Assessing the influence of the Internet on Portfolio Risk in Microfinance Institutions *

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March 20, 2026

Abstract

This paper examines whether internet penetration influences portfolio risk in microfinance institutions (MFIs). Using a cross-country panel that combines institution-level data from the MIX Market with country-level measures of internet usage, we estimate fixed-effects models to assess the relationship between digital connectivity and portfolio delinquency. We find that higher internet penetration is associated with economically meaningful reductions in portfolio-at-risk ratios at both 30 and 90 days. The results are robust to MFI-level controls, MFI and year fixed-effects, and alternative specifications. Heterogeneity analyses indicate that the effect is concentrated in group lending models, consistent with enhanced monitoring and information-sharing mechanisms. Dynamic panel estimations using system-GMM and an instrumental variables approach exploiting variation in mobile cellular subscriptions supports a causal interpretation of this relationship. Overall, the evidence suggests that digital infrastructure plays an important role in improving portfolio quality in microfinance markets.

Keywords: Microfinance Institutions, Portfolio at Risk, Credit Risk, Microcredit, Internet, Digital Financial Infrastructure.

*The leading author also thanks the support from FAPERJ - Grant "Jovem Cientista do Nosso Estado" SEI-260003/003309/2022.

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1 Introduction

Over the past two decades, microfinance institutions (MFIs) have become central actors in expanding financial access to low-income populations traditionally excluded from formal banking systems (Xie, 2025). By providing small loans to households and microentrepreneurs with limited collateral and credit histories, MFIs aim to foster income generation, smooth consumption, and alleviate poverty, while balancing social outreach with financial sustainability (Blanco-Oliver et al., 2023). However, lending to clients with limited collateral and high exposure to income volatility makes portfolio risk management a persistent challenge. Information asymmetries and credit rationing problems, as emphasized by Stiglitz and Weiss (1981), remain particularly salient in microfinance markets.

In parallel, the rapid diffusion of internet access has transformed economic and financial interactions worldwide. Digital connectivity reshapes how individuals access information, conduct business, and engage with financial services (Pan et al., 2020). In developing and emerging economies, mobile-based internet infrastructure has become the primary channel for digital inclusion (Francis et al., 2017). A growing literature shows that digital finance can enhance access to credit and reduce financing frictions for small and medium-sized enterprises (Jun and Ran, 2024), yet concerns remain about digital exclusion and unequal access (Kandie and Islam, 2022; Siqueira et al., 2023). Despite these advances, relatively little is known about how broad-based internet penetration, distinct from specific fintech platforms, affects risk outcomes in traditional microfinance institutions.

This paper investigates whether and how internet penetration is associated with portfolio risk in MFIs. We combine institution-level data from the MIX Market database with country-level measures of internet usage compiled by the International Telecommunication Union and the World Bank. Exploiting within-MFI variation over time in a fixed-effects framework, we examine whether higher levels of internet penetration are systematically related to portfolio delinquency, measured by portfolio-at-risk ratios at 30 and 90 days.

We document a robust negative association between internet penetration and microcredit delinquency. A one-tertile increase in internet usage is associated with economically meaningful reductions in both short-term and more persistent arrears. These findings are consistent with evidence that digital connectivity enhances economic opportunities and productivity among small-scale entrepreneurs (Jun and Ran, 2024) and may indirectly improve subjective well-being and financial outcomes (Lei et al., 2023). The results hold after controlling for MFI-level characteristics and fixed effects, suggesting that digital infrastructure plays a complementary role in microfinance performance.

We explore two non-mutually exclusive mechanisms. First, greater internet access may improve borrowers' repayment capacity by increasing the profitability and resilience of microenterprises, facilitating market access and reducing transaction costs. Second, internet penetration may strengthen monitoring and enforcement by MFIs themselves, improving information flows and enabling earlier intervention in repayment difficulties. This interpretation aligns with the broader view that financial innovation is a key driver of microfinance development. Consistent with a monitoring channel, we find that the reduction in delinquency is concentrated in group lending models, where peer monitoring and coordination are central features.

To address endogeneity concerns, we implement several complementary strategies. Dynamic panel estimations using system GMM account for the persistence of delinquency and potential reverse causality. An instrumental variables approach exploits variation in mobile cellular subscriptions as a source of exogenous variation in internet usage, following the logic that telecommunications infrastructure diffusion shapes digital access independently of short-run MFI performance. Across specifications, the main results remain qualitatively unchanged. Additional analyses using alternative risk measures show that internet penetration reduces write-off ratios but does not significantly affect broader measures of institutional solvency, suggesting that digital connectivity primarily improves portfolio-level credit performance rather than overall firm risk.

This paper contributes to the literature on microfinance and digital finance in three

ways. First, it provides cross-country evidence linking general digital infrastructure to credit risk outcomes in MFIs. Second, it shifts attention from platform-specific digital credit innovations to the broader role of internet penetration as a complementary input in microfinance operations. Third, it offers evidence consistent with monitoring-based mechanisms through which digital inclusion can enhance repayment performance, thereby complementing existing work on financial sustainability and institutional incentives in MFIs (Leite et al., 2019; de Oliveira Leite et al., 2020).

