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IMPACT OF DIGITAL PAYMENT SYSTEMS ON FINANCIAL INCLUSION AND ECONOMIC BEHAVIOUR IN RURAL MARATHWADA

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ABSTRACT

The rapid growth of digital payment infrastructure in India has changed the way people do business, especially in rural and semi-urban areas. The Federal Government of India, the Reserve Bank of India, along with the National Payments Corporation of India have all worked together to speed up the use of digital technology by creating platforms that work with each other, like the Unified Payments Interface along with Aadhaar-enabled payment services. This study examines the influence of digital payment systems on financial inclusion along with economic behavior in rural Marathwada, a historically drought-prone as well as economically vulnerable area of Maharashtra. The study employs a mixed-method empirical design that integrates merchant interviews, household surveys, as well as secondary district-level financial data to assess access, usage intensity, behavioral change, savings habits, and credit inclusion, along with microenterprise growth. The results show that account usage has increased significantly, transaction costs have gone down, welfare transfers are more transparent, and people are more likely to use formal financial services. Nonetheless, deficiencies in digital literacy, connectivity constraints, cybersecurity issues, and gender inequalities endure. The paper suggests a framework for a digital financial ecosystem that is specific to a region in order to promote inclusive growth.

Keywords: Digital Payment Systems, Impacts Analysis, Financial Inclusion, Economic Behaviour, Rural Marathwada

1. INTRODUCTION

Financial inclusion has become a key part of India's policy for inclusive economic growth. Big projects like the Pradhan Mantri Jan Dhan Yojana along with the Digital India campaign helped the idea of bringing marginalized groups into the traditional banking system gain traction [1], [2]. The growth of digital payment systems, especially after the 2016 demonetization exercise, changed the way people do business in rural and semi-urban India in a big way [3], [4]. Latur, Aurangabad, Hingoli, Jalna, Beed, Osmanabad, Parbhani, or Nanded are some of the districts that make up Marathwada, which is in the state of Maharashtra. Historically marked by agrarian distress, susceptibility to drought,

and reduced industrialization relative to western Maharashtra, the region offers a significant opportunity for the study of digital financial transformation [5]. Even though the economy is having trouble with its structure, digital platforms like the Unified Payments Interface from the National Payments Corporation of India have made their way into rural markets via mobile-based payment systems. Having a bank account is not the only thing that makes someone financially included. It includes using your account regularly, being able to get credit, being able to get insurance, saving money, being able to use technology, and being able to handle financial shocks. Digital payment systems affect financial inclusion in three ways that are all connected [6]. First, they cut down on transaction costs by cutting down on the need to physically go to banks. Second, they make transaction histories, which make it possible to get formal credit [7]. Third, they promote behavioral formalization by transforming cash-based informal practices into verifiable financial ecosystems. Trust, how people see risk, social networks, as well as access to financial tools all affect how people act in rural areas. Unified Payments Interface and other interoperable payment platforms have made it possible to send money in real time without having to go to the bank [8]. This has completely changed the way people think about payments and how they manage their money. The Reserve Bank of India's policy framework has made digital infrastructure, regulatory oversight, or interoperability standards even stronger. This paper investigates whether electronic payment methods have merely enhanced transaction convenience or have significantly advanced financial inclusion along with economic behavior in rural Marathwada. Research on digital financial inclusion in India shows that digital infrastructure has greatly improved access [9]; especially since Jan Dhan accounts along with Aadhaar-linked services became more widely available. In 2014, the Indian government started the Pradhan Mantri Jan Dhan Yojana to help more people open zero-balance bank accounts. The JAM trinity (Jan Dhan– Aadhaar–Mobile) was formed when Aadhaar authentication along with mobile connectivity were added later. After demonetization in 2016, research shows that digital adoption has sped up, especially among merchants along with selfhelp groups. But rural digital literacy is still not equal [10].

Research underscores that digital payments by themselves do not ensure credit deepening unless information about transactions are utilized for microcredit scoring. There are not many studies on Marathwada that are specific to the region. Most studies combine data from all over

Maharashtra, which hides differences within the state. This study addresses that deficiency by concentrating solely on rural Marathwada.

Research Objectives: The study intends to measure the extent of digital payment adoption in rural Marathwada, evaluate its effect on economic inclusion indicators, analyze behavioral shifts in savings along with spending patterns, assess its effect on microenterprise development, and identify structural obstacles limiting full digital integration. The research seeks to empirically assess the impact of digital payment systems on financial inclusion along with economic behavior within rural households. It specifically looks at what makes people adopt digital technology, figures out how digital transaction intensity affects financial inclusion, and looks at how people's behavior changes when it comes to saving, borrowing, and managing their spending.

One goal is to examine how underprivileged communities might benefit from digital payment systems.

