The Journal of Asia Entrepreneurship and Sustainability RESEARCH ARTICLE

Digital Financial Inclusion and Bank Profitability: A Recent Analytical Study on Indian Banking System

Dr. Soumen Mukherjee[1], Ritwik Dutta[2*]

[1]Professor and Dean, School of Health Sciences and School of Skill Education, The Neotia University, Sarisha, Diamond Harbour Road, South 24 Parganas, West Bengal, India, Email: soumen.mukherjee@tnu.in, ORCID Id: 0000-0001-7239-0536

[2*]PhD Research Scholar, School of Humanities, Management, and Social Sciences, The Neotia University, Sarisha, Diamond Harbour Road, South 24 Parganas, West Bengal, India, Email: rd@tnu.in, ORCID Id: 0009-0003-6680-8475

Abstract

In modern India, high speed internet connectivity, and penetration of mobile network coverage in almost every corner of the nation have majorly contributed to rapid digitalization of the fundamental banking and financial services and activities. It has remarkably accelerated the progress of digital financial inclusion (DFI) in the country. DFI refers to the affordable provision of banking and financial services to the underserved, remote and economically poor section of the population through use of digital technologies such as mobile phones, internet, and other technical devices. Aside from the user or customer centric importance of DFI, it can also become a highly crucial resource or tool for the banks and financial institutions to enhance or improve their economic performance or profitability. This would expectedly strengthen the stability and efficiency of the entire banking and financial system which is one of the prerequisites to ensure long term economic growth and development of any nation. Based on this premise, this paper primarily aims at estimating the impact of the components of DFI on bank profitability by using the most recent monthly panel data on a sample of 10 different private and public banks in India from 2021 to 2025. The study employs Pooled OLS Regression Method (PORM) to measure the overall or general impact of DFI on bank profitability. To examine the effect of DFI components on bank profitability for each specific bank over the study timeline, Hausman Taylor Panel Data Analysis (HPTDA) method has been used. The independent variable or bank profitability in the study is represented by Return on Asset (ROA) of the sample banks. The independent variables or DFI components selected in the study include number of online credit card transaction for each bank, number of mobile money transactions for each bank, total number of ATMs established by each bank, total number of POS terminals installed by each bank, whether the selected banks offer RuPay card services or otherwise, and volume of UPI or Unified Payment Interface transactions per bank for each month from 2021 to 2025. The findings of the study indicate that from a general standpoint, online credit card transactions for each bank, mobile money transactions each bank, number of POS terminals installed by each bank, and banks offering RuPay card services have a significantly positive impact on bank profitability or ROA. Conversely, number of ATMs for each bank and volume of UPI transactions for each bank exhibit negative association with bank profitability or ROA. Bank specific study on the effect of DFI on bank profitability implies that mobile money transaction for each sample bank and the number of POS terminals set up by each bank have a significantly positive impact on ROA or profitability of any given bank in the study sample. Whereas, number of ATMs of each bank, volume of UPI transactions for each bank, and number of online credit card transactions for each bank show a negative effect on bank profitability or ROA. These findings essentially construe certain organizational policy implications for individual bank managers and policymakers to enhance profitability and improve economic performance of respective banks which are elaborately discussed in this paper.

Keywords: Digital Financial Inclusion, Bank Profitability, Indian Banking and Financial System, Digitalization, Unified Payment Interface, Hausman Taylor Panel Data Analysis

JEL Classification: G21, O33, C23

1. Introduction

1.1 Background and Context

The tremendous rise in digital financial and banking services has notably facilitated the consolidation of the overall financial inclusion in India over the last decade. With better internet connectivity and penetration of mobile network coverage across the country, digital financial inclusion has finally reached the rural fringes which previously remained as one of the most financially excluded regions in the country. Digital financial services and online banking facilities are now provided by almost all the public sector and private commercial banks which have enabled the customers or users all over the country to enjoy a much faster, convenient, and remote banking and financial facilities and services. Furthermore, this has

also ensured an influx of many new users or customers into the banking system and strengthened the accessibility dimension of financial inclusion. However, it is also crucial to consider the possible impacts of the digitalization of the entire banking system on the commercial and economic performance of the individual banks and financial institutions as the stability and efficiency of financial and banking system is absolutely imperative for the overall socio-economic growth and progress of any nation. In other words, digital financial inclusion (DFI) is essential for banking stability and efficiency through its involvement in determining individual and overall bank profitability. DFI generally refers to the penetration of digital banking and financial services to the financially excluded and deprived section of the population through usage of mobile phones or any kind of technical devices to enhance the accessibility of digital financial and banking products and services to the financially underserved people (Ozili, 2018) (Shen, Hueng & Hu, 2019).

1.2 Growth of Digital Banking and Dimensions of Digital Financial Inclusion in India

The advent and rapid proliferation of Information Communication Technology (ICT) in the banking sector have pervasively contributed to a deeper entrenchment of DFI. It has not only digitalized the major banking and financial practices conducted by both banks and the customers but revolutionized the entire banking and financial system by completely shifting away from the conventional banking operations. With the help of numerous RBI policies and modifications in the digital technologies and banking infrastructure, both private and public sector banks have rapidly adopted to various digital banking modes to retain as well as expand their respective market shares. This ideally means that the banks would be able to increase their liquidity inflow through higher customer deposits, interest payments on loans and credits, maturing assets and loan repayments (Azmi, Akhtar, & Nadim, 2020). On the other hand, deeper penetration of internet services into the remotest corners of the country has allowed the customers to enjoy the benefits and conveniences of DFI to the maximum capacity possible. Almost all the banks and financial institutions now increasingly offer various digital banking services such as ATM cards, mobile banking, credit and debit cards, Rupay card services, retail Point of Sale (POS) terminals, Unified Payment Interface (UPI) facilities etc. which constitute the various components of DFI (Ozili, 2022). Hence, the customers across the nation are now able to perform most of the financial and banking activities and transactions through online or digital mode without having to visit physical bank branches leading to lower workload for bank employees and reduced usage of bank's physical assets (Malhotra and Singh, 2006). Therefore, higher consolidation of DFI components through digitalization of banking services and internet penetration has expectedly contributed to improved bank performance.

