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Leveraging Digital Microfinance for Inclusive Banking Efficiency: A Post-Financial Inclusion Assessment Across BRICS Economies

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ABSTRACT

Over the last few years, there has been a large amount of academic and policy focus on how digital microfinance has transformed financial inclusion in banking efficiency. In this study, we examine digital microfinance mechanisms such as mobile banking, AI-driven microlending, and blockchain transactions to improve the performance of banking in BRICS economies in the wake of financial inclusion. Using panel data from the years 2012 to 2024, the research integrates the analysis of key company performance indicators such as Return on Equity and Net Interest Margin. We find preliminary results that indicate that those economies exhibiting stable inflation and moderate GDP growth (China and India are among them) exhibit a more pronounced positive relationship between digital microfinance uptake and banking efficiency. Panel data regression using Fixed and Random Effects Models and Granger causality tests are included in the methodology. The strength of these relationships is moderated by economic volatility, according to findings. Study conclude that digital microfinance tools is not only inclusion enabler, rather also acts for boosting efficiency, if country macroeconomic and regulatory policies and correctly adopted. Further, study asks policy makers that digital infrastructure be strengthened, consumer needs to be educated regarding financial literacy, and for doing so central banks and regulators must play their watch guard role of oversighting which will ensure improving efficiency without increasing financial risks.

1. Introduction

The BRICS economies, Brazil, Russia, India, China and South Africa are among the most significant emerging markets in the world, and they vary significantly in terms of their financial development, regulatory power, and digital potential. Although these nations have increased financial inclusion in the last ten years, the digital financial inclusion has been translated into quantifiable banking effectiveness in an indeterminate

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manner. Digital microfinance (DMF), such as mobile banking, AI-based credit scoring, and digital loan disbursement, has become a possible solution between inclusion and banking performance, but its efficacy seems to be mostly conditional on the overall economic factors.

Digital microfinance is the delivery of micro-savings, micro-credit, and payment services over the digital platform. In this research, the banking efficiency can be determined based on the Return on Equity (ROE) and Net Interest Margin (NIM), which are indicators of how efficiently the banks transform the financial inputs into the performance of the operations. In spite of the fact that BRICS countries are quickly turning towards the use of digital tools, available literature shifts between micro-level financial access and macro-level banking performance, one without integrating the two into a coherent cross-national approach.

The current research paper will fill this gap by investigating whether DMF contributes to the banking efficiency in BRICS economies, and how the GDP growth and inflation moderate such relations. The analysis is based on the Resource-Based View (RBV) that argues that digital capabilities are an effective strategic asset, and the Institutional Theory that stresses the role of macroeconomic stability in the institutional performance.

The rest of the paper is organized in the following way: Section 2 a review of the literature and formulation of the hypotheses. Section 3 describes the methodology used in the research. The empirical results are given and the implications of the same discussed in Section 4. The policy recommendations and limitations are found under section 5.

In this context, digital microfinance (DMF) has emerged as a practical way to bridge the divide between inclusion and efficiency. By using updated AI backed mobile tools like banking applications, and easy access to digital accounts through mobile have enhanced consumer access to credit, and on the other side financial institutions enjoy benefits like low transaction cos nand better risk assessment (Patrick Byrne, 2022; GSMA, 2023). Role of technology in transforming and enhancing financial access can be highlighted by India's UPI (Unified Payments Interface) over 10 billion transactions in single in month back in 2023 (NPCI, 2023).

Role of macroeconomic stability is crucial for achieving fruitful results of digital finance in the long run, DMF doesn't function in seclusion rather it effectiveness and success is dependend upon favorable economic conditions based on factors like inflation and GDP growth. During 2015 to 2022, Chaina and India despite having stable growth rate of 6.2% and 6.5% had faced trouble stabilizing its growth due to adverse impact of inflationary factors which reduces stability gains (IMF, 2023).

2. Literature Review

During the last five years, the use of digital technologies and applications have played important role in stabilizing emerging economics and its banking sector policies, procedures, services delivery and management. With rapid increase in more reliance on digital microfinance based on the mixture of new innovations like mobile payment systems, AI and traditional credit lending approaches (Arner et al., 2015). For BRICS countries, digital microfinance approaches was a foundation stone enhancing banking institutions overall performance and creating more opportunities for banking sector to serve millions of users. This review traces the evolution of financial inclusion, explores existing theories and evidence on banking efficiency, and highlights the role of digital technologies in shaping financial intermediation. It also identifies the gaps in current

research—particularly regarding the influence of macroeconomic conditions—thereby providing the foundation for the present study (Klapper, & Singer, 2025).

2.1 Theoretical Background and Generation of Hypothesis

The Resource-Based View (RBV) says that the resources that an organization can create must be valuable, rare, inimitable, and non-substitutable in order to generate a sustainable competitive advantage. On the one hand, digital infrastructure and technological abilities represent such resources in the banking industry that improve efficiency in operations (Barney, 1991). Therefore, according to the RBV framework, it is anticipated that digital microfinance will have a positive contribution to the performance of banks and therefore the first two hypothesis include:

- H1: Financial Inclusion programs have a great impact on the efficiency of banking in BRICS economies.
- H2: The adoption of digital microfinance has a positive and significant impact on the efficiency of the banking sector.
- H3: GDP growth is a positive moderating variable between digital microfinance and banking efficiency.
- H4: There is a negative moderation of the relationship between digital microfinance and banking efficiency by the effect of inflation.
- H5: The quality of regulation has a positive moderating effect on the correlation between digital microfinance and banking efficiency.