The remainder of the paper proceeds as follows. Section 2 reviews the related literature. Section 3 describes the data and empirical strategy. Section 4 presents the main results and robustness analyses. Section 5 concludes.

2 Literature Review

2.1 Loan Portfolio Quality in Microfinance Institutions

Loan portfolio quality is a cornerstone of the microfinance literature, widely regarded as the primary determinant of an institution's financial sustainability. Mohammad Yunus, the founder of the Grameen Bank in 1983 and Nobel Peace Prize laureate in 2006, pioneered the concept of microcredit by providing small loans that traditional banks deemed too risky. Yunus' model demonstrated that, despite initial perceptions, these loans could help alleviate extreme poverty and social vulnerability, with borrowers repaying their loans when given the opportunity, thereby creating a flexible business model (Pankaj Dixit et al., 2019). Yunus's work highlights that microcredit is not merely small loans, but a transformative practice that requires methodologies grounded in historical success and proven frameworks.

Lately, empirical researches consistently employ Portfolio at Risk (P@R) as the benchmark metric for assessing credit risk and institutional performance (Ramírez Silva et al., 2015; de Oliveira Crevelari, 2017; Chikalipah, 2018; Inekwe, 2019; Durango-Gutiérrez

et al., 2023; Abusharbeh, 2023). Within this scholarship, P@R serves as a robust proxy for portfolio health, reflecting a combination of borrower repayment capacity, credit discipline, and the internal effectiveness of an MFI's screening and monitoring frameworks (Crabb and Keller, 2006; Wu et al., 2022).

Among the available metrics, Portfolio at Risk exceeding 30 days (P@R30) is the most pervasive indicator in microfinance studies (Lassoued, 2017; Chikalipah, 2018; Durango-Gutiérrez et al., 2023). By measuring the share of the gross loan portfolio overdue by more than one month, P@R30 identifies early-stage frictions before they escalate into terminal default (Crabb and Keller, 2006; Wu et al., 2022) In contrast, Portfolio at Risk beyond 90 days (P@R90) captures severe delinquency, signaling a significantly higher probability of realized loan losses (Wu et al., 2022; Abusharbeh, 2023).

The repayment and arrears dynamics captured by these indicators provide a granular view of an MFI's overall asset quality (Crabb and Keller, 2006). Recent evidence confirms that spikes in P@R30 and P@R90 are symptoms of deteriorating credit quality, leading to operational inefficiencies, and threatening long-term financial viability of microfinance providers (Durango-Gutiérrez et al., 2023; Sifrain, 2022; Abusharbeh, 2023). Accordingly, these metrics are frequently integrated into empirical models to evaluate how credit volatility impacts institutional efficiency (Khan et al., 2021; Wu et al., 2022).

Given that the loan portfolio represents the most critical asset for any MFI, its protection against delinquency and default is paramount (Danstun and Harun, 2019). Indeed, the survival of lending institutions hinges on portfolio performance, which directly dictates the returns on loan investments. High levels of risk often reveal underlying weaknesses in an institution's lending, monitoring, or collection protocols; once delinquency breaches certain thresholds, the resulting pressure on profitability becomes a major constraint on institutional growth and stability (Danstun and Harun, 2019).

2.2 Digital Infrastructure and Portfolio Risk in MFIs

The rapid development of network-connected technologies, such as mobile payments, social networks, and cloud computing, has transformed the financial sector (Pan et al., 2020). According to Lei et al. (2023), internet usage can indirectly affect financial practices, including microcredit, by facilitating access to online financial platforms. This connectivity allows rural populations to access microcredit more easily, potentially improving their subjective well-being. However, as the microfinance sector continues to evolve, there is an increasing need to understand how different digital services impact credit offerings.

The availability of internet access also empowers financial agents to conduct more thorough credit screenings, enhancing the effectiveness of credit scoring tools and improving default monitoring. For borrowers, the digital financial network reduces financing costs since loans can be disbursed through mobile money, and converted to cash through existing agent networks (Francis et al., 2017) and enhances access to financial resources (Jun and Ran, 2024). However, the premise here is that this country's network infrastructure already exists and performs sufficiently well, although this is not true for most developing countries.

The development of digital infrastructure and credit market institutions are closely related. Beck et al. (2007) show that both the degree of credit information sharing and the development of physical infrastructure are positively associated with financial sector outreach and depth. These factors are directly linked to internet availability, as digital infrastructure facilitates information flows, credit assessment, and monitoring processes.

The underlying premise is that digital infrastructure may influence key mechanisms related to credit risk, including screening, monitoring, and repayment behavior, even when MFIs themselves are not fully digitalized. By facilitating access to information, reducing transaction costs, and enabling faster communication, internet availability may indirectly affect portfolio delinquency outcomes. There is evidence that microcredit programs must be integrated with policies that address broader social issues, such as digital inclusion

(Dulhunty, 2022) in order to maximize results.