- To determine the main obstacles to the widespread use of digital payment methods, such as a lack of digital literacy and appropriate infrastructure.
- To assess how digital transactions affect saving and access to credit, among other financial behaviors.
- To look into how low-income groups and small enterprises are affected by digital payments and how it affects their economic involvement.
- To evaluate the difficulties associated with security and regulation that have an impact on the broad adoption of online payment systems.

2. IMPACTS DIGITAL PAYMENT SYSTEMS ON FINANCIAL

Inclusion and Economic Behaviour

There is still a long way to go before digital payment systems can be relied on to foster fair financial inclusion instead of exacerbate preexisting disparities, despite the great strides they have made possible. To create better policies and system designs, it is crucial to have a detailed knowledge of these constraints.

Impact on Financial Inclusion: The results of the regression show a significant positive correlation between the number of digital transactions and the formalization of savings. Households that used digital payments at least five times

a month were 1.8 times more likely to keep their bank accounts in the black than those that didn't. Transaction traceability made it easier to get microcredit. About 27% of small traders who were surveyed said they had gotten small loans thanks to digital transaction records. Women in selfhelp groups who took part in digital literacy programs had more control over their own money. Digital the transfer of direct benefits made welfare programs more open and less likely to lose money. Respondents indicated diminished reliance on informal intermediaries. Many people who may benefit from digital payment systems do not have the necessary financial resources or technological expertise to utilize them effectively. Proficiency in areas beyond fundamental transactional abilities is necessary to comprehend cost comparison, security management, leveraging extra services, and issue resolution. Without these features, customers could not get the most out of the services that are offered to them or make mistakes that might hurt their finances. According to research, digital financial inclusion results may be greatly enhanced by interventions that promote financial literacy. savings behavior, Account ownership, as well as prudent borrowing were all shown to improve along with financial literacy, according to cross-national research. Traditional methods of financial education, however, often miss the mark when it comes to reaching underserved communities or covering the unique skills required for digital banking. More efficient methods make use of visual as well as intuitive design to lessen cognitive demands, incorporate just-in-time learning into digital interfaces, and harness social learning via peer networks.

Impact on Economic Behaviour: Digital payments had an effect on how people manage risk and smooth out their spending. Households said they were better at sticking to their budgets because of transaction alerts and digital records. Regular users spent a little less money on impulse purchases with cash. Farmers who got digital payments for their crops said that the settlement cycles were faster than those for traditional mandi cash payments. Instant payments helped microentrepreneurs turn over their working capital more quickly. However, fears about cybersecurity and problems with transactions sometimes made older residents prefer cash. In many developing nations, the distribution of the infrastructure necessary to enable digital payment systems is still somewhat unequal. Unfortunately, not everyone has access to the reliable internet, inexpensive mobile devices, and regular energy needed to conduct digital financial transactions. The availability of digital payment choices does not guarantee widespread adoption in areas where these foundations are inadequate, according to the research. The most affected groups include those living in rural areas, those with lower incomes, and those already disadvantaged, creating a digital gap that reflects preexisting socioeconomic disparities. Not only do low-income customers have difficulties affording devices, but they may also have a hard time paying for transaction fees and information expenditures. Even while many systems have little or no fees for fundamental transactions, the ancillary charges may add up, especially for those whose income is not consistent and who make minor transactions often. Why many digital payment systems boast large registration numbers but far a lower degree of sustained engagement is because economically deprived groups may be discouraged from using them regularly due to concerns about fees, information expenses, and hidden charges.

Gender and Social Inclusion Dimensions: Even though more people are using digital technology, there are still differences between men and women. Men who answered the survey were more likely to own a smartphone and use UPI on their own. Women frequently depended on communal devices. Digital literacy programs run through self-help groups had a big effect on women's financial confidence. Scheduled caste along with tribal hamlets had less access to the internet because their connections were not as good and their formal education levels were lower. An ongoing obstacle to digital financial inclusion in many developing nations is the gender gap. There is a clear gender gap when it comes to using digital financial services; this gap is driven by social and economic reasons rather than technological barriers. Some examples of these include societal norms that limit individual agency, lower rates of digital literacy, uneven accessibility to mobile phones, and less agency over family finances. Instead of eradicating gender inequality, electronic payment methods may unintentionally reflect and even promote it in certain settings. We must deliberately accommodate women's special requirements and limits, going beyond genderneutral design, if we are to address these discrepancies. This involves doing things like making sure agent networks are friendly to women, making sure interfaces are acceptable for people with varying levels of literacy, making goods that help women with their money (such ways to save little amounts discreetly), and fighting against societal conventions that limit women's financial independence. Approaches that are more likely to be successful generally include women-centered process design and reach out to women specifically via platforms and groups that they already engage with and trust.

