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Mobile Banking And Microfinance Sustainability: Evidence From The Global MIX Market Database

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Abstract
Mobile banking has revolutionised the delivery of financial services, but its impact on the financial viability of Microfinance Institutions (MFIs) remains poorly understood. Previous studies have mainly investigated the demand-side effects of digital finance on household welfare and financial inclusion, but empirical evidence on its institutional implications is limited, especially from a global perspective. This paper explores the impact of mobile banking on the financial sustainability of MFIs using an unbalanced panel of 3116 institutions extracted from the World Bank MIX Market Database for the period 1999-2019. In this study, a two-way Fixed Effects panel regression model is used to assess the impact of mobile banking transaction intensity on three complementary indicators of financial sustainability: Operational Self-Sufficiency (OSS), Operating Expense Ratio (OPEX), and Return on Assets (ROA), controlling for institutional characteristics and common time effects. The findings indicate that mobile banking transaction intensity does not have a statistically significant short-run impact on institutional sustainability. In contrast, institutional scale positively impacts operational self-sufficiency and profitability and reduces operating costs, whereas deteriorating portfolio quality negatively impacts financial performance. The findings suggest that the payoffs of digital transformation are likely to materialise over a longer horizon once institutions have recovered significant initial technology investments. Our study contributes to the literature by providing global evidence on the institutional effects of mobile banking and policy insights for fostering financially sustainable digital financial inclusion.

Keywords: *Mobile Banking; MFIs; Financial Sustainability; Digital Finance; Fixed Effects; MIX Market Database.*

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I. Introduction

Financial inclusion has become one of the main pillars of sustainable economic development over the last three decades. When they have access to affordable and reliable financial services, they can smooth consumption, accumulate productive assets, invest in education and health, and better manage income shocks. Governments, multilateral agencies and financial institutions have recognised the developmental benefits of inclusive finance and increasingly recognised it as an essential instrument to reduce poverty, promote entrepreneurship and achieve several Sustainable Development Goals (SDGs). In this context, microfinance institutions have played a revolutionary role in providing financial services to economically deprived sections of society that remain largely outside the purview of traditional banking systems. Unlike commercial banks, which usually require collateral, formal credit histories and stable income sources, micro-finance institutions (MFIs) are designed to provide small loans, savings facilities, insurance products and a variety of other financial services to low-income households and micro-entrepreneurs tailored to their specific needs (Armendariz de Aghion and Morduch, 2010).

The microfinance industry has expanded rapidly worldwide, demonstrating that financial services can be successfully delivered to traditionally unbankable populations. Over the past few decades, the sector has evolved from donor-funded poverty alleviation programs to a diversified financial ecosystem encompassing non-governmental organisations, cooperatives, rural banks, regulated microfinance banks, and specialised financial institutions in both developed and developing economies. But as the industry has matured, the goals have become more complicated. Modern MFIs are expected to be financially sound while fulfilling their social mission of serving economically vulnerable populations. A much-discussed concept in the literature is the double bottom line, which requires institutions to balance commercial sustainability and social outreach (Hermes and Hudon, 2018). This is one of the longest-standing challenges in the microfinance industry worldwide. The operations of traditional microfinance are intrinsically plagued by high transaction costs, which present a major barrier to long-term sustainability. Microfinance differs from traditional commercial lending in that it typically involves many

small loans. This requires intensive client screening, frequent field visits, monitoring of clients in groups, disbursement of loans, collection of repayments and ongoing supervision of borrowers. Such activities demand huge investment in both human resources and branch infrastructure and generate relatively high operating costs per unit of credit disbursed (Cull et al., 2007).

Administrative costs are a major component of the total cost of lending, and many MFIs are under constant pressure to increase interest rates, increase the average loan size, or concentrate on relatively better-off borrowers to remain financially viable. These strategic changes can improve short-term financial performance but often at the cost of the social goal of serving poorer households, contributing to what the literature refers to as "mission drift" (Schreiner, 2002). In economies, the challenge of balancing outreach and sustainability is particularly acute, as geographic dispersion, poor infrastructure, and low banking penetration substantially increase the cost of delivering financial services. The economics of maintaining physical branches and field operations in sparsely populated areas often exclude rural and remote communities from the purview of formal financial institutions. Previous research has shown that these kinds of structural mismatches between the demand for financial services and the supply of financial institutions create permanent barriers to financial inclusion, particularly in low-population-density areas with poor transport and communication networks (Sarma, 2015). Therefore, enhancing the efficiency of financial service delivery has become a key policy priority for governments and development agencies as they work to expand inclusive finance without imposing unsustainable financial burdens on lending institutions.

New developments in digital technologies are changing the way that financial services are created and delivered. The rapid development of financial technology (FinTech) has created opportunities for financial institutions to revolutionise traditional banking processes through technology-based delivery channels (Gomber et al., 2018), which are enabled by the ubiquitous use of mobile phones, internet connectivity, cloud computing, and digital payment infrastructure. Of these innovations, mobile banking has been one of the most powerful developments for financial inclusion. This enables borrowers to access financial services via their mobile devices, allowing financial institutions to digitise loan applications, customer identification, loan disbursement, repayment collection, balance inquiry and other routine financial transactions. Moving from manual branch-based transactions to digital platforms can reduce transaction costs, improve operational efficiency, enable better portfolio monitoring, and increase customer convenience (Duncombe and Boateng, 2009).

