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Total Factor Productivity of Indian Banking Sector - Impact of Information Technology

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Technological changes play a vital role in increasing Total Factor Productivity (TFP) of an economy. This study focuses on the TFP of Indian banking sector and the impact of information technology on productivity. TFP is worked out for the Indian banking sector covering public, private and foreign banks operating in India using a non–parametric Data Envelopment Analysis (DEA). An attempt is also made to find out the impact of information technology on the productivity of the Indian banking sector using a multiple regression model. The results of the study show that the Indian banking industry experienced a growth in productivity as judged by Malmquist Productivity Index during 2008-10. The succeeding years showed a diminished growth of productivity. Further, the multiple regression model suggests that increased electronic transactions in the banking channel have resulted in increase in productivity. Additionally, the intermediation cost which is a proxy for technology investment is also significant for the productivity of the banking sector.

JEL Classification : G21,C14,C25,C67.

Key words : Data Envelopment Analysis, Malmquist Productivity Index, Total Factor Productivity, Multiple Regression

Introduction

Since the banking sector reforms, the Indian banking sector has been evolving with increased emphasis on competition and enthused technology-based services towards universal banking. Banks have implemented core banking solutions, enterprise risk management and business process re-engineering and reached social banking which has enrooted the performance, productivity and efficiency of the Indian banking sector. Banking sector reforms in India were initiated in 1992 with one of the major objectives being the strengthening of Indian

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banks by improving their productivity, efficiency and profitability. The advancement of information technology (IT) in the Indian banking sector and other financial intermediaries resulted in growth and development of banks' productivity and efficiency. There has been noticeable improvement in the performance of financial institutions and the service sector by incorporating IT into their functionality. These show an increasing share and enhanced competitiveness at the global level because of adopting the IT culture (Leeladhar 2006). Higher productivity led to a decrease in credit risk and a positive influence on bank capitalization, whereas poor performers were more prone to risk taking than better performing organizations (Das and Ghosh 2004). IT improvements are useful for reducing costs and improving the efficiency of banks. Technological efficiency can result in lower transaction costs and increased revenues for banks (Rishi and Saxena 2004). Finance growth literature suggests that if banks become better functioning entities, this will expectedly be reflected in safety and soundness of the financial system and will ultimately lead to an increase in the rate of economic growth. The efficiency and productivity analysis of the banking sector is also useful to enable policymakers to identify the success or failure of policy initiatives or, alternatively, highlight different strategies undertaken by banking firms which contribute to their successes (Mohan 2005).[1] It is evident from the fact that the intermediation cost of the Indian banking sector has been drastically reduced from year 1990 to 2012 which is an indication of reduction of operating expenses. The operational cost for technology and technology based services is one of the component of operating expenses. Banks' high value transactions are routed through Real Time Gross Settlement Systems (RTGS) which is a proven efficient payment and settlement mechanism provided by the Reserve Bank of India and has led to a paradigm shift due to IT initiatives in the banking sector. The gross value of electronic payments cleared and settled in the country is presently almost 7.5 times larger than India's annual GDP.[2]

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[1] Author's calculations using data from statistical tables relating to banks in India of the Reserve Bank of India's publication (various years).

[2] Author's calculations using the Reserve Bank of India's monthly bulletin.

The banks need to implement robust information systems and IT architecture and should harness the power of IT systems for business development. Besides, a strong IT system will also aid in the adoption of better risk management practices (Chakraborty 2013).

The objective of this paper is 2-fold. First, the study estimates TFP for the Indian banking sector covering public, private and foreign banks operating in India using non-parametric the Malmquist Productivity Index approach employing the Data Envelopment Analysis (DEA). Second, it estimates the impact of information technology on the productivity of the Indian banking sector by using a multiple regression model. The rest of the paper is organized as follows. Section II deals with the review of related literature. Section III depicts the methodology employed. Section IV is about data, variables and analysis. Section V provides a conclusion to the study.

Section II
Review of literature

There are few studies related to the impact of IT on the banking industry. However, research contributions available in this area are reviewed in this section. A literature review is arranged chronologically in both the foreign as well as Indian context.