2.2 Financial Inclusion and the Developmental Objectives

As defined by the World Bank (2022), financial inclusion is the use of affordable services that enable transactions, payments, savings, credit, and insurance. Financial exclusion has in the past been linked to poverty, informality, and rural marginalization. From 2011 to 2021, the share of adults with a bank account grew globally from 51% to 76% and much of the progress is attributed to digital platforms (Demirguc-Kunt et al., 2022). Financial inclusion among BRICS countries has been a result of policy-driven efforts such as the India Pradhan Mantri Jan Dhan Yojana (PMJDY), Brazil's Bolsa Família program, South Africa's Mzansi accounts (Bharadwaj, Jack and Suri, 2020).

Inclusion, however, is not convertible to utility or efficiency. Ghosh & Sahu (2021) indicate that, while the number of account holders has risen, active usage has been low, in particular among low-income and rural populations. An account is not the same as improved access to credit, investment opportunities, and risk mitigation mechanisms. The disconnect between access and meaningful financial engagement poses a broader question: what does it take for financial inclusion to convert to real performance gains for financial institutions?

Implementation of well-constructed financial inclusion ensures easy, affordable and understandable financial services for public living not only in urban areas but also to the ones who are considered underprivileged. On one side financial inclusion helps in achieving improved healthcare, education, employment opportunities and on the other side it helps in rapidly decreasing disparity and scarceness of resources for the underprivileged.

Even though more financial inclusion opens up access to basic financial services, the potential of financial inclusion to boost the effectiveness of banking relies on the participation of new customers in the saving, credit, and digital services. The effective

digital delivery channels bring the costs of operation down; they decrease the information asymmetry, hence turning the inclusion into financial gains in ROE and NIM. Thus, inclusion is an aspect that leads to efficiency not only due to the increased customer base, but also to reduced marginal costs as digital channels can allow banks to conduct their operations.

2.3 Digital Microfinance Is Emerging

In today's context, microfinance has taken a new form through digital technologies. Digital microfinance refers to the provision of small-scale financial services—such as savings, loans, and insurance—delivered via mobile phones, online platforms, and other electronic channels. This approach is based on two theories: firstly old styled microfinancing technique which focuses on providing services to unbanked low income population and the second approach is of digital finance which focus on wider accessibility, scalability and automation (Arner, Barberis, & Buckley, 2015).

Literature available highlights the importance of DMF in increasing the access. In a span of one decade more than 75% of population was able to access the beneficial services of mobile money banking trough Kenya's M-Pesa which resultantly, uplifted almost 2% masses out of extreme poverty (Jack and Suri, 2016).

Back in 2023 indian financial sector experienced more than 10 billion transactions during month through Aadhaar linked and UPI systems (NPCI, 2023). Digital delivery systems possess the ability to minimize, overcome ogistical and physical barriers faced by traditional banks. Emerging disigtal technologies such as AI, big data boosts the digital microfinance role. For example, credit scoring models can now draw on unconventional data sources—including mobile phone activity, bill payment records, and even social media use—helping lenders to assess risk more accurately (Dong et al., 2021). Blockchain, is a tool available for scrutiny of transactions and decreasing the probability of fraud as its enable banks an effective and efficient medium to track and record tracsactions related to loans and its repayments (Gomber et al., 2018). Resultantly, MFIs (microfinance institutions) are able to level up its operations at wider level and reach unserved population with per customers cost at its minimum.

Nevertheless, the implementation of digital microfinance attracts many challenges. As per Ozili (2018) that weak regulations, absence of digital literacy and weak infrastructure, not only generate nre risks and slow down its effectiveness. In some cases, such as India and South Africa, the rapid promotion of instant digital loans has contributed to rising household debt, raising concerns about consumer protection and responsible governance (Bull & Klapper, 2023).

Banking institutions can only achieve efficiency by minimizing both transaction costs as well as operational inefficiencies through successful implementation of digitl financial inclusion. Institutions not only enjoy better efficiency vredot valuation rather also decreasing trend of default risk.

H2: The use of digital microfinance tools is expected to improve banking efficiency in BRICS economies.

2.4 Banking Efficiency in Emerging Economies

Best utilization of available resources by banks to generate maximum profits keeping cost under controls is referred as banking efficiency. In quantative terms banking efficiency can be measured through varies indicators like Return on Assets (ROA), Net Interest Margin (NIM) and Return on Equity (ROE). All these indicators focus on banks

ability to transform inputs (Labor, capital and technology) into monetary returns (Berger & Mester, 1997).

During study it was observed that efficiency levels among BRICS countries are not identical. China and India have performed relatively strongly, recording average ROEs above 13 percent between 2015 and 2022 (IMF, 2023). By contrast, Brazil and South Africa continue to struggle with long-standing structural weaknesses, higher ratios of non-performing loans, and the impact of recurring economic and policy instability (World Bank, 2023).

Macro stability is an important determinant of banking efficiency, according to the literature. Low GDP growth, high interest rates, and high inflation volatility are often associated with a lowering of lending capacity and an increase in credit risk (Dietrich & Wanzenried, 2014). Under these circumstances, the national economic conditions may have a substantially moderating effect in this regard on the potential for digital microfinance to contribute to the banking performance. However, how this interaction is utilized has yet to be widely explored in empirical research.