As per institutional thinking, the economic value of mobile banking is much more than simple technological modernization, which could change microfinance's cost structure by substituting labour-intensive processes with scalable digital infrastructure. Traditional lending models rely heavily on repeated physical interaction between loan officers and borrowers. Mobile banking, however, allows many of these transactions to be done electronically, thus reducing travel costs, administrative delays, cash handling risks and information asymmetries. These improvements may enhance institutional efficiency by reducing operating costs and enabling MFIs to serve larger client bases without commensurate increases in administrative costs. If sustained, such efficiency gains could translate over the longer term into improved operational self-sufficiency, better asset performance and greater institutional resilience, while promoting broader financial inclusion objectives.

The importance of digital financial services is increasing, but evidence regarding their impact on institutional sustainability remains inconclusive. Much of the existing literature has focused on the demand side effects of digital finance, how mobile money affects household consumption, savings behaviour, financial inclusion and poverty alleviation (Jack and Suri, 2014). However, the supply-side implications of microfinance institutions themselves have been less studied. Studies of institutions are typically based on a single-country experience, a relatively small sample, or a limited period of observation. Furthermore, the long-term financial consequences of implementing mobile banking are still not understood, as the digital transformation process generally involves significant upfront investments in technology, software, cyber security, staff training, and regulatory compliance. The implementation costs may be too high to offset the short-term financial gains from digitalisation before operational efficiencies are realised.

In this context, the present study investigates the role of mobile banking in the financial sustainability of microfinance institutions, using a comprehensive global panel dataset from the World Bank's MIX Market Database. The analysis is based on an unbalanced panel of 3,116 MFIs observed over the period 1999-2019. The study employs a two-way fixed-effects panel regression model to investigate the effect of mobile banking transaction intensity on three substitutive dimensions of institutional performance, i.e., Operational Self-Sufficiency (OSS), Operating Expense Ratio (OPEX), and Return on Assets (ROA). Our empirical approach accounts for institutional heterogeneity and common shocks over time to identify the relationship between digital transaction intensity and financial sustainability across different institutional and geographic settings.

The current study adds three important issues to the existing literature. First, it shifts the analytical lens from the well-studied demand-side effects of mobile finance to the relatively less studied supply-side performance of financial institutions. Second, unlike previous studies that focus on a single indicator of institutional performance, this study considers sustainability through the lens of several complementary dimensions such as

profitability, operational self-sufficiency and cost efficiency. Third, the analysis uses one of the largest longitudinal datasets to date for the global microfinance industry, providing internationally comparable evidence on the relationship between digital financial innovation and institutional sustainability over two decades of structural transformation. The results are expected to add to the existing academic literature in digital finance and microfinance as well as to policy discussions on designing sustainable financial inclusion strategies in developing economies.

II. Literature Review

Microfinance Sustainability and the Double Bottom Line

Microfinance has come a long way from being an intervention to reduce poverty to a core element of the global financial system. Early microfinance programmes were mainly funded through donor aid and government subsidies. However, the rapid commercialisation of the sector has transformed the operating environment of Microfinance Institutions (MFIs). Today's MFIs are expected to be financially sustainable, yet they also need to provide financial services to the poor and the financially excluded. This twin objective is commonly referred to as the double bottom line. Institutions need to find a balance between financial sustainability and social outreach (Hermes and Hudon, 2018).

Financial sustainability is defined as the MFI's ability to generate enough operating income to cover its operating expenses, the cost of funds, and loan loss provisions, without relying on subsidies. Institutions that cannot recover these costs systematically will face long-term financial instability and will be limited in their ability to expand outreach and continue serving disadvantaged communities. Therefore, sustainability has become one of the most studied dimensions of microfinance performance. Cull et al. (2007) analysed global data on leading microfinance institutions and found that those which were financially sustainable tended to perform better on measures of operational efficiency and donor resource reliance. However, they found that a greater commercial orientation could undermine outreach to poorer borrowers, posing a key trade-off between financial performance and social objectives.

This trade-off has long been debated in microfinance literature. Schreiner (2002) defined mission drift as the tendency of institutions under pressure to increase profitability to shift their lending portfolios toward wealthier clients who borrow larger amounts and are lower credit risks. Although such a strategy improves the financial indicators, it jeopardises the original objective of promoting the financial inclusion of vulnerable households. Hermes and Hudon (2018) further argue that sustainable microfinance should be evaluated not only by profitability measures but also by the institution's capacity to sustain long-term outreach to economically marginalised segments. Therefore, in recent times, the performance evaluation of MFIs has favoured recognising sustainability as a multi-dimensional concept involving operational self-sufficiency, profitability, efficiency and social performance.

Transaction Cost Economics and Agency Theory

The complementary perspective of Transaction Cost Economics and Agency Theory can explain the theoretical link between mobile banking and institutional sustainability.

