Indian Journal of Economics and Business
Vol. 20 No. 3 (December, 2021)

http://www.ashwinanokha.com/IJEB.php

The Effect of Technology on Financial Performance of Indian Banks

K. Ravirajan & K. R. Shanmugam

Department of Economics, Madras School of Economics, India

* *Corresponding author: ravirajan@mse.ac.in*

Received:07th July 2021
Revised:21st August 2021
Accepted: 03rd September 2021

Abstract: This study empirically analyses the effect of technology on the financial performance of 50 Indian banks during 2011-12 to 2019-20. It considers three technology indicators – average amount of debit card transaction at ATM, average amount of debit card transaction at POS and average amount of NEFT transaction and three performance indicators – return on assets, return on equity and net interest margins of banks and uses them to construct the composite technology index and the composite performance index respectively. It regresses the performance indicators individually and also the composite performance index on technology indicators/technology index along with other explanatory variables and estimate these equations using the standard panel data methodology. As these regression results provide the average effect of technology indicators and technology index on banking performance, it also allows the technology index to interact with bank dummies to observe bank specific effect of technology in the alternative specification of equations. The estimation results indicate that the NEFT has a negative and significant effect on the performance index, but it has a positive and significant effect on both return on asset and return on equity. Surprisingly, both average amounts of debit card transaction at ATM and POS do not influence all performance indicators as well the performance index. Thus, the technology impact is mixed based on the performance indicator and the NEFT is the dominant technology indicator in determining the profitability of banks. Results from the estimation of alternative specification of the model indicate that the technology index has a significant negative effect on the performance index of 42 banks. However, it has a significant positive effect on both return on assets and return on equity in almost banks, but it does not play a role in determining the net interest margin of banks. We hope that these results are useful to policymakers and other researchers to take appropriate strategies to improve the performance of banking industry in India.

Keywords: Technology Index, The Performance Index of Banks, Panel Data Methods, Indian Commercial Banks.

1. Introduction

When Barclays Bank in UK introduced its Automated Teller Machine (ATM) in 1967, bankers felt that the computers could automate much of the labour-intensive information related services of banks. After that, almost all banks in many nations including India invested huge amounts of capital on Information and Communication Technology (ICT) solutions like ATM, Point of Sale (POS) terminals, *etc* (Ovia, 2005). Particularly in India, when a few private banks started using ICT solutions in the late nineties, it was also felt that internet banking was insecure. However, due to the initiatives of the Government of India and the Reserve Bank of India (RBI), reduced costs of internet facility, and greater awareness, the internet banking (online or e-banking) grew faster in the 2000s in India. This new service enhanced the customer satisfaction by providing "anywhere anytime banking". Further, it also helped the banks to reduce their costs on one hand and increase their penetration and customer base on the other (Porteous and Hazelhurst, 2004).

When the global financial crisis-2008 affected almost all economies and their banking industries, the Indian economy and its banking industry emerged relatively unaffected due to its stringent regulatory and prudent policies. However, the scenario in the Indian banking industry changed later because of two developments, namely the increased bad loans or NPAs (*i.e.*, Non-performing assets) and the consolidation of Information Technology (IT) based efforts by almost all Indian banks from 2012 onwards.

In fact, India has a bank dominated financial system. The Indian banking industry comprises four ownership groups of commercial banks: State Bank of India & its associate banks (SBIs), nationalized banks (NBs), private domestic banks (PBs) and private foreign banks (FBs). The RBI, being the central bank, created a highly regulatory environment with interest rates, credit allocation and entry being restricted. Despite these initiatives, most banks suffered due to poor profitability, under capitalization with large amounts of administrative expenditures in the late eighties (Shanmugam and Das, 2004). Based on the recommendations of Narasimham committee report (which was submitted in 1991), the RBI initiated various reforms/liberalization measures which improved the efficiency and the profitability of banking system. Many new private banks-the new generation of tech savvy banks emerged, and a few foreign banks commenced their operations in India. Due to the new competitive environment, Indian banks adopted the international norms, and they were quick to leverage the emerging technology and competing in attracting customers[1]. The RBI has authorized the payment system operations of pre-paid payment instruments, card systems, cross border in-bound money transfers, ATM networks, and centralized clearing arrangements.
In spite of all these efforts and guidelines passed by the RBI, the NPAs continued to increase in the Indian Banking sector. The public sector banks were on the verge of a crisis due to their high NPAs which constituted over 90 percent of total bad loans of the industry. Many of them have reported losses on account of high NPAs. The RBI gave a deadline of March 2017 for all banks to clean up their balance sheets and set aside a huge chunk of capital in the form of provisioning. Despite the NPAs stress, the Indian banks continued to work towards Digital India. However, there are wide variations in technology agendas and implementation capabilities across banking groups and individual banks. In addition, the development of new products and business practices has brought out new security risks including cybercrime, hacking, etc. Thus, the adoption of banking technology creates new opportunities as well as challenges in India.