2.3 Assessing Digital Infrastructure in Microfinance Institutions

The digital infrastructure plays a significant role, as it directly impacts each locality's capacity to generate wealth. This phenomenon underscores the importance of considering wealth production capacity, which is strongly influenced by internet availability. In regions with greater internet access, individuals are more likely to pursue distance education or promote their micro-online entrepreneurial ventures.

Measuring the level of internet adoption is a complex task, largely due to qualitative differences in how individuals and institutions engage with digital technologies. For instance, disparities in access to broadband or advanced software affect both the intensity and quality of internet usage (Beilock and Dimitrova, 2003). Despite these measurement challenges, the Internet Usage Rate (IUR), remains the standard indicator for cross-country comparisons (Wolcott et al., 2001).

The literature identifies a strong link between infrastructure development, income levels, and internet penetration (Beilock and Dimitrova, 2003). Research by Koutroumpis (2009) also demonstrates that internet penetration correlates closely with macroeconomic indicators, suggesting that digital infrastructure is deeply embedded in broader economic development. While internet usage data can be segmented by demographic characteristics (Jiang et al., 2013), many studies use aggregated measures as proxies for the overall digital environment rather than specific individual skills (Koutroumpis, 2009).

Heterogeneous levels of economic development often lead to different usage behaviors and digital capabilities (Jiang et al., 2013). Nevertheless, in cross-country empirical work, the IUR is typically interpreted as a proxy for the maturity and availability of digital infrastructure (Beilock and Dimitrova, 2003). This interpretation allows researchers to capture the broad technological environment in which economic agents and institutions operate.

Fundamental advances in mobile communications, distributed computing, and data processing have supported a wide range of financial innovations in recent years (Claessens et al., 2018). Consumers in both advanced and emerging economies have increasingly adopted digital financial services for their convenience and accessibility (Claessens et al., 2018). In this context, access to mobile money has been shown to help individuals manage income and health shocks, highlighting how digital infrastructure can enhance financial resilience (Suri and Jack, 2016).

2.4 Literature Gaps and Contribution

Understanding how the internet affects loan portfolio performance in MFIs can contribute to improving credit quality and the long-term survival of these institutions. This is particularly relevant as empirical studies have indicated that microcredit can effectively reduce poverty and enhance social well-being (Källestål et al., 2020), with these effects being even more pronounced for those who are less poor and less vulnerable (Phan et al., 2023).

Despite extensive research on portfolio at risk and the determinants of credit risk in microfinance institutions, the literature remains fragmented. The academic literature surrounding microcredit has advanced in recent years, although substantial work remains to differentiate between types of microcredit institutions, including fintechs, payment institutions, and credit unions that offer digital financial services (Santos et al., 2022).

While studies focusing on MFIs primarily emphasize institutional characteristics, borrower profiles, governance structures, and social indicators as drivers of portfolio quality, the literature on digitalization and financial inclusion largely concentrates on household-level outcomes, Fintech platforms, or individual access to digital financial services. Empirical evidence directly linking aggregated digital infrastructure, captured through country-level internet usage indicators, to portfolio delinquency in MFIs is still limited. Consequently, the role of the broader digital environment in shaping loan portfolio quality

remains underexplored. This study presents a quantitative approach to examine the modeling factors that affect portfolio at risk for MFIs and addresses this gap by integrating financial and technological proxies, examining whether variations in internet usage are systematically associated with portfolio at risk in microfinance institutions.

While Khan et al. (2021) combine financial and social proxies to evaluate microfinance efficiency, this study instead combines financial and technological proxies, aiming to jointly account for financial sustainability and network infrastructure. In doing so, portfolio at risk is used to capture loan portfolio quality, while internet usage is employed as a proxy for the digital environment in which MFIs operate. This approach aligns with prior studies that use quantitative methods to model the determinants of portfolio at risk in microfinance institutions (Abusharbeh, 2023).

3 Methods and Data

3.1 Sample

We construct a novel panel dataset by combining firm-level information on microfinance institutions (MFIs) with country-level indicators of digital infrastructure. Specifically, MFI-level data are obtained from the MIX Market database, which provides detailed financial and operational information on microfinance providers across a wide range of countries. To capture cross-country heterogeneity in digital access, we augment these data with macro-level proxies for digital connectivity. Internet penetration is measured as the percentage of individuals using the Internet, based on data from the International Telecommunication Union (ITU), as reported in the World Bank's World Development Indicators (WDI). In addition, we include mobile cellular subscriptions per 100 inhabitants—also drawn from the WDI—as a complementary indicator of digital and telecommunications infrastructure.

The final sample covers the period from 1999 to 2018, allowing us to explore both

cross-country differences and changes over time in digital access. Table 1 reports the summary statistics, and Table 2 presents the correlation matrix.

