EXPLORING THE IMPACT OF FINANCIAL TECHNOLOGY ON COMMERCIAL BANKING EFFICIENCY: AN EMPIRICAL INVESTIGATION

Explorando o impacto da tecnologia financeira na eficiência bancária comercial: uma investigação empírica

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ABSTRACT

This study investigates the impact of Financial Technology (FinTech) on the efficiency of commercial banks in India. It explores whether FinTech enhances operational productivity and fosters financial inclusion in the rapidly evolving financial landscape. The research employs an empirical framework, analyzing annual data from 2012 to 2022 for 29 Indian commercial banks. Efficiency is measured using the Data Envelopment Analysis (DEA)-based Malmquist Index, while the FinTech Development Index is constructed using text-mining techniques. Regression models, including Pooled OLS, Fixed Effects, Random Effects, and Generalized Method of Moments (GMM), are employed to test hypotheses. The results indicate that FinTech adoption significantly enhances commercial bank efficiency. Innovations like mobile banking, digital payments, and blockchain technology improve customer experiences while reducing operational costs. Positive correlations were observed between FinTech development, GDP growth, and capital adequacy ratios, supporting the hypothesis that FinTech is a catalyst for efficiency and innovation in banking. The study is limited to Indian commercial banks and relies on secondary data. Future research could extend the scope to include comparative analyses across emerging markets and incorporate primary data for deeper insights. The findings emphasize the need for Indian banks to embrace digital transformation by integrating FinTech solutions into their operations. This approach could foster financial inclusion, enhance service delivery, and bolster economic growth. By leveraging FinTech, banks can improve access to financial services for underserved populations, contributing to poverty alleviation and economic equity. This study provides empirical evidence of the transformative role of FinTech in enhancing commercial banking efficiency in India, offering actionable insights for policymakers, financial institutions, and stakeholders.
Keywords: FinTech, Banking efficiency, Digital transformation, Financial innovation

EXPLORANDO O IMPACTO DA TECNOLOGIA FINANCEIRA NA EFICIÊNCIA BANCÁRIA COMERCIAL: UMA INVESTIGAÇÃO EMPÍRICA

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RESUMO

Este estudo investiga o impacto da tecnologia financeira (FinTech) na eficiência dos bancos comerciais na Índia. Ele explora se a FinTech aumenta a produtividade operacional e promove a inclusão financeira no cenário financeiro em rápida evolução. A pesquisa emprega uma estrutura empírica, analisando dados anuais de 2012 a 2022 para 29 bancos comerciais indianos. A eficiência é medida usando o índice Malmquist baseado em análise Envoltória de dados (DEA), enquanto o Índice de desenvolvimento de FinTech é construído usando técnicas de mineração de texto. Modelos de regressão, incluindo OLS agrupados, efeitos fixos, efeitos aleatórios e método generalizado de momentos (GMM), são empregados para testar hipóteses. Os resultados indicam que a adoção das Fintechs aumenta significativamente a eficiência dos bancos comerciais. Inovações como Mobile banking, Pagamentos digitais e tecnologia blockchain melhoram as experiências dos clientes enquanto reduzem os custos operacionais. Foram observadas correlações positivas entre o desenvolvimento das Fintechs, o crescimento do PIB e os índices de Adequação de capital, apoiando a hipótese de que as fintechs são catalisadoras de eficiência e inovação no setor bancário. O estudo é limitado a bancos comerciais indianos e se baseia em dados secundários. Pesquisas futuras podem ampliar o escopo para incluir análises comparativas em mercados emergentes e incorporar dados primários para insights mais profundos. Os resultados enfatizam a necessidade de os bancos indianos adotarem a transformação digital integrando soluções FinTech em suas operações. Essa abordagem poderia promover a inclusão financeira, melhorar a prestação de serviços e impulsionar o crescimento econômico. Ao alavancar a FinTech, os bancos podem melhorar o acesso a serviços financeiros para populações carentes, contribuindo para o alívio da pobreza e a equidade econômica. Este estudo fornece evidências empíricas do papel transformador da FinTech no aumento da eficiência do Banco Comercial na Índia, oferecendo insights acionáveis para formuladores de políticas, instituições financeiras e partes interessadas.
Palavras-chave: FinTech, Eficiência bancária, Transformação digital, Inovação financeira

INTRODUCTION

India has one of the world's largest unbanked populations, and it is a difficult market for fintech companies to break into a regulatory environment. However, with the Reserve Bank of India making a strong push for financial inclusion in recent years, fintech space has begun to gain serious traction (Priya & Anusha, 2019). Over the past year, the Indian fintech space has been heating and there is now a race to bring innovative financial services to the market. There is increasing investment in Indian fintech, and the country is now home to numerous fintech companies, innovation laboratories, and other financial technology initiatives (Zhou, 2023). With fintech making significant progress in the Indian market, it is important to understand how it affects the efficiency and behaviour of financial institutions in the country.