Berg et al. (1992) studied the change in productivity in the Norwegian banking industry for 1980-89. Their study concluded that productivity declined on average before deregulation and it showed an increasing trend after deregulation in 1984-85. Grifell et al. (1997) analysed the various causes of productivity change in the Spanish banking industry for 1986-93 by using the Malmquist Productivity Index. They found that commercial banks had a lower rate of productivity growth as compared to saving banks but these banks had a higher rate of potential productivity growth. Das and Ghosh (2006) examined the inter-relationship among risk, capital and productivity changes in public sector banks in India from 1995-96 through 2000-2001. He concluded that higher productivity led to a decrease in credit risk and a positive influence on bank capitalization. Poor performers were more prone to risk taking than better performing organizations. The study supported the fact that productivity, capital and risk taking tend to be determined jointly and that these compensated each other.

Janki (2002) analysed the effect of technology on the productivity of employees for 1986-91 by employing the DEA methodology. He found that public sector banks had the highest efficiency followed by foreign banks. Private banks were found to be the least efficient. The author also found a temporal improvement in the performance of foreign banks. Ram Mohan and Ray (2004) attempted a comparison between public sector banks and their private sector counterparts based on measures of productivity during 1992-2000. They used Tornqvist and Malmquist Total Factor Productivity growth for comparison.[3] They found that there was no significant difference in productivity growth between the public and private sectors in the period under study. Bhandari (2010) studied Total Factor Productivity improvement achieved by 68 Indian commercial banks from 1998-99 to 2006-07. He decomposed the TFP into technical change, technical efficiency change and scale (efficiency) change. The results suggest that public sector banks were, on an average, adjusting themselves to the changing environment better and improving their performance relative to their counterparts under private and foreign ownership.

Beccalli (2007) investigated the effect of investment in information technology on the performance of European banks for 1995-2000 by using both the profit efficiency measure and standard accounting ratios. He argued that traditional accounting ratios may not reflect organizational capabilities, improved product variety, quality and customer satisfaction due to enhancement of information technology. Due to this reason, an advanced measure of productivity at the global level called x-efficiency

[3] The Tornqvist TFP Index is similar to the Malmquist Productivity Index. It is the ratio of two Tornqvist output and input quantity indices. The Tornquist Productivity Index can be measured without any knowledge of the underlying technology so long as data are available for the input and output quantities as well as the shares of the individual inputs and outputs in the total cost. The advantages of the Malmquist Index over other indices has been mentioned in Section III of this paper.

was used. He found that the relationship between total IT investment and improved bank profitability or efficiency indicated the existence of a profitability paradox. The impact of IT investment on hardware and software seems to reduce banks' profit performance whereas IT services from external providers have a positive influence on accounting profit and profit efficiency.

Koutsomanoli et al. (2009) studied bank efficiency and productivity change across Central and Eastern European (CEE) countries and across banks with different ownership status for 1998–2003 using the [4]directional technology distance function. Their results demonstrate strong links of competition and concentration with bank efficiency. Productivity for the whole region initially declined but improved more recently with further progress on institutional and structural reforms. Overall, productivity change in CEE was driven by technological change rather than efficiency change. Mittal and Dhingra (2007) assessed the impact of computerization on productivity and profitability of Indian banks employing DEA. Private sector banks, which took more IT initiative, were found to be more efficient in productivity and profitability parameters than public sector banks. Out of the many factors analysed, increased IT investments was one of the vital contributing factors for enhanced performance. (Rajput et al. 2011) studied the impact of IT on the Indian commercial banking industry based on the DEA technique. The results conveyed that all scheduled commercial banks showed a significant and improving trend in their performance due to the adoption of IT. There was an increasing trend in the performance of Indian banks because of IT innovations and enlarged investment in new information technologies during the recent time period 2005-10 as judged by a stochastic frontier analysis (Kumar et al. 2011). On both cost and profitability based parameters, productivity and efficiency of Indian banks has seen a definite improvement over

[4] The directional technology distance function proposed by Chambers et al. (1996) completely characterizes technology and allow firms to optimize by seeking simultaneously the maximum expansion of outputs and contraction of inputs that are technologically feasible. If the bank is technically efficient the value of the directional diction function would be zero. A positive value indicates inefficient production. For more details, see Chambers et al. (1996).

the last two decades. Further at a bank group level, public sector banks performed better than new private banks and foreign banks on various benchmarks (Chakraborty 2013).