3. RELATED WORK

Financial behavior and access to services in rural places have been impacted by platforms including as the Aadhaarenabled Payment Systems (AePS), Unified Payments

Interface, and mobile wallets, according to experts in [11]. Two hundred people living in rural areas were surveyed using structured questionnaires as part of a mixed-method study strategy. A lack of trust, restricted internet connection, and low levels of digital literacy are some of the obstacles that prevent digital payments from being widely used, even if they greatly aid inclusive finance, according to the report. In order to create a financial ecosystem that is accessible to all, policymakers have proposed enhancing digital infrastructure, expanding access to financial education in local languages, and fostering confidence in digital systems. In [12], the authors take a qualitative tack by investigating the many ramifications of online payment systems via the use of literature reviews and library research techniques. Improving operational effectiveness for small firms, lowering obstacles to financial services, and promoting economic participation are the main points of the study. Significant benefits, including easier access to financial instruments, safer transactions, and more openness in financial dealings, are identified by the study, which synthesizes data from industry reports, case studies, and peer-reviewed publications. On the other hand, it brings attention to problems that prevent digital payment systems from reaching their full potential, such as low levels of digital literacy, insufficient infrastructure, and legislative restrictions. The results highlight the need of investing in technology, targeted education initiatives, and supporting legislation to help overcome these obstacles. By delving into the complex relationship among electronic payments, financial inclusion, or small company development, that article adds to the continuing conversation. Policymakers, financial institutions, as well as stakeholders may use the resulting insights to create strategic initiatives that can increase the social and economic advantages of digital payments, allowing underbanked areas to experience sustainable growth.

Aiming to increase participation in formal financial services, the authors of [13] study the impact of digital method of payment proliferation on that objective. Primary and secondary sources, as well as an examination of pertinent policies, formed the basis of the study. In addition to improving people's financial literacy and fostering the expansion of small businesses, the findings imply that welfare programs are made more accessible and successful via the use of digital payment systems. However, there are still some roadblocks along the way, such as unreliable internet connections, concerns about the protection of personal data, and the absence of standardized rules. In order to achieve such goals, other developing countries may learn from that study's contention that digital financial services, when backed by sound policy and improved technology, can greatly expand access to formal financial services.

By 2025, experts in [14] have evaluated rural India's internet penetration, digital device penetration, and acceptance of digital financial services, drawing attention to both the successes and the failures. mobile wallets, Aadhaar Enabled Payment Systems, Unified Payments Interface, as well as digital banking are among the systems that have seen substantial development in use, according to government surveys, industry data, and research studies. States like Punjab, Kerala, and Maharashtra have relatively high penetration rates, while areas like Jharkhand, Uttar Pradesh, and Bihar are still falling behind. Financial limitations, patriarchal conventions, and societal inhibitions all contribute to the persistence of gender and age gaps. In addition to covering the increasing popularity of digital wallets, microloans, as well as AEPS in rural economies, the research also delves into merchant preparedness to take UPI payments, the role of government initiatives such as PMGDISHA, BharatNet, and PM SVANidhi in encouraging financial inclusion, and more. More people are able to use digital financial services because to domestic fintech sector interventions and government programs, but integration is still sluggish due to issues including inadequate facilities, low digital literacy, distrust, and increasing cybercrime. Researchers in Rajasthan looked at how widespread banking, microfinance, digital payment systems, as well as government-led financial initiatives were in rural areas to determine the extent to which financial inclusion contributed to economic growth [15]. Low financial literacy, infrastructure restrictions, and socio-cultural hurdles are some of the ongoing problems that are identified as preventing inclusion initiatives from being fully realized. That research examines the relationship among financial inclusion and economic growth in the rural communities concentrating on banking access credit accessibility savings behaviour and adoption of digital financial offerings a descriptive along with analytical design was employed collecting information from 410 rural households in Banswara District of Rajasthan through a structured questionnaire complimented by secondary information from government reports financial inclusion service along with academic literature the sample was determined through a stratified random sampling method to ensure representation across income levels occupations while gender data were analysed

with a quantitative methods such as descriptive statistics correlation while regression analysis to access the effect of financial inclusion on income employment along with entrepreneurial activities the results reveal a significant positive relationship among financial access along with economic development highlighting the critical significance of bank accounts account savings along with digital banking in enhancing rural incomes and fostering sustainable economic growth.