Fintech, or financial technology, has become a major player in one of the largest industries in the world: the financial industry. This affects how institutions do business, make investment decisions, and change the way individuals manage their finances (Lu et al., 2020). As technology, such as digital payments, improves, there has been an increase in the number of technical applications to the financial sector to strengthen the digital economy. Fintech has and will continue to transform consumer behaviour, financial markets, and the traditional banking industry (Christian et al., 2020). This evolving fintech space inspired a large wave of innovation in the financial industry in some of the nation's financial markets. Several regions have embraced fintech globally; however, India has been a mainstay in fintech innovation.

It is important to understand the current state of the Indian banking environment, in which fintech companies are trying to thrive. After a decade of consistently high growth, banking in India has become one of the most efficient service industries in the world with the increasing use of technology and a focus on customer-centric products and services (Nguyen, 2022). Indian banks are increasingly embracing the global standards for their operations and services. Advancements in financial technology have provided them with innovative solutions to overcome hurdles in their way to global recognition. Today, the Indian banking industry is at a crossroads (Zhao et al., 2019). Traditional practices must be preserved, while at the same time advancements in technology must be capitalized to maximize efficiency. This is a difficult task; however, it is vital to ensure that a vision of the global status of Indian banks is realized.

Fintech is emerging as a notable industry in India that will revolutionize banking and financial services. The emergence of new technologies and players in the financial services market has increased the industry's competitive dynamics of the industry (Zveryakov et al., 2019). The surge in innovative products and delivery channels will not only create a demand for professionals with new skill sets but also new regulatory challenges. Fintech aims to change the status quo of traditional banking to which it must be ready.

Bank efficiency is influenced by various factors including ownership structure, capital adequacy, and net interest margin (NIM). Foreign banks are often more efficient than local banks, because they have access to advanced technologies and practices (Bonin et al., 2005). Studies have shown that higher capital adequacy ratios contribute to increased bank efficiency in banks (Sang, 2021). However, a high NIM may not always indicate efficiency, as it could be a result of factors such as lack of competition rather than operational efficiency (Bonin et al., 2005). In India, where foreign banks have low market share, efficiency dynamics may differ from global trends (Bonin et al., 2005). Public-sector banks in India tend to have higher capital adequacy ratios than private banks, which can impact their efficiency levels (Sang, 2021). The relationship between NIM and efficiency is complex, as it depends on how effectively banks manage the trade-off between returns and risks from interest rate-sensitive activities (Bonin et al., 2005). Overall, bank efficiency is crucial for financial intermediation and stability of financial systems (Staikouras et al., 2008). The entry of foreign banks can stimulate local banks to enhance their efficiency and service quality of services (Liu et al., 2021). Understanding the impact of factors such as ownership, capital adequacy, and NIM on bank efficiency is essential for policymakers and stakeholders in the banking industry to promote a competitive and stable financial sector.

Bank efficiency is a critical aspect that reflects how effectively banks utilize their inputs to generate outputs. In the context of India, a developing country, studies indicate that Indian banks exhibit lower efficiency levels than banks in developed nations (Sathye, 2003). Bank efficiency is often assessed through methods such as Data Envelopment Analysis (DEA), which allows for a comprehensive evaluation of how well banks transform inputs into outputs (Sathye, 2003). One of the key determinants of bank efficiency is the ability to minimize costs while

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engaging in financial intermediation, which is a core function of banks (Sathye, 2003). Studies have shown that public-sector banks in India tend to demonstrate superior efficiency scores compared to private and foreign banks (Akhtar et al., 2021). Additionally, the relationship between efficiency and capital adequacy in Indian banks has been highlighted, with more efficient institutions among public-sector banks holding higher levels of capital (Sarkar et al., 2019). Efficiency in the banking sector is crucial not only for individual banks but also for the overall stability and performance of the financial system (Kale, 2020). Banks' efficiency can be influenced by various factors such as risk management, capital ratios, and operational policies (Sarkar et al., 2019). Understanding the interplay between these factors and efficiency is essential for policymakers and stakeholders to promote a competitive, stable banking environment in India. The efficiency of Indian banks is a multifaceted issue influenced by various internal and external factors. By employing rigorous methodologies such as DEA and considering factors such as ownership structure and capital adequacy, researchers can provide valuable insights into enhancing banking sector efficiency and performance.