Section III
Methodology

Productivity is generally defined in terms of the input and output produced by a firm. In a simple sense, it is defined as the ratio of input and output. The larger values of this ratio are associated with better performance of a firm. Productivity is also defined in terms of efficiency improvement and technical changes with which inputs are transformed into outputs in the production process. When multiple inputs and outputs are involved, productivity measure is the simple ratios of the output and input quantities called Total factor productivity (TFP) or Multi Factor productivity (MFP). It is an overall indicator of productivity of a firm in which how optimally uses all of its resources to create its yield.

Furthermore, TFP is a broader measure of economic and technical efficiency reflecting several other factors including managerial efficiency, economies of scale and human capital utilization; TFP can be split into two major components -- technological progress and improvement in technical efficiency. Technological progress is often directly related to TFP, especially in banking. A characteristic of the banking sector is its predominance of new technology which may be attributed to the introduction of latest technology, technology based service mechanisms, management, *etc.*, which leads to the expansion of the best production frontier and thereby results in higher output with the given input of resources. A reader may refer to Coelli et al. (2005) for more details about productivity, efficiency and its measurements. Malmquist indexes can be estimated either by using an input-oriented approach or an output-oriented approach.

Conceptually input orientation means how much input quantities can be proportionally reduced without changing the output quantity produced. Output orientation means how much output quantities can be proportionally expanded without altering the input quantities used.

The two measures provide the same value under the Constant Return Scale (CRS) but are different when the Variable Return Scale (VRS) is assumed (for more details on CRS and VRS reader may refer to Coelli et al. 2005).

Even though both the input and output based Malmquist TFP indexes are widely used, by following and Isik and Hassan (2003), Jaffry et al. (2007) and Isik (2008), among others, the output oriented Malmquist Productivity Change Index is adopted for this study. Jaffry et al. (2007) pointed out that output orientation is more appropriate given the objectives of a developing country's banking industry. The non-parametric DEA based Malmquist Productivity Index can be estimated by exploiting the relationship of [5]distance functions to technical efficiency measures. This technique is an index of productivity change. Therefore, it does not require cost or revenue shares to aggregate inputs and outputs and was introduced to literature by Caves et al. (1982). In order to calculate the Malmquist Output Oriented TFP Change Index the first step is to define distance functions with respect to two different time periods.

A convenient way to describe a multi-input, multi-output production technology is to use the technology set, *S*. Following Fare and Primont (1995), the notations X and *q* are used to denote an *N x l* input vector of non-negative real numbers and a non-negative *M x l* output vector, respectively. The technology set is defined as

$$S = \{(X, q): X \text{ can produce } q\} \tag{1}$$

This set consists of all input-output vectors *(X, q)* such that *X* can produce *q*.

Production technology defined by the set *S*, may be equivalently defined by the output set *P(x)* which represents the set of all output vector *q*, that can be produced by input vector *X*. The output set is defined by:

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[5] Distance functions are useful in describing technology in a way that makes it possible to measure efficiency and productivity. The concept of a distance function is closely related to production frontiers. The basic idea underlying distance functions is quite simple, involving radial contractions and expansions in defining these functions. The notion of a distance function was introduced independently by Malmquist (1953) and it has gained prominence only in the last three to four decades.

$$P(x) = \{(X, q) \in S\} \quad (2)$$

The output distance function is defined on the output set, $P(x)$, as:

$$d_0(x, q) = Min\{\delta : (q / \delta) \in P(x)\} \quad (3)$$

where δ is the ratio of two points in the production set. The Malmquist TFP Index in Fare et al. (1994) measures the TFP change between two data points by calculating the ratio of the distances of each data point relative to a common technology. Due to this, no longer do we have a situation where the ratio of the distance functions provides a measure of TFP change that is identical to technical change (that is, frontier shift). Thus, when panel data are available, one can obtain a measure of TFP change that has two components -- a technical change component and a technical efficiency change component.