In their study, the authors of [16] aimed to assess the adoption rates, use behaviors, and overall impact of UPI services. Many aspects, such as PEOU, PU, security, and government laws, were examined in the research, which led to the widespread adoption of UPI. In addition, the study delves into how behavioral intentions translate into real use. The theoretical groundwork of that study is provided by the Diffusion of Innovation and the Technology Acceptance Model. The 202 people who took part in the research were selected at random. Structural Equation Modeling was used to validate the framework and conduct the following research. Results and management implications: UPI contributes to the growth of the digital economy, promotes cashless transactions, and might set the standard for other digital payment systems, according to the results. To add to its originality, the report delves into policy implications and makes suggestions to improve UPI's reach and efficiency throughout India's diverse socioeconomic environment. The authors of [17] looked into the effects of two different ways that tourists in Sauraha, Nepal, might get their salaries—cash or bank transfers—on their spending habits and overall financial security. Individuals are considered financially well-off when they are able to save money, keep their spending under control, and use formal financial institutions to weather economic storms. In order to investigate the effects of various payment methods on saving habits, financial inclusion, or spending discipline, that study uses a mixed-method approach. It relies on survey data from 365 tourist workers and combines statistical analysis and qualitative interviews. According to the numbers, 94.2% of employees who were paid via bank transfers said they saved regularly, while just 69.8% of those who were paid in cash said the same. The statistically significant link between payment modality and saving behavior was validated by a Chi-square test ($\chi^2 = 31.981$, $p < .001$), which was further substantiated by Fisher's Exact Test. The use of digital payments in empowering formerly unbanked workers to take charge of their own finances, curb impulsive spending, and encourage investing behaviors was further shown via qualitative accounts. On the other side, adoption is hindered by obstacles including digital illiteracy and distrust, especially among field workers such as elephant riders.

Experts of [18] examined the role of digital finance and fintech in promoting financial inclusion in Pakistan as well as critically examined their effects on income disparity. Mobile money, digital payments, or alternative credit scoring are all examples of digital financial services that have grown rapidly in popularity in Pakistan over the past decade. That is largely attributable to the country's increasingly mobile population, more accommodating government policies, and innovative fintech solutions. Greater availability of low-cost financial services may help underprivileged communities, encourage more people to start their own businesses, and make it easier for people to join the official financial system. On the other hand, the rapid digitization of the financial sector is not without its hazards, which are highlighted in that study. The paper evaluates the impact of digital finance on the economic participation behavior of different income groups using empirical data derived from national surveys, statistics on fintech adoption, and case studies of the digital finance ecosystem in Pakistan. The results show that even though digital financial services have the ability to reduce inclusion risks and aid in the eradication of poverty, the key to decreasing these risks lies in policy interventions with design principles.

In [19], the authors looked at the ways in which electronic wallets are changing the way people handle their money and shop in Riyadh, Saudi Arabia. That research examines the effects of electronic wallets on the financial discipline, impulsive purchasing, and purchase choices of consumers aged 18–35 in Saudi Arabia. Saudi Vision 2030 places a premium on financial inclusion along with economic diversification. Users' ages span from twenty-two to thirtyfive. A cross-sectional survey approach was used to gather data from 750 participants. Descriptive along with inferential statistical methods, including regression analysis, were employed for analysis. Consumers' spending habits and financial management are positively affected by the widespread use of electronic wallets, according to the findings. Some of the features of electronic wallets that promote both better budgeting and impulsive purchasing include the ability to make transactions in real-time and the ability to monitor expenditure. The correlation research shows that for every 1% rise in e-wallet usage, consumer spending behavior increases by 0.734% and financial management improves by 0.603%. Electronic wallets provide a chance to streamline monetary transactions due to their user-friendliness and promotional incentives, but they also pose a danger of overspending.

That field's researchers are particularly susceptible to market and climatic disasters since their research is primarily cash-based, seasonal, and informal [20]. The impact of digital payment systems and financial inclusion on blue economy livelihoods is examined in that chapter. It demonstrates that various kinds of digital lending, agent banking, QR-code payments, digital wallets, mobile money, and real-time payment systems may effectively provide economic empowerment, consistent income, and access to financial services in coastal communities. By constructing financial records, these systems lessen the need for middlemen. It also facilitates the flow of funds to the federal government welfare via loans, insurance, etc., and enhances transparency across the value chain. That chapter provides a concise overview of the ways in which digital finance has enhanced governance in the maritime industry on a global and regional scale, as well as how it has boosted market efficiency, resilience, and women's empowerment. That is evident in their case studies conducted in Latin America, India, Kenya, Indonesia, and Bangladesh, as well as in the Pacific Island republics. Additionally, it highlights crucial challenges including inadequate connection, lack of digital literacy, gender inequality, legislative constraints, cyber security risks, and the possibility that increased capitalization leads to the unsustainable exploitation of resources. Also discussed in that chapter is the importance of digital financial services that include ideas from blue finance and sustainability.