1.3 Bank Efficiency or Profitability Paradox?

Progressive involvement of digital technology and spread of DFI in the national banking system would expectedly enhance bank profitability due to reduced cost of employees, lower dependence on bank resources and physical infrastructure, better accessibility of financial services, transformed banking activities, and higher competition in the banking industry (Adrian, 2025) (Parmar, 2025). However, concerns remain with regards to imprudent investment on advanced technologies by the banks which might lead to monetary loss, service inefficiency and increased operational cost actually causing profitability loss, a phenomenon known as Profitability Paradox (Singhal and Jain, 2023). Although, increasing adoption of digitalization may facilitate revenue generation, new customer acquisition and cost reduction, it can also imply higher initial investment on digital technologies, maintenance and operational cost of the digital resources, frequent and unpredictable service interruptions for customers, repairment cost and so forth thereby raising the overall business cost of the banks and offsetting the profitability gains due to digital transformation (Abedin & Dawan, 2016) (Al-Aazawwi & Altmimi, 2015).

Based on these empirical contentions, this paper intends to investigate the impact of digital financial inclusion on the profitability of a combination of 10 selected private and public commercial banks in India by using monthly panel data from 2021 to 2025. The research aims to test the notion of profitability paradox or in other words, whether imprudent and inefficient technological investment and operation by banks actually nullify the expected profitability gain due to the expansion of digital financial services in the context of Indian banking sector. To achieve this objective, the present study mainly emphasizes on two specific research questions: -

i)What is the overall or general impact of digital financial inclusion on bank profitability with respect to all the 10 banks selected for the study?

ii)What is the effect of digital financial inclusion on bank profitability specific to each bank or within the individual banks chosen for the study?

The first research question aims to outline the general or comprehensive impact of the different components of DFI on the bank profitability or performance without considering any bank specific variation in profitability at an individual level. Whereas, the latter seeks to examine the factors or components of DFI

that cause variation in profitability for each single bank or within the bank variability in profit over a certain period of time.

II.LITERATURE REVIEW

Several studies in the past have examined the empirical connection between DFI or technological digitalization of financial and banking services and bank profitability around the world and uncovered insightful findings. The literature review section of this paper is divided into two sub-sections. The first sub-section explores the relevant studies conducted on other countries aside from India and the other presents studies that are exclusively based on the Indian context.

2.1 DFI and Bank Profitability in Other Countries

The issue of technological transformation of the financial and banking system and bank profitability trends has attracted the attention of many researchers across the world. Aziz et al (2024) evaluated the empirical relationship between DFI and bank performance in developing countries which involve a cluster of 111 different countries from 2016 to 2020. The study captured both the access and usage dimensions of DFI and concluded a significantly positive association between DFI and bank profitability in the concerned countries. In a similar line of argument, increasing usage of financial technology or fintech has been influential in strengthening the financial inclusion (FI) indicators. Various tools of fintech have evidently reinforced FI indicators and have a significant positive effect on various profitability indicators such as Return on Asset (ROA), Return on Earnings (ROE) and earnings per share (Al Shehadeh & Al Khawaja, 2022). In a study examining the empirical connection between DFI and bank profitability on commercial banks in China from 2012 to 2021, Zhao et al (2024) contends that DFI and profitability have conjointly increased exhibiting a strong positive correlation across the Chinese provinces considered in the estimation. During the same time period, DFI and bank competition have a positive impact on bank stability in Sub-Saharan African countries through profitability boost (Chinoda & Kapingura, 2023). In a study evaluating the impact of digital banking channels on the profitability of 10 different money deposit banks in Nigeria, Owoloja et al (2020) found a crucial and positive effect of ATM, mobile banking, internet banking, unstructured supplementary service data and POS terminals have a crucial and positive impact on bank profit. In this regard, DFI also played an instrumental role in promoting and maintaining bank stability during COVID period or 2016 to 2020 for 65 Islamic banks spreading across 6 different countries (Banna et al, 2021).

However, several studies have also highlighted the angle of profitability paradox and the challenges that remain in the adoption and effective maintenance of digital technologies in the banking domain. Bett & Bogonko (2017) used a survey data of 261 respondents and conducted a multiple regression analysis to determine the relationship between online banking and bank performance indicated by bank ROA in Kenya. The study revealed a negative impact of some of the indicators of online banking such as usage of online banking applications for financial activities, NEFT, RTGS, and adoption of Equitel information system on net banking on bank profitability in Kenya. This essentially implies the adversities faced by both banks and customers in the adoption of ICT related banking and financial services and maintenance inefficiencies due to persistent downtime of the digital banking tools and apps deployed by the banks. The banks not only have to confront higher maintenance cost of its digital resources but the country faces much bigger impediment due to slower adoption rate of internet banking and fintech. In a study conducted on 19 different commercial banks in Sweden from 2007 to 2022, the magnitude of the impact of internet banking on bank profitability is contingent on the age group of the customers using net banking (Edin, Limaei & Yazdanfar, 2025). The authors of the study employed both Ordinary Least Square (OLS) and Fixed Effect (FE) Panel Data Regression model to analyse the possible connection between internet banking and bank profitability and interestingly found that on the contrary to popular perception, the intensity of the relationship is relatively much higher for the older customers in comparison to their younger counterparts thereby advocating that younger and tech-savvy customers are not always contributors of digital value added in banking. Banna (2020) examines the role of DFI on banking stability in Bangladesh from 2011 to 2018 and reveals a negative effect of DFI on bank stability in the country within the time period of the study. A separate DFI index has been constructed by incorporating 6 various components of DFI as an independent variable in the study which exhibited a negative impact on bank stability. It possibly demonstrates the nascent stage of digital finance in Bangladesh and would take some time further to consolidate.

A similar study conducted by Abusharbeh (2023) on 6 selected commercial banks in Palestine from 2015 to 2020 revealed a significantly negative relationship between investment in hardware and software of digital resources by banks and bank profitability. Nevertheless, number of ATMs installed by selected banks has a positive impact on profitability. Setaiwan & Prakoso (2024) aims to investigate the impact of digital banking adoption and bank performance in Indonesia based on 30 listed commercial banks during the time period 2013 to 2022 and found a negative impact of digital banking adoption on ROA of the

selected banks. However, the intensity of this negative relationship is reduced by the independent variable bank size indicating that increasing bank size contributes to weakening of the negative effect of digital banking adoption on the bank ROA.