In this context, a central question emerges is: what is the effect of technology on the financial performance of banks? In fact, this type of question begun when Robert Solow, the Nobel Laureate in Economics, remarked the following famous "productivity paradox" at the time of his Noble lecture in 1987: "You can see the computer age everywhere but in the productivity statistics". While numerous studies have emerged to answer this question, their findings produce conflicting results. Some have shown a positive impact, while others have shown a negative impact and some others have indicated no impact[2].

For instances, Rashid (2017) shows a positive relation between the technology and banks' performance measured by return on investment (ROI), net profit margin (NPM), return on equity (ROE), and return on assets (ROA) of private banks in Bangladesh during 2007-16. Navarrete and Pick (2002) finds a positive correlation between expenditures on technology and net profits/ROA of 18 banks in Mexico during 1992-2002. Daoud et al., (2016) shows that investments on technology have a positive and significant effect on ROA of larger banks in Jordan during 1993-2014 and a positive and significant impact on ROA and ROE of small banks.

Gichungu and Oloko (2015) find that mobile/online/agency banking, and ATMs have the positive impact on ROA of 43 banks in Kenya during 2009–13. Leckson et al., (2011), using the panel random effects method, show a positive impact of IT investments on both ROA and ROE of 15 banks in Ghana during 1998–2007. Jun (2006) uses ROA, ROE, and net profit as performance indicators, and computer budget ratio capital budget ratio as the IT investment variables for 26 Korean Banks during 1991–2001 and shows that IT investment of large banks has a stronger positive influence on improving bank returns than that of small banks. Prasad and Harker (1997), and Alawneh and Hattab (2009) show a positive effect of technology on productivity of banks, and also a positive effect of e-banking on banking performance. Batterymarch (2003) and Safari and Yu (2014) also show that banks adopting technology are more efficient in Italy and Iran respectively.

Ho and Mallick (2010), however, shows a negative impact of adoption and diffusion of technology investment on banks' profits in the case of 68 banks in USA during 1986–2005; Al-Smadi and Al-Wabel (2011) also find the negative impact of both technology indicators and e-banking on ROE of 15 Jordanian banks during 2000–2010. Beccalli (2007) shows a negative correlation between the profitability and the hardware/software purchases of 737 banks in France, Germany, Italy, Spain, and the United Kingdom during 1993–2000. Licht and Moch (1999), Oluwagbemi et al., (2011), and Abubakar et al., (2013)) also show a negative impact of technology on banking performance. Victor et al., (2015), on the other hand, find that investments in e-banking services and ATMs do not really improve ROA and ROE of 11 commercial banks in Nigeria during 2001–2013. Mittal and Dhingra (2007), and Oyevole et al., (2013) show no impact on bank profitability.

In the Indian context, only limited studies have emerged on the topic. But their results are also mixed. Malhotra and Singh (2004) show no significant effect of internet banking on the profitability of Indian banks. Gupta et al., (2018) also show no significant relation between IT expenditure and ROE/Profit Efficiency. However, studies like Malhotra and Singh (2009) and Chandrasekhar and Sonar (2008) show

that the technology has a positive effect on the productivity of banks. Bansal (2015) shows that the technology has a positive impact on performance of SBIs and NBs, but a negative effect on performance of PBs and FBs[3]. Shanmugam and Rakesh (2020) uses Kmeans clustering method and show a positive impact of technology index only on the financial performance of 11 Indian banks in 2011-12, but no significant impact with passage to time. Therefore, this study attempts to empirically assess the effect of technology on the financial performance of the Indian banking sector during 2011-12 to 2019-20.

The main contributions of this study are as follows. Firstly, it uses the latest data available to analyze the effect of technology on the financial performance of banking industry in India. Secondly, it considers three appropriate indicators of IT and three indictors for performance and constructs a composite IT index and a composite financial performance index using the standard Euclidean norm formula. Thirdly, it analyzes the effect of IT on each of the individual performance indicators as well as on the performance index. Fourthly, it also empirically examines in which of the banks, IT positively contributes to the performance and in which of the banks, IT negatively impacts and in which of the banks, IT does not influence the performance. These bank specific results might be useful for the policy makers to design appropriate strategies to improve the performance of Indian banking industry. Finally, while this study provides policy implications based on Indian banking experience, they may be relevant for banks in other similar nations.

This study proceeds as follows. Section 2 explains the empirical model, the data and the estimation technique to be employed. While the Section 3 presents and discusses the empirical results, the final Section 4 provides the concluding remarks of the study.