1 THEORETICAL BACKGROUND

1.1 The Influence of Fintech on Commercial Banks' Efficiency

The incorporation of financial technology (fintech) into the operations of commercial banks has led to significant improvements in efficiency and service delivery. Fintech has played a crucial role in enhancing the outreach of banking services and promoting financial inclusion, particularly in countries with high Internet and mobile penetration rates, such as India (Maryunita & Nugroho, 2022). By collaborating with fintech companies such as Suvidhaa and Eko, banks can establish cost-effective last-mile access points and expand their services to unbanked populations in rural areas more effectively than traditional branch-based banking (Qi et al., 2022). Research has demonstrated that fintech innovations, such as mobile money services like M-PESA in Kenya, have greatly enhanced access to financial services and contribute to poverty reduction (Arena et al., 2023). Initiatives such as ICICI's digital village project in India have shown positive outcomes by utilizing technology-based banking solutions and the business entrepreneur model to improve economic conditions in rural areas (Yudaruddin, 2024). These advancements streamlined fund transfers, direct benefit transfers, and other financial services, leading to more efficient allocation of capital within the economy (Ozili, 2020). Moreover, fintech adoption in the banking sector has the potential to reduce informal financial activities, enhance operational efficiency, and generate positive externalities for banks and the broader population (Li et al., 2017). The impact of fintech on bank risk-taking behavior and operating efficiency has been a subject of interest, with studies highlighting the transformative role of fintech in reshaping traditional banking practices (Nguyen et al., 2021). Fintech development has also been associated with changes in market power dynamics, with fintech companies influencing the banking industry's competitive landscape (Yao & Song, 2021). The integration of fintech into commercial banking operations has brought about a paradigm shift in service delivery, efficiency and financial inclusion. By leveraging fintech solutions, banks can reach underserved populations, reduce operational costs and drive economic growth through enhanced access to financial services.

Technology Spillover Theory, as a theoretical framework for this study, explored how FinTech interacts with conventional banks. Commercial banks are capable of appreciably increasing output per input Total Factor Production (TFP), as they take advantage of FinTech. Nevertheless, an initial outlay for commercial banks is necessary to build financial technologies such as big data risk control systems, distributed systems, and intelligent advisory systems. Banks adopting fintech may boost their investment in environmental issues; thus, they must balance profits and related risk. As such, commercial banks' adoption of FinTech can increase production costs, leading to a decrease in TFP (Buchak et al., 2018; Li et al., 2021; Zheng & Siddik, 2022; Abdul-Rahim et al., 2022; Qi et al., 2022; Campanella et al., 2022; Vergara & Agudo, 2021; Al-Okaily et al., 2021; Yao & Song, 2021; Wei, 2023). However, it is unclear how fintech affects the efficiency of commercial banks. Thus, this study formulated the following hypothesis:

H0: There is a negative correlation between FinTech and commercial bank efficiency.
H1: The use of Financial Technology (FinTech) enhances commercial bank efficiency.

2 DATA AND METHODOLOGY

2.1 Sample

This study examines how fintech companies influence performance in the Indian commercial banking sector using annual data for the period 2012–2022. A Case of India's Spectacular Growth in the Fintech Industry. This study measures commercial bank efficiency using a database from the Reserve Bank of India (RBI), an annual report from banks, and the essential financial technology (FinTech) development index from the National Payments Corporation of India (NPCI) and RBI. Using a multiple regression model, this empirical analysis examined how FinTech influences commercial banking efficiency.

2.2 Variables

Efficiency: This study examines the efficiency of commercial banks as an explanatory variable represented by total factor productivity (M).   In this case, we apply the Malmquist Index within the DEA TFP estimation context for commercial banks. Commercial banks are largely intermediaries who convert deposits into assets by lending and utilizing labour to obtain interest.   The selected input indicators are deposits and labour, while the selected output indicators are loans and net interest. This information is presented in table 1 (Berger and Humphrey, 1997).

Table 1 - The TFP index has a list of business banks and a FinTech index glossary

Total Factor Production Index Selection of Commercial Banks	Direction		Index Name		Financial Indicators for measurement	
	Input		Total Deposit		Resident deposits + interbank deposits	
			Labour Force		Labor force	
			Total Loan		Total loan size	
	Output		Net Interest Income		Interest income - interest expense	
Fintech Index thesaurus	**Dimension**		**Specific Description**			
	Payment settlement	Third-party payment	Digital Currency	Mobile payment	Online payment	
	Deposits & loans & capital rising	Crowdfunding	Online Financing	Network investment	Online banking services	
	Investment management	Electronic Transaction	Internet finance	Internet insurance	Online finance	
	Market facilities	Big Data	Cloud computing	Artificial intelligence	Blockchain	

*Notes: Definitions of the input and output indices are presented in the first part of the table. This section describes the words used to create FinTech scores.

