting in lower TFPCH scores. Remaining twelve banks have their TFPCH score more than one including Kotak Mahindra Bank

(1.014), ICICI Bank (1.093), Federal Bank (1.001), Indus Ind Bank (1.061), City Union Bank (1.087), State Bank of India (1.048), IDBI (1.150), Punjab National Bank (1.202), Canara Bank (1.062), Bank of India (1.030), Corporation Bank (1.055) depicting an improvement in productivity level of the same.

After the analysis of TFPCH (input oriented variable returns to scale), it is imperative to analyze the Malmquist Productivity Index of banks through the application of input oriented constant returns to scale. Table 10 describes Malmquist Productivity Index of public and private ownership banks operating in India for the period 2007-2017 by applying input oriented constant returns to scale. Input and output variables have been selected considering Production Model. TFPCH score of all the banks varies between the minimum of 0.942 to a maximum of 1.289. Average TFPCH score of all the banks is 1.110 which is more than one revealing an overall productivity development of banks. Efficiency Change score of all the banks vary from a low of 0.943 to a high of 1.155. Average Efficiency Change score of the banks is 1.038, depicting improvement in Pure Technical Efficiency and Scale Efficiency. Technical Change score of all the banks vary from a least of 0.961 to a highest of 1.204. Average Technical Change score of the banks is 1.071, indicating overall technological advancement among the banks. HDFC Bank (0.942) and Andhra Bank (0.969) have their TFPCH score less than one, revealing their productivity loss. Productivity digression of HDFC Bank may be due to reduction in Technical Change score. Andhra Bank may have experienced declined productivity level due to reduced Efficiency Change score. Remaining eighteen banks including Kotak Mahindra Bank, ICICI Bank, Axis Bank, Federal Bank, Indus Ind, Yes Bank, City Union Bank, Karur Vysya Bank, DCB, State Bank of India, Bank of Baroda, IDBI, Punjab National Bank, Canara Bank, Bank of India, Central Bank, Indian Bank and Corporation Bank have their TFPCH score more than one, indicating development in their productivity. Productivity growth of most of these banks may be the result of Pure Technical Efficiency growth or Scale Efficiency growth. It indicates high level managerial efficiency among these banks. Technological progress may also be the reason behind the productivity development of some of the banks. It is revealed from table 10 that productivity

growth among both the ownerships has been on the same pace.

Banks	Efficiency Change	Technical Change	TFPCH
HDFC	1.013	0.961	0.942
Kotak	1.021	0.994	1.040
ICICI	1.057	0.989	1.003
AXIS	1.050	1.067	1.136
Federal	0.965	1.153	1.073
Indus Ind	1.131	1.097	1.179
YES	1.085	1.165	1.289
City Union	1.054	1.093	1.100
Karur	0.965	1.204	1.154
DCB	1.027	1.029	1.004
SBI	1.010	1.066	1.040
BOB	1.112	1.060	1.233
IDBI	1.035	1.112	1.151
PNB	1.155	1.101	1.264
Canara	1.103	1.063	1.197
BOI	1.049	1.067	1.147
Centeral	0.943	1.055	1.057
Indian	0.970	1.039	1.083
Corporation	1.034	1.105	1.148
Andhra	0.988	0.995	0.969
Average	1.038	1.071	1.110
Min	0.943	0.961	0.942
Max	1.155	1.204	1.289
SD	0.058	0.061	0.096

Table 11 depicts Malmquist Productivity Index of public and private ownership banks operating in India for the period 2007-2017 by applying output oriented variable returns to scale. Input and output variables have been selected considering Production Model. TFPCH score of all the banks varies from a least of 0.944 to a highest of 1.271. Average TFPCH score of the banks is 1.104 which is more than one revealing an overall productivity development of banks. Efficiency Change score of all the banks vary from a low of 0.979 to a high of 1.089. Average Efficiency Change score of the banks is 1.023, depicting improvement in Pure Technical Efficiency and Scale Efficiency. Technical Change score of all the banks vary form a minimum of 0.948 to a maximum of 1.208. Average Technical Change score of all the banks is 1.077, indicating overall technological advancement among the banks. Four banks have

their TFPCH score lower than one, depicting loss of productivity, including HDFC Bank (0.944), Kotak Mahindra Bank (0.987), ICICI Bank (0.992) and Andhra Bank (0.961). HDFC Bank and Andhra Bank are having Technical Change score lower than the Efficiency Change score, indicating technological digression. Lower TFPCH score of Kotak Mahindra Bank and ICICI Bank may be the result of managerial or scale inefficiency. Remaining sixteen banks have their TFPCH score more than one, depicting improvement in their productivity level. All the public ownership banks except Andhra Bank are having improved level of productivity.