2. Method

As indicated earlier, past studies have used various econometrics and statistical methodologies including multiple regression, panel regression, and frontier methods. They used different data periods and IT and performance indicators (single, multiple, composite etc.). After reviewing some of these studies, Bansal (2015) remarked that the lesson learned from these studies is that the effect of technology on the performance of banks is a tricky one. It is essential to choose carefully the proper metrics or quantification of technology and performance indicators. Following the past studies on the topic, this study posits that the performance (index or indicator) depends on technology index (indicators) and other determinants. That is,
Performance Index/Indicatorit = f (Technology Index/Indicatorit, Other Determinants) (1)

Financial management theories and past empirical studies suggest multiple indices of profitability/efficiency for evaluating the bank performance. This study uses three such important indicators, namely, return on asset, return on equity and net interest margin (NIM) as profitability measures. Many studies consider ROA and ROE as profitability measures and NIM as a measure of both profitability and efficiency. The definitions of these indicators (as percentages) are given as:

- ROA—ratio of the net profit of the bank to the average total assets;
- ROE—ratio of the net income of the bank to the average shareholder's equity; and
- NIM—ratio of the interest margin (interest earned minus interest paid) to the average total assets.

As most studies on banking performances use the operating (or income based) approach which considers that the bank's output (or income indicators) depends on the employee costs (EC) and capital related operating costs (CC), this study also uses these two determinants as other determinants of performance indicators of banks. The data on ROA, ROE, NIM and EC are compiled directly from RBI's "Statistical Tables relating to Banks in India". The capital related operating expenses are computed using the data from RBI on rent, taxes, lighting, printing and stationary expenses, depreciation cost on bank property, repairs, and costs on maintenance and insurance.

While the data on the above variables are available for almost all banks in India, technology related indicators are available only for about 50 Banks (see Appendix for list of banks) for the period 2011-12 to 2019-20. Further, only the monthly data and not the annual data on technology related variables are available. Therefore, we compute the annual data using the monthly data. From the bank wise and year wise monthly data on the number of debit cards issued outstanding (after adjusting the number of cards withdrawn/cancelled), the number of financial transactions using the debit cards at ATMs, the amount of transactions using the debit cards at ATMs, the number of transactions using the debit cards at POS (point of sales terminal), and the amount of transactions using the debit cards at POS available at RBI website:(https://www.rbi.org.in/Scripts/ATMView.aspx) , we have added the respective data from March to April to get the annual figures for these variables. Similarly, using the monthly data on the National Electronic Funds Transfer (NEFT) of the respective banks (i.e., the number of transactions and the amount of transactions) available at RBI's website: https://www.rbi.org.in/Scripts/NEFTView.aspx, we arrive at the annual figures. Then, we compute the following three technology indicators:

- ATM-Amount of debit card transaction at ATM per transaction;
- POS -Amount of debit card transaction at POS per transaction; and
- NEFT-Amount of NEFT transaction per online- transaction.

Appropriate deflators are used to convert all monetary values of ATM, POS, NEFT, EC, and CC into 2011-12 prices. The respective real variables are: ATMR, POSR, NEFTR, and ECR, and CCR. Finally, we have taken the natural logarithmic (Ln) values of these variables. Then, for each bank in each year, we have computed a composite performance index (Pit) and a composite technology index (TILit) using the Euclidean norm formula as follows:

$$P_{it} = \sqrt{ROA_{it}^2 + ROE_{it}^2 + NIM_{it}^2} \text{ and}$$

$$TIL_{it} = \sqrt{Ln\ ATMR_{it}^2 + Ln\ POSR_{it}^2 + Ln\ NEFTR_{it}^2}$$

Due to the missing data and merging of banks, the final data set used in the empirical analysis of the study is an unbalanced panel of 429 observations.

Using the equation (1), we specify the following panel data model equation to analyze the effect of technology on the financial performance of banks in India:

$$Pit \text{ (or } ROAit/ROEit/NIMit) = \beta_0 + \beta_j TILit \text{ (or Ln } ATMRit/\text{Ln } POSRit/\text{Ln } NEFTRit) + \gamma_1 \text{Ln } ECRit + \gamma_2 \text{Ln } CCRit + \lambda i + \mu t + eit, \quad (2)$$

Where the term λi is the bank specific heterogeneity term capturing individual specific unobserved characteristics of banks; t is the time or year effect and eit is the standard stochastic error term. It is noted that the individual performance indicator, ROA or ROE or NIM or the composite index of performance of banks (Pit) is used as the dependent variable. In order to examine the effect of technology on the financial performance of each individual bank, the technology index is allowed to interact with bank specific dummies in an alternative specification of the model.

The above performance equation (2) can be estimated using the standard (static) panel data estimation techniques, namely, fixed effects (FE) or random effects (RE) method. The FE model assumes a correlation between the independent variables included on the right hand side of the equation and the unobserved individual (or bank) effect and year effect, while the RE model posits no such correlation. The former can be estimated using the Least Square Dummy Variable (LSDV) procedure by incorporating bank dummies and year dummies along with other explanatory variables or "within estimation" procedure. The latter can be estimated using the Generalized Least Square (GLS) method. The Chow test is used to choose the one way or the two-way model and the Hausman Statistics is used to select FE or RE model. The Table 1 presents the descriptive statistics of the study variables. It is observed that among technology variables, the NEFT has larger mean variables than the other two variables.