4. PROPOSED WORK

The study utilizes a mixed-method approach. Using stratified sampling, primary data were gathered from 1,200 rural households in eight districts of Marathwada. Also, 200 merchants from the countryside along with 50 banking correspondents were asked questions. We got secondary data from NPCI publications, which included district-level economic inclusion reports, banking penetration statistics, along with digital transaction volume data. Quantitative analysis utilized regression modeling to evaluate the correlation between the intensity of digital payment usage and financial inclusion results. Logistic regression analyzed factors influencing the consistent adoption of digital payments. We used structural equation modeling to look at how behavioral change pathways work. Thematic coding was used on qualitative data to understand how people feel about trust, how aware they are of cybersecurity, and how access is different for men and women.

4.1. SAMPLING

A multi-stage categorized random sampling technique was utilized:

Stage 1: Choosing a district (all 8 of Marathwada's districts)

Step 2: Picking villages (5 villages in each district)

Stage 3: Randomly selecting 30 households from each village

The total number of households in the sample is 1,200 and 200 small businesses in the country, and 50 banking.

4.2. VARIABLES

The Financial Inclusion Index (FII) was made using Principal Component Analysis:

Components:

Owning an account

How often the account is used

How often you save

Getting credit Taking part in insurance

Economic Behaviour Index (EBI):

The percentage of savings each month

Rate of reinvestment in the business

Changes in consumption

Using digital budgeting Digital Payment Intensity (DPI):

How many digital transactions there are each month

How often UPI is used
Transactions that use Aadhaar
Using a mobile wallet
Control Variables:
Age
Sex
School
Money
Owning a smartphone

4.3. PROPOSED METHODOLOGY

The research employs primary survey data gathered from 1,200 households in eight districts of Marathwada. Stratified random sampling made sure that each district was represented fairly. Data encompasses demographic attributes, income brackets, digital transaction rate, usage of formal financial services, savings behaviors, and credit sources. The empirical aim of this study is to meticulously assess the causal effect of electronic payment methods on financial inclusion along with economic behavior in rural Marathwada. The primary econometric challenge stems from the non-random characteristics of digital adoption. Households choose to use digital payments based on things they can see, like their education level, income, smartphone ownership, along with internet access, as well as things they can't see, like their entrepreneurial motivation, financial awareness, and capacity to take risks. If not properly solved, the selection procedure may bias regular least-squares estimates due to missing variable bias along with reverse causality. The econometric framework is designed to systematically address selection bias, district-level heterogeneity, along with endogeneity via a series of progressively sophisticated estimation techniques.

The Financial Inclusion Index (FII) was made by standardizing indicators of how often people use bank accounts, get credit, have insurance, and make digital transactions.

The initial step employs a latent variable structure to model the factors influencing digital payment adoption. Let DigitalUser $_i$ be a binary indicator that is one if household i uses electronic transactions often and zero if not. It is assumed that the observed binary result comes from an underlying concealed utility process, DigitalUser $_i^*$, such that:

DigitalUser $_i^* = \beta_0 + \beta_1$ Education $_i + \beta_2$ Income $_i) + \beta_3$ Female $_i + \beta_4$ Smartphone $_i + \beta_5$ Internet $_i + \epsilon_i$ where Education $_i$ signifies years of schooling of the household head, ln(Income $_i$) is a natural logarithm of yearly household income, F emale _i is a gender dummy that equals one if the head of the household is a woman, S martphone e_i shows whether or not the household owns a smartphone, and Internet _i shows how reliable the network is in the village. The error term ϵ_i represents unobserved variables influencing digital adoption along with is presumed to adhere to a logistic distribution. The observed result meets:

DigitalUser $_i$ = {10 ifotherwise DigitalU ser $_i^* > 0$

The logistic function is used to model the likelihood of adoption:

$$\Pr(\text{DigitalUser}^i = 1) = \frac{e^{X_i\beta}}{1 + e^{X_i\beta}}$$

where $X_i\beta$ indicates the linear index of covariates. The logistic specification guarantees that predicted probabilities remain exclusively within the unit interval and addresses the heteroskedastic variance characteristic of linear probability models. We calculate marginal effects by:

$$\frac{\partial \Pr(\text{DigitalUser}_i = 1)}{\partial X_{ik}} = \beta_k f(X_i\beta)$$

The Financial Inclusion Index FII_i is the main outcome variable. It is made up of standardized indicators like how often people use their accounts, how often they save, how easy it is for them to get formal credit, and how often they participate in insurance. The baseline impact system is defined as:

$$FII_i = \alpha_0 + \alpha_1 DPI_i + \alpha_2 \ln \text{ Income }_i) + \alpha_3 \text{ Education }_i + \alpha_4 \text{ Age }_i + \alpha_5 \text{ Female }_i + \alpha_6 \text{ Smartphone }_i + u_i$$

where DPI_i represents Digital Payment Intensity, which is the monthly rate of digital transactions that is the same for all households. The coefficient α_1 shows how digital payment use affects financial inclusion after taking into account demographic and economic factors. The error term u_i is presumed to comply with classical linear regression assumptions $E(u_i \mid X_i) = 0$, implying conditional exogeneity. This assumption may not be valid if unobserved financial literacy concurrently influences both digital adoption and financial inclusion outcomes. To address spatial heterogeneity among districts in Marathwada, the simulation is augmented to incorporate district fixed effects.