3.2 Empirical Strategy

In order to assess the relationship between internet usage and portfolio delinquency in microfinance institutions (MFIs), we estimate regressions with the following baseline specification:

$$P@R(30/90 \text{ days})_{i,t} = \beta \cdot Internet_{i,t} + X'_{i,t}\delta + \theta_i + \tau_t + \epsilon_{i,t},$$

where $P@R(30/90 \text{ days})_{i,t}$ denotes the portfolio at risk of MFI i in year t, measured as the share of the loan portfolio with payments overdue by more than 30 (or 90) days. The main variable of interest $Internet_{i,t}$, captures the intensity of internet usage and is coded as -1 for MFIs in the bottom tertile of internet usage, 0 for those in the middle tertile, and +1 for those in the top tertile. This specification implies that the coefficient β measures the effect of a one-tertile increase in internet usage on portfolio delinquency. For instance, moving from the bottom to the middle tertile, or from the middle to the top tertile, corresponds to a one-unit change in $Internet_{i,t}$ and is associated with a change of β in the portfolio at risk.

The vector $X_{i,t}$ includes a set of time-varying MFI-level control variables that may affect portfolio quality, such as the profit margin, the ratio between the gross loan portflio to total assets (as a proxy to the riskiness of the MFI), and the percent of female borrowers. We include MFI fixed effects (θ_i) to control for time-invariant unobserved heterogeneity across microfinance institutions (such as managerial quality, organizational culture, or long-run business models), and year fixed effects (τ_t) to capture common shocks and global trends affecting all MFIs, including macroeconomic conditions and technological diffusion.

Under this specification, the identification of β relies on within-MFI variation in internet usage over time, net of common year effects and observed controls. While the estimates should be interpreted as conditional correlations rather than causal effects, this framework allows us to assess whether higher levels of internet usage are systematically associated with better (or worse) portfolio quality in microfinance institutions. Nevertheless, in the robustness section, we estimate additional specifications that move toward identifying a causal relationship.

4 Empirical Results

4.1 Main Results

The results from the main estimations are reported in Table 3. We find that a one-tertile increase in internet usage is associated with a 1.7% reduction in P@R 30 days and a 2.0% reduction in P@R 90 days. These estimates suggest that higher levels of internet usage are systematically linked to lower portfolio delinquency, with the magnitude of the association increasing with the severity of arrears. The stronger effect observed for P@R at 90 days indicates that internet usage may be particularly relevant for mitigating even persistent repayment problems. Overall, the results point to a correlation between digital connectivity and improved portfolio quality in microfinance institutions, even after controlling for covariates and accounting for MFI and year fixed effects.

<Insert Table 3 around here.>

Two non-mutually exclusive mechanisms may explain the negative association between internet usage and portfolio delinquency observed in Table 3. First, greater internet usage may increase the returns to small-scale entrepreneurial activities financed by microfinance loans. Access to the internet can improve borrowers' ability to gather market information, reach new customers, compare input prices, and increase overall efficiency. By expanding market access and reducing information frictions, internet usage can raise business

profitability and income stability, thereby improving borrowers' repayment capacity and reducing the likelihood of delinquency. This channel is consistent with a growing literature showing that digital connectivity enhances productivity and income generation in small and informal enterprises (Jun and Ran, 2024).

A second explanation relates to improvements in monitoring and enforcement by microfinance institutions themselves. Higher internet usage may facilitate the adoption of digital tools for loan tracking, communication with borrowers, and early detection of repayment problems. Enhanced connectivity can lower the cost of information acquisition and coordination, allowing MFIs to monitor loan performance more effectively and to intervene earlier when repayment difficulties arise. Improved monitoring may be particularly important for preventing loans from transitioning into more severe states of delinquency, which is consistent with the stronger association observed for P@R at 90 days relative to P@R at 30 days.

Taken together, these mechanisms suggest that internet usage may affect portfolio quality both by strengthening borrowers' repayment capacity and by improving MFIs' operational effectiveness. While the empirical framework does not allow us to separately identify these channels, the results are consistent with the view that digital connectivity plays a complementary role in enhancing the functioning of microfinance markets. In the robustness section, we further explore these interpretations by estimating additional specifications designed to strengthen the causal interpretation of the relationship between internet usage and portfolio delinquency.

4.2 Additional Estimations

4.2.1 Profit Status

Microfinance institutions can be broadly classified as for-profit or not-for-profit organizations, a distinction that shapes managerial incentives and operational strategies de Oliveira Leite et al. (2020), without necessarily affecting their long-term sustainability

(Leite et al., 2019). Differences in profit orientation may therefore influence how MFIs adopt and leverage digital technologies, particularly in areas such as borrower screening, monitoring, and loan recovery. In this subsection, we examine whether profit status acts as a mechanism underlying the observed reduction in microloan default rates, by assessing whether the relationship between internet usage and portfolio delinquency varies systematically across for-profit and not-for-profit MFIs.