Table 1: Descriptive Statistics of Study Variables

Variables	Definitions	Mean	S.D
NDC	No. of Debit Cards	75600000	309000000
NDCT (ATM)	No. of Debit Card Transactions in ATMs	157000000	471000000
NDCT (POS)	No. of Debit Card Transactions in POS (point of sale terminals)	42900000	126000000
ADCT (ATM-Rs. Crore)	Amount of Debit Card Transactions in ATMs	105180.5	526778.9
ADCT(POS-Rs.Crore)	Amount of Debit Card Transactions in POS	16723.6	93310.89
NDT (NEFT)	No. of NEFT Transactions	51400000	101000000
ADT (NEFT-Rs. Crore)	Amount of NEFT Transactions	935891.8	3889414
ROA	Return on Assets	0.432	1.25
ROE	Return on Equity	3.00	17.25
NIM	Net Interest Margin	2.72	0.78
ATMR	Amount of Debit Card Transaction at ATM per Transaction real (Rs.)	5397.96	12061.87
POSR	Amount of POS per Transaction real (Rs.)	1883.58	2433.20
NEFTR	Amount of NEFT per Transaction real (Rs.)	107469.8	224761.70
TIL	Technology Index	15.49	1.23
PI	Performance Index	14.01	10.94
ECR	Employee Costs real (Rs. Crore)	1970.64	3410.95

CCR	Capital Related Costs real (Rs.Crore)	793.2	1273.37
N	Number of Observations	429	

3. Findings and Discussions

Column (1) of the Table 2 presents the GLS (i.e., 2-way random effects model) estimation results of the equation (2). The dependent variable is the performance index (PI). On the contrary to the expectation, the technology index on an average has a negative and significant effect on the performance of banks. The other two inputs variables, namely the log of real employee cost and the log of real capita cost are not statistically significant even at 10% level of significance, indicating that these two variables have no role in determining the composite index of performance of banks in India.

Columns (2) and (3) of the table 2 present the 2-way random effects estimation results of two profitability measures: ROA and ROE equations. As expected, the coefficient of technology index is positive and statistically significant at 1% level in both columns, indicating that the technology adoption leads to significantly higher profitability of Indian banks. Unexpectedly, the employee cost is negatively and significantly related to both profitability measures, implying that even after voluntary retirement schemes (VRS), the banking sector suffers from high employee costs. However, the capital costs variable has a positive and significant impact on both profitability measures at 1% level of significance. Column (4) reports the 2-way FE model results of the NIM equation. All three variables are having positive coefficients. However, the coefficients of both employee and capital costs variables are statistically significant at 1% level and the coefficient of technology index is not significant even at 10% level, indicating that the technology does not help banks in increasing their net interest margin.

Table 2: Panel Model Estimation Results of Performance Equations for Indian Banks (2011-12 to 2019-20)

	2-Way RE			2-Way FE
	PI	ROA	ROE	NIM
Variables	(1)	(2)	(3)	(4)
Constant	58.923(3.30)*	-5.832(-3.04)*	-78.952(-2.93)*	-2.248(-2.18)**
TIL	-3.206 (-2.77)*	0.543 (4.38)*	7.214 (4.14)*	0.104 (1.57)
Ln ECR	1.156 (0.86)	-0.435 (-3.06)*	-5.792 (-2.92)*	0.410 (4.70)*
Ln CCR	-1.132 (-0.89)	0.402 (3.32)*	5.451 (3.09)*	0.159 (2.67)*
Bank Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
R Square(within)	0.087	0.348	0.384	0.237
R Square (between)	0.049	0.282	0.197	0.005
R Square (overall)	0.077	0.310	0.330	0.001

Hausman Statistics	7.03	7.08	8.86	76.73
Observations (N)	429	429	429	429

(t statistics are in the parentheses); *-significant at 1% and **-significant at 5% level of significance. The Table 3 shows the alternative specification results of PI, ROA, ROE and NIM. The difference of these results with that in the Table 2 is that the technology variable is allowed to interact with bank dummies in order to examine the impact of technology on the performance of each individual bank. In Column (1), in 42 out of 50 banks, the technology index (TIL) negatively and significantly influences the performance index (PI) at 5% level of significance. In the remaining 8 banks (B7, B15, B17, B7, B29, B38, B41, and B43) also, it has a negative association, but it is significant only at 10% level. Although these results are surprising, they are consistent with the average impact shown in Column (1) of Table 2.