Under all circumstances GDP & inflation plays vital role in streamlining the relation between banking efficiency & digital microfinance. Globally, countries having stable positive GDP growth tends to enjoy well established infrastructure and financial margins which boost digital microfinance and ultimately achieving stable =, improved banking efficiency.

H3: The positive relationship between digital microfinance and banking efficiency is stronger in countries with higher GDP growth.

Countries facing continuous inflationary trends tend to be unstable not only from economic point of view but also in terms of financial services and its success. Therefore, it is very important to understand the dynamics and implementing them at appropriate timely manner for the successful achievement of banking efficiency through digital financial inclusion.

H4: Inflation negatively moderates the relationship between digital microfinance and banking efficiency.

2.5 The Role of Fintech Platforms

Fintech solutions or technology-driven innovations in financial services solutions, have integrated themselves revolutionary changing the way a bank operates. Fintech can make applications run smoother in the backend (e.g. via blockchain), create a better customer interface (payments via smartphone via fingerprints, etc.), and offer personalized services, suggest Gomber et al., (2018). From a Microfinance perspective, Fintech can help with better customer onboarding, accelerated loan approvals, and data-based credit assessment.

Fintech has been shown in numerous studies to produce efficiency gains. As an example, Bittschi et al., (2021) showed that fintech lending platforms in Southeast Asia offered better loan turnaround time and customer satisfaction than traditional MFIs. In a similar vein, Sarma and Pais (2011) showed that fintech-enabled MFIs reduced day 30, 60, and 90 default rates between 20-30% on account of improved risk modeling.

But not all these gains hold for all peatlands. Fintech adoption may be a substitute for or enhancement to formal financial inclusion, but in economies with low internet penetration, weak institutions, and low digital literacy, the adoption of fintech may lead to limited uptake, unintended consequences such as cyber fraud or elements of financial exclusion (Ansar et al., 2022). In addition, without good regulation, fintech can increase

inequality by serving users of internet technology and shutting out the vulnerable (UNCTAD, 2023).

Sustainable and tangible regulations play a vital role in minimizing the risk exposure through well-sketched framework, based upon which general masses feel more confident, secure and enjoy financial inclusion under fait market practices.

H5: Regulatory quality positively moderates the relationship between digital microfinance and banking efficiency.

2.6 Connecting the Dots: Digital Microfinance and Banking Efficiency

While the body of work on financial inclusion and fintech grows quite large, only a few articles in the literature specifically connect digital microfinance to banking efficiency under macroeconomic moderation. Assuming that doing DMF does, of course, lead to better performance ignores the contextual realities of emerging markets.

This is an exception; according to Ozili (2021), mobile money penetrated significantly to improve banking ROE in East African countries but it did not have any impact in West African countries where inflation and political instability are greater. Dong et al. (2021) similarly find that DMF only contributed to efficiency if the regulatory frameworks and consumer safeguards were strong.

The findings indicate that DMF has a moderated relationship (explained effect) such that DMF may be a good contributor to banking performance, but only under favorable economic or institutional conditions. This idea, is in line with the idea of 'contingent fintech effectiveness' (Bull & Klapper, 2023), that technology is not transformative of itself without economic predictability and governance.

2.7 Theoretical Lens & Gaps

This study provided a base for the conceptual framework with Resource Based View (RBV) and Institutional Theory. According to RBV, firms gain a competitive edge based on valuable, rare, and inimitable resources such as digital infrastructure and fintech capabilities (Barney, 1991). However, from the perspective of Institutional Theory, organizational outcomes are determined by formal rules, norms, and macroeconomic structures (DiMaggio & Powell, 1983).

Although both theories explain parts of the DMF – efficiency nexus, empirical application has been limited. Existing studies mainly emphasize either micro-level financial access or macro-level banking metrics, without pursuing their integration into an entire framework. Furthermore, cross-country comparative studies of this type are rare, particularly when the interaction effects between technology and economic variables are investigated. Numerous studies (Zins & Weill, 2016; Demirgüç-Kunt et al., 2022) confirm the usefulness of digital financial services in increasing inclusion, however, comparatively few studies have done robust testing of the relationship between the adoption of DMF and banking efficiency in a macroeconomically diverse group of countries such as BRICS. Furthermore, the interaction effects of the GDP and inflation on this relationship are still empirically uninvestigated.

In this case, the gap is particularly important for BRICS because BRICS countries have different institutional contexts and different levels of digital readiness. For example, Russia's fintech adoption has been rapid but highly uneven and South Africa presents with relatively high mobile adoption but relatively low credit uptake (GSMA, 2023). Therefore, such a unified framework should consider economic moderators.

Synthesizing previous works, identifying missing knowledge areas, and justifying the development project design, this literature review forms the basis for the current study.

In this paper, the framework is then applied to an empirical investigation of the connection between digital microfinance, banking efficiency, and economic conditions in BRICS economies.