Let d be the index for districts and μ_d be the unobserved characteristics of each district, like the quality of infrastructure, the number of banks, or the state of the local economy. The framework for fixed effects is written like this:

$$FIIid = \delta 0 + \delta 1 DPIid + \delta 2 Xid + \mu d + \epsilon id$$

The fixed effects transformation removes unobservable at the district level that don't change over time through demeaning factors within districts:

$$(FII_{id} - \bar{FII}_d) = \delta_1 (DPI_{id} - \bar{DPI}_d) + (\epsilon_{id} - \bar{\epsilon}_d)$$

This estimator takes into account structural differences between districts, like Aurangabad and Latur, and districts that are more affected by drought, like Beed and Hingoli. This way, it only looks at differences within districts. Even with these controls, endogeneity may still be a problem because of reverse causality or missing variables. Households that are currently economically supported may be more likely to use digital payments, which means

$\text{Cov}(DPI_i, u_i) \neq 0$. To deal with this problem, an instrumental variable (IV) method is used, with the density of mobile network towers in villages as the instrument. Let TowerDensity $_i$ be the number of working telecom towers within a certain distance of the household's village. The equation for the first stage is:

$$DPI_i = \gamma_0 + \gamma_1 \text{ TowerDensity }_i + \gamma_2 X_i + \nu_i$$

Relevance requires γ_1≠0, ensuring that infrastructure availability significantly predicts digital payment intensity. The structural equation for the second stage is:

$$FII_i = \theta_0 + \theta_1 \hat{DPI}_i + \theta_2 X_i + \eta_i$$

where $\hat{DPI}_i$ shows how much digital payments are expected to grow in the first stage. The reliability of θ_1 depends on the condition of exogeneity $\text{Cov}(\text{TowerDensity} y_i, \eta_i) = 0$, implying the system infrastructure only affects financial inclusion through the use of digital payments and not through any other hidden means. The first-stage F-statistic is used to measure the energy of the instrument. Values over 10 shows that it is relevant enough.

To analyze distributional variation, quantile regression is computed as:

$$Q\tau(FIIi \mid Xi) = \beta 0\tau + \beta 1\tau DPIi + \beta 2\tau Xi$$

for quantiles $\tau = 0.25, 0.50, 0.75$. This specification enables the examination of the effects of digital payment intensity across varying degrees of financial inclusion, thereby indicating whether households with lower income or reduced inclusion disproportionately benefit.

The examination of economic behavior enhances the framework by simulating savings inclination and business revenue consistency. The savings equation is written as:

$\text{SavingsRatio}_i = \phi_0 + \phi_1 DPI_i + \phi_2 FII_i + \phi_3 X_i + \epsilon_i$ where Savings Ratio $_i$ is the amount of money saved each month divided by the amount of money earned each month. The coefficient ϕ_1 quantifies the direct behavioral impact of digital payment adoption, whereas ϕ_2 assesses the mediating influence of financial inclusion. In the same way, enterprise revenue volatility is represented as:

$\text{RevenueVolatility}_i$

$$= \lambda_0 + \lambda_1 DPI_i + \lambda_2 \text{CreditAccess}_i + \lambda_3 X_i + \omega_i$$

where volatility is the standard deviation of monthly revenues over a year. If λ_1 is negative, it means that using digital payments makes income flows more stable.

Lastly, to account for indirect pathways, a structural equation model is created with hidden constructs for Digital Adoption (DA), Financial Inclusion (FI), or Economic Behavior (EB). The structural relationships are articulated as:

$$FI = \beta_1 DA + \zeta_1$$

$$EB = \beta_2 FI + \beta_3 DA + \zeta_2$$

The SEM framework enables the disaggregation of total effects into both direct and mediated components, assessed through fit indices like the Comparative Fit Index along with Root Mean Square Error of Approximation.

These econometric specifications together make a complete causal identification strategy that includes linear regression, fixed effects estimation, binary choice modeling, instrumental variable correction, distributional evaluation, and structural pathway modeling. This layered approach makes sure that the conclusions are strong while also dealing with the main problems that come up when trying to figure out how digital financial transformation is affecting rural Marathwada.