Fare et al. (1994) take the Malmquist Index of TFP growth, defined in Caves et al. (1982), and describe how one can decompose the Malmquist TFP change measures into various components,including technical change and efficiency change.

The Malmquist (output-orientated) TFP Change Index between period *s* (the base period) and period *t* is can be written as:

$$m_0^t = (q_s, x_s, q_t, x_t) = \frac{d_0^t(q_t, x_t)}{d_0^t(q_s, x_s)} \quad (4)$$

Alternatively, if in the period *s* reference technology is used, it is defined as:

$$m_0^s = (q_s, x_s, q_t, x_t) = \frac{d_0^s(q_t, x_t)}{d_0^s(q_s, x_s)} \quad (5)$$

In these equations the notation $d_0^s(q_t, x_t)$ represents the distance from the period *t* observation to the period *s* technology. A value of greater than one indicates positive TFP growth from period *s* to period *t* while a value less than one indicates a TFP decline. The Malmquist TFP Index is often defined as the geometric mean of these two indices in the spirit of Caves et al. (1982). That is:

$$m_0^s = (q_s, x_s, q_t, x_t) = \left[\frac{d_0^s(q_t, x_t)}{d_0^s(q_s, x_s)} \times \frac{d_0^t(q_t, x_t)}{d_0^t(q_s, x_s)}\right]^{1/2} \quad (6)$$

The distance functions in this productivity index can be rearranged to show that it is equivalent to the product of a technical efficiency change index and an index of technical change:

$$m_0^s = (q_s, x_s, q_t, x_t) = \frac{d_0^t(q_t, x_t)}{d_0^s(q_s, x_s)}\left[\frac{d_0^s(q_t, x_t)}{d_0^t(q_t, x_t)} \times \frac{d_0^s(q_s, x_s)}{d_0^t(q_s, x_s)}\right]^{1/2} \quad (7)$$

The ratio outside the square brackets in equation 7 measures the change in the output-oriented measure of Farrell technical efficiency between periods *s* and *t.* The remaining part of the index in equation 7 is a measure of technical change.

It is the geometric mean of the shift in technology between the two periods, evaluated x_t and also at x_s Thus the two terms in equation 7 are:

Efficiency Change (EC)

$$= \frac{d_0^t(q_t, x_t)}{d_0^s(q_s, x_s)} \quad (8)$$

Technical Change (TC)

$$= \left[\frac{d_0^s(q_t, x_t)}{d_0^t(q_t, x_t)} \times \frac{d_0^s(q_s, x_s)}{d_0^t(q_s, x_s)}\right]^{1/2} \quad (9)$$

Technical efficiency change can be decomposed into scale efficiency and 'pure' technical efficiency components when the distance functions in the equations given earlier are estimated relative to a Constant Return Scale (CRS) technology.

This decomposition involving scale efficiency has been widely used in the literature.

A number of additional possible decompositions of these technical efficiency changes and technical change components have been proposed by various authors. Some of these options are discussed in Fare et al.'s (1998) survey paper. The decomposition proposed by Fare et al. (1994) is given by:

Pure efficiency change:

$$= \frac{d_{0v}^t(q_t, x_t)}{d_{0v}^s(q_s, x_s)} \quad (10)$$

and a *scale efficiency change* component. Scale efficiency change:

$$= \left[\frac{d_{0v}^{t}(q_t, x_t) / d_{0c}^{t}(q_t, x_t)}{d_{0v}^{t}(q_s, x_s) / d_{0c}^{t}(q_s, x_s)} \times \frac{d_{0v}^{s}(q_t, x_t) / d_{0c}^{s}(q_t, x_t)}{d_{0v}^{s}(q_s, x_s) / d_{0c}^{s}(q_s, x_s)} \right]^{1/2} \quad (11)$$

The scale efficiency change component in equation 11 is the geometric mean of two scale efficiency change measures. The first is relative to the period *t* technology and the second is relative to the period *s* technology. The extra subscripts, v and c, relate to the VRS and CRS technologies respectively.