2.2 DFI and Bank Profitability in India

In the context of Indian banking industry, comparatively fewer studies have emphasized on the empirical connection between DFI and digital banking on bank stability or bank profitability. Roy & Thangaraj (2020) estimated the impact of technology investment by a combination of 34 public and private commercial banks in India from 2003 to 2018 by using panel data analysis. The study results reveal a strong positive effect of technology investment by the banks on profitability but the impact is much stronger for the private sector banks in comparison with the public banks selected for the study. The research documents a sharp divide between private and public banks in the consequences of technology investment on bank performance. The evolution of fintech and digital technology in the banking sector has contributed to a periodic change in the profitability trends mainly in the form of higher internet penetration and digital payment in the banking and financial sector. Such occurrence can be empirically attributed to certain changes in the behaviour of the Indian financial sector (Painoli, Dhinkaran & Vijai, 2021). A significantly positive impact of fintech implementations by Indian banks on their profitability level has also been advocated by Singh, Malik & Jain (2021). The study attempts to evaluate the impact of fintech adoption on ROA and ROE of the concerned banks. In this instance, fintech adoption has been represented by variable fintech dummy which encompasses blockchain, artificial intelligence or AI, cloud computing, payment technology, and robotic process automation. Trivedi & Ali (2025) investigates the influence of DFI on the bank profitability in India from 2017 to 2023 based on a sample of few public sector banks. The results contend a strong positive correlation between certain components of DFI such as number of ATMs nationwide, digital banking transaction volume, and number of mobile banking apps for each bank and bank ROA. Puri et al. (2023) also reports a significantly positive impact of National Electronic Fund Tranfer (NEFT) and Real Time Gross Settlement (RTGS) on bank profitability based on a study conducted on selected commercial banks in India from 2011 to 2020. As an estimation of the association between fintech adoption and profitability of rural banks in India, Yadav et al. (2025) finds contribution of fintech adoption to operational efficiency of rural banks in the nation. With the rapid expansion of fintech banking facilities, the rural banks are now available to access a much greater consumer base by transcending geographical and infrastructural boundaries and improve profitability and liquidity situation in the process. Comprehensive usage of mobile banking, digital wallets and various microcredit services offered by different private and public sector banks to the rural population of the country have played a pivotal role in enhancing the accessibility dimension of DFI and betterment of bank profitability. Therefore, in last a strong and positive connection between DFI and bank profitability has been essential for rural banks and cooperatives in India to tap into untouched customer bases and generate innovative revenue streams which can consequently drive higher profitability (Sarma & Pais, 2011).

Few studies have also documented negative empirical relationship between DFI and bank profitability in India. Cross-country evidences indicate that digital lending or credit facilities through digital banking has adversely affected banking stability and performance efficiency of the banks (Dutta, Bana & Sanyal, 2026). Similarly, Motwani & Vora (2021) uncovers a significantly negative impact of internet banking on bank profitability attributable to the networking effect of mobile banking. The study focuses on a cluster of 10 banks including both private and public sector banks conducted over a period of 10 years from 2008 to 2018 using yearly data. To measure the empirical linkage between IT expenditure and bank profitability on 13 selected commercial banks from 2006 to 2013, Gupta, Roychaudhury & Haldar (2018) confirms profitability paradox in the Indian banking sector by finding a negative effect of IT or Information Technology expenditure by selected banks on their ROA. In recent years, ICT based banking services have led to negative financial productivity trends among both private and public sector banks thereby reaffirming the productivity paradox notion in the Indian context (Sharma, 2011). The negative effect of DFI on bank profitability has also been registered by Sathye & Sathye (2016) as reflected by a significantly negative connection between ATM intensity by banks and their commercial performance. This evidently suggests that banks and financial institutions need to be circumspect concerning any decision on digital banking investment.

III.RESEARCH NOVELTY

Owing much to the previous literature on the concerned topic, based on both global and Indian context, this paper intends to assess the overall or general effect of DFI components on bank profitability. However, as an empirical extension of most of the previous studies, the present research also emphasizes on estimating specific bank-based fluctuations in profitability that can be statistically attributed to some or all the DFI components included in the study. This can be used as a micro-level comparative analysis on individual bank performance

in the modern era of digital finance and banking thereby possibly highlighting some policy implications for bank managers and other institutional policymakers and stakeholder concerning each individual bank. Furthermore, majority of studies have considered pre-Covid and during the Covid time period and unveiled important derivations for further research in future. This paper uses the most recent data on all the relevant variables until the month of December in 2025 which predominantly covers the post-Covid situation.

Although, the selection of independent variables in the current study is driven by the author's selection in previous studies, the inclusion of UPI transactions per bank in the current study is expected to yield some insightful and interesting results in the context of post-Covid bank performance in India. The intensity of UPI based payments and transactions has momentously increased among both individuals and businesses all over the country in the last 5 to 6 years. Various initiatives have been implemented under the PMJDY to further proliferate digital financial inclusion efforts in the entire nation mainly through promoting cashless digital payment system for both individual and commercial transactions. Since its inception in 2016 by NPCI, UPI has acted as a real time instant payment interface that facilitates a comprehensive digital payment system network in India with the primary intention of establishing a cashless digital economy (Goerge & Goerge,2023). All the private and public sector banks included in the present study support UPI transaction through numerous UPI portals such as Phone pay, Google pay, Paytm, Navi etc. and is instrumental in consolidation of DFI in modern India.

IV.RESEARCH OBJECTIVES

As an extension of the previous studies conducted on the empirical linkage between DFI and bank performance, this paper seeks to identify some of the individual components of DFI that can cause variation in bank profitability in India by using the most recent monthly panel data from 2021 to 2025. Hence, the study employs individual monthly data points for each year for the entire 5 years of study period. In this pursuit, the present research aims to analyse the empirical impact of DFI on bank profitability from two distinct perspectives. First, to find out the general or comprehensive effect of DFI on the overall bank profitability variation during the entire period considered in the study regardless of the profitability variation across individual banks. Secondly, to observe the involvement of DFI in determining individual bank specific variation in profitability or how profitability varies for each individual bank in the sample due to DFI components over the time span of the study. Therefore, the concerned study attempts to answer the following two research questions: -

i)What is the impact of DFI components on the overall or general monthly variation in bank profitability in India from 2021 to 2025?

ii)How do DFI components influence monthly variation in profitability limited to or focusing on each individual bank in India from 2021 to 2025?