Transaction Cost Economics, first introduced by Coase (1937) and refined by Williamson (1979), suggests that organisations are always looking for institutional arrangements that can reduce the costs associated with economic transactions. The costs are information gathering, negotiation, monitoring, enforcement and administrative coordination. Transaction costs are particularly high in microfinance because of the large number of small-value loans to geographically dispersed borrowers, frequent repayment schedules, and intensive monitoring requirements. Therefore, the cost of administration per unit of credit is much higher than in traditional commercial banking (Hermes et al., 2011).

Mobile banking fundamentally changes this cost structure by substituting labour-intensive physical transactions with digital financial platforms. Electronic loan applications, digital repayments, mobile wallets, automated notifications and real-time transaction processing are some of the ways that greatly reduce the need for repeat visits to the branches and manual record management. Digital delivery channels can enhance institutional efficiency and financial sustainability over the long term by increasing operational scalability and reducing variable transaction costs (Duncombe and Boateng, 2009; Ghalib and Malki, 2019).

Agency Theory also addresses the possible advantages of digital financial technologies. According to Jensen and Meckling (1976), the information asymmetry between the principal and the agent leads to monitoring costs and increases the probability of opportunistic behaviour. In microfinance, information asymmetries exist because borrowers generally know more about their repayment capacity and investment plans. The traditional lending system relies heavily on loan officers' physical monitoring of borrowers to address the problems of moral hazard and adverse selection (Stiglitz and Weiss, 1981). Digital financial platforms partly address these agency problems by creating ongoing electronic records of transactions that improve transparency, help supervise

borrowers, and allow for more precise credit assessment. Therefore, mobile banking can reduce transaction costs, improve the quality of the portfolio and hence improve the performance of the institution.

Mobile Banking, Digital Finance and Institutional Efficiency

Rapid advances in digital financial technologies have reshaped the structure of financial intermediation in both developed and developing countries. Financial institutions have been able to revolutionise conventional service delivery models through advances in mobile communication, internet connectivity, cloud computing, and digital payment systems. Another is mobile banking, which is considered a powerful tool for promoting financial inclusion, as it greatly reduces geographical barriers and the cost of delivering financial services (Gomber et al., 2018).

Mobile banking is a service that allows borrowers to access financial services remotely from a mobile device, rather than through branch-based banking. This allows institutions to digitise processes such as loan applications, customer identification, fund transfers, repayment collection, account management, and customer support. According to Duncombe and Boateng (2009), digitalisation offers a more flexible operation and reduces the risk of cash handling and administrative delays. These technologies are particularly effective for microfinance institutions (MFIs) operating in rural and geographically dispersed areas where maintaining a physical branch network is expensive.

Digital finance is not limited to the development of mobile payment systems. Today's fintechs are using artificial intelligence, machine learning, biometric identification and alternative credit scoring to improve lending decisions and lower the risk of default. Berg et al. (2020) find that the digital footprint of online transactions can be a valuable source of information for credit assessment, thereby reducing information asymmetry between lender and borrower. Recent research also finds that digital finance platforms are more operationally efficient because they automate routine administrative tasks, improve portfolio monitoring, and reduce turnaround time for processing credit applications. But these are benefits that are unlikely to be immediate, because institutions often need to make large upfront investments in technological infrastructure, cybersecurity, staff training and regulatory compliance. The economic benefits of digital transformation are often realised only when institutions have the right scale of operations.

Empirical Evidence and Research Gap

Empirical studies have produced mixed results concerning the link between digital finance and institutional performance. Much of the literature in this area has focused on household welfare, financial inclusion, consumption smoothing, saving behaviour, and poverty alleviation. For example, Jack and Suri (2014) found that mobile money systems increase household resilience via efficient risk sharing and lower transaction costs in the face of adverse economic shocks. The studies demonstrate the developmental importance of digital financial services from users' perspectives, but they offer relatively little evidence regarding the institutional consequences of these services.

Conversely, MFIs' performance on the supply side is relatively limited. Existing institutional studies tend to concentrate on operational efficiency, outreach or financial sustainability in a specific country or region. The results of Sarma (2015) show that operating expenses and institution size are strong determinants of branch efficiency, emphasising the significance of cost control in the sustainability of microfinance operations. Borbora and Sarma (2020) also found that participation in microfinance programs is correlated with higher household income and consumption expenditure. However, the affordability of credit, closely tied to institutional operating costs, ultimately determines improvements in client welfare. Results imply that technological innovations that lower transaction costs could have positive effects on both institutional sustainability and borrower welfare.

Despite these important contributions, there remain three key research gaps. First, there is a lack of research investigating the direct link between mobile banking adoption and MFIs' financial sustainability using large cross-country panel datasets. Second, existing research tends to assess sustainability using a single performance indicator, i.e., a partial assessment of institutional performance. Third, a lot of empirical studies are based on relatively short periods of observation or on country-specific data sets. This restricts the external validity of the findings. The current study overcomes these limitations by utilising one of the largest longitudinal datasets from the Global MIX Market Database to analyse the role of mobile banking transaction intensity across different dimensions of microfinance sustainability, such as Operational Self-Sufficiency (OSS), Operating Expense Ratio (OPEX), and Return on Assets (ROA).