There are two major approaches for measuring the distance functions that make up the Malmquist TFP Index. One is non- parametric DEA-like linear programming methods suggested by Fare et al. (1994), and the other approach is the use of stochastic frontier methods. Following Fare et al. (1994), one can calculate the distance measures in equation 6 using DEA-like linear programmes. For the i^{th} firm, we must calculate four distance functions to measure the TFP change between two periods. This requires the solving of four linear programming (LP) problems. As noted earlier, Fare et al. (1994) use a Constant Returns to Scale (CRS) technology in their TFP calculations. This ensures that resulting TFP change measures satisfy the fundamental property that if all inputs are multiplied by the (positive) scalar δ and all outputs are multiplied by the (non-negative) scalar α, then the resulting TFP Change Index will equal α/δ .

[6]The required LPs are:

$$d_0^t[(q_t, x_t)]^{-1} = Max_{\phi\lambda}\phi \quad (12)$$

$$\text{subject to} \quad \begin{aligned} &-\phi q_{it} + Q_t\lambda \geq 0, \\ &x_{it} - X_t\lambda \geq 0, \\ &\lambda \geq 0, \end{aligned}$$

[6] The DEA based liner programme (LP) problems mentioned in equations 12–15 were solved using software DEAP02.1.LPs are calculated for each bank in the sample. All indices (EC, TC,PEC,SEC and TFP) are relative to previous years. Hence, the output begins with the second year only, that is, indices are calculated for 2005-12.In order to maintain uniformity data for multiple regressions is also considered for 2005-12.

$$d_0^s\left[(q_s, x_s)\right]^{-1} = Max_{\phi\lambda}\phi \tag{13}$$
$$\begin{aligned} & -\phi q_{is} + Q_s\lambda \geq 0, \\ \text{subject to } & x_{is} - X_s\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned}$$

$$d_0^t\left[(q_s, x_t)\right]^{-1} = Max_{\phi\lambda}\phi \tag{14}$$
$$\begin{aligned} & -\phi q_{is} + Q_t\lambda \geq 0, \\ \text{subject to } & x_{is} - X_t\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned}$$

$$d_0^s\left[(q_t, x_t)\right]^{-1} = Max_{\phi\lambda}\phi \tag{15}$$
$$\begin{aligned} & -\phi q_{it} + Q_s\lambda \geq 0, \\ \text{subject to } & x_{it} - X_s\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned}$$

Section IV
Data, Variables and Analysis

The DEA based Malmquist TFP Index requires bank inputs and outputs whose choice is always an arbitrary issue (Berger and Humphrey 1997). They point out that the production approach might be more suitable for branch efficiency studies, as most of the times bank branches basically process customer documents and bank funding, while investment decisions are by and large, not under the control of branches. This study follows the asset approach proposed by Sealey and Lindley (1977) which views the institution as using labour, capital and deposits to produce earning assets. This approach is the most common in conventional literature. Moreover, banking literature has found that different approaches to measuring output have generally led to similar conclusions concerning the cost structures of financial firms (Mester 1993).

This paper uses annual account data of banks operating in India during 2004-12. The source of data is the balance sheets, profit and loss accounts generated from the Reserve Banks data warehouse, *Database on Indian*

Economy.[7] A total of 58 banks including public sector banks, private sector banks and foreign banks operating in India were considered for the study. The banks with incomplete data were omitted. The data were cleaned and missed values estimated by averaging nearby points.