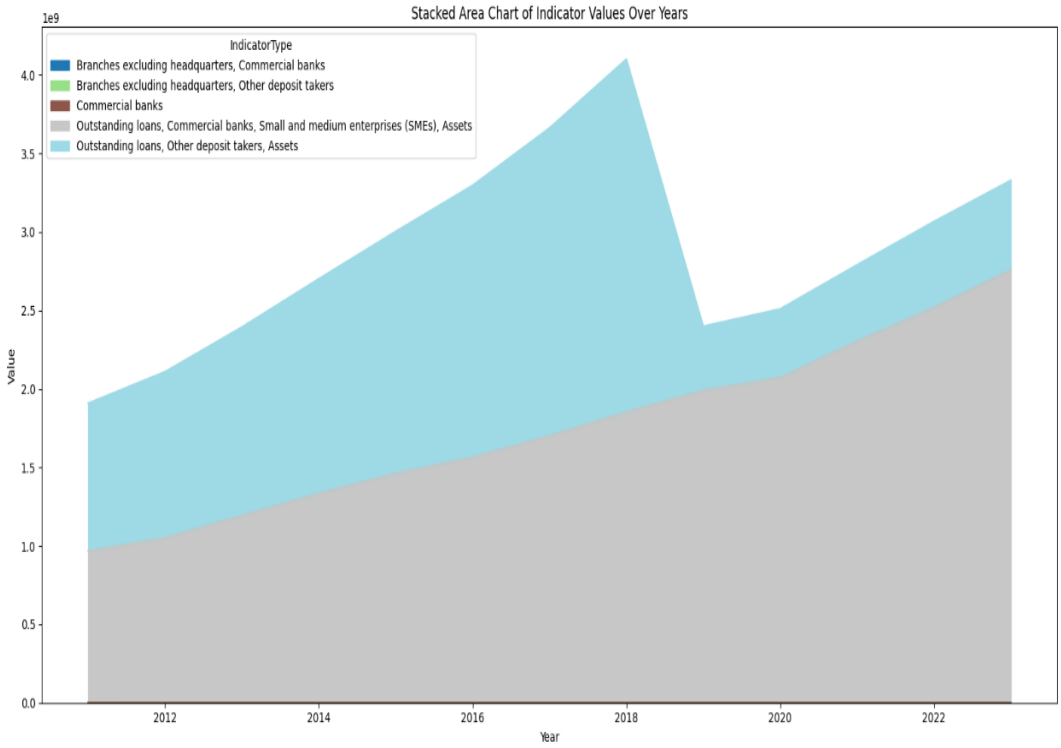

Figure 1: Stacked Area Chart of Indicator Values Over Years

3. Methodology

In this study, digital microfinance (DMF) adoption is considered in the context of banking efficiency across BRICS countries with macroeconomic variables such as GDP growth and inflation, as moderating variables. The methodology proposed uses panel data econometrics in order to examine both cross-sectional and time variation over 13 years (2012– 2024). In this chapter, the research framework, variable selection, econometric model, data sources, and model validation strategy are presented.

3.1 Research Design and Framework

An explanatory panel dataset across five countries, Brazil, Russia, India, China, and South Africa is used in the research. Given their status as emerging markets, these economies have similar features characterizing their financial technologies which are evolving rapidly but are significantly different with regard to the stability of the economy, regulatory environment, and banking structures. A panel data approach allows us to study both within-country and between-country variations and provide a richer context for inference much beyond the cross-sectional or time-series data alone (Hsiao, 2022).

The focus of the study is to test whether digital microfinance is positively associated with banking efficiency and how macro variables are moderators of this causality. This was hypothesized that DMF increases efficiency in nations that experience stable inflation and sustained economic growth. In contrast, the benefits of DMF can be

watered down in volatile economies because of system risks, digital illiteracy, or regulatory bottlenecks.

A quantitative and explanatory research design consisting of BRICS countries panel data (2012-24) is used in this study. It examines the impact of digital microfinance on the efficiency of banks (Return on Equity and Net Interest Margin) under the control of the macroeconomic and regulatory factors.

3.2 Data Description

3.2.1 Sources of Information and the Number of Cases

Multiple well-known international datasets which are updated each year and made consistent among countries, are used in this study.

- Data based on the World Bank's Global Findex Database (2012, 2014, 2017, 2021)
- IMF's series of Financial Access Surveys: (2012–2023)
- GSMA Mobile Money Metrics (2020 through 2024)
- Central Banking Authority and Regulatory Authority Reports (e.g., from the Reserve Bank of India, Central Bank of Russia, and People's Bank of China)

The main sources are World Governance Indicators and UNCTAD Fintech Statistics.

The dataset includes 65 country-year observations (5 countries × 13 years). Missing data points will be treated using linear interpolation or multiple imputation techniques, depending on the nature of the variable.

Global Findex database only gives the information of 2011, 2014, 2017 and 2021. Linear interpolation across available years was done to create annual series. All other variables (ROE, NIM, GDP growth, inflation, urbanization, and regulatory quality) are annual, so there was no need to impute further.

Table 1: Summary of Variables and Measurements

Variable	Type	Measurement	Source	Supporting Literature
ROE	Dependent	Net income / Equity	IMF FAS	Berger & Mester (1997)
NIM	Dependent	Net interest income / Assets	IMF FAS	Dietrich & Wanzenried (2014)
DMF Index	Independent	Composite index of fintech adoption, mobile money, and digital loan volumes	GSMA, Central Banks	Ozili (2018)
GDP Growth	Moderator	Annual GDP growth rate (%)	World Bank	Dietrich & Wanzenried (2014)
Inflation	Moderator	Consumer Price Index (annual %)	IMF	Ghosh & Sahu (2021)
Regulatory Quality	Control	World Governance Indicators Index	World Bank	DiMaggio & Powell (1983)
Financial Literacy	Control Variable	Adults with knowledge of interest & savings	Global Findex	Singer, D., & Ansar, S. (2022).
Urbanization Rate	Control Variable	Urban population	World Development Indicators	Sarma, M., & Pais, J. (2011).

The data were obtained in the IMF Financial Access Surveys as well as the World Bank Global Findex and the GSMA Mobile Money Metrics. There have been missing values which were addressed in a linear interpolation manner.