III. Research Hypotheses

This paper draws on theoretical insights from Transaction Cost Economics and Agency Theory, as well as the empirical literature on microfinance sustainability and digital financial services. We provide four hypotheses that can be tested to establish the relationship between mobile banking and the financial performance of Microfinance Institutions (MFIs). The hypotheses will be tested to examine whether technology-driven

financial innovation has a positive effect on institutional sustainability through greater operational efficiency, increased profitability and reduced transaction costs.

Hypothesis 1: Mobile Banking and Financial Sustainability: The integration of mobile banking into microfinance operations is expected to improve the financial sustainability of institutions through the reduction of transaction costs, fast processing of loans, timely repayment of loans and improved operational efficiency. Digital distribution systems can help institutions reach more people without increasing administrative costs, thereby improving MFIs' capacity to cover operational costs and provide sustainable financial returns. As such, increasing mobile banking transaction intensity is projected to lead to higher OSS and improved ROA .
H1: The intensity of mobile banking transactions has a positive and significant impact on the Operational Self-Sufficiency (OSS) and Return on Assets (ROA) of Microfinance Institutions.

Hypothesis 2: Mobile banking and cost efficiency: One of the main economic benefits of digital financial technology is the reduction in the transaction costs of traditional branch-based lending. Mobile banking replaces labour-intensive procedures with electronic transaction platforms, thereby reducing costs associated with cash handling, field visits, manual record-keeping, and loan administration. With higher volumes of digital transactions, institutions should enjoy greater operational efficiency and lower administrative costs per loan.
H2: Mobile banking transactions negatively and significantly impact the Operating Expense Ratio (OPEX) of Microfinance Institutions.

Hypotheses 3: Institutional Scale and Sustainability: The literature consistently shows economies of scale in larger financial organisations. As the asset base grows, fixed administrative costs can be distributed to a broader portfolio of loans, improving operational efficiency and financial performance. Larger MFIs also have access to greater financial resources to invest in technology, risk management systems, and educated human capital, thereby increasing sustainability over the long run. It is assumed that there is a positive correlation between the size of the institution and its financial success.
H3: The natural logarithm of total assets, as a measure of institutional scale, positively and significantly impacts the financial sustainability of Microfinance Institutions.

Hypothesis 4: Risk and Sustainability of the Portfolio: The quality of the loan portfolio is one of the main factors that determine the viability of the company. High portfolio delinquency levels increase the need for loan-loss provisioning, reduce interest revenue, erode liquidity, and ultimately harm financial performance. Institutions with high PAR30 are expected to be less operationally self-sufficient and lucrative.
H4: Portfolio at Risk above 30 days (PAR30) has a negative and significant impact on the financial viability of Microfinance Institutions.

We assess the empirical validity of these assumptions using a two-way Fixed-Effects panel regression model that allows for institution-specific heterogeneity and common time-specific shocks. This study offers an in-depth assessment of the institutional effects of mobile banking use in the global microfinance industry by simultaneously analysing multiple measures of financial sustainability: Operational Self-Sufficiency (OSS), Operating Expense Ratio (OPEX), and Return on Assets (ROA).

IV. Data And Methodology

Data Source and Sample Selection

The empirical analysis is based on the Global MIX Market Database, which is one of the most extensive international databases on the financial and operational performance of Microfinance Institutions (MFIs). The database contains standardised financial statements and institutional performance metrics submitted by regulated and non-regulated MFIs in a range of industrialised and emerging economies. Due to its broad geographic coverage and standardised reporting framework, the MIX Market database has been widely used in empirical studies on microfinance sustainability, operational efficiency, financial inclusion, and institutional performance (Cull et al., 2007; Hermes and Hudon, 2018).

In the present analysis, annual institution-level observations for the period 1999–2019 were obtained from the database. The resulting data are an unbalanced panel dataset of 3,116 Microfinance Institutions with 41,256 observations over the years. The reason for using an unbalanced panel is that the frequency of reporting, institutional arrivals and exits, mergers, and missing observations varied across nations and years, a common feature of large multinational panel datasets.

The year 2020 was excluded from the research since only a very limited number of institutions supplied full financial information during that period. If these data were kept, the sample imbalance would be quite large, and the econometric estimations would be less reliable. All continuous financial variables were winsorized at the

1st and 99th percentiles to mitigate the effect of extreme reporting values. This reduces the effect of outliers without fundamentally changing the underlying distribution of data (Sarma, 2015).

Measurement of Variables

In this study, we investigate the impact of mobile banking transaction intensity on three complementary criteria of microfinance sustainability. Table 1 outlines the variables used in empirical analysis.

Table 1. Definition of Variables

Variable	Measurement	Expected Sign
Operational Self-Sufficiency (OSS)	Operating Revenue / (Financial Expense + Operating Expense + Loan Loss Provision)	-
Operating Expense Ratio (OPEX)	Operating Expense / Gross Loan Portfolio	-
Return on Assets (ROA)	Return on Assets reported by MIX Market	-
Mobile Banking	*ln*(Mobile Banking Transaction Value +1)	+ (OSS, ROA), - (OPEX)
Institutional Scale	ln(Total Assets)	+
Portfolio at Risk (PAR30)	Portfolio at Risk >30 Days	-
Outreach	Average Loan Balance per Borrower	±

Source: Author's compilation.