The data were deflated with the Wholesale Price Index during the period. The final data set is a balanced panel of 522 observations on outputs and inputs. This study used two output variables and three input variables. The output variables are: investments (y_1) represent total investments including investments in non-SLR securities and net interest income (y_2) is the total interest earned *less* total interest paid. The input variables are deposits (x_1) which includes demand and time deposits, borrowings (x_2) comprise of inter-bank borrowings and inter-bank deposits at call or short notice not exceeding 14 days, and fixed assets (x_3) comprise of balances with the 'banking system' in current account, balances with other banks in other accounts, money at call and short notice, advances to banks and other assets which cannot be classified under any of the four items.

The software package DEAP V2.1 was used to perform DEA and estimations. The descriptive statistics of the input and output variables were measured in lakhs which are used to construct TFP indices for 2004-12 (Table 1).

It is interesting as well as useful to investigate the impact of information technology on the productivity of the Indian banking sector. For this, a multiple regression model was employed. The selection of IT variable is a challenging issue because of the lack of suitable published data. Most of the banking technology and related research is based on qualitative data or perceptions of technology experts. With these limitations, the available data was collected from various publications of the Reserve Bank of India.

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[7] All 26 public sector banks including the State Bank of India and its associates are considered. In case of private sector banks, some banks are not included as data is not available for the period 2004-12. Due to this, 16 private banks were considered. A good amount of banks have not been included in the case of foreign banks as most of the banks do not have information on all the variables considered for the study. Further many banks were established in India recently and therefore 16 foreign banks were considered for the study.

Descriptive Statistics of the Input-Output Variables

(₹ lakh)

Descriptive Statistics	*Investments* Y_1	*Net Interest income* Y_2	*Deposits* x_1	*Borrowings* x_2	*Fixed Assets* x_2
Min	*101.92*	*19.76*	*469.43*	*6.43*	*3.09*
Maximum S.D.	*15556267.56*	*1160509.94*	*30912136.42*	*3946767.17*	*335240.50*
Mean	*602842.75*	*50164.15*	*1467904.26*	*131981.95*	*17201.76*
SD	*1378296.83*	*109715.88*	*3069072.95*	*420390.93*	*37139.13*

The variables considered were total volume and value of paper transactions and electronic transactions turned out in the country during 2005-12.[6] The ratio of cheque transaction volume and electronic transaction volume is one of the independent variable considered, that is, CHVOL/ECVOL, ECVOL which includes high value transactions mainly through the Real Time Gross Settlement Systems (RTGS), retail transactions represented by the National Electronic Fund Transfer (NEFT) and card transactions (credit and debit cards). The second explanatory variable considered is the ratio of cheque transaction value (CHVAL) to non-agricultural GDP. Improvements in the efficiency of the banking system are expected to be reflected in the indicator like operating expenditure. Several indicators have been employed in literature to compare banking production costs across time. Illustratively, intermediation costs, defined as the ratio of operating expense to total assets, needs to be weighed against the large expenditures incurred in upgradation of information technology and institution of 'core banking solutions' (Mohan 2005). Following this, the third explanatory variable considered is intermediation cost (INTCOST) as a proxy of investment for technology systems and its maintenance. The dependent variable considered is the ratio of input and output as a productivity measure (PDY) during 2005-12.

Table 2 summarizes the decomposition of Total Factor Productivity (TFP) of the overall banking sector for 2005-12. It is obvious from Table 2 that the period 2008 to 2010 experienced positive productivity growth. It is also evidenced that the technological progress which

Table 2: Decomposition of TFP in the Indian Banking Sector for 2005-12

Indices					
All Banks	**Efficiency change (EC)**	**Technological change (TC)**	**Pure technical efficiency change (PTEC)**	**Scale efficiency change (SEC)**	**Total factor Productivity (TFP)**
2005	1.0490	0.9520	0.9950	1.0540	0.9990
2006	1.0230	0.9360	1.0120	1.0110	0.9580
2007	1.0710	0.7830	1.0250	1.0460	0.8390
2008	0.9650	1.0460	0.9720	0.9930	1.0100
2009	0.9470	1.0570	0.9920	0.9550	1.0010
2010	0.7120	1.9040	0.9190	0.7750	1.3550
2011	1.2230	0.7560	1.0260	1.1930	0.9250
2012	1.0140	0.6830	1.0500	0.9660	0.6930
Average for the period 2008-10	0.8665	1.2816	0.9605	0.9024	1.1106
Average for the period 2005-12	0.9906	0.9660	0.9981	0.9928	0.9573