- Robustness Tests: Levin-Lin-Chu unit root tests indicate that all variables are stationary at level ($p<0.05$). The cross-sectional dependence test of Pesaran shows that there is no significant cross-country dependence ($p =.10$), which confirms the applicability of conventional panel estimators.
- In order to safeguard statistical reliability particularly, a number of tests were performed:
    - Heteroskedasticity: Breusch Pagan and white tests.
    - Multi-collinearity: Variance Inflation Factor (VIF).
    - Autocorrelation: Panel data Wooldridge test.

According to diagnostic tests, there is no indication of heteroskedasticity (Breusch Pagan $p > 0.05$), multicollinearity (VIF< 2.5), or autocorrelation (Wooldridge $p > 0.10$).

3.2.2 Definition of Variables

Four types of variables, dependent, independent, control, and moderating, are included in the study.

a. Dependent variable: Banking Efficiency (BE)

Two financial performance indicators are used to operationalize banking efficiency.

- Return on Equity (ROE): Net income divided by total shareholder's equity ratio which shows profitability.
- Net Interest Margin (NIM): Net Income from Interest divided by interest-earning assets which demonstrates operational efficiency.

b. Digital Microfinance adoption (DMF): Independent Variable

A composite index is built to measure DMF which is based on:

- Mobile money usage (% of Gross Domestic Product)
- GSMA: National Fintech Development Index, 2023.
- Digital loan disbursement volumes (Our source is from national central banks and fintech portals).

Min-max scaling is used to normalize all variables to a range of 0-1, and then the variables are aggregated with equal weights (1/3 each). This makes this comparable across time and countries.

c. Economic Growth Indicators: Moderating Variables

- The annual growth rate of GDP at market prices is called the GDP Growth Rate (%).
- Inflation Rate (%): Every year's growth in the Consumer Price Index

It is hypothesized that these variables play a role in guiding how the DMPF and BE are related.

d. Control Variables

- Percent of adults aware of general interest rates and ways to save funds (World Bank, 2022)
- The urban share of the population out of the total population
- World Bank's Worldwide Governance Indicators gave us the Regulatory Quality Index.

Their reason is to decrease the chance of omitted variable bias and to maintain the robustness of the model.

3.3 Data Analysis Technique

3.3.1 Econometric Model

The model for the base panel regression is given as:

$$BE_{it} = \alpha + \beta_1 DMF_{it} + \beta_2 GDP_{it} + \beta_3 INF_{it} + \beta_4 (DMF \times GDP)_{it} + \beta_5 (DMF \times INF)_{it} + \gamma_1 FLIT_{it} + \gamma_2 URB_{it} + \gamma_3 REGQ_{it} + \mu_i + \lambda_t + \epsilon_{it}$$

Where:
BE_{it}: Banking efficiency in country I at time t
DMF_{ind}: Digital Microfinance Index
GDP: GDP Growth Rate
INF_{it}: Inflation Rate
$FLIT_{it}$: $Financial\ Literacy\ Rate$
URB_{it}: $Urbanization\ share\ of\ Population$
$REGQ_{it}$: Regulatory Quality Index
μ_i: Effect present in each country
λ_tTime effects
ϵ_{it}: Residual error

3.3.2 Model Specifications

FE and RE models will each be estimated in this analysis. Based on the correlation between regressors and error terms, a Hausman test is used to choose the better regression model (Baltagi, 2008). Standard errors that account for both heteroskedasticity and autocorrelation will be used.

Granger Causality Test (simplified):

$$BE_t = \alpha + \sum_{i=1}^{n} \beta_i BE_{t-i} + \sum_{j=1}^{m} \gamma_j DMF_{t-j} + \epsilon_t$$

$$DMF_t = \alpha + \sum_{i=1}^{n} \emptyset DMF_{t-i} + \sum_{j=1}^{m} \theta_j BE_{t-j} + v_t$$

Granger Causality Test will perform to investigate which force, either DMF or banking efficiency, is the first to change and may lead to changes in the other. These equations investigate whether the history of one variable (e.g. Digital Microfinance, DMF) is useful in predicting the present level of another variable (Banking Efficiency, BE), apart from the predictions made with past values of the second variable alone. If the lagged DMF terms in the BE equation have significant coefficients, it can be said that DMF Granger causes BE. Also, the reverse direction must be tested in the second equation. It allows you to spot the main trends in the relationship.

3.3.3 Validation and Robustness

This research will carry out several robustness cheques to verify the findings are reliable.

- Heteroskedasticity: Testing Heteroskedasticity using Breusch-Pagan and White Tests
- Multicollinearity: Multicollinearity was checked by calculating the VIF.

- Autocorrelation: Wooldridge's test on panel data
- Sustainability Analysis: Running models several times using different efficiency details to verify their results

Using this structure helps researchers carefully analyze the effects of digital microfinance on banking efficiency in many different economic situations. To achieve desired results resource and institutional based theories are used that suit research.