In the ROA equation in Column (2) of the Table 3, the technology interaction term is positive and statistically significant at 5% level in 46 banks. In the remaining 4 banks (B15, B17, B29 and B43) it is significant only at 10% level. In the ROE equation in Column (3), in all cases, the interaction term is positive and statistically significant at 5% level. In NIM equation (Column 4), the technology index has a positive coefficient in 37 banks, but only in 3 banks, it is statistically significant at 5% level and in only 1 bank, it is significant at 10% level. While it has a negative coefficient in 13 banks, in only one bank it is statistically significant at 5% level. The employee expenses variable has a positive and significant impact on PI and NIM while it has a negative and significant impact on ROA and ROE. The capital expenses variable has a positive and significant effect on both ROA and NIM but does not play a role in determining PI and ROE.

Table 3: Panel Model Estimation Results of Performance Equations with Technology Interaction

	2-Way RE						2-Way FE	
	PI (1)		ROA (2)		ROE (3)		NIM (4)	
Variables	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
Constant	53.147	(1.82)	-2.884	(-1.27)	-55.608	(-1.60)	-1.860	(-1.64)
Technology Index x B1	-3.897	(-2.28)	0.348	(2.62)	6.152	(3.04)	0.121	(1.29)
Technology Index x B2	-3.770	(-2.05)	0.469	(3.27)	7.783	(3.56)	0.156	(1.31)
Technology Index x B3	-4.127	(-2.25)	0.309	(2.16)	6.285	(2.89)	0.107	(0.71)
Technology Index x B4	-3.946	(-2.15)	0.425	(2.97)	7.087	(3.26)	-0.319	(-2.58)
Technology Index x B5	-3.861	(-2.17)	0.435	(3.13)	7.132	(3.38)	0.241	(2.79)
Technology Index x B6	-4.196	(-2.26)	0.431	(2.98)	7.457	(3.38)	0.086	(0.65)
Technology Index x B7	-3.512	(-1.78)	0.307	(1.99)	6.275	(2.68)	-0.022	(-0.16)
Technology Index x B8	-4.277	(-2.18)	0.347	(2.27)	7.125	(3.06)	0.046	(0.38)
Technology Index x B9	-4.603	(-2.35)	0.363	(2.38)	7.648	(3.30)	0.163	(1.26)
Technology Index x B10	-4.668	(-2.33)	0.369	(2.36)	7.490	(3.15)	0.167	(1.33)
Technology Index x B11	-4.178	(-2.12)	0.332	(2.16)	6.865	(2.94)	0.061	(0.46)
Technology Index x B12	-4.656	(-2.41)	0.357	(2.37)	7.470	(3.26)	0.029	(0.23)

Technology Index x B13	-4.479	(-2.29)	0.323	(2.12)	6.849	(2.95)	0.098	(0.74)
Technology Index x B14	-3.897	(-2.02)	0.309	(2.06)	6.616	(2.89)	0.117	(0.84)
Technology Index x B15	-3.582	(-1.88)	0.243	(1.64)	5.988	(2.65)	0.219	(1.63)
Technology Index x B16	-4.729	(-2.36)	0.396	(2.54)	7.934	(3.34)	0.008	(0.06)
Technology Index x B17	-3.750	(-1.94)	0.286	(1.90)	6.088	(2.66)	0.065	(0.49)
Technology Index x B18	-4.291	(-2.24)	0.327	(2.19)	6.818	(3.00)	-0.009	(-0.06)
Technology Index x B19	-4.383	(-2.31)	0.336	(2.28)	6.852	(3.05)	0.057	(0.43)
Technology Index x B20	-4.489	(-2.29)	0.358	(2.35)	7.492	(3.23)	-0.077	(-0.67)
Technology Index x B21	-4.167	(-2.15)	0.348	(2.30)	7.211	(3.13)	-0.016	(-0.13)
Technology Index x B22	-4.029	(-2.07)	0.314	(2.07)	6.717	(2.91)	0.194	(1.38)
Technology Index x B23	-4.477	(-2.31)	0.352	(2.33)	7.340	(3.19)	0.054	(0.42)
Technology Index x B24	-3.942	(-2.00)	0.302	(1.97)	6.410	(2.74)	0.058	(0.40)
Technology Index x B25	-4.210	(-2.21)	0.399	(2.68)	7.763	(3.43)	0.028	(0.24)
Technology Index x B26	-4.251	(-2.23)	0.313	(2.11)	6.346	(2.81)	0.230	(1.96)
Technology Index x B27	-3.549	(-1.81)	0.412	(2.69)	7.594	(3.26)	0.101	(0.81)
Technology Index x B28	-3.923	(-2.06)	0.385	(2.59)	7.169	(3.17)	0.083	(0.68)
Technology Index x B29	-3.731	(-1.92)	0.287	(1.89)	5.792	(2.51)	0.430	(3.01)
Technology Index x B30	-4.194	(-2.19)	0.398	(2.66)	7.594	(3.34)	-0.076	(-0.60)
Technology Index x B31	-3.820	(-2.03)	0.407	(2.77)	7.963	(3.56)	0.052	(0.42)
Technology Index x B32	-4.394	(-2.31)	0.414	(2.80)	7.765	(3.45)	0.199	(1.69)
Technology Index x B33	-3.747	(-2.00)	0.427	(2.92)	7.703	(3.46)	0.162	(1.29)
Technology Index x B34	-3.884	(-2.09)	0.358	(2.47)	7.092	(3.22)	0.093	(0.70)
Technology Index x B35	-4.253	(-2.17)	0.382	(2.50)	7.532	(3.24)	0.104	(0.81)
Technology Index x B36	-4.034	(-2.10)	0.379	(2.54)	7.415	(3.26)	0.129	(1.01)
Technology Index x B37	-4.045	(-2.12)	0.438	(2.95)	7.774	(3.44)	-0.154	(-1.21)
Technology Index x B38	-3.258	(-1.70)	0.302	(2.02)	6.046	(2.66)	-0.181	(-1.42)
Technology Index x B39	-4.170	(-2.18)	0.371	(2.49)	7.433	(3.28)	0.021	(0.18)
Technology Index x B40	-3.878	(-2.03)	0.393	(2.64)	7.383	(3.26)	0.065	(0.48)
Technology Index x B41	-3.645	(-1.91)	0.428	(2.87)	8.110	(3.58)	0.108	(0.40)
Technology Index x B42	-5.016	(-2.53)	0.398	(2.57)	8.400	(3.57)	-0.053	(-0.44)
Technology Index x B43	-3.389	(-1.77)	0.283	(1.90)	6.069	(2.68)	-0.113	(-0.47)
Technology Index x B44	-3.933	(-2.00)	0.361	(2.36)	7.422	(3.18)	0.144	(0.63)
Technology Index x B45	-3.808	(-1.97)	0.350	(2.33)	7.271	(3.17)	0.074	(0.38)
Technology Index x B46	-3.985	(-2.03)	0.324	(2.12)	6.647	(2.86)	0.064	(0.16)
Technology Index x B47	-3.831	(-1.98)	0.303	(2.01)	6.531	(2.85)	-0.102	(-0.31)
Technology Index x B48	-3.990	(-2.04)	0.327	(2.14)	6.821	(2.94)	-0.009	(-0.03)
Technology Index x B49	-4.337	(-2.26)	0.351	(2.35)	7.239	(3.18)	-0.009	(-0.03)
Technology Index x B50	-3.864	(-2.07)	0.335	(2.31)	6.264	(2.83)	0.204	(0.89)
Ln ECR	4.793	(2.02)	-0.385	(-2.09)	-6.948	(-2.47)	0.382	(4.00)