Table 2 - Total Factor production of India's commercial bank from 2012 to 2022

Year	Efficiency change	Technical efficiency	Pure efficiency change	Scale efficiency change	TFP change
2022-21	1.011	0.609	1.000	1.011	0.616
2021-20	0.997	0.759	1.000	0.997	0.756
2020-19	0.978	0.863	1.000	0.978	0.844
2019-18	0.999	0.809	1.000	0.999	0.808
2018-17	1.027	0.818	1.000	1.027	0.840
2017-16	0.996	0.942	1.000	0.996	0.938
2016-15	1.001	0.893	1.000	1.001	0.894
2015-14	0.988	0.924	1.000	0.988	0.913
2014-13	0.990	0.916	1.000	0.990	0.906
2013-12	1.002	0.913	1.000	1.002	0.914

Mean	0.999	0.838	1.000	0.999	0.837

Using deap2.1 software, TFP calculations for India's 29 commercial banks were performed. Finally, every commercial bank within a particular category was assigned an average annual TFP value. As Table 2 shows, commercial banks experienced no appreciable change in TFP scores between 2012 and 2022.

This study examined Fintech as the main independent variable. Two major techniques are used to assess financial science and technology development indices. Another method is text mining, in which RBI and NPCI measure the amount of information retrieved to generate the FinTech development index. Second, the magnitude of Internet-based third-party payments is adopted as a substitute for the Internet financial index, using this ratio between third-party payments and online payment magnitudes. Empirically, this study uses the first method to build a FinTech index and other approaches for substitution in the robustness test (Li et. al., 2017).

Several stages were involved in forming the FinTech index using the text mining method. The development of the initial FinTech thesaurus in Table 1 is made possible using a steering committee to categorize different FinTech models. Subsequently, the RBI search engine was used to obtain monthly frequency data of all terms per month for every year, ranging from 2012 to 2022, and then to calculate the average annualized values for yearly word frequencies that were used in this study. The estimated coefficient matrix and percentage of attribution were obtained through a factor analysis, which served as a weighting factor. The annual FinTech index was computed using data weighting and normalization procedures.

2.3 Control Variables

Additionally, this study pinpoints control variables that may affect bank output efficiency, either at the country- or firm-level. At the macro level, the research adopted two indicators: the GDP Growth Rate (GDP). The capital adequacy ratio (CAR) is used at the financial institution level to regulate the effect of a bank's liquidity position and its risk exposure. Appendix A and Table A1 provide a thorough account of all variables, while Table 3 defines the variables and provides descriptive statistics. Rajan's (2005) TFP data include 319 cases (mean = -0.0203, SD = 0.137). This study employs panel data to examine how FinTech affects commercial banks' operational efficiency.

$$M_{it} = \beta_0 + \beta_1 * NV + \beta_2 * RV + \beta_3 * MBV + \beta_4 * DCV + \beta_5 * TA + \beta_6 * GDP + \beta_7 * CAR + \epsilon_{it} \quad (1)$$

$$M_{it} = \beta_0 + \beta_1 * M_{it-1} + \beta_2 * NV + \beta_3 * RV + \beta_4 * MBV + \beta_5 * DCV + \beta_6 * TA + \beta_7 * GDP + \beta_8 * CAR + \mu_i + \epsilon_{it}$$
$$(2)$$

Subscript is a symbolic or lower-case letter that comes behind an index "i" of a certain bank, "t" for a definite year, and "M" is the macro-indicator for accumulative total factor productions over all other banks. NV (National Electronic Funds Transfer Value), RV (Real-Time Gross Settlement Value), MBV (Mobile Banking Value), and DCV (Bit card value). GDP and CAR are macro- and company-level control variables, respectively. Bank FE is represented by μ_i, and the random error at time t is denoted by ϵ it.

To test this hypothesis, this study involves all the sample data in equations (1) and (2); however, multicollinearity is likely to arise in a fast-growing sector such as the FinTech index. Therefore, to circumvent problems, such as data stationarity and multicollinearity across the entire sample, this study adopts the difference method based on the first difference of the logarithmic variables. This sample is then entered into Equation (2) to determine whether there is a correlation between FinTech and commercial bank effectiveness. Because this study employed short panel data, the P_OLS, FE, and RE estimators were adopted. Furthermore, equation (2) includes a lagged term for the dependent variable and considers the cross – effects between the explanatory variables and commercial bank efficiency, raising the endogeneity problem in the model. Therefore, as it is related to Equation (2), it uses a differential GMM model.

3 RESULTS AND DISCUSSION

3.1 Empirical analysis

Correlation test and stability test: The initial phase entailed correlation analysis for each variable. The results of this study are summarized in Table 4. This demonstrates that the correlation coefficient values were larger than 0.5 among FinTech and GDP, CAR, and SIZE. The VIF test showed that the VIF value for each explanatory variable was less than 10; hence, there was no problem with high multicollinearity in the current investigation. Each variable is tested for stationarity. The last row of Table 4 indicates that no unit root exists between the dependent and the independent variables. First, the empirical data did not capture pseudo-regression. The study used resilient standard errors in the empirical analysis to consider heteroscedasticity and see how it changed the study's results. A graphical method was used to check the stationarity. Second, the results indicated a significant relationship between the dependent and independent variables.