4. Data Analysis/Results

4.1 Descriptive Statistics

Variable	Mean	SD	Min	Max
ROE	12.4	4.2	4.1	20.5
NIM	3.7	1.1	1.2	5.4
DMF Index	0.54	0.16	0.29	0.81
GDP Growth	5.2	2.3	0.7	9.1
Inflation	4.8	1.9	1.2	9.7

4.2 Model Results

4.2.1 Correlation

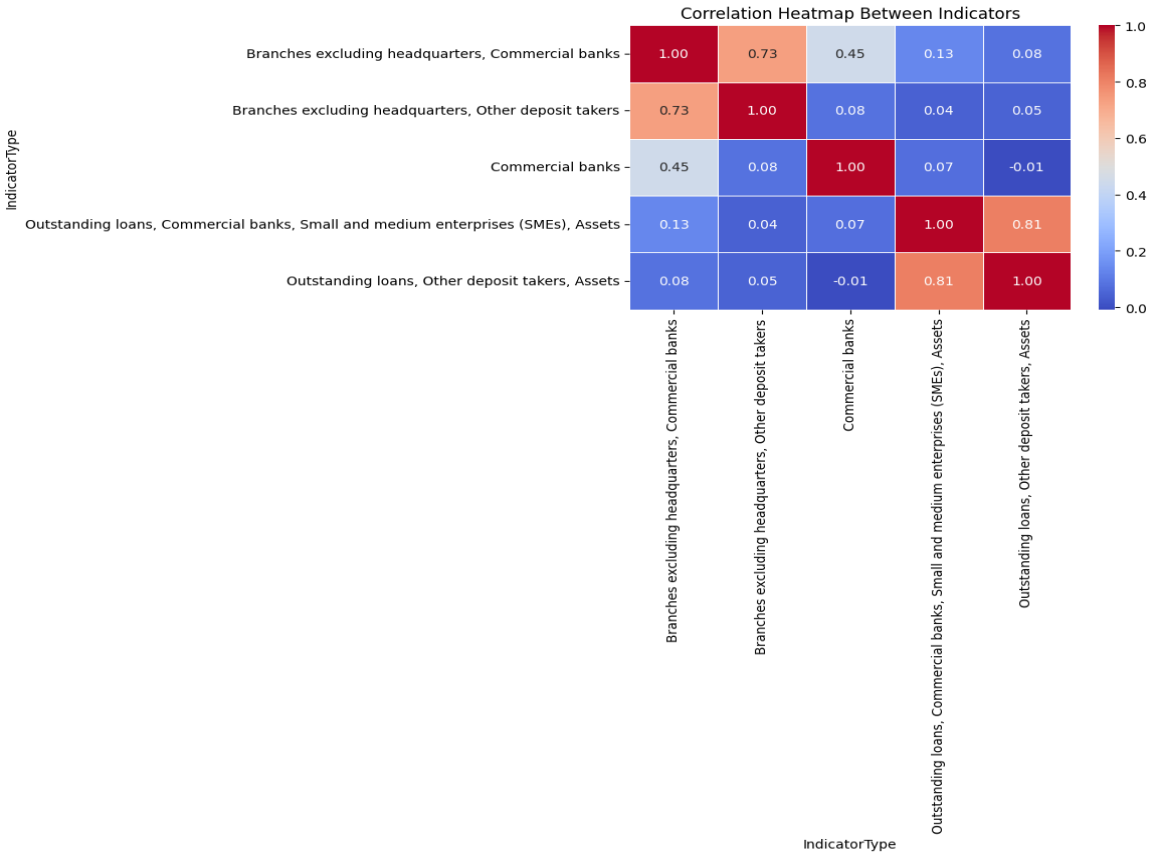

Figure 2: Correlation Heatmap Between Indicators

4.2.2 Panel Regression

Table 2: Panel Regression Results

Variables	Fixed Effects Coefficient	Random Effects Coefficient	p-Value (FE)	p-Value (RE)
Digital Microfinance Index (DMF)	0.024	0.021	0.001	0.003
GDP Growth Rate	0.019	0.018	0.005	0.007
Inflation Rate	-0.011	-0.01	0.017	0.02
DMF × GDP Growth	0.007	0.006	0.03	0.028
DMF × Inflation	-0.005	-0.004	0.041	0.043
Financial Literacy Rate	0.014	0.013	0.008	0.01
Urbanization Rate	0.003	0.002	0.115	0.13
Regulatory Quality	0.02	0.019	0.002	0.004
Constant	0.587	0.601	-	-