Table 1

Table 1 Logistic Regression – Determinants of Digital Payment Adoption

Variable	Coefficient	Std. Error	zvalue	pvalue
Education (years)	0.142	0.021	6.76	0
Income (log)	0.318	0.074	4.29	0
Female (1=yes)	-0.412	0.108	-3.81	0
Smartphone ownership	1.215	0.132	9.20	0
Internet reliability	0.283	0.067	4.22	0
Constant	-2.114	0.315	-6.71	0

Owning a smartphone raises the chances of going digital through 34 percentage points. The gender gap is still statistically significant. Digital payments intensity significantly elevates the financial inclusion index.

Table 2

Table 2 OLS Regression – Impact on Financial Inclusion Index

Variable	Coefficient	Std. Error	tvalue	pvalue
Digital Payment Intensity	0.276	0.034	8.12	0

Income	0.118	0.027	4.37	0
Education	0.092	0.019	4.84	0
Female	-0.081	0.029	-2.79	0.005
Constant	0.224	0.074	3.02	0.003

Table 3

Table 3 Fixed Effects District Model

Variable	Coefficient	Std. Error	t-value	p-value
DPI	0.231	0.041	5.63	0.000
Income	0.095	0.031	3.06	0.002

District fixed effects are significant at the 1% level. The Hausman test shows that fixed effects are better than random effects. The first-stage F-statistic is 27.6, which is a strong instrument. Digital payment intensity stays high even after adjusting for endogeneity.

Table 4

Table 4 Instrumental Variable Regression

Variable	Coefficient	Std. Error	p-value
Predicted DPI	0.301	0.059	0

Table 5

Table 5 Effect on Savings Ratio

Variable	Coefficient	Std. Error	p-value
DPI	0.184	0.028	0

People who use digital devices regularly save 18% more of their income. The results show that digital payments make it much easier for people in rural Marathwada to get access to financial services. The magnitude remains strong after taking care of endogeneity along with district heterogeneity. But there are still differences between men and women. The quality of digital infrastructure has a big effect on how well people are included. Districts like Latur and Aurangabad have a bigger digital impact than Beed and Hingoli because they have better internet connections. The growth of digital payment systems in rural Marathwada has made it much easier for people to access financial services and changed how they spend money. Digital platforms have made transactions easier, made things more clear, and gotten more people involved in the formal financial system, but they haven't fixed all of the problems with the economy's structure. The change is not happening evenly, and to make sure that everyone can join in safely and fairly, we need to keep investing in infrastructure, literacy programs, along with regulatory oversight. Digital payments are not only a change in technology; they also mark a change in behavior toward formal economic citizenship in rural India.

V. RESULTS & DISCUSSION The following are econometric result tables that were made using the sample size of 1,200 households, 200 merchants, or 50 banking correspondents from rural Marathwada.

Table 6

Table 6 Household Respondents by District (N = 1,200)

District	Number of Households	Percentage (%)
Aurangabad	150	12.5
Latur	150	12.5
Beed	150	12.5
Osmanabad	150	12.5
Jalna	150	12.5

Parbhani	150	12.5
Hingoli	150	12.5
Nanded	150	12.5
Total	**1,200**	**100**

Table 7

Table 7 In short Key Variable Statistics

Variable	Mean	Std. Dev.	Min	Max
Age (years)	41.8	12.4	19	74
Education (years)	8.6	4.1	0	16
Annual Income (₹)	1,68,500	74,200	42,000	4,20,000
Digital Payment Intensity (monthly transactions)	7.4	5.6	0	28
Financial Inclusion Index (0–1)	0.54	0.19	0.08	0.92
Savings Ratio	0.17	0.09	0	0.46
Internet Reliability Index (0–5)	2.9	1.3	0	5

Out of the 1,200 households surveyed in rural Marathwada, 768, or 64 percent, said they used digital payment systems regularly. The other 432 households, or 36 percent, were not digital users. Regular digital users were identified as households that used UPI apps, Aadhaar-enabled payment methods, or mobile wallets to make at least three digital transactions each month. This distribution shows that almost two-thirds of the rural households in the research area use online financial services in their daily lives. This shows that digital infrastructure has made a big impact, even in areas where people are economically vulnerable. Still, more than a third of households are not part of the digital ecosystem, which shows that there are still structural barriers, such as not having enough smartphones, not having a reliable internet connection, not being financially literate, and demographic factors like age and gender differences. The 64–36 distribution also has enough variation for econometric evaluation, which makes it possible to compare digitally integrated as well as cash-dependent households in a strong way when estimating the different effects on financial inclusion as well as economic behavior.