Figure 1 - The effect of FinTech on the performance of commercial banks
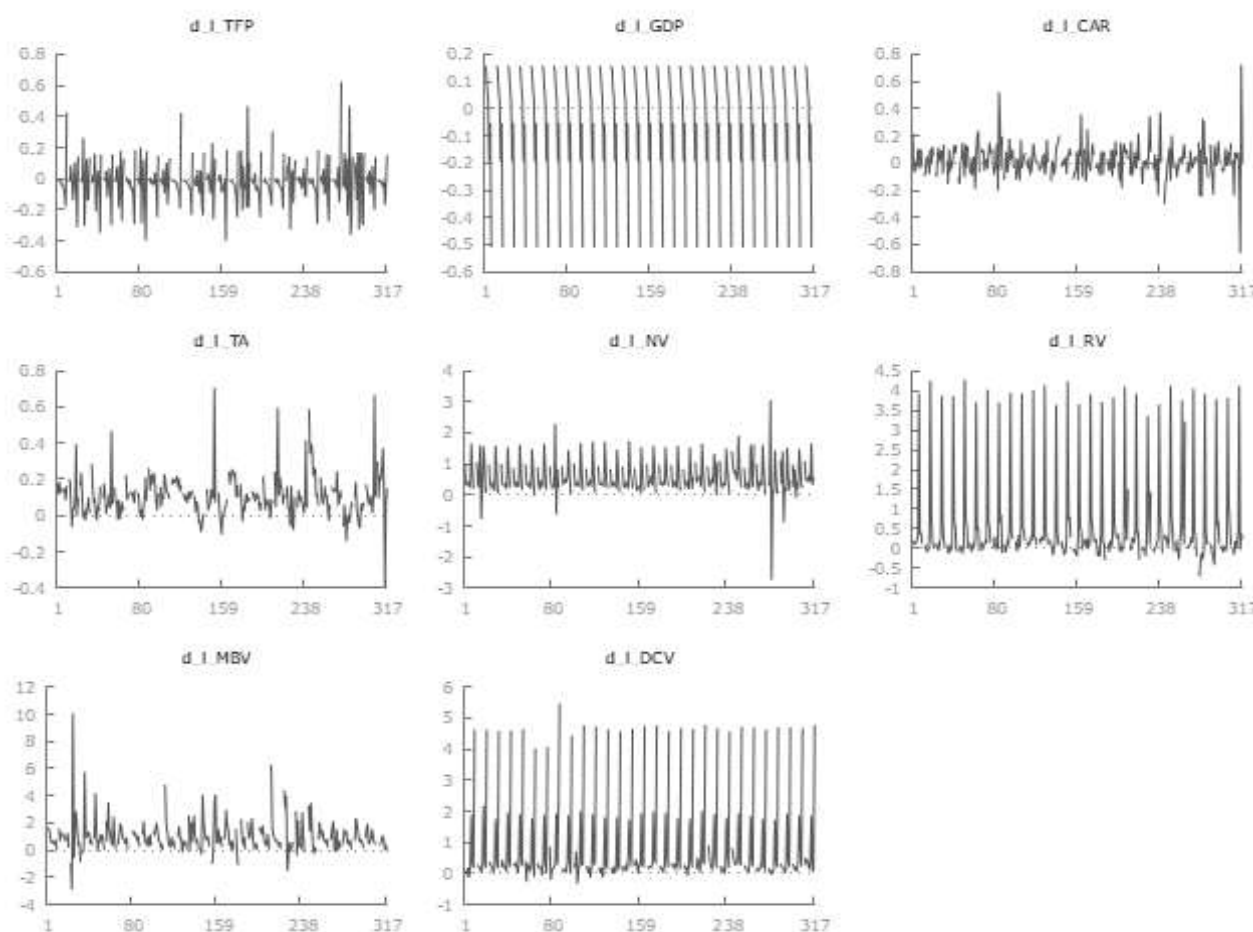
In this study (figure 1), the estimation of equation (1) is first performed using Pooled OLS, Fixed Effects model (FE), and the random effects model abbreviated RE proceeds, with further results arising from the estimations summarized in Table 5. First, using OLS estimation based on Equation (1) can be a step. However, problems with this scheme were evident in the F-test, indicating the necessity of finding an alternative strategy. For the RE model, Equation (1) was applied using the Lagrangian multiplier test. A Hausman test was also performed; the null hypothesis was rejected and a correlation between the random disturbance term and explanatory

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variables was suggested. Considering the suspected endogeneity concerns provided by their tests, we use equation (2), constructed via the GMM approach, as a more reliable countermeasure through econometric modelling.