The potential findings of the study could reveal certain important policy implications and open avenues for future research on the concerned subject area which will be discussed in further details.

V.RESEARCH METHODOLOGY

5.1 Data Source, Sample Size, and Study Period

This paper employs possibly the most recent monthly panel data on 6 different components of DFI and ROA of 10 different private and public sector banks in India as profitability indicator during the last 5 years from 2021 to 2025. All the relevant data on DFI components have been collected from the online database of National Payment Corporation of India (NPCI) and the quarterly data on ROA of the sample of 10 banks for each year has been extracted from RBI Database on Indian Economy. The sample banks selected in the study represent the top 10 ranked banks in the market capitalization rate as of March 2026. These banks include HDFC bank, State Bank of India (SBI), ICICI bank, Axis Bank, Kotak Mahindra Bank, Bank of Baroda, Punjab National Bank (PNB), IDBI Bank, Bank of India (BOI), and IndusInd Bank. Out of these banks, SBI, PNB, Bank of Baroda, PNB, and BOI represent public sector banks and the rest are private banks.

5.2 Variable Description

Owing to the literature review, the dependent variable, or the profitability indicator of the sample banks in the study is selected as ROA of each bank for the duration of the study. The independent or the explanatory variables in the study include mobile money transactions for each bank (MT), total number of ATMs of each bank(ATM), number of online credit card transactions for each bank (CC), total number of POS terminal set up by individual banks(POS), total number of UPI transactions of each bank (UPI), and whether the selected banks accommodate RuPay credit card and debit card payments online (RuPay Dummy).

The RuPay dummy variable denotes the value of 0 if the bank offers RuPay credit and debit card to its customers and 1 if it does not. RuPay card services have been officially launched in 2012 by NPCI which is hailed as the first domestic card payment system of India as counterpart to the international payment interfaces such as Visa and Mastercard. It ideally enables the customers to conduct low cost and convenient financial transactions through online bank apps, e-wallet, POS terminals, ATMs, and almost all the UPI platforms such as Google Pay, Phonepay, BHIM etc. Essentially, RuPay card services were issued by NPCI

as part of the Pradhan Mantri Jan Dhan Yojana (PMJDY) which is one of the major policy initiatives undertaken by Government of India to promote and strengthen DFI in the country (Goerge & Goerge, 2023). The symbol and description of independent and dependent variables are provided below in Table-1.

Table-1. Symbol and Description of Variables

Independent Variables Related to DFI Symbol	Variable Description
MT	Number of mobile money transactions for each bank
ATM	Total number of ATM machines set up by each bank
CC	Total number of online credit card transactions for each bank
POS	Total number of POS terminals installed by each bank
UPI	Total number of UPI transactions under each bank
RuPay Dummy	Dummy variable denoting whether the banks offer RuPay card services
Dependent Variable Symbol	Variable Description
ROA	Return on Asset of each bank representing individual bank profitability

5.3Research Method

To measure the overall or general impact of DFI on monthly bank profitability variation Pooled OLS Regression Method (PORM) has been employed which is intended to provide a comprehensive explanation on the empirical association between DFI components and bank profitability within the duration of the study. It excludes any bank specific variation in profitability or ROA across considered in the study. The analysis has been conducted by using Stata software version 17.

On the other hand, Hausman Taylor Panel Data Analysis (HTPDA) is employed to measure the variation in profitability within each individual bank attributable to DFI components. To amend for possible heteroskedasticity error in the model, Robust Standard Error HTPDA Regression Model has been used which adjusts the standard errors to be consistent in the model and corrects for heteroskedasticity. HTPDA method also automatically rectifies any endogeneity problem that might be present in the model. The proposed model specification is presented below:

$$ROA_{it} = \alpha + \beta_1 MT_{it} + \beta_2 ATM_{it} + \beta_3 CC_{it} + \beta_4 POS_{it} + \beta_5 UPI_{it} + \beta_6 RuPayDummy_{it} + \varepsilon_{it}$$

Where,

ROAit=Return on Asset of bank i in month t

MTit=Number of mobile money transactions for each bank i in month t

ATMit=Number of ATM machines set up by each bank i in month t

CCit= Total number of credit card transactions online for each bank i in month t

POSit=Total number of POS terminals installed by each bank i in month t

UPIit=Total number of UPI transactions for each bank i month t

RuPay Dummy=Dummy variable showing whether each bank i offers RuPay card services in month t with "0" being yes and "1" denoting no.

α denotes the intercept term in the model

εit represents the error term in the model

To check for multicollinearity among the explanatory or independent variables in the model which represent the DFI components, Variance Inflation Factor or VIF test has been performed and the results of the same are reported in Table-2.

Table-2: Results of VIF test

Variables	VIF	1/VIF
POS	7.79	0.128371
UPI	7.12	0.140416
MT	6.72	0.148731
CC	6.06	0.165058
ATM	2.85	0.350781
RuPay Dummy	1.41	0.710018
Mean VIF	5.33	

Based on the results of the VIF test presented in Table-2, all the independent variables in the model exhibit a VIF value less than 10 which is the rule of thumb or maximum threshold for rejecting multicollinearity. Now, following O Brien (2007), since the VIF values of all the independent variable are within the acceptable rule of thumb value of 10, the model can be considered to be acceptable.

5.4Model Justification

The PORM treats the entire panel data as a cross-sectional dataset and examines the overall or general effect of the independent variables on the dependent variable regardless of the individual specific impacts which are determined by Fixed Effect or Random Effect Panel Data Regression Model. With regards to the present study, PORM is intended to provide a comprehensive empirical impact of the individual DFI components on bank ROA by using monthly panel data from 2021 to 2025 with all the 10 sample banks combined irrespective of individual bank specific effects.