Hence we estimate the following model in the first two columns of Table 4, in which $Profit_{i,t}$ assumes the value of 1 for for-profit MFIs, and 0 for their non-profit counterparts:

$$P@R(30/90 \text{ days})_{i,t} = \beta \cdot Internet_{i,t} + \gamma \cdot Internet_{i,t} \times Profit_{i,t} + X'_{i,t}\delta + \theta_i + \tau_t + \epsilon_{i,t}.$$

<Insert Table 4 around here.>

The results show no statistically significant difference in the effect of internet usage on the reduction of default rates between for-profit MFIs and their not-for-profit peers. This non-result is informative, as it suggests that the relationship between internet usage and portfolio quality is unlikely to be driven primarily by differences in profit-oriented incentives or organizational objectives. Instead, the findings are more consistent with mechanisms that operate broadly across institutional types, such as improvements in borrowers' income-generating opportunities or general enhancements in monitoring and information flows enabled by digital connectivity. Taken together, these results indicate that the benefits of internet usage for portfolio performance are not confined to MFIs with stronger profit incentives, but rather reflect more fundamental effects of digital access on microfinance operations and borrower behavior.

4.2.2 Group Lending

In this subsection, we aim to disentangle the monitoring channel from the direct effect of internet usage on the returns to borrowers' investment projects. To this end, we exploit differences in lending methodologies by interacting internet usage with a dummy variable

that equals one when the MFI lending is organized under a group lending scheme and zero when lending is conducted on an individual basis. Group lending arrangements typically rely on peer monitoring and joint liability, which substitutes the direct monitoring by the MFI. In contrast, individual lending places greater emphasis on institutional monitoring and borrower-specific information.

This heterogeneity allows us to assess whether the effect of internet usage on portfolio delinquency operates primarily through enhanced monitoring by MFIs or through improved returns to borrowers' economic activities. If internet usage mainly monitoring, its impact should be more pronounced in group lending settings, where internet usage improves the group monitoring capability on the individuals that comprise the group. Conversely, if internet usage primarily improves borrowers' repayment capacity by increasing the profitability of their ventures, the effect should be similar across lending methodologies. By comparing the estimated effects across these two lending models, this approach provides indirect evidence on the relative importance of the proposed mechanisms.

Hence we estimate the following model in the last two columns of Table 4:

$$P@R(30/90 \text{ days})_{i,t} = \beta \cdot Internet_{i,t} + \gamma \cdot Internet_{i,t} \times GroupLending_{i,t} + X'_{i,t}\delta + \theta_i + \tau_t + \epsilon_{i,t}.$$

The results indicate that the effect of internet usage on portfolio delinquency is concentrated in group lending arrangements. This pattern strengthens the interpretation that the observed relationship operates primarily through enhanced monitoring rather than through an increase in the net present value of the projects undertaken by borrowers. Because group lending relies heavily on peer monitoring and information sharing among participants, the stronger effect in this setting suggests that digital connectivity amplifies existing monitoring mechanisms, facilitating information flows and coordination that improve repayment behavior.

4.2.3 GMM Estimations

In this subsection, we further strengthen the causal interpretation of our findings by estimating a dynamic panel model using a system GMM approach. This methodology allows us to address potential endogeneity concerns arising from reverse causality, omitted variable bias, and the persistence of loan delinquency over time. Specifically, we instrument potentially endogenous regressors using their own lagged values, employing first differences as instruments for the level equation and lagged levels as instruments for the differenced equation. By exploiting within-MFI variation over time and relying on internally generated instruments, the system GMM framework mitigates biases associated with unobserved heterogeneity and simultaneity between internet usage and portfolio performance.

The system GMM approach is particularly well suited to our setting, as portfolio delinquency exhibits substantial persistence and internet adoption may respond endogenously to past loan performance. Under standard moment conditions, this strategy allows us to isolate plausibly exogenous variation in internet usage that is orthogonal to contemporaneous shocks to default rates. While this approach does not fully resolve all identification challenges, it provides a complementary and more demanding test of the relationship between digital connectivity and microcredit portfolio quality, thereby reinforcing the robustness of our main results. Table 5 presents the results of the GMM estimations.

<Insert Table 5 around here.>

The results again indicate that higher internet usage is associated with lower portfolio risk. We find that a one-tertile increase in internet usage is associated with a 0.3% reduction in P@R (30 days) and a 0.6% reduction in P@R (90 days). The smaller magnitudes relative to the baseline fixed-effects estimates are consistent with the more conservative nature of the system GMM approach. By explicitly accounting for the dynamic persistence of delinquency and using lagged values as instruments, system GMM isolates variation in internet usage that is less likely to be correlated with contemporaneous shocks

to portfolio performance. As a result, part of the association captured in the baseline specifications, potentially reflecting reverse causality or time-varying omitted factors, is absorbed by the dynamic structure of the model, leading to attenuated but more plausibly causal estimates. Importantly, despite the reduction in magnitude, the direction and statistical significance of the effects remain consistent with the main results, reinforcing the interpretation that internet usage contributes to lower default risk in microcredit portfolios.