Note: All indices are geometric average.

happened in 2008, 2009 and 2010 resulted in an increase of TFP in the respective years. Specifically, 2010 witnessed 35 per cent annual productivity growth due to a major contribution of the technological change component. During 2009-10, most of the banks implemented Core Banking Solutions and other technology based services which ultimately contributed to TFP. The average annual productivity growth rate in 2008-10 was 11 per cent which was mainly due to the result of a 28 per cent technological progress during the period. The succeeding years showed a diminished growth of productivity. This may be partly due to factors such as lack of upgradation of IT systems to cope with service requirements, a changing regulatory environment, demand for novel customer services through social network and mobile banking. All these factors need to be analysed deeply which is not attempted in this paper. Further, it is suggested that technology reforms in the banking sector may be made so as to keep it in tandem with the innovations happening in the rest of the world.

Table 3 depicts bank group-wise (public sector, private sector and foreign) TFP growth and its components which are averaged for the period 2008-10 and 2005-12. Private sector and foreign banks showed an average productivity growth of 4.5 per cent and 9.6 per cent respectively

Table 3: Decomposition of TFP in the Indian Banking Sector for 2005-12: bank category-wise *(Contd.)*

Indices					
	Efficiency change (EC)	**Technological change (TC)**	**Pure technical efficiency change (PTEC)**	**Scale efficiency change (SEC)**	**Total factor Productivity (TFP)**
Public sector Banks					
2005	1.0013	0.9618	1.0028	0.9985	0.9631
2006	1.0238	0.9132	1.0007	1.0230	0.9351
2007	1.0061	0.7539	1.0142	0.9920	0.7588
2008	0.9326	0.9911	0.9420	0.9900	0.9243
2009	0.8941	1.0102	0.9488	0.9422	0.9031
2010	0.6750	1.6252	1.0349	0.6523	1.0970
2011	1.3167	0.6976	0.9683	1.3597	0.9185
2012	1.0370	0.9403	0.9650	1.0748	0.9749
Average for the period 2008-10	0.8256	1.1762	0.9744	0.8474	0.9711
Average for the period 2005-12	0.9714	0.9575	0.9841	0.9871	0.9302
Private sector Banks					
2005	1.0459	1.0250	0.9839	1.0629	1.0720
2006	1.1091	0.9529	1.0695	1.0371	1.0569
2007	1.1747	0.6860	1.0674	1.1005	0.8058
2008	0.9604	1.1563	0.9564	1.0042	1.1105
2009	0.9602	0.9962	1.0257	0.9361	0.9564
2010	0.7121	1.5093	0.9181	0.7756	1.0746
2011	1.2451	0.7650	1.0252	1.2144	0.9524
2012	0.9692	0.7018	1.0208	0.9495	0.6801
Average for the period 2008-10	0.8692	1.2025	0.9657	0.9000	1.0450
Average for the period 2005-12	1.0097	0.9430	1.0072	1.0025	0.9521
Foreign Banks					
2005	1.1353	0.8694	0.9951	1.1409	0.9870
2006	0.9428	0.9586	0.9759	0.9658	0.9037
2007	1.0822	0.9492	1.0003	1.0819	1.0271
2008	1.0263	1.0335	1.0405	0.9863	1.0607
2009	1.0240	1.0786	1.0314	0.9929	1.1044
2010	0.8199	1.3727	0.8243	0.9947	1.1256
2011	1.0755	0.8476	1.1055	0.9729	0.9115
2012	0.9972	0.3913	1.1816	0.8441	0.3906
Average for the period 2008-10	0.9516	1.1523	0.9599	0.9913	1.0966
Average for the period 2005-12	1.0086	0.8922	1.0146	0.9941	0.8999

during 2008-10. However, public sector banks were near to the frontier and the technological change component was very prominent.