Banks	Efficiency Change	Technical Change	TFPCH
HDFC	0.999	0.948	0.944
Kotak	0.979	1.002	0.987
ICICI	1.013	1.018	0.992
AXIS	1.041	1.035	1.065
Federal	0.981	1.208	1.149
Indus Ind	1.083	1.016	1.092
YES	1.066	1.097	1.150
City Union	1.023	1.125	1.106
Karur	1.007	1.173	1.182
DCB	1.010	1.097	1.078
SBI	1.016	1.005	1.000
BOB	1.089	1.073	1.248
IDBI	1.010	1.137	1.155
PNB	1.064	1.176	1.271
Canara	1.060	1.155	1.237
BOI	1.027	1.113	1.163
Centeral	0.993	0.984	1.016
Indian	0.980	1.125	1.143
Corporation	1.023	1.091	1.136
Andhra	1.007	0.965	0.961
Average	1.023	1.077	1.104
Min	0.979	0.948	0.944
Max	1.089	1.208	1.271
SD	0.034	0.076	0.097

Malmquist Productivity Index scores of output oriented constant returns to scale and output oriented variable returns to scale are equal. A Malmquist Index computed under the assumption of constant returns to scale depicts that the results of the output oriented approach and input oriented approach would not have a significant difference. (Coelli, 1996; Thanassoulis, 2001).

CONCLUSION

In the present research paper, Malmquist Prouctivity Index (MPI) approach of DEA has been utilized. The research paper focuses on the measuring Total Factor Productivity and its components of twenty banks operating in India for the period 2007-2017. TFPCH of the banks under reference is compared based on different ownerships namely public ownership banks and private ownership banks. In case of private ownership banks four out of ten banks have achieved productivity score more than one while all the public ownership banks have achieved TFPCH scores higher than one revealing an overall improvement in the productivity level. It is suggested from the measurement of TFPCH scores of public and private ownership banks that private sector should focus more on its technological operations. The research paper adopted two models of input-output combinations to represent banking TFPCH Frontier and established that the Efficiency Change and Technical Change of the functioning of banking industry have significant impact on its Total Factor Productivity. According to Intermediation Model under input oriented variable returns to scale, the average of Efficiency Change, Technical Change and Total Factor Productivity Change scores are 1.008, 1.010 and 0.997 respectively. Maximum TFPCH under the same has been scored by State Bank of India (1.204) and minimum TFPCH is achieved by Karur Vysya Bank (0.881).

Under input oriented constant returns to scale, averages of Efficiency Change, Technical Change and Total Factor Productivity Change are 1.025, 1.083 and 1.048 respectively. Maximum TFPCH under the same has been achieved by IDBI (1.228) and HDFC Bank has scored the minimum TFPCH. Averages of Efficiency Change, Technical Change and TFPCH under output oriented variable returns to scale are 1.011, 1.125 and 1.094 respectively. Highest TFPCH score is achieved by IDBI (1.328) and HDFC Bank has achieved the lowest TFPCH score under the same. It is clear from the average scores that the productivity level of banks has increased except in case of input oriented variable returns to scale. According to Production Model, under input oriented variable returns to scale, the overall averages of Efficiency Change, Technical Change and Total Factor Productivity Change scores over the period are 1.016, 1.026 and 1.039 respectively. Yes Bank has scored the highest

TFPCH (1.254) and Karur Vysya Bank has the lowest TFPCH score (0.914) under the same. Under input oriented constant returns to scale, averages of Efficiency Change, Technical Change and Total Factor Productivity Change are 1.038, 1.071 and 1.110 respectively. Maximum TFPCH (1.289) is achieved by Yes Bank and minimum TFPCH (0.942) is scored by HDFC Bank under the same. Averages of Efficiency Change, Technical Change and TFPCH under output oriented constant returns to scale are 1.023, 1.077 and 1.104 respectively. Punjab National Bank has achieved the highest TFPCH (1.271) and the lowest TFPCH is scored by HDFC Bank (0.944) under the same. According to Production Model, input oriented constant returns to scale scores are equal to output oriented constant returns to scale.

Productivity of banks has increased under Production Model indicating efficiency and technological growth among the banks under reference. Thus it is concluded that the overall productivity level has increased under Production Model while in case of Intermediation Model (input oriented variable returns to scale) TFPCH has reduced. After the comparative analysis of productivity of banks under both the ownerships, it is concluded that all the public ownership banks under reference are having positive productivity while private ownership banks having positive productivity is only 40 per cent of the total. However, we have used DEA methodology to measure the productivity and its economically meaningful components, which is based on mathematical programming techniques. Possible fallacies have not been contemplated in this research paper that may affect the analysis. There may exist alternative methodologies which may have their respective advantages and disadvantages likewise this research also have its respective constraints and further scope for research.

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