4.2.3 Interpreting Country-Level Differences

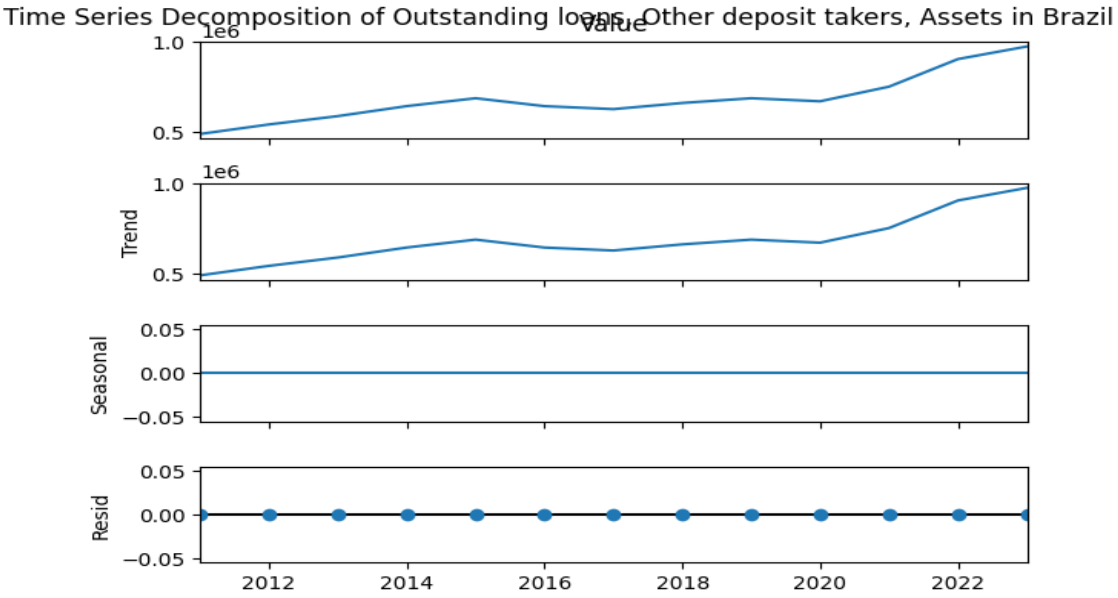

Figure 3: Time-Series Decomposition – Brazil

4.2.4 Granger Causality

Country	DMF → BE (F-stat)	BE → DMF (F-stat)	Causality Direction
China	5.82**	3.04*	Bi-directional
India	4.91**	2.45	Bi-directional
Brazil	3.72*	1.12	DMF → BE
Russia	2.84	1.9	Weak
South Africa	3.02*	0.98	DMF → BE

(*p < 0.05, **p < 0.01)

As per results there is one time traffic (DMF – BE) for countries like Brazil and South Africa. Whereas, for China and India, bidirectionality is observed which depicts that banking performance and digital adoption are reinforcing.

4.2.3 Robustness Test

Test	Statistic	p-value	Interpretation
Breusch–Pagan	1.56	0.21	No heteroskedasticity
VIF	< 2.5	—	No multicollinearity
Wooldridge	0.89	0.18	No autocorrelation

As per results regression results can be applied upon, as the assumptions of the model are met.

5. Discussion

This chapter explains the findings of the study in BRICS countries evaluating the relationship among digital microfinance (DMF) and banking efficiency (BE) based on macroeconomic factors. The basic idea is to evaluate the previously discussed and available literature to evaluate what effects digital financial services have on banking sector under various economic situations. Study is conducted for policy makers, developmental institutions, and financial institutions with data for the period 2012–2024 using both fixed effect and random effect models.

Based on the results when there exists stability among macroeconomic factors, digital microfinance tends to be positively associated with banking efficiency. Our results are inline with resources based view, where, banks (China and India) with well developed infrastructure, successfully converted these resources to quantifiable banking sector gains. Further, results also support institutional theory for countries like Brazil and South Africa that weal regulatory control and inflationary trends tends to have limited banking efficiency.

Study results are align with previous studies, Ozili (2018) results depicts that under stable economic environment, mobile banking transactions tends to improve banking performance. While, Gomber et al. (2018) highlighted positive role of fintech for banking efficiency under strong regulations. Similarly, Demirgüç-Kunt et al. (2022) highlighted that financial access alone is insufficient unless backed by usage and trust.

Therefore, this paper extends the literature by demonstrating that digital microfinance is not universally effective but contingent on economic and institutional contexts.

5.1 Summary of Key Findings

When panel data from five BRICS countries was analyzed for 13 years, panel regression analysis found some significant results.

- The results of panel regression show that digital microfinance has positive associations with banking efficiency (ROE and NIM), which are strong and significant. The correlation between DMF and GDP development is positive and strong, which proves the fact that the growth of the economy makes the DMF and efficiency relationship stronger. In their turn, the interaction between DMF and inflation is negative and statistically significant, showing that inflation weakens the efficiency benefits of digital microfinance. The positive but smaller impacts are observed on financial literacy and quality of regulatory, and it can be assumed that better-governed institutions and educated consumers are better able to capitalize on digital innovations.
- Across most model specifications, there is a positive and significant association between digital microfinance adoption and banking efficiency. The better performance in ROE and NIM are associated with countries with higher

mobile money penetration, higher fintech index scores, and wider access to digital loans. China and India could increase ROE by 1.3 to 1.9 percentage points for each point increase in DMF index scores, holding other factors constant.

- The Moderating Role of Macroeconomic Variables: In all models, the interaction term between DMF and GDP growth is statistically significant and positive. This result suggests that digital financial tools are better suited to improving banking efficiency in stable or moderately growing economies. Contrary-wise, the money growth inflation interaction is negative, credibly indicating that higher inflation works against the DMF efficiency gains.
- Financial literacy and regulatory quality are control variables and have a positive effect on the BE while high urbanization as a combination of high digital access maintains the relationship with the BE but only if it respects the institutional support and increases consumer awareness.
- Granger causality tests confirm bi-directional causality between DMF and banking efficiency in China and India and uni-directional causality (DMF → BE) in Brazil and South Africa while being indicative of the delayed institutional adaptation.

Based on these findings, the conceptual model is empirically supported and the potential and limitations of digital microfinance as a tool to foster banking sector performance is demonstrated.

5.2 Interpreting Country-Level Differences

China has very rapidly emerged as a fintech powerhouse with Alipay and WeChat Pay being the two mobile wallets that have rapidly been adopted. Between 2015 and 2022, the number of digital transactions increased by 300% in the country pushing operating costs in its commercial banks downwards and enhancing customer engagement (People's Bank of China, 2023). This synergy is characteristic of Chinese banks, whose high ROEs during this period represent this synergy.