Dependent Variables

Financial sustainability is evaluated by three common metrics of institutional success, which are stated below:

The Operational Self-Sufficiency (OSS) indicates the extent to which an institution can meet its operating costs, financing costs and loan-loss provisions with its operating revenue. If the OSS value is more than one, then the institution can survive without external financial support and is consequently financially self-sufficient (Cull et al., 2007; Sarma, 2015).

Operating Expense Ratio (OPEX) is defined as the ratio of operating expenses to gross loan portfolio. This variable measures the operational efficiency of lending activities as it reflects the administrative cost required in providing the unit credit. The lower the value, the more economical it is.

Return on Assets (ROA) is a typical metric of financial performance, indicating the profitability derived from the institution's asset base. The higher the ROA, the more efficiently institutional assets are being utilized to generate earnings.

Independent Variable

Mobile Banking Transaction Intensity is the key explanatory variable, which reflects the degree of an institution's engagement in digital financial activities.

The variable is measured as the natural logarithm of the monetary value of transactions delivered via mobile banking channels, as reported in the Global MIX Market Database.

$$ln(Mobile\ Banking\ Transactions + 1)$$

The log transformation diminishes the effect of extreme observations and allows you to interpret the predicted coefficient in terms of elasticity. A unity constant is included prior to the transformation to retain observations with zero mobile banking transactions in the estimated sample.

Control Variables

To isolate the independent contribution of mobile banking, several institutional characteristics identified in previous literature are incorporated as control variables.

Institutional Scale (ln Assets) measures the natural log of total assets. Larger institutions are more likely to have economies of scale, stronger capital bases, and stronger managerial competencies; hence, there is a positive association with financial sustainability (Cull et al., 2007).

Portfolio at Risk higher than 30 days (PAR30) is the percentage of outstanding loan portfolio that is overdue for more than thirty days. It's a measure of portfolio quality and credit risk. Higher values are likely to reduce institutional sustainability, given the increased loan-loss provisioning requirements.

Outreach Depth is evaluated as average loan balance per borrower. This variable is a proxy for the socio-economic profile of the borrowers. Smaller average loan balances are typically associated with deeper outreach to impoverished households, while larger loan balances appear to be associated with a shift toward relatively affluent clientele (Schreiner, 2002).

Econometric Model

In this study, a panel data approach is applied because of the longitudinal nature of the data, and it can account for unobserved institutional heterogeneity. Microfinance Institutions (MFIs) are heterogeneous in terms

of organisational structure, regulatory environment, governance practices, ownership patterns and country-specific characteristics. Conventional pooled Ordinary Least Squares (OLS) estimation may yield biased and inconsistent estimates due to omitted variable bias (Wooldridge, 2010).

Thus, this analysis uses a two-way fixed-effects (FE) panel regression model that simultaneously adjusts for institution and year fixed effects. Institution fixed effects control for the effects of all time-invariant MFI-specific factors, while year fixed effects control for the effects of common macroeconomic shocks, technological developments, policy changes and global financial conditions that are common to all institutions in a given period.

Three different regression equations are estimated to evaluate different dimensions of institutional sustainability.

Model 1: Operational Self-Sufficiency

$$OSS_{it} = \beta_0 + \beta_1 MB_{it} + \beta_2 Assets_{it} + \beta_3 PAR30_{it} + \beta_4 Outreach_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Model 2: Operating Expense Ratio

$$OPEX_{it} = \beta_0 + \beta_1 MB_{it} + \beta_2 Assets_{it} + \beta_3 PAR30_{it} + \beta_4 Outreach_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Model 3: Return on Assets

$$ROA_{it} = \beta_0 + \beta_1 MB_{it} + \beta_2 Assets_{it} + \beta_3 PAR30_{it} + \beta_4 Outreach_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where:

- $i$denotes the Microfinance Institution.
- $t$denotes the year.
- $\mu_i$represents institution fixed effects.
- $\lambda_t$denotes year fixed effects.
- $\varepsilon_{it}$is the idiosyncratic error term.

Model Diagnostics and Robustness

One of the main problems with panel estimates is endogeneity due to reverse causality. More financially sound institutions may have more financial resources to invest in digital technology; hence, institutional performance may influence mobile banking uptake. Although this possibility cannot be ruled out within the static panel framework, the inclusion of institution fixed effects and year fixed effects significantly reduces the omitted-variable bias by accounting for time-invariant institutional characteristics and common macroeconomic influences (Baltagi, 2013; Wooldridge, 2010).

The Hausman Specification Test is used to test the consistency of the Fixed Effects and Random Effects estimators and the validity of the Fixed Effects specification. The test does not reject the null hypothesis that individual effects are uncorrelated with the explanatory variables, thereby favouring the Fixed Effects estimator.

Moreover, diagnostic tests suggest the existence of heteroskedasticity and serial correlation in the panel residuals. Therefore, all regressions are estimated with Huber–White heteroskedasticity-robust standard errors clustered at the institutional level as suggested by Arellano (1987). This method yields standard errors that are statistically valid in the presence of heteroskedasticity and within-panel serial correlation.

V. Results And Discussion

Descriptive Statistics

Before estimating the econometric models, it is useful to examine the sample's basic characteristics. Table 2 presents the descriptive statistics of the principal variables used in the empirical analysis. The dataset comprises 3,116 Microfinance Institutions (MFIs) observed over the period 1999-2019, although the number of observations varies across variables due to missing institutional reporting in certain years.