Table 3 - Variable design and descriptive statistics

Type	Variable	Symbol	Variable design	Mean	Median	Standard deviation	Min	Max
Explained variable	Total factor productivity	M	DEA-Malquist	-0.0203	-0.0189	0.137	-0.402	0.622
Core explanatory variable	NEFT	NV	Fintech development index	0.553	0.378	0.533	-2.73	3.05
	RTGS	RV		0.556	0.153	1.16	-0.661	4.27
	Mobile Banking	MBV		0.994	0.763	1.19	-2.94	10.0
	Debit Card	DCV		0.839	0.248	1.38	-0.342	5.45
Control Variable	Macroeconomics level	Gdp	GDP growth rate	-0.0751	-0.0104	0.217	-0.511	0.157
	Bank risk-taking	CAR	Capital adequacy ratio	0.0183	0.0146	0.123	-0.663	0.722
	Bank Size	TA	Total Assets	0.109	0.0982	0.113	-0.390	0.705

Source: Output of Gretl Software

Table 4 - Correlation test and stability test for each variable.
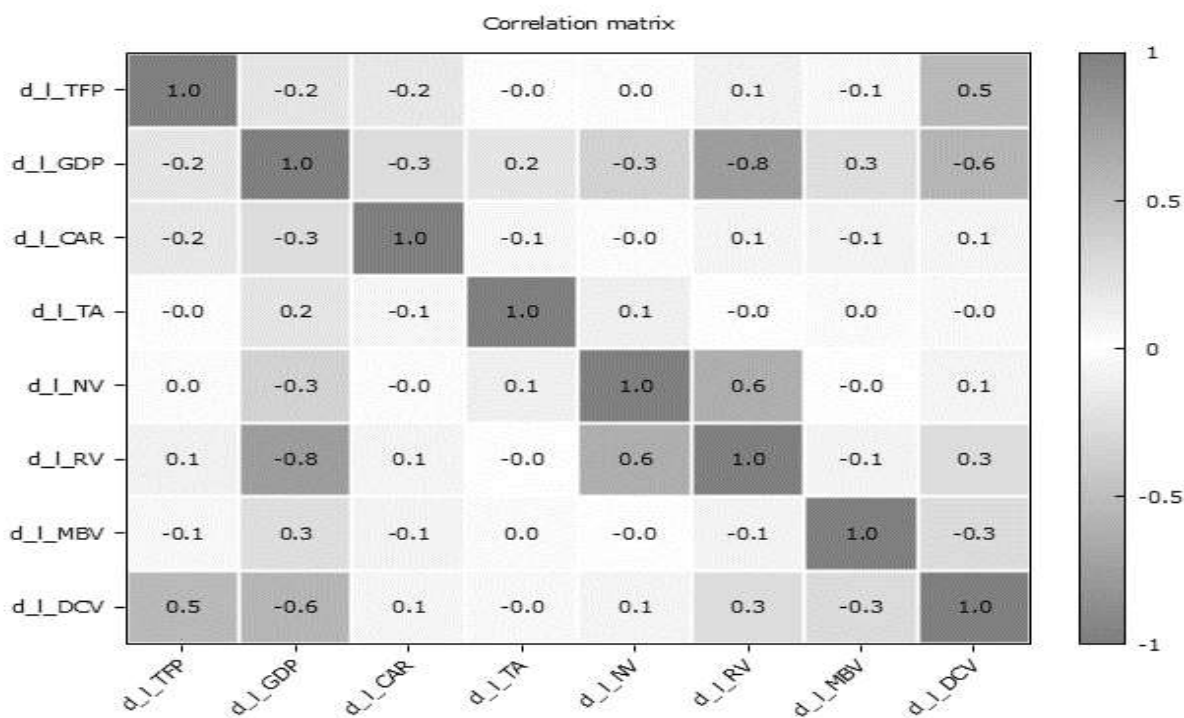
Source: Output of Gretl Software

The Pearson correlation coefficient matrix provided in Table 4 shows the degree of correlation between the variables associated with the work done for the baseline regression analysis. This includes a DEA-based approach to overall factor productivity related to FinTech. GDP is an indication of the rate at which a country facilitates its gross domestic product in comparative terms, whereas CAPS represents the capital adequacy ratio. CAR is a key indicator that characterizes the level and state of financial stability as well as banks. The intercorrelation matrix

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applied to the correlation provided by this analysis confirms that FinTech is highly correlated with the overall factor productivity, as illustrated below. This implies that the adoption of fintech solutions plays a significant role in the heightened efficiency and productivity levels in the financial sector. Moreover, the matrix has a positive correlation with GDP and CAR because, when economies grow, banks have high capital adequacy ratios, indicating a sound banking industry. In general, the correlation coefficient matrix is a source of necessary data on the finite interaction between FinTech climatic condition development and financial security. For instance, the implementation of FinTech solutions, including online banking interfaces and mobile payment structures, has simplified transactions to eliminate physical and manual activity. Not only has this done much to enhance efficiency, but it also faces financial services for individuals and firms, significantly increasing the overall factor productivity. Furthermore, the positive CAR–GDP relationship implies that a growing economy enables banks to earn higher profits, thereby contributing to the acquisition and maintenance of healthy capital. This is important for banking balance.