To examine the bank specific variation of ROA due to DFI components, the study employs HTPDA which would reveal the effect of DFI components on bank profitability or ROA that is specific to each individual bank or within each particular bank. The same objective could be achieved by using Fixed Effect Panel Data Regression and to test the appropriateness between Fixed Effect Regression and HTPDA in this context, Hausman test has been conducted. The results of the test have been presented in Table-3. The test registers a p-value of 0.1238 which is greater than the minimum threshold p-value of 0.05 concluding that HTPDA could be preferred over Fixed Effect Panel Data Regression. Therefore, the null hypothesis that HTPDA estimators are valid and consistent compared to Fixed Effect model cannot be rejected.

A comparative test of model validity has also been performed on Fixed Effect and Random Effect Panel Data Regression Model by running Hausman test. Again, a p-value of 0.000 or less than 0.05 contends that Random Effect Panel Data Regression Model is also ideally not the most appropriate model in this instance. Furthermore, since the current study uses a dummy variable which is time invariant or remains constant over the entire time period of the study, HTPDA is relatively more effective to capture the between the bank effect of RuPay Dummy variable on bank ROA compared to Fixed Effect model. HTPDA also resolves any endogeneity issue in the model as multiple endogenous independent variables are suspected such as MT, ATM, POS, UPI. Both Random and Fixed Effect models assume that there is no endogeneity among independent variables or they are uncorrelated with individual specific error terms (Baltagi, Bresson & Pirotte, 2003).

Table-3: Results of Hausman Test Comparing FE Model and HTPDA

	Coefficients			
Variables	**FE Model**	**HTPDA**	**Difference**	**Standard Error**
MT	3.25e-10	3.12e-10	1.26e-11	5.97e-12
ATM	-.0001262	-.0001151	-.0000111	5.42e-06
CC	-1.88e-08	-1.74e-08	-1.37e-09	6.65e-10
POS	4.14e-07	4.09e-07	4.47e-09	
UPI	-4.44e-10	-4.26e-10	-1.77e-11	8.01e-12
Chi Square	4.18			
Prob>Chi Square(P-value)	0.1238			

5.5Study Hypothesis

The alternate hypotheses of the current study have been presented below based on the proposed objectives of the study: -

H1: Number of mobile money transactions has a significant impact on the ROA of selected banks

H2: Number of ATM machines set up by the banks has a significant impact on the ROA of the selected banks

H3: Number of online credit card transactions for each bank has a significant impact on the ROA of selected banks
H4: Total number of POS terminals installed by each bank has a significant impact on the ROA of selected banks
H5: Total number of UPI transactions per bank has a significant impact on the ROA of selected banks
H6: RuPay credit card services issuance by banks has a significant impact on the ROA of selected banks

VI.RESULTS

6.1 Descriptive Statistics

The descriptive statistics of all the variables has been presented in Table-4 which includes the mean or average, standard deviation, and the range of the values of respective variables. The mean values denote the measure of central tendency, standard deviation is the measure of the dispersion, and the difference between the minimum and maximum values of each variable represents the measure of range for each variable. The total number of observations or data points used in the study is 600 which has been calculated as Sample Size of banks*Total Number of Months= (10*60). The details of the descriptive statistics essentially provide the diverse characteristics of the sample banks and can be conceived as a parameter to comprehend the differing nature of private and public banks in terms of economic performance and the status of various DFI components within the last 5 years.

Table-4: Descriptive Statistics of Variables

Variable	Observations	Mean	Standard Deviation	Min	Max
ROA	600	1.3426	.7116556	-.33	4.22
MT	600	6.65e+08	8.71e+08	2000503	5.35e+09
RuPay Dummy	600	.3	.4586399	0	1
ATM	600	15524.2	17169.51	2574	65796
CC	600	1.45e+07	1.78e+07	41477	7.49e+07
POS	600	591509.7	703758.6	13015	2465861
UPI	600	3.91e+08	4.47e+08	1.33e+07	2.31e+09

As reported by Table-4, number of ATMs countrywide has a significantly high range with a minimum of 2574 and a maximum of 65796 indicating a significant variability in the number of offsite and onsite ATMs among the banks. The measure of dispersion or standard deviation is also quite significant for number of ATMs for each bank. There is also a considerable volatility in the range of POS terminals installed by the banks as the minimum number of POS terminals is 13015 and the maximum number of POS by any bank is 2465861 with a higher standard deviation or dispersion as well. This ideally signifies the difference in the amount of investment on digital banking by individual banks and between private and public banks on various DIF components such as POS terminals and ATM establishment. Moreover, as a measure of range and dispersion, the total volume of online credit card transactions for each bank also varies notably with a variability in the number of digital or online credit card payments and remittance among individual banks reflecting the lack of uniformity among the users or customers of credit card from different private and public banks. It might also be possible that sale of credit card also varies considerably across individual banks as the customer preference regarding financial products is practically contingent on brand reputation and visibility of the issuing bank, card policies and additional benefits, and financial risk factors.

6.2 Overall Impact of DFI on Bank Profitability

The results of the Pooled OLS Regression Model have been presented in Table-5. The dependent variable in the model is the monthly ROA of 10 private and public banks selected for the study. The model shows the results concerning the general effect of DFI components on bank profitability or ROA of the sample banks from 2021 to 2025. First, as shown by Table-4, the adjusted R square value of the model has been reported as 0.2904 implying that the overall goodness of fit of the model is around 29% to 30%. In other words, the entire model explains almost 29% to 30% of the overall variation in the monthly ROA of all the 10 banks selected for the study from 2021 to 2025. The total number of observations or datapoints in the model is 600 which is denoted as N in the table.
The level of significance or the p-value in Table-5 has been used for hypothesis tests to check whether we can accept or fail to reject the alternate hypothesis for all the independent variables or otherwise. The alternate hypothesis for all the independent variables states that each independent variable has a significant impact on bank ROA or profitability and null hypothesis states the otherwise. The p-values corresponding to all the independent variables are statistically significant meaning $p<0.01$, $p<0.05$, and $p<0.10$ as reported in Table-5. The predictive variables with $p<0.01$, $p<0.05$ and $p<0.10$ are

statistically significant at 1%, 5%, and 10% respectively. Hence, the alternate hypothesis can be accepted for all the independent variables. All the explanatory variables MT, RuPay Dummy, ATM, CC, POS, and UPI have a statistically significant impact on ROA or bank profitability based on all the 10 sample banks combined as the OLS regression coefficients denote the overall or general influence of DFI components on bank ROA over the entire duration of the study.