Table 2 indicates that the average Operational Self-Sufficiency (OSS) ratio is 1.167, suggesting that the sampled MFIs, on average, generate sufficient operating income to cover their operating expenses, financing costs, and loan-loss provisions. Since an OSS value exceeding unity generally indicates operational sustainability, the descriptive evidence suggests that a considerable proportion of institutions operate without continuous dependence on external subsidies. Nevertheless, the relatively large standard deviation reveals substantial variation in institutional performance across countries and institutional types, reflecting differences in governance structures, regulatory environments, and operational practices.

Table 2: Summary Statistics of Selected Microfinance Variables (1999–2019)

Variable	Obs.	Mean	Std. Dev.
Operational Self-Sufficiency (OSS)	27,776	1.167	0.898
Operating Expense / Loan Portfolio	24,704	0.281	1.005
Asset-Efficiency Tracker (ROA)	34,272	0.781	0.210
Mobile Banking Transaction Value	404	25.06 (in million $)	274.90 (in million $)
Total Assets	34,548	474.00	50,423.46

		(in million $)	(in million $)
Portfolio at Risk > 30 Days (PAR30)	32,568	0.071	0.170
Average Loan Balance per Borrower	36,720	$44,414	$8,032,060

Source: Author's calculation based on MIX Market data.

The average Operating Expense Ratio (OPEX) is 0.281, or roughly 28 per cent of the gross loan book. Considerable dispersion about the mean implies considerable heterogeneity in cost efficiency across institutions. Such variation is expected, given the sample includes institutions operating under different regulatory regimes and serving borrowers with different geographic and socioeconomic characteristics.

The average Return on Assets (ROA) indicates that the sampled institutions' profitability is moderate. However, the variation in the figures across observations indicates that many MFIs still struggle to translate asset growth into sustainable financial returns. Likewise, Portfolio at Risk (PAR30) is around 7.1 per cent, indicating that a large share of outstanding loans is overdue by more than 30 days. This variable is expected to be critical to explaining institutional sustainability, as deteriorating portfolio quality directly affects provisioning expenses and profitability.

A striking feature of the dataset is the low number of reported mobile banking transactions. Only a relatively small share of institution-year observations reports measurable mobile banking activity, which is consistent with the gradual diffusion of digital financial technologies during the period of study. This pattern supports the case that digital transformation in microfinance is a relatively recent phenomenon and justifies the use of a long panel dataset to capture institutional changes over time.

Fixed Effects Estimation Results

Table 3 presents the estimated coefficients from the two-way Fixed Effects models. We estimate three different regression models using Operational Self-Sufficiency (OSS), Operating Expense Ratio (OPEX), and Return on Assets (ROA) as alternative measures of institutional sustainability. All specifications control for institution and year fixed effects to account for unobserved heterogeneity and common macroeconomic effects.

The Hausman Specification Test strongly favours the Fixed Effects estimator over the Random Effects alternative, suggesting that institution-specific characteristics are correlated with the explanatory variables. Thus, the estimated coefficients represent within-institution effects, controlling for time-invariant institutional differences.

Mobile Banking and Institutional Sustainability

The main objective of this study is to assess the impact of mobile banking on the financial sustainability of Microfinance Institutions. The estimated coefficient for Mobile Banking Transaction Intensity is not statistically significant in any of the three empirical models. Most importantly, the coefficient is negative in both the Operational Self-Sufficiency and Operating Expense models, whereas the effect on Return on Assets is positive but statistically insignificant.

The results indicate that more mobile banking activity does not lead to immediate, measurable improvements in the financial performance of institutions. Hence, the empirical evidence does not adequately support the Hypotheses H1 and H2 in the short-term estimation period.

The lack of statistical significance should not be taken as evidence that digital financial technologies are ineffective. These findings are probably a reflection of the economic dynamics of technology adoption. Mobile banking also requires substantial start-up investments in information technology infrastructure, software development, cybersecurity, regulatory compliance, staff training, customer education, and digital payment integration. These costs add to fixed costs in the initial phases of implementation and could offset short-term savings from lower transaction costs. So, the financial gains from digital transformation may only materialise once institutions reach transaction volumes that enable economies of scale.

This interpretation is consistent with Transaction Cost Economics, which argues that organisations incur adjustment costs before they can realise efficiency benefits from new organisational arrangements (Coase, 1937; Williamson, 1979). It also resonates with recent studies suggesting that digital transformation is a long-term strategic investment and not an immediate source of profitability (Ghalib and Malki, 2019).