4.2.4 Cellphone Usage as an Instrumental Variable

In this subsection, we seek to assess the effect of internet penetration on microcredit portfolio delinquency by adopting an instrumental variables approach. Specifically, we use data on mobile cellular subscriptions (per 100 people), obtained from the International Telecommunication Union in partnership with the World Bank, as an instrument for internet usage. The rationale for this strategy is that the diffusion of mobile cellular technology is a key driver of internet access, particularly in developing and emerging economies, where mobile networks constitute the primary infrastructure through which individuals and firms connect to the internet. As a result, mobile cellular subscriptions are strongly correlated with internet usage, satisfying the relevance condition for a valid instrument.

At the same time, mobile cellular subscription rates are plausibly exogenous to short-run fluctuations in microcredit portfolio delinquency. The expansion of mobile telephony largely reflects long-term investments in telecommunications infrastructure, regulatory reforms, and technological diffusion at the country level, rather than contemporaneous changes in MFI-specific credit risk or borrower repayment behavior. Importantly, mobile subscriptions affect portfolio delinquency primarily through their impact on internet access and usage, rather than through direct channels related to microfinance lending decisions, supporting the exclusion restriction. Under these assumptions, the 2SLS framework allows us to isolate variation in internet usage that is driven by exogenous differences in

mobile connectivity, thereby strengthening the causal interpretation of the relationship between internet penetration and microcredit portfolio performance. Results are provided in Table 6.

The second-stage estimates are both economically and statistically similar to those obtained in our baseline specifications. The magnitude of the coefficients remains comparable, and the direction of the effect is unchanged, indicating that greater internet penetration continues to be associated with lower levels of portfolio delinquency. Importantly, the precision of the estimates is preserved, and conventional weak-instrument diagnostics confirm the strength of the first stage. Taken together, these results suggest that our main findings are not driven by reverse causality or omitted variable bias, but instead reflect a robust relationship between digital connectivity and microcredit portfolio performance.

4.2.5 Alternative Measures of Riskiness

As a final robustness test, we replace our baseline dependent variables with two alternative measures of risk: the write-off ratio and the MFI-level Z-score. The write-off ratio captures realized credit losses and therefore provides a direct measure of ex post portfolio deterioration, while the Z-score reflects overall institutional stability by combining profitability, leverage, and earnings volatility into a summary indicator of insolvency risk. The results are presented in Table 7.

We find that higher levels of internet penetration are significantly associated with lower write-off ratios, reinforcing the evidence that digital connectivity improves portfolio quality and reduces realized credit losses. In contrast, internet penetration does not exhibit a statistically significant relationship with MFIs' Z-scores. This pattern suggests that the benefits of digital inclusion operate primarily through improved borrower repayment performance and portfolio management, rather than through broader changes in institutional solvency or firm-level risk exposure.

5 Conclusion

This paper examines the relationship between digital connectivity and portfolio risk in microfinance institutions (MFIs). Using a large cross-country panel of MFIs combined with country-level measures of internet penetration, we document a robust negative association between internet usage and portfolio delinquency. A one-tertile increase in internet penetration is associated with economically meaningful reductions in both P@R 30 days and P@R 90 days, even after controlling for time-varying institutional characteristics and absorbing unobserved heterogeneity through MFI and year fixed effects. The results suggest that digital connectivity is systematically linked to improved portfolio quality in microfinance markets.

We explore several mechanisms and conduct multiple robustness tests to strengthen the interpretation of this relationship. First, we show that the effect does not differ significantly between for-profit and not-for-profit MFIs, indicating that the documented association is not primarily driven by differences in organizational profit incentives. Second, we find that the reduction in delinquency is concentrated in group lending models, consistent with a monitoring channel whereby internet access enhances information flows and peer coordination. Third, dynamic panel estimations using system GMM yield statistically significant effects, suggesting that the baseline estimates are driven by reverse causality or omitted variables. Fourth, an instrumental variables strategy exploiting variation in mobile cellular subscriptions provides further support for a causal interpretation. Finally, alternative measures of risk reveal that internet penetration is associated with lower write-off ratios, but not with broader measures of institutional solvency such as the Z-score. Taken together, these findings indicate that digital connectivity primarily improves portfolio-level credit performance rather than altering overall firm risk.

Our results contribute to the literature on microfinance, digital finance, and financial development by highlighting the role of general digital infrastructure—rather than specific fintech innovations—in shaping credit risk outcomes. While much of the existing research focuses on digital lending platforms or algorithmic credit scoring, we show that

broader internet penetration itself is associated with measurable improvements in loan repayment performance. This suggests that investments in digital infrastructure may generate indirect financial stability benefits within microfinance markets.

From a policy perspective, the findings underscore the importance of digital inclusion as a complement to microcredit programs. Expanding internet access may enhance the effectiveness of microfinance by strengthening monitoring mechanisms and facilitating borrower coordination, particularly in group lending settings. At the same time, the absence of a significant effect on overall institutional solvency cautions against overstating the transformative impact of digital connectivity on MFI-level stability.