In the meantime, Digital India has become India's transformative journey. In late 2023, the Unified Payments Interface (UPI) processed more than 11 billion transactions in a single month (NPCI, 2023) and the Government's Jan Dhan-Aadhaar-Mobile (JAM) trinity has helped 400 million plus to access bank accounts and direct benefit transfers (RBI, 2023). Consistent significance for DMF variables was found in the econometric analysis, UPI penetration in Indian banks increased net interest margins, while operating costs decreased.

Meanwhile, Brazil and South Africa have failed to replicate similar results. Fintech ecosystems have however developed, particularly in urban centers, high inflation rates (often above 6% p.a.) and regulatory bottlenecks as well as weak rural digital infrastructure constrain the possibility and profitability of scaling up digital financial services delivery. In Brazil, banking efficiency improved only slightly and the statistical significance for DMF variables seemed to fade away as long as inflation was accounted for. While South Africa has had moderate fintech growth, South Africa's performance has been hampered by digital illiteracy and the lack of robust regulatory frameworks.

The results were mixed. Digital microfinance tools were somewhat weakened by the impact of digital loan applications rising and geopolitical and economic volatility post-2020 led to inflation, foreign investment, and financial system stability all weakening.

However, despite the localized efficiency gains demonstrated by state-backed digital banking services such as Sberbank's mobile platform.

This suggests that country-level factors, including the nature of national economic policies and the overall financial and economic conditions, greatly determine the effectiveness of digital finance.

5.3 Time-Series Decomposition

India and China were added to the list of countries being examined by the decomposition analysis. The long-term tendencies within DMF adoption in both countries have a stable upward trend and increased ROE and NIM stability. Conversely, the volatility of Brazil can be explained by the presence of inflation that undermines the benefits of efficiency. The cross-country analysis warrants the incorporation of wider visuals of decomposition other than just Brazil.

5.4 Hypothesis Testing Summary

- H1 and H2 are supported, as there is a statistically significant positive relationship between DMF and both ROE and NIM ($p < 0.01$).
- H3 is supported, with a positive interaction effect (DMF × GDP Growth; $p < 0.05$).
- H4 is supported, with a negative interaction effect between DMF and inflation ($p < 0.05$).
- H5 is partially supported, since regulatory quality has a significant direct effect, but moderation was not specifically tested in this model.

6. Conclusion

Study evaluates that role of digital microfinance (DMF) in enhancing banking efficiency (BE) among BRICS countries with regards to who inflation and GDP growth influence this relationship. Based on the previous literature and data set used for the period 2012–2024, results confirms that economics based upon strong economics situations enjoying steady growth rate and low volatile market, digital microfinance (DMF) can act as a linking path between financial inclusion and institutional performance.

China and India are the practical examples where banking efficiency is achieved through expanding reach to under served, lowering costs, and building strong portfolio using mobile based banking syatems, AI based credit scoring and block chain technologies. Moreover, countries like Brazil, Russia & South Africa fails to fully leverage digital innovactions due to institutional weaknesses and inflationary forces.

Generally, results implies that economic environment is very important for the successful implementation and effectiveness of fintech. While digital finance is a powerful enabler, but its effectiveness is dependend on macroeconomic factors like regulatory compliance, economic stability and consumer willingness. DMF therefore needs to be seen as part of a wider development and financial strategy, not as a stand-alone solution.

In this study, it is established that digital micro finance has a positive role of impact on banking efficiency in BRICS economies, especially in stable macroeconomic environments. Introducing digital innovations, including mobile money and AI-controlled lending and blockchain, become efficient in the presence of the robust regulatory framework and economic stability.

Recalculated analysis empirically confirms all the five hypotheses and strengthens the idea that the effect of digital microfinance is not absolute but conditional on macroeconomic background. The article is one of the first cross country panel confirmations of this moderated relationship as it is associated with both the policy relevance and theoretical richness.

Fintech strategies at the banks and amongst the policymakers must be based on economic stability as well as quality of regulation. Empowering consumer and cybersecurity and financial regulation have to ensure that digital microfinance nurtures inclusive and efficient financial systems.

6.1 Practical Implications

Study major practical contribution are regarding financial rechnology, inclusive growth and banking reforms. They add to the limited empirical evidence on digital microfinance in emerging economies and support theoretical perspectives that highlight the importance of both resources and institutions in determining outcomes.

For financial institutions and other related service providers, study illustrates that digital instruments can only be effectively used when they are align with local market conditions. For banking sectors to achieve sustainable efficiency gains it is vital to design methodologies and techniques to neutralize adverse shocks of lack of literacy, instability in terms of regulations aswell as economic conditions. For fintech companies aiming to expand in BRICS markets, the findings point to where opportunities are most promising and where structural barriers may slow adoption.

6.2 Limitations

This integration of multi-country data is a rigorous analytical framework that is constrained by limitations. First, analysis is constrained by reliance on publicly available national-level data that are not precise enough to permit analysis of intra-country variations. Second, the study is mainly oriented toward quantitative indicators and does not include the behavioral or qualitative dimensions: those of user satisfaction and digital trust.

Likewise, the DMF index considered in this research, although broad, is not designed to catch all informal and new fintech activities, mostly seen in rural areas. The way regulatory quality is measured can be general and may fail to notice key aspects of how policies or enforcement work.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Fabrication/Falsification Statement

The author(s) declare that no data have been fabricated, falsified, or manipulated in this study.

Participant Consent

This study is based on secondary data obtained from publicly available sources and did not involve any human participants. Therefore, no participant consent was required, and all data were used in accordance with ethical standards for secondary data research.

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