Table 3: Two-Way Fixed Effects Estimation Results

Independent Variable	Model 1: OSS	Model 2: OPEX	Model 3: ROA
Mobile Banking Intensity (ln)	-0.00194 (0.00179)	-0.00322 (0.00207)	0.00045 (0.00051)
MFI Scale (ln Assets)	0.03061^{***} (0.00605)	-0.07157^{***} (0.01577)	0.01244^{***} (0.00311)
Portfolio Quality (PAR30)	-0.31265^{***} (0.09837)	0.07666 (0.09645)	-0.04112^{***} (0.01054)
Average Loan Balance	-0.00000	0.00000^{***}	-0.00000

	(0.00000)	(0.00000)	(0.00000)
MFI Fixed Effects	Included	Included	Included
Year Fixed Effects	Included	Included	Included
Within R^2	0.0062	0.0044	0.0081
Number of Groups	2,477	2,241	2,904
F-Statistic	4.798^{***}	6.736^{***}	5.112^{***}
Hausman Test (χ^2)	124.58^{***}	98.14^{***}	141.02^{***}

Note: Clustered standard errors are reported in parentheses.
Significance indicated by $^{***}p < 0.01$.
Source: Author's calculation based on MIX Market data.

Institutional Scale and Economies of Scale

In all the estimated models, institutional size is one of the most important determinants of financial sustainability. The coefficient for the logarithm of total assets in the equations for Operational Self-Sufficiency and Return on Assets is positive and highly significant, and significantly negative with the Operating Expense Ratio.

The findings provide strong empirical support for economies of scale in the global microfinance industry. As institutions grow and the base of assets expands, fixed administrative costs such as management expenses, information technology infrastructure, accounting systems and branch administration can be spread over a larger loan portfolio. This lowers the average cost of operations and increases the institution's profitability.

Larger institutions also have the capacity to invest in cutting-edge digital infrastructure, professional management systems and sophisticated risk management practices. Such institutional advantages improve the efficiency of operation and financial robustness. These results thus support Hypothesis H3 and are generally in line with the earlier findings of Cull et al. (2007), Hermes et al. (2011) and Sarma (2015).

This implies that on the policy front, institutional strengthening may be as important as technological innovation. Small MFIs may not be able to realise the benefits of digital finance without the support of shared technology infrastructure, strategic alliances or collaborative digital platforms.

Portfolio Quality and Financial Sustainability

The results also suggest that the quality of the portfolio continues to be an important factor in institutional sustainability. The adverse effect of Portfolio at Risk (PAR30) on both Operational Self-Sufficiency and Return on Assets indicates that a decline in loan portfolio quality has a significant negative impact on institutions' financial performance.

The relationship is economically intuitive. Loan delinquency reduces interest income and increases the need for loan-loss provisioning. This results in less profitable and less operationally self-sufficient institutions with higher default rates. Therefore, the results lend strong empirical support to Hypothesis H4 and reaffirm the traditional banking literature, which highlights the significance of prudent credit risk management for institutional sustainability.

Interestingly, there is no statistically significant relationship between Portfolio at Risk and Operating Expense Ratio. This finding suggests that deteriorating portfolio quality mainly impacts institutional profitability instead of directly increasing administrative operating costs.

Outreach and Sustainability

The estimated coefficient on the average loan balance per borrower is not statistically significant in the Operational Self-Sufficiency and Return on Assets equations but is significant in the Operating Expense equation. The results show that the average loan size is insufficient to ensure greater institutional sustainability.

Larger loans could reduce the administrative costs per unit of lending, but they do not necessarily improve profitability if they are associated with deteriorating portfolio quality or inefficient credit allocation. This observation lends support to Schreiner's (2002) argument that a rise in loan size should not be viewed as an alternative to institutional efficiency.

Further, Borbora and Sarma (2020) show that larger loans do not necessarily improve borrower welfare unless credit is productively used and the cost of borrowing is affordable. Therefore, institutional efficiency and effective portfolio management are more important determinants of long-term sustainability than mere portfolio expansion.

Discussion and Policy Implications

The evidence suggests that technology alone is not enough to ensure the financial sustainability of the microfinance sector. Mobile banking provides an important technological basis for reducing transaction costs and increasing financial inclusion. However, the financial benefits seem to come slowly rather than instantly.

Rather, institutional sustainability still largely depends on three interrelated factors:
1. Sufficient institutional size to achieve economies of scale.
2. Quality loan books, reducing credit losses and provisioning costs.
3. Cost control so institutions can remain sustainable while serving low-income borrowers;

From a policy perspective, the findings suggest that governments and development agencies should not assess digital financial initiatives solely by technology adoption rates. Strengthening institutional governance, improving risk management systems, enhancing managerial capacity, and fostering technological collaboration among smaller MFIs should also receive greater attention. Shared digital infrastructure, interoperable payment systems and public support to technological modernisation could enable smaller institutions to enjoy the benefits of digital finance without the crippling costs of implementation.

More generally, the results suggest that mobile banking should not be considered as a quick fix to institutional sustainability, but rather as a long-term strategic investment whose benefits depend on complementary improvements in institutional capacity, operational efficiency and portfolio management.

VI. Limitations And Future Research

This paper provides extensive empirical evidence on the relationship between mobile banking and the financial sustainability of Microfinance Institutions (MFIs). Some limitations do, however, must be considered in interpreting the findings.

First, the empirical analysis is constrained by the availability of data in the Global MIX Market Database, which contains consistent institutional data only through 2019. The analysis, therefore, does not consider the unprecedented boom in digital financial services following the COVID-19 pandemic, with mobile banking, digital payments, and remote financial transactions soaring in many developing economies. Future research based on post-2020 observations could thus provide further insights into the long-term institutional effects of digital transformation.