The independent variables that are significant at 1% or $p<0.01$ include MT or number of mobile money transactions for each bank, RuPay Dummy or whether the banks offer RuPay card services or not, total number of ATMs established by the individual banks or ATM, and POS or point of sale terminals installed by banks. Among these variables, MT and POS exhibit a positive association or effect on ROA of the banks within the study period. Variables showing negative relationship with or impact on bank ROA are RuPay Dummy variable and ATM. Now, the independent variables with 5% significance level or $p<0.05$ are CC and UPI. Interestingly, the relationship between UPI and bank ROA is negative implying a negative or inverse impact of UPI on bank profitability. CC exhibits a positive association with bank ROA having a positive effect on ROA or bank profitability.

With regards to the coefficient values of the respective independent variables, the coefficient of MT has been computed as 2.69e-10 signifying as the number of mobile money transactions for all banks combined increases by 1 the bank ROA rises by approximately 2.69e-10. There is a difference in bank ROA of almost .373 between the banks that are offering RuPay card services and the ones that have discontinued offering or does not offer. This essentially indicates that by offering the services the banks can augment their profitability or ROA by nearly .37 as opposed to not doing so. As the number of ATMs in the country increases by 1 the bank ROA decreases but by a negligible margin of .0000244 roughly. Increase in online credit card transaction by 1 is associated with an increase in bank ROA by 7.52e-09. The bank ROA tends to rise by 2.90e-07 as the banks install one more POS terminal all across the nation and lastly, with each UPI transaction the bank ROA decreases by nearly 3.75e-10.

Table-5: Results of the Pooled OLS Regression Model

Independent Variables	Regression Coefficients	Standard Error	't' Statistics	Level of Significance(p-value)
MT	2.69e-10***	7.29e-10	3.69	0.000
RuPay Dummy	-.3731585***	.063379	-5.89	0.000
ATM	-.0000244***	2.41e-06	-10.13	0.000
CC	7.52e-09**	3.39e-09	2.22	0.027
POS	2.90e-07***	9.71e-08	2.99	0.003
UPI	-3.75e-10**	1.46e-10	-2.56	0.011
Cons	1.52045***	.0482557	31.51	0.000
Number of Observations (N)	600			
Adjusted R square	0.2904			

6.3Bank Specific Impact of DFI on Bank Profitability

Table-6 presents the results of Hausman Taylor Panel Data Regression model. The coefficients of the independent variables, MT, CC, ATM, POS, RuPay Dummy, and UPI explain the variation in monthly ROA within each individual or single bank due to the variation in these DFI components or independent variables selected in the study during 2021 to 2025. This basically shows the bank specific approach to understand the impact of DFI components on bank profitability in last 5 years. The independent variables in the model have been classified into time variant and time invariant. The time variant variables are the predictors which are not same or different for each individual bank over the entire time span of the study. In contrast, the time invariant variable remains fixed for all the banks over the study period. As indicated by Table-6, the time variant variables include MT, CC, ATM, POS, and UPI. It means that the number of mobile money transactions, number of online credit card transactions, number of ATMs, POS terminals installed, and number of UPI transactions are different for each individual bank chosen for the study within the timeline considered. On the other hand, the dummy variable RuPay has been observed to be time-invariant as the banks which initially started offering RuPay card services have continued to do so since its official implementation in the country and the time trend also applies to the counterpart banks. The model also distinguishes the predictor variables based on endogeneity separating the endogenous and

exogenous variables and identifying them accordingly. The endogenous variables are assumed to be correlated with the error term or the factors that are outside the model such as the individual characteristics of the banks such as management type, brand reputation, working culture and so forth. Variables such as MT, ATM, POS, and UPI have been recognized as endogenous by the model or assumed to be correlated with these unidentified characteristics or factors which are not included in the model and are not related to DFI. On the other hand, CC and RuPay dummy variable are the exogenous variables in the model and are deduced to be uncorrelated with the error term or individual bank related factors that are outside the model.

The Chi-square value of the model is 54.6 with a p-value of 0.000 indicating that the model is highly significant and effectively explains the variation in bank ROA with respect to the independent variables or DFI components used in the study. The p-values associated with 5 independent variables or DFI components are statistically significant at 1% level implied by p-value<0.01. Table-6 reports that these variables include MT, CC, ATM, POS, and UPI implying that number of mobile money transactions, number of online credit card transactions, number of ATMs, POS terminals installed, and number of UPI transactions have a highly significant and strong impact on the dependent variable bank ROA at micro level for each individual bank over the entire timespan of the study. The variables or DFI components exhibiting positive impact on bank ROA are MT or mobile money transactions and POS or number of POS terminals installed by each bank signifying that these two variables have contributed positively to the ROA of any given specific bank in the sample. The dummy variable RuPay also exhibits a positive relationship with bank ROA which suggests that specific banks offering RuPay card services from the beginning have experienced a rise in profitability or ROA but the variable coefficient is not significant. Conversely, the results demonstrate that CC or number of credit card transactions, number of ATMs or ATM, and number of UPI transactions or UPI have registered a significantly negative impact on ROA of any specific individual bank over time. The coefficients of all the independent variables essentially show that a 1 unit rise in each independent variable is associated with either a positive or negative change in monthly bank ROA for any given bank used as sample from 2021 to 2025.