The year 2010 showed an annual productivity growth of 9.7, 7.4 and 12 per cent respectively by public, private and foreign banks. This was reflected in the overall baking productivity as explained in Table 2. The three categories of banks showed a downward trend in TFP growth from 2011 and the same diminishing tendencies were observed in the technological progress component index. Both public sector and private sector banks were almost persistent in their scale of operations which was in contrast with foreign banks. This may be partly due to the fact that both public and private sector banks having been in existence for a long time in India and being known to their customers could have helped their inputs usage and in getting closer to the frontier.

The regression model was employed here only to know the impact of technology on growth of productivity keeping in view the technological improvements that happened in the Indian banking sector during

2005-12. This model is not used for any forecasting purposes; however, an attempt has been made to know the impact of some of the technology related variables and how they can explain banking productivity and its growth. It also assumes that all banks come from a similar regulatory environment. The problem of multi-collinearity has been addressed. In detail, the following multiple regression equation model is estimated:

$$ln(PDY)_t = \beta_0 + \beta_1 ln\left(\frac{ECVOL}{CHVOL}\right)_t + \beta_2 ln\left(\frac{CHVAL}{GDP}\right)_t + \beta_3 ln(INTCOST)_t + \varepsilon_t \qquad (15)$$

where t is the time period, and ε is error term independently and identically distributed with $N(0,\sigma^2)$. Following De bandt and Davis (2000) and Staikouras et al. (2008) among others the log linear form is chosen as it typically improves the goodness fit of the model and may reduce a simultaneity bias.

The model parameters were estimated using the software package SPSS16.0.The regression coefficients that were estimated are presented in Table 4.

Table 4: Effect of Technology on Productivity Growth: Empirical Results

	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t-value	Sig*.
Constant	*1.732*	*0.149*		*11.640*	*0.000*
ECVOL /CHVOL	*0.096*	*0.027*	*0.997*	*3.549*	*0.024*
CHVAL/GDP	*0.385*	*0.120*	*1.472*	*3.206*	*0.033*
INTCOST	*-1.688*	*0.370*	*-1.465*	*-4.567*	*0.010*

* 5% level of singnificance,R^2 = 0.933, adjusted R^2 =0.883. Dependent variable is the ratio of input and output as a productivity measure (PDY) during 2005-12.

The coefficient of the ratio of electronic transactions to paper transactions (ECVOL /CHVOL) exhibit a statistically significant (5 per cent level) relationship with productivity growth, meaning that increased electronic transactions in the banking channel resulted in an increase in growth of productivity. The second variable is the ratio of total cheque value settled in the country to non-agricultural GDP (CHVAL/GDP) which shows a significant (5 per cent) positive relationship with productivity meaning the contribution of GDP to the nation. In the present scenario, paper settlements in the country were less than electronic settlements. As mentioned in the previous variable, the reduction in paper transactions will certainly increase productivity, these variables are more or less similar to the first variable which substantiate the model's fitness. The intermediation cost as the ratio of operating expense to total assets was also significant at the 5 per cent level. A reduction in intermediation is the direct positive impact of efficiency and productivity which is consistent with earlier empirical evidence on banking efficiency and productivity (Mohan 2005, Chakraborty 2013).

Section V
Conclusion

This study analysed TFP of the Indian banking sector during 2005-12; 58 banks including public sector banks, private sector banks and foreign banks operating in India were considered for this study. A non-parametric Data Envelopment Analysis (DEA) based Malmquist Productivity Index was worked out bank group-wise for the Indian banking sector. Impact of information technology on the productivity the of Indian banking sector was also investigated by employing a multiple regression model. The results of the study show that the Indian banking industry was productive as judged by the Malmquist Productivity Index during 2008 to 2010 compared with the preceding and succeeding years in the time band 2005-12. The average annual productivity growth rate in 2008-10 was 11 per cent which was mainly due to the result of a 28 per cent technological progress during the period. Further, it is observed that increased electronic transactions in the banking channel resulted in increase in productivity. Additionally, the intermediation cost which is a proxy of technology investment was also significant for the productivity of the banking sector.

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