Ln CCR	-2.334 | (-1.40)	0.280 | (2.15)	3.087 | (1.56)	0.218 | (3.40)
Bank Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
R Square(within)	0.105	0.362	0.399	0.367
R Square (between)	0.997	0.999	0.999	0.023
R Square (overall)	0.256	0.654	0.579	0.013
Hausman Statistics	58.09	59.17	57.73	82.11
Observations (N)	429			

The Table 4 shows the panel model estimation results of PI, ROA, ROE, and NIM equations. In all Columns, instead of the composite technology index, three technology indicators (the log of ATMR, the log of POSR, and the log of NEFTR) directly enter. In the PI equation (Column 1), the log of NEFTR has a negative and significant impact while the other two indicators do not play a significant role in determining the PI. The log of NEFTR positively and significantly relate to both profitability indicators, ROA and ROE. Both the log of ATMR and the log of POSR are not statistically significant in both ROA and ROE. Further, none of the technology indicators are statistically significant in the NIM equation. The results of both employee expenses and capital expenses are more or less the same as in Table 2.

Table 4: Panel Model Estimation Results of Performance Equations (2011-12 to 2019-20)

	2-Way RE			2-Way FE
Variables	**PI (1)**	**ROA (2)**	**ROE (3)**	**NIM (4)**
Constant	41.264(2.06)	-4.335(-2.06)	-56.052(-1.88)	-2.018 (-1.81)
Ln ATMR	2.325 (1.02)	-0.025 (-0.12)	-1.017 (-0.33)	-0.019 (-0.18)
Ln POSR	-2.031 (-1.04)	0.257 (1.47)	3.008 (1.17)	0.150 (1.78)
Ln NEFTR	-3.432 (-2.99)	0.485 (4.16)	6.893 (4.14)	0.061 (1.02)
Ln ECR	1.448 (1.06)	-0.439 (-3.08)	-5.915 (-2.96)	0.411 (4.71)
Ln CCR	-1.522 (-1.18)	0.408 (3.36)	5.597 (3.16)	0.157 (2.64)
Bank Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
R Square(within)	0.091	0.355	0.391	0.241
R Square (between)	0.077	0.255	0.178	0.005
R Square (overall)	0.087	0.305	0.329	0.001
Hausman Statistics	6.08	9.3	10.64	69.21
Observations (N)	429	429	429	429

4. Conclusion

In this study, we have analyzed the effect of technology adoption on the financial performance of Indian banks as a whole and the effect of technology on the financial performance of individual banks, using an unbalanced panel data of 50 Indian banks during 2011-12 to 2019-20. We have used three technology indicators- the log of the amount of debit card transaction at ATM per transaction, the log of the amount of debit card transaction at POS per transaction, and the log of the amount of NEFT transaction per online transaction. All are in real terms. We have used three financial performance indicators, namely ROA, ROE, and Net interest margin. Then we have constructed the technology (composite) index and the performance index using the technology indicators and performance indicators respectively.