Table-6: Results of Hausman Taylor Panel Data Regression Model

Variable Category	Variable Name	Coefficient (Std. Error)	Significance Level (p-value)
Time Varying Exogenous	CC	-1.74e-08*** (3.37e-09)	0.000
Time Varying Endogenous	MT	3.12e-10*** (5.92e-11)	0.000
	ATM	-.0001151*** (.0000176)	0.000
	POS	4.09e-07*** (9.11e-08)	0.000
	UPI	-4.26e-10*** (1.20e-10)	0.000
Time Invariant Exogenous	RuPay Dummy	-1.827446 (1.322477)	0.167
Intercept	Cons	3.647307*** (.800263)	0.000
Model Diagnostics	Value		Significance Level (p-value)
Chi Square	54.16		0.000
Number of Observations(N)	600		
Hausman Test (FE Model vs HTPDA)	4.28		0.1238

6.4Comparison between General and Bank Specific Impact of DFI on Profitability

A comparison between the results of PORM and HTPDA has been presented in Table-7. The coefficients of all the independent variables or DFI components have been compiled for both PORM and HTPDA in the table in two separate columns with their corresponding standard errors in parenthesis. The total number of observations or N for both models are 600 and the adjusted R Square of PORM is 0.2904 indicating that the overall model explains nearly 29% to 30% of the overall variation of monthly ROA or profitability of all the 10 sample banks with respect to the variations of the 6 DFI components selected in the study for the entire timeline of the study. On the other hand, HTPDA fundamentally explains the bank specific variation in ROA or profitability or within the bank changes in ROA or profitability attributable to the 6 DFI components of independent variables within the time span of the analysis. The Wald Chi Square value of 54.16 with a significance level of 1% suggests that the HPDTA model effectively and significantly explains the variation in profitability or ROA within each specific bank. The stars assigned to the coefficient values of the independent variables represent the significance level of the variables in both models with *** denoting significance at 1%, ** representing significance at 5% and *** significance at 10% level respectively.

With reference to the contrasting nature of the main results of PORM and HTPDA as registered mainly in Table-8, number of online credit card transactions for each bank has a significantly positive impact on bank profitability from a general standpoint considering all the banks in the entire sample. However, focusing on the individual bank specific context, it exhibits a negative effect on the profitability of any given bank in the sample. The banks offering all the RuPay card services to its customers throughout the study duration have witnessed a relatively higher profitability in comparison to their counterpart banks both from a general standpoint as well as bank specific approach. Although, the coefficient of RuPay dummy variable is statistically not significant for the bank specific or within the bank context. All the other independent variables or DFI components such as number of mobile money transactions per bank and number of POS terminals set up by the banks have a significantly positive impact on overall or general bank profitability and bank specific or profitability of any given bank in the sample as well. The number of UPI transactions and the number of ATM installation per bank register a significantly negative effect on profitability of banks in general and for individual bank profitability at the same time.

Table-7: Comparison between the Results of Pooled OLS Regression Model (PORM) and Hausman Taylor Panel Data Analysis (HTPDA)

Variable Category	Variable Name	PORM	HTPDA
Time Varying Exogenous	CC	7.52e-09** (3.39e-09)	-1.74e-08*** (3.37e-09)
Time Varying Endogenous	MT	2.69e-10*** (7.29e-11)	3.12e-10*** (5.92e-11)
	ATM	-.0000244*** (2.41e-06)	-.0001151*** (.0000176)
	POS	2.90e-07*** (9.71e-08)	4.09e-07*** (9.11e-08)
	UPI	-3.75e-10*** (1.46e-10)	-4.26e-10*** (1.20e-10)
Time Invariant Exogenous	RuPay Dummy	-.3731585*** (.063379)	-1.827446 (1.322477)
Intercept	Cons	1.52045*** (.0482557)	3.647307*** (.800263)
Number of Observations(N)		600	600
Adjusted R-Square		0.2904	
Wald Chi Square			54.16***

Hausman Test(p-value)			0.1238

Table-8: Summary of the Key Results of PORM and HTPDA Models

Variable Name	Variable Description	PORM	HTPDA
CC	Total number of online credit card transactions for each bank	Positive & Significant	Negative & Significant
MT	Number of mobile money transactions per bank	Positive & Significant	Positive & Significant
ATM	Total number of ATMs for each bank	Negative & Significant	Negative & Significant
POS	Total number of POS terminals installed by each bank	Positive & Significant	Positive & Significant
UPI	Volume of UPI transactions for each bank	Negative & Significant	Negative & Significant
RuPay Dummy	Indicates whether a particular bank offers RuPay card services	Positive & Significant	Positive & Non-Significant

VII.MAIN FINDINGS AND IMPLICATIONS

The study primarily investigates the general or overall and bank specific or within the individual bank effect of DFI on bank profitability and observe any empirical presence of profitability paradox in the context of Indian banking system particularly in the last 5 years. Study results contend that the DFI related factors that have commonly worked in favour of majority of the banks in general as well as for individual specific banks include number of mobile money transactions and number of POS terminal set up by the banks. In alignment with several previous studies, these results can possibly signify that increasing digitalization of financial payments and transactions might have enabled the sample banks to cut down on various infrastructural costs such as salary expenses of employees in branches responsible for handling in person payments and manual cheque processing and other paperwork and documentation costs associated with payment and transaction acceptance. Furthermore, online or mobile app-based payment and transaction facilities can also boost customer satisfaction by providing the convenience of hassle-free and remote digital transactions and consequently enhance the customer acquisition of the banks. An increase in the number of POS terminals set up by individual banks all over the country in last 5 years might have enabled the banks to reduce operational and overhead costs of building and administering physical branches especially in remote and underserved regions and increase transaction volumes. Moreover, several banks usually charge additional service fees and commissions on any customer payment conducted through the POS terminals thereby contributing to income generation for the concerned and improved bank profitability. Therefore, as the results show, these phenomena could evidently justify enhancement of bank profitability for both the majority of the banks collectively and for each individual bank during the last 5 years. The number of credit card transaction for each bank has a positive impact on bank performance from a general perspective but a negative effect on the same for any given bank during the study timeline.

This ideally points out that increasing usage of online credit card payments and transactions is associated with a profitability hike in the banking industry in general but has a reciprocal effect for a specific bank in the last 5 years. It is possible that as many banks charge additional charges for certain credit card payments online such as interest fees, card processing fees, service and convenience fees, annual card fees, over the limit payment charges, foreign transaction charges, late payment fees etc, it might lead to higher liquidity inflow especially for private banks causing rise in profitability. On the other hand, for any specific bank, it can raise the maintenance and processing costs of the digital card payments having a negative profitability impact. The various customer benefits linked with online credit card usage such as cashback and reward programs, discounts offered on specific card payments, cost of new card issuance in case of damaged or lost card, fraud detection expenses and so forth can impede profitability for individual banks by inflating these additional costs. These are the individual bank specific characteristics which are not captured while analysing the overall changes in bank profitability.