The regression results are presented at the bottom of table 5. A smaller p-value for the AR (2) model indicates that there is no significant second-order autocorrelation in the disturbance component. Sargan's statistic is greater than 0.1, implying that the over-identification restriction is not violated, and that the instruments used in the model are valid and exogenous. This study suggests that the adopted instrumental factors provide evidence that supports the hypothesis of the dynamic model obtained through empirical analysis. According to the system GMM regression findings, the estimated coefficient of finance technology has a positive and statistically significant sign, implying an increase in commercial banks' efficiency. Therefore, these findings lend credence to H1 and do not support H0. Differences arise from variations in the techniques employed to measure the efficiency of commercial banks and the dissimilarity in the sample used. This finding implies that consumer theory of disruptive innovation has a higher success rate than the technology spillover hypothesis on the impact of commercial banks.

Table 5 - To examine the influence of Financial Technology (FinTech) on the operational efficiency of commercial banks within the whole sample

Variable	P_OLS	RE	FE	D_GMM	S_GMM
NV	−0.0385640*** (0.0058)	−0.0314853** (0.0428)	−0.0284419* (0.0829)	−0.0337276** (0.0322)	−0.0490894** (0.0492)
RV	0.0386784*** (4.21e-05)	0.0378571*** (9.50e-05)	0.0379897*** (0.0003)	0.0367542** (0.0112)	0.0495933** (0.0122)
MBV	0.00160320 (0.7352)	0.00272131 (0.6223)	0.00356416 (0.5535)	0.00108167 (0.8806)	0.00292546 (0.6958)
DCV	0.0636079*** (5.85e-028)	0.0543670*** (1.81e-017)	0.0549956*** (9.73e-014)	0.0539974*** (8.85e-017)	0.0573912*** (1.03e-09)
TA	−0.0936789 (0.1500)	−0.0948526 (0.1748)	−0.0852898 (0.4362)	−0.0905387 (0.2908)	−0.0213086 (0.9216)
GDP	0.282376*** (1.11e-06)	0.275603*** (2.55e-05)	0.282442*** (7.34e-05)	0.199728* (0.0675)	0.309594** (0.0133)
CAR	0.118575** (0.0493)	−0.114640* (0.0869)	−0.119080 (0.1056)	−0.0704023 (0.3296)	−0.0471496 (0.7871)
LM				−0.315752*** (1.84e-05)	−0.162243 (0.1243)
_Cons	−0.0178312 (0.1598)	−0.0218504 (0.1160)	−0.0257789 (0.1344)	−0.315752*** (1.84e-05)	−0.0267712 (0.2537)
F	27.71801 (5.19e-27)		5.136615 (2.20e-13)		
R²	0.473204		0.534572		
LM		−0.211305*** (0.0067)			
Hausman		7.16853 (0.518564)			
AR (1)				-2.36941 [0.0178]	-2.05864 [0.0395]
AR (2)				-2.35823 [0.0184]	-1.05747 [0.2903]

Sargan				154.38 [0.1919]	83.4811 [0.0264]

Note: Table 5 serves as a guide for the role of financial technology (fintech) in commercial bank operations in India. The first three columns show the regression results obtained using pool-OLS, fixed effects, and random effects calculations, respectively, while the last two columns show the regression results obtained using the different GMM methods and system GMM methods. M is factor productivity derived from the DEA model. Finance technology (FinTech) is used as the FinTech development index. The GDP growth rate is captured through the GDP. Here, CAR stands for capital adequacy ratio. Lagged M (LM) is the final variable term in the model and _Cons denotes a constant term. The F-test determines whether the variances are equal, represented by R^2 or the coefficient of determination. The test known as LM denotes the Pagan Lagrange multiplier test, while Hausman refers to the Hausman test. The first- and second-order serial correlation tests are denoted AR (1) and AR (2), respectively. Finally, the Sargan test is applied to the GMM model and it is called the Sargan test. Values within brackets under the regression coefficient indicate a robust standard error. On the right-hand side, the p-values are displayed in brackets to fit the model option. * Denotes statistical significance at the 10% level of confidence; ** indicates statistical significance at the 5% confidence level; and *** shows statistical significance at the 1% confidence level. Table 1 displays the input and output variables chosen for the DEA-Malmquist.