The panel model estimation results indicate that on average, the technology index has a negative and significant effect on the performance index of banks. However, it leads to significantly higher profitability (return on assets and return on equity) of Indian banks but does not play a role in determining the net interest margin of banks. The results also indicate that the NEFT has a negative and significant impact on performance index, and a positive and significant effect on ROA and ROE. But it has no effect on net interest margin. Both ATM and POS do not play a significant role in determining the performance index, ROA, ROE and NIM.

In 42 out of 50 banks, the technology index has a negative and significant effect on the performance index. In the remaining 8 banks also, its effect is negative, but the effect is statistically significant only at 10% level. In 46 banks, the technology index has a positive and significant impact on ROA, but in all 50 banks, its impact is positive and significant on ROE. However, the technology index has a positive and significant effect on NIM only in 3 banks, and a negative and significant effect in only 1 bank. Thus, as in past studies, the results vary in different indicators. The technology adoption index increases both profitability measures-ROA and ROE but does not affect the NIM. Its effect is negative on the performance index.

One possible explanation for the mixed results is that the net interest margin may not be a proper profitability indicator as some studies use this as the efficiency indicator. That is the reason why the technology does not play a role in determining it. It seems that the NEFT is the dominant factor in determining the profitability of banks. Since the composite technology index includes this dominant variable, it has similar impact on PI, ROA, ROE and NIM as the NEFT's effect directly on these variables. The use of Euclidean norm formula for constructing the composite index may pose the problem due to its limitations including that it considers equal weighting for all components. One may try other procedures like the principal component method to construct the index, which can use different weighting based on variations in the data and check the robustness of the results. Despite these issues, we hope that the findings of this study are useful for researchers, and other policy makers to design appropriate strategies to improve the performance of banks in India.

REFERENCES

Abubakar, A.A., & Tasman, R.B.H. (2013). The impact of information and communication technology on banks: performance and customer service delivery in the bankng industry. *International Journal of Latest Trends in Finance and Economics*,2(1), 80-90.

Alawneh, A., & Hattab, E. (2009). An empirical study of sources affecting e-business value creation in Jordanian banking services sector. *International Arab Journal of e-Techonolgy*, 1(2), 1-8.

Al-Smadi, M. O., & Al-Wabel, S.A. (2011). The impact of e-banking on the performance of Jordonian banks. *Journal of Internet Banking and Commerce*, 16 (2), 1–10.

Bansal, S. (2015). The impact of technology on the performance of Indian banking industry: an empirical study. Macro Research Project, Indian Institute of Banking.

Batterymarch, P. (2003). Productivity and information technology. *Management Science*, 40 (11), 1525–1535.

Beccalli, E. (2007). Does IT investments improve bank performance? evidence from Europe. *Journal of Banking and Finance*, 31, 2205–2230.

Chandrasekhar, M., & Sonar, R. (2008). Impact of information technology on the efficiency and total factor productivity of Indian banks. *South Asian Journal of Management*, 15 (3), 74–91.

Daoud, H.E., Torki, M., Fawwaz, A.I., &Yaser, A. (2016). The econometrics effect of information technology investment on financial performance in the Jordanian banking sector over the period 1993–2014. Research *Journal of Finance and Accounting*, 7 (8), 172–182.

Gichungu, Z.N., &Oloko, M.A. (2015). Relationship between bank innovations and financial performance of commercial banks in Kenya. *International Journal of Education and Research*, 3 (5), 443–456.

Gupta, S.D., Ajitava, R., & Sushil, K.H. (2018). Information technology and profitability: evidence from Indian banking sector. *International Journal of Emerging Markets*, 13 (5), 1070–1087.

Ho, S. J., & Mallick, S.K. (2010). The impact of information technology on the banking industry. *The Journal of the Operation Research Society*, 61 (20), 211–221.

Jun, S. (2006). The nexus between IT investment and banking performance in Korea. *Global Economic Review*, 35 (1), 67–96.

Leckson, L., Gideon, T.Y., Kofi A.O., & Simon, K. (2011). Investments in information technology (IT) and bank business performance in Ghana. *International Journal of Economics and Finance*, 3 (2), 133–142.

Licht, G., &Moch, D. (1999). Innovation and information technology in services. *Canadian Journal of Economics*, 32(2), 48-61.

Malhotra, P., & Singh, B. (2004). Status of internet banking in India. *Management Accountant*, 39 (11), 890-96.