Some of the findings are also consistent with the Profitability Paradox ascertaining its applicability in the Indian banking system during the post Covid times. On the contrary to several previous research and popular perceptions, the present study reveals that bank profitability has taken a dip as the number of ATMs for each bank and more intriguingly, number of UPI transactions per bank increase for both general and bank specific profitability level. First, the increasing intensity of online cashless transactions through mobile banking apps and third-party financial apps have notably reduced the usage of the ATMs as most merchants and businesses now accept online payments from customers. This basically means that the banks still have to incur operational, maintenance, and sometimes repair costs for the machines that are basically sitting idle and underused causing a massive hike in overall cost and a dent in profitability. The ATM machines also have a high-risk exposure due to theft and fraud vulnerability and usually do not generate enough transactions due to high inclination among customer towards cashless transactions in recent times. For specific banks, the additional cost of establishing an ATM can possibly outweigh its monetary gains due to these adverse elements. The presence of profitability paradox for UPI transaction volume for each bank is empirically interesting. As the volume of UPI transactions for each bank rises the banks are expected to have a profitability gain through cross selling of other financial products such as personal loans, insurance, credit card offers, offers and discounts on certain purchases through various UPI portals and so on. Nonetheless, it is possible that since there is 0% MDR for regular bank to bank UPI transactions, the individual banks do not earn any fees or commissions as non-interest income or revenue unlike other transactions. Additionally, the affiliated banks have to incur the entire processing, technical and infrastructural costs related to any UPI transaction conducted through savings or current account of those respective banks. All these factors might possibly explain the profitability decline in conjunction with the rise in the volume of UPI transactions for each bank from both general and bank specific viewpoint.

Considering the bank specific results of this study, the key findings may entail some useful and crucial policy implications for individual banks incorporated in the study. For the bank managers and CEOs, these observations could provide some insights on how to further augment profitability with respect to specific or individual banks. First, the administrators of each bank could perhaps capitalize on the positive effect of volume of mobile money transactions and POS installation across the country on profitability by investing more on the improvement and mechanization of their banking apps in alignment with the changing financial needs and preferences of the customers. This would expectedly lead to higher customer satisfaction and a resultant surge in customer acquisition. These apps could also essentially be utilized for promoting existing and new financial products such as insurance, new credit card launch, SIPs and mutual funds, stock trading options, various loan offers, and much more which could potentially generate higher revenue by inducing higher sale. The policymakers can also emphasize on improving the technical and infrastructural aspects of POS terminals for better performance of the POS machines and reduction of damages and malfunctioning as these are significant profitability generators at the individual bank level. Some of the measures could include improvement of the speed and connectivity of the POS devices, technological upgradation of the machines, user-friendly interface for both merchants and customers, and betterment of the security features of each transaction.

To compensate for the negative profitability impact of ATM establishment, volume of online credit card transaction, and volume of UPI transaction, specific banks need to ensure better functionality and higher usage of both the onsite and offsite ATM machines to reduce inactivity despite increasing digitalization of financial activities. Alternatively, the policymakers can reduce the operational and maintenance costs on these machines of they prove to be inactive assets in the long run to improve individual bank profitability. To partially mitigate the negative profitability impact of UPI transactions, the banks can possibly focus on enhancing revenue streams from various UPI portals by offering instant overdrafts, increasing transaction processing and service fees based on transaction

types, charging higher interest on EMI payments done through UPI apps, and selling financial products with high profit margin. This can also offset considerably high transaction related expenses on UPI apps that individual banks have to bear. It is also advisable that individual bank managers can decrease the monetary amount of certain customer benefits connected with online credit card payments such as cashback offers, reward programs, waived off transaction, service, and convenience fees etc. These along with a relatively more conservative spending on maintenance and processing of digital card payments could potentially encourage desired profitability outcomes for each bank. It is to be noted that these policy suggestions might not be adequate to eliminate the negative profitability impacts of the concerned DFI components but could only alleviate any such undesirable outcome to a certain extent.

VIII.LIMITATIONS AND FUTURE SCOPE OF STUDY

To estimate the bank specific determinants of DFI and their impact on bank profitability, the present study excludes some of the bank related individual characteristics which can influence the main hypothesis of the study. Future researchers can conduct a study based on how these additional bank related characteristics such as bank size, bank management type, total number of bank branches in the country, and some sources of non-interest income that can evidently influence the relationship between DFI components and profitability at the individual bank level. Furthermore, although the current research uses the most recent data on the concerned variables, the timeline of the study could be extended by including few more years or number of observations in the study. One of the limitations of doing so could be the missing data on volume of UPI transaction for each bank as obtaining older data on the variable would not be possible as it was just launched during the pre-Covid era. With regards to the number of independent variables incorporated in the current research, the future studies can also increase the independent variables in the model by including total number of National Electronic Fund Transfer (NEFT) and Real Time Gross Settlement (RTGS) transaction, and total volume of online debit card transactions for each bank. However, this could also expose the research model to a higher risk of multicollinearity thereby invalidating the model. This is precisely the reason behind restricting the number of independent variables or DFI components in the research models undertaken by this study. Lastly, future researchers can consider comparing the variation in profitability due to DFI components between different individual banks instead of observing how such association is applicable for a particular bank over the entire timespan of the study, which is the aim of this research. This could be an interesting study reflecting variation in profitability across different banks over a certain time period.

IX.CONCLUSION

This paper attempts to analyse the empirical impact of DFI components on bank ROA or profitability indicator from both general standpoint and for any particular bank as well over the last 5 years. In accordance with some previous literature, the study results reveal certain mixed findings indicating both positive and negative relationship between bank profitability and DFI components during the timespan of the study. In contrast to few past studies, the present study registers a negative impact of some of the DFI components on bank profitability such as Number of ATMs established by each bank and volume of UPI transactions for each bank advocating that not everything about digitalization of banking and financial services is beneficial for commercial and economic performance of the individual private and public sector banks. This also possibly unravel the infrastructural and operational gaps and challenges that are still confronted by some or many of the banks across the country especially in the post-Covid times. On the other hand, positive profitability contributors such as mobile money transactions for each bank, RuPay dummy variable, and online credit card transactions only for general profitability empirically confirm the findings of most previous researches highlighting the positive aspects of digitalization that has accelerated in recent years. The contrasting findings of the present study set a conducive platform for future researchers to investigate deeper into the topic and comprehensively explore the additional underlying determinants of bank performance.

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