Future research could explore borrower-level data to more directly disentangle the channels through which internet access affects repayment behavior, as well as investigate potential nonlinearities or threshold effects in digital adoption. Moreover, understanding how digital infrastructure interacts with regulatory frameworks and competitive dynamics in microfinance markets remains an important avenue for further inquiry. Overall, this paper provides evidence that digital connectivity is not merely a background technological trend, but a relevant factor in shaping risk dynamics in microfinance institutions.

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A Figures and Tables

Table 1: Summary statistics

We report summary statistics for the main variables used in the analysis. Portfolio at Risk (30 days) and Portfolio at Risk (90 days) measure the share of the loan portfolio with payments overdue by more than 30 and 90 days, respectively. Write-off Ratio captures realized credit losses, and Z-score is a proxy for institutional stability. Internet Tertiles classify countries into three groups based on internet penetration (-1: low, 0: medium, 1: high). Profit Margin, Gross Loan Portfolio, and Percent of Female Borrowers are MFI-level controls. Profit Status equals 1 for for-profit MFIs and 0 otherwise. Group Lending equals 1 for MFIs using group-based lending methodologies. Cellphone Use Tertiles classify countries based on mobile cellular subscriptions per 100 people.

Variable	Obs	Mean	Std. Dev.	Min	Max
Portfolio at Risk (30 days)	3106	.06	.12	0	.8
Portfolio at Risk (90 days)	2833	.04	.11	0	.79
Writeoff Ratio	2737	.03	.05	0	.29
Zscore	2769	1.95	3.12	.03	21.94
Internet Tertiles	4176	-.03	.82	-1	1
Profit Margin	3524	-.07	.77	-5.51	.65
Gross Loan Portfolio	3888	.81	.33	.08	2.97
Percent of Female Borrowers	3078	.77	.28	0	1.23
Profit Status	3892	.47	.5	0	1
Group Lending	4178	.34	.47	0	1
Cellphone Use tertiles	4178	-.03	.81	-1	1

Table 2: Cross-correlation table

We report pairwise correlations among the main variables in the sample. Portfolio at Risk (30 days) and Portfolio at Risk (90 days) measure delinquency at different horizons. Internet Tertiles capture variation in digital connectivity across countries. Cellphone Use Tertiles measure mobile infrastructure and are used as an instrumental variable in later specifications. Other variables correspond to MFI-level characteristics described in Table 1.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Portfolio at Risk (30 days)										
2.Portfolio at Risk (90 days)	0.960									
3. Writeoff Ratio	0.241	0.194								
4. zscore	-0.047	-0.045	-0.083							
5. Internet Tertiles	0.039	-0.001	0.246	0.075						
6. Profit Margin	-0.285	-0.329	-0.136	0.070	0.134					
7. Gross Loan Portfolio	0.018	0.034	-0.118	-0.028	0.064	0.125				
8. Percent of Female Borrowers	-0.159	-0.123	-0.141	0.006	-0.292	0.064	0.207			
9. Lastknownprofitstatus==Non-profit	-0.029	-0.004	-0.204	-0.039	-0.074	-0.040	0.080	-0.050		
10. lend	-0.021	-0.010	0.007	0.007	-0.025	0.068	0.081	0.279	-0.169	
11. 3 quantiles of usocelular	0.042	0.018	0.234	0.022	0.807	0.133	0.108	-0.217	-0.081	0.067

Table 3: Results of estimation: Main Results

We report fixed-effects panel regression results using Portfolio at Risk at 30 and 90 days as dependent variables. Internet Tertiles capture the level of internet usage in each country-year. Control variables include Profit Margin, Gross Loan Portfolio, and Percent of Female Borrowers. All specifications include MFI and year fixed effects. Standard errors are reported in parentheses. Statistical significance is denoted by * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Portfolio at Risk (30 days)		Portfolio at risk (90 days)	
	1A	1B	1C	1D
Internet tertiles	-0.0127	-0.0169*	-0.0145*	-0.0200**
	(0.00667)	(0.00699)	(0.00698)	(0.00710)
Profit Margin		-0.0544***		-0.0617***
		(0.00388)		(0.00402)
Gross Loan Portfolio		0.0430***		0.0438***
		(0.00927)		(0.00891)
Percent of Female Borrowers		-0.0938***		-0.0893***
		(0.0202)		(0.0206)
Constant	0.00205	-0.000832	0.0426*	0.0568*
	(0.0350)	(0.0466)	(0.0189)	(0.0256)
Observations	3104	2648	2833	2441
R^2	0.028	0.135	0.027	0.163
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 4: Results of estimation: Moderation