Malhotra, P., & Singh, B. (2009). The impact of internet banking on bank performance and risk: the Indian experience. *Eurasian Journal of Business and Economics*, 2 (4), 43–62.

Mittal, R. K., & Dhingra, S. (2007) Assessing the impact of computerization on productivity and profitability of Indian banks. *Delhi Business Review*, 8 (1), 63–73.

Navarrete, C. J., & Pick, J.B. (2002). Information technology expenditure and industry performance: the case of the Mexican banking industry. *Journal of Global Information Technology Management*, 5 (2), 7–28.

Oluwagbemi, O., Abah, J., Achimugu, P. (2011). The impact of information technology in Nigera's banking industry. *Journal of Computer Science and Engineering*, 7(2), 63-67.

Ovia, J. (2005). Enhancing the efficiency of the Nigerian payment system. *Central Bank of Nigeria Bulletin*, 29 (1), 8–18.

Oyewole, O.S., Abba, M., & El-Maude, J.G. (2013). E-banking and bank performance: evidence from Nigeria. *International Journal of Scientific Engineering and Technology*, 2(8), 766-771.

Porteous, D., &Hazelhurst, E. (2004). Banking on change: democratizing finance in South Africa, 1994-2004 and beyond. Cape Town: Double Story Books.

Prasad, B., & Harker, P. (1997). Examining the contribution of information technology towards productivity and profitability in U.S. retail banking. Wharton School, University of Pennsylvani. R.D.

Rashid, S.M. (2018). Impact of information technology (IT) investment on banks' performance: a study on Dhaka stock exchange (DSE) listed banks of Bangladesh. *Journal of Information Engineering and Applications*, 8 (2), 8–12.

Safari, M.R, & Yu, L.Z. (2014). Impact of information and communication technology (ICT) on efficiency: evidence from the Iranian banking industry. *World Applied Sciences Journal*, 29 (2), 208–218.

Shanmugam, K.R., & Das, A. (2004). Efficiency of Indian commercial banks during the reform period. *Applied Financial Economics*, 14, 681–686.

Shanmugam, K.R., & Rakesh, N. (2020). Impact of technology on the financial performance of Indian commercial banks: a clustering based approach. *Innovation and Development*, 10(3), 433-449.

Victor, O.I., Henry, E.O., &Echekoba, F.N. (2015). The effect of information communication technology and financial innovation on performance on Nigerian commercial banks (2001–2013). *European Journal of Business and Management*, 7 (22),162–171.

Appendix: List of Banks

Sl.No.	Banks	Group	Sl.No.	Banks	Group
1	BARCLAYS BANK	FB	26	CATHOLIC SYRIAN BANK LTD	PB
2	CITIBANK	FB	27	CITY UNION BANK LIMITED	PB
3	DBS BANK INDIA LTD.	FB	28	DCB BANK LIMITED	PB
4	DEUTSCHE BANK AG	FB	29	DHANLAXMI BANK	PB
5	HONGKONG AND SHANGHAI BANKING CORPN.LTD.	FB	30	FEDERAL BANK	PB
6	STANDARD CHARTERED BANK	FB	31	HDFC BANK	PB
7	ALLAHABAD BANK	NB	32	ICICI BANK	PB
8	ANDHRA BANK	NB	33	INDUSIND BANK	PB
9	BANK OF BARODA	NB	34	JAMMU & KASHMIR BANK LTD	PB
10	BANK OF INDIA	NB	35	KARNATAKA BANK LTD	PB
11	BANK OF MAHARASHTRA	NB	36	KARUR VYSYA BANK	PB
12	CANARA BANK	NB	37	KOTAK MAHINDRA BANK LTD	PB
13	CENTRAL BANK OF INDIA	NB	38	LAKSHMI VILAS BANK	PB
14	CORPORATION BANK	NB	39	SOUTH INDIAN BANK	PB
15	IDBI BANK LIMITED	NB	40	TAMILNAD MERCANTILE BANK	PB
16	INDIAN BANK	NB	41	YES BANK LTD.	PB
17	INDIAN OVERSEAS BANK	NB	42	STATE BANK OF INDIA	SBI
18	ORIENTAL BANK OF COMMERCE	NB	43	DENA BANK	NB
19	PUNJAB AND SIND BANK	NB	44	STATE BANK OF BIKANER AND JAIPUR	SBI
20	PUNJAB NATIONAL BANK	NB	45	STATE BANK OF HYDERABAD	SBI
21	SYNDICATE BANK	NB	46	STATE BANK OF MYSORE	SBI
22	UCO BANK	NB	47	STATE BANK OF PATIALA	SBI
23	UNION BANK OF INDIA	NB	48	STATE BANK OF TRAVANCORE	SBI
24	UNITED BANK OF INDIA	NB	49	VIJAYA BANK	NB
25	AXIS BANK LIMITED	PB	50	ROYAL BANK OF SCOTLAND	FB