Table 6 - Explanation of all variables

Type	Variable	Symbol	Variable design	Source
Explained variable	Total factor productivity	M	DEA-Malmquist	Bank Focus
Core explanatory variable	NEFT	NV	Fintech development index	RBI Report
	RTGS	RV		
	Mobile Banking	MBV		
	Debit Card	DCV		
Control Variable	Macroeconomics level	Gdp	GDP growth rate	Office for National Statistics
	Bank risk-taking	CAR	Capital adequacy ratio	Bank Focus
	Bank Size	TA	Total Assets	Bank Focus

CONCLUSION

This is because the speed of growth has been rapid over the past couple of years through technologies such as artificial intelligence, big data, blockchain, and cloud computing, which affect the business model in traditional banking. The impact of FinTech on the efficiency of commercial banks has been studied using the consumer theory, disruptive innovation theory, and technological spillover. This study relies on a sample of 29 commercial banks across the period to 2012-to-2022. As such, this study addresses the TFP of Commercial Banks, defined in terms of DEA measurement methodology. Additionally, one of the main explanatory variables for this research is the text-mining-based measure of the financial technology index. The above results can be summarized as follows:

Fintech improves the functional efficiency of commercial banks. According to consumer theory, fintech innovations result in consumers obtaining more convenient and effective banking services that have positive effects on commercial banks' general functional efficiency. The disruptive innovation theory posits that fintech disrupts conventional banking practices and pushes financial institutions to improve their activities to create greater efficiency. Furthermore, technological spillover theory suggests that, as fintech solutions are introduced by banks, other areas of their operations can also benefit from knowledge and technology transfer, thus raising the efficiency level. Thus, FinTech can be interpreted as a positive driver that enhances commercial banks' operational effectiveness. Additionally, the adoption of fintech in commercial banks improves both customer experience and

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satisfaction. With the introduction of new technologies, such as mobile banking apps and online payment systems, customers have easy access to their accounts. This not only saves customers' time and effort, but also avoids physical bank branches, thereby lowering costs for banks. In summary, FinTech implementation not only offers operational efficiency but also increases customer satisfaction; hence, a win-win situation exists for both banks and their customers.

Hence, this study proposes the following practical suggestions for commercial banks, fintech enterprises, and regulators. Financial technology/FinTech has impacted the business model and production strategy of commercial banks because of the nexus between the information revolution and financial services. With respect to rapid growth in fintech, commercial banks should think away from this box. By contrast, they should focus on customer-oriented techniques that can correctly identify and satisfy the needs of their customers. Large commercial organizations should incorporate the advantages offered by fintech firms by using their strong financial resources and a more customer approach. These enterprises can compete with fintech startups and collaborate to navigate the new era of fintech for innovative corporate expansion opportunities. For example, financial institutions can create a digital environment by adopting the mobile Internet, big data approach, cloud computing systems, and many other modern technologies. Their high – caliber financial science and technology workforce can be developed in a short span through autonomous research, development of crux technologies, and improved service standards. Other banks may even undertake shows, demonstrations, competitions, and people movement and networking so that they can improve their capacities, managerial and performance skills, and levels. By integrating the physical branch networks of cross-regional commercial banks with electronic Internet store fronts, asset-light approaches can be realized in specific locations, which will lead to cost reductions while maintaining profits.

Therefore, the local governments in every state must be instrumental in nurturing Financial Science and Technology. These should promote the development and implementation of policies as well as governing laws and ordinances, enhance investment in infrastructural facilities, and encourage the influx of professionals to speed up progress in this area. Fintech firms must strike an optimal balance between their commercial interests and the public good when offering cross-border financial services. During the past five years, fintech companies have made it easier for people and organizations to conduct business. The payer, deposit, loan, and financial aspects of these services make them profitable for end-users. However, Internet financial companies must overcome precise limitations and resist data monopolies when providing financial services. Firms should exploit such transaction information and data in lawful and compliant business processes and continue to develop new banking products for individuals and organizations, respectively.

The emergence of fintech businesses introduced novel risks and challenges in the realm of financial services, including the unauthorized use of consumer data and illicit securities practices. Consequently, it is imperative for regulators to adopt a comprehensive supervisory approach that aligns with the fundamental nature of the financial industry. Regulatory bodies must intensify their scrutiny and examination of the possible ramifications of Financial Technology (FinTech) to establish solid groundwork and effectively enhance supervisory mechanisms, thereby mitigating financial risks. Market access and ongoing supervision of fintech businesses must be implemented within the existing legal and regulatory framework. Additionally, it is essential that fintech companies adhere to the same business standards and risk management requirements as other entities do. Active participation of relevant authorities in research on the development, impact, and oversight of Financial Technology (FinTech) by international organizations.

Authorities must engage in collaborative efforts to examine and develop regulatory frameworks adaptable to changing times. These regulations should be designed to guarantee the efficacy of supervision and effectively mitigate and address substantial financial risks.

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