Second, Mobile Banking is defined as the value of transactions done through a mobile delivery channel. This indicator is a good proxy for the intensity of digital financial activity but does not capture other relevant dimensions of digital transformation, such as the number of active mobile users, digital loan applications, biometric verification systems, artificial intelligence-based credit assessment or customer adoption rates. The addition of these complementary indicators would present a more complete picture of the mechanisms through which digital technologies affect institutional performance.

Third, while the two-way Fixed Effects model largely controls for unobserved institutional heterogeneity and common time effects, it cannot fully address endogeneity arising from reverse causality or omitted time-varying institutional characteristics. Financially stronger institutions may be able to invest more in digital technologies, and institutions that adopt mobile banking may be undertaking broader organisational reforms that affect financial performance. Future research using dynamic panel estimators, instrumental-variables techniques or quasi-experimental designs could provide further causal evidence.

Finally, the present analysis focuses only on outcomes at the institutional level, and does not speak directly to welfare at the borrower level. Financial sustainability is often expected to improve people's access to affordable financial services. An important avenue for future research is to examine the extent to which digital transformation contributes to improvements in household income, consumption, poverty reduction and financial resilience. Combining institutional panel data and household survey data would provide a more integrated picture of the broader developmental impacts of digital financial innovation.

Future studies can also investigate cross-country heterogeneity in adoption of digital finance by comparing the regulatory environment, the institutional ownership structure and the development level of the financial sector. These analyses would improve the understanding of the conditions under which digital financial technologies contribute to sustainable improvements in institutional performance.

VII. Conclusion And Policy Implications

The rapid proliferation of digital financial technologies has fundamentally transformed the operational delivery of financial services. Against this backdrop, the present study examined whether mobile banking helps Microfinance Institutions (MFIs) achieve financial sustainability using a comprehensive global panel dataset derived from the Global MIX Market Database. The study uses a two-way Fixed-Effects panel regression model, with a sample of 3,116 institutions over 1999–2019, to assess institutional sustainability using three complementary indicators: Operational Self-Sufficiency (OSS), Operating Expense Ratio (OPEX), and Return on Assets (ROA).

The empirical findings show that the intensity of mobile banking transactions has no statistically significant short-run effect on any of the three measures of institutional sustainability. While digital financial technologies are expected to enhance operational efficiencies through reduced transaction costs and increased process automation, the findings suggest these benefits may not be realised immediately. Yet, the upfront costs

of technology infrastructure, digital platforms, cybersecurity, staff training, and regulatory compliance seem to outweigh the immediate operational benefits of adopting mobile banking. These findings suggest that digital transformation should be considered a long-term strategic investment, not an immediate source of financial improvement.

By contrast, the analysis shows that financial sustainability is primarily driven by the institution's scale and portfolio quality. Larger institutions tend to be more operationally self-sufficient, have lower operating costs and are more profitable, providing strong evidence of economies of scale in the microfinance sector. In contrast, a deterioration in the quality of the loan portfolio has a significant negative impact on the institution's financial performance, underscoring the importance of prudent credit risk management in sustaining the institution's long-term viability. The results reinforce the view that technology cannot substitute for weak institutional fundamentals.

The study contributes in several important ways to the existing literature. First, it adds a comprehensive supply-side assessment of mobile banking in the global microfinance industry to the predominantly demand-side literature of digital finance. Second, the study provides a multidimensional assessment of institutional sustainability by considering simultaneously operational self-sufficiency, operating cost efficiency, and profitability, rather than relying on a single financial indicator. Third, we employ one of the largest international panel datasets currently available, enabling us to provide evidence that is considerably more generalizable than that of previous country-specific studies.

The findings have important implications for policymakers, financial regulators, development agencies and microfinance practitioners. The findings suggest that, for policymakers, digital financial inclusion strategies should not only focus on encouraging technology adoption but also strengthen MFIs' institutional capacity through investments in governance, risk management, and financial infrastructure. Regulators should facilitate the development of interoperable digital payment ecosystems, standardised technology platforms and enabling regulatory structures that reduce implementation costs, particularly for smaller institutions.

The evidence suggests that investments in mobile banking must be incorporated into broader institutional development strategies for MFIs rather than be viewed as stand-alone technological initiatives. Investments in organisational capacity, portfolio management, training, cybersecurity, and customer education all support successful digital transformation. The long-term benefits of digital financial innovation are more likely to be realised by institutions that simultaneously enhance operational efficiency and portfolio quality.

Development agencies and international financial institutions can also play an important role in providing shared digital infrastructure, supporting technical assistance programmes, and encouraging collaborative technology platforms that will enable smaller MFIs to access advanced digital services without incurring prohibitive capital costs. Such initiatives would mitigate barriers to digital transformation, while preserving the social mission of financial inclusion.

The findings in this study suggest that mobile banking is a critical enabling technology rather than an independent determinant of institutional sustainability. Long-term success will depend on the quality of institutional management, operational scale and prudent portfolio risk management. Digital financial innovation should be viewed as part of a broader strategy for Microfinance Institutions to enhance their financial sustainability and social outreach. Modernisation of the technology, coupled with good institutional governance, can together achieve financial viability and inclusive economic development, the twin objectives of the microfinance sector.

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