We report fixed-effects panel regression results including interaction terms to assess heterogeneity in the relationship between internet usage and portfolio delinquency. Internet × For-Profit interacts internet usage with a dummy equal to 1 for for-profit MFIs. Internet × Group Lending interacts internet usage with a dummy equal to 1 for MFIs using group lending methodologies. Control variables include Profit Margin, Gross Loan Portfolio, and Percent of Female Borrowers. All specifications include MFI and year fixed effects. Standard errors are reported in parentheses. Statistical significance is denoted by * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	profit vs non-profit		group lending	
	P@R 30 days	P@R 90 days	P@R 30 days	P@R 90 days
Internet tertiles	-0.00918	-0.0105	-0.00499	-0.00358
	(0.00840)	(0.00831)	(0.00885)	(0.00895)
Profit Margin	-0.0573***	-0.0657***	-0.0544***	-0.0620***
	(0.00398)	(0.00413)	(0.00387)	(0.00401)
Gross Loan Portfolio	0.0473***	0.0482***	0.0429***	0.0436***
	(0.00941)	(0.00903)	(0.00926)	(0.00889)
Percent of Female Borrowers	-0.0981***	-0.0942***	-0.0970***	-0.0920***
	(0.0205)	(0.0210)	(0.0202)	(0.0206)
Internet × For-Profit	-0.0114	-0.0170		
	(0.00997)	(0.0101)		
Internet × Group Lending			-0.0166*	-0.0221**
			(0.00756)	(0.00735)
Constant	0.00313	0.0571*	0.0129	0.0739**
	(0.0465)	(0.0258)	(0.0469)	(0.0262)
Observations	2550	2343	2648	2441
R^2	0.145	0.177	0.137	0.167
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 5: Results of estimation: GMM

We report dynamic panel regression results estimated using the system GMM approach. The dependent variables are Portfolio at Risk at 30 and 90 days. Lagged dependent variables are included to account for persistence in delinquency. Internet Tertiles is treated as a potentially endogenous variable and instrumented using its lagged values. Control variables include Profit Margin, Gross Loan Portfolio, and Percent of Female Borrowers. Hansen test p-values are reported to assess instrument validity. Standard errors are reported in parentheses. Statistical significance is denoted by * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Portfolio at Risk (30 days)	Portfolio at risk (90 days)
Internet tertiles	-0.00299***	-0.00625***
	(0.000836)	(0.000573)
Profit Margin	-0.0382***	-0.0436***
	(0.000722)	(0.000818)
Gross Loan Portfolio	0.0533***	0.0543***
	(0.00206)	(0.00158)
Percent of Female Borrowers	-0.0517***	-0.0565***
	(0.00169)	(0.00148)
L.Portfolio at Risk (30 days)	0.567***	
	(0.00460)	
L.Portfolio at risk (90 days)		0.501***
		(0.00398)
Constant	0.0397***	0.0377***
	(0.00248)	(0.00223)
Observations	1964	1760
No. of banks	435	390
No. of instruments	247	202
Hansen test p-value	0.347	0.162

Table 6: Results of estimation: Instrumental Variable

We report instrumental variables (2SLS) regression results using Portfolio at Risk at 30 and 90 days as dependent variables. Internet Tertiles is instrumented using Cellphone Use Tertiles, measured as mobile cellular subscriptions per 100 people. Control variables include Profit Margin, Gross Loan Portfolio, and Percent of Female Borrowers. Standard errors are reported in parentheses. Statistical significance is denoted by * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Portfolio at Risk (30 days)	Portfolio_at_risk_90_days
Internet tertiles	-0.111***	-0.199***
	(0.0250)	(0.0478)
Profit Margin	-0.0552***	-0.0628***
	(0.00369)	(0.00433)
Gross Loan Portfolio	0.0330***	0.0235*
	(0.00901)	(0.0105)
Percent of Female Borrowers	-0.0807***	-0.0668**
	(0.0194)	(0.0227)
Constant	0.165	0.0631
	(0.0846)	(0.0971)
Observations	2648	2441
R^2	0.442	0.261

Table 7: Results of estimation: Alternative Dependent Variable

We report fixed-effects panel regression results using alternative dependent variables: Write-off Ratio and Z-score. Write-off Ratio captures realized credit losses, while Z-score measures institutional stability. Internet Tertiles is the main explanatory variable. Control variables include Profit Margin, Gross Loan Portfolio, and Percent of Female Borrowers. All specifications include MFI and year fixed effects. Standard errors are reported in parentheses. Statistical significance is denoted by * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	Writeoff Ratio	Writeoff Ratio	Z-score	Z-score
Internet tertiles	-0.00553*	-0.00468*	-0.0253	-0.0385
	(0.00252)	(0.00238)	(0.0262)	(0.0275)
Profit Margin		-0.0102***		0.0192
		(0.00134)		(0.0203)
Gross Loan Portfolio		-0.00665*		0.141***
		(0.00338)		(0.0389)
Percent of Female Borrowers		-0.000369		-0.363***
		(0.00741)		(0.0835)
Constant	-0.00426	-0.00435	1.867***	2.114***
	(0.0144)	(0.0146)	(0.124)	(0.155)
Observations	2736	2385	2767	2333
R^2	0.039	0.060	0.027	0.044
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$