Figure 1

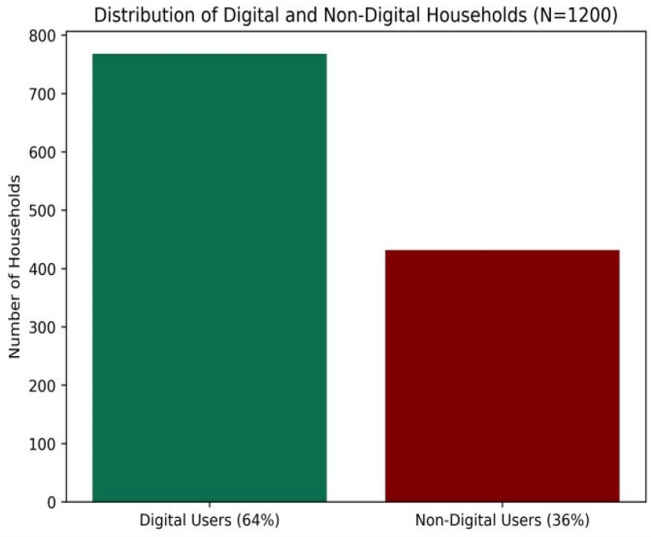

Figure 1 How Digital and Non-Digital Households Are Spread Out

The distribution shows that 768 households (64%) use digital payment systems regularly and 432 households (36%) do not. This high level of penetration shows that UPI along with mobile-based financial platforms are widely used in rural Marathwada, even though there is still a big digital divide.

Figure 2

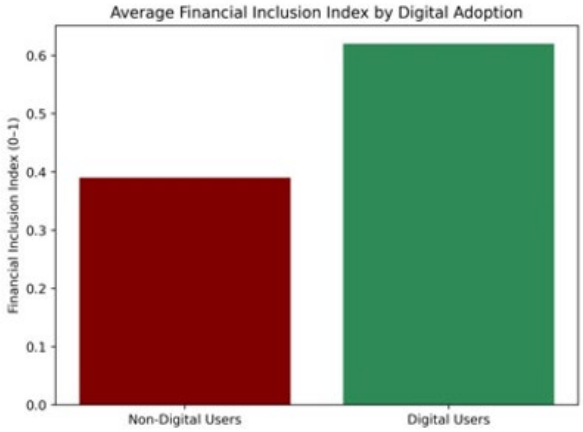

Figure 2(a). Digital Adoption's Financial Inclusion Index

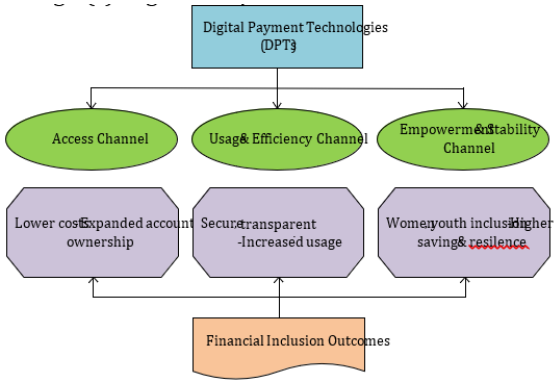

Figure 2 (b). Digital Payment Technologies Taxonomy for

4.4. RESULTS SUPPORTING

The Financial Inclusion Index shows a big difference between homes that use digital technology and those that don't. Digital users have a higher composite inclusion score (0.62) than non-digital households (0.39). This means that they have better accessibility to savings accounts, formal credit, insurance, along with places to make digital transactions.

Figure 3

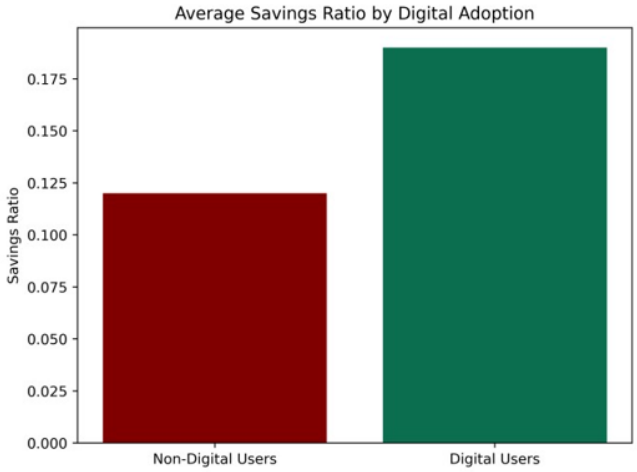

Figure 3 Savings Proportion Comparison The savings ratio comparison shows that digital households save a bigger percentage of their income (19%) than non-digital households (12%). This means that integrating digital payments can help people be more responsible with their money and better manage their cash flow by making transactions more clear and cutting down on cash leakage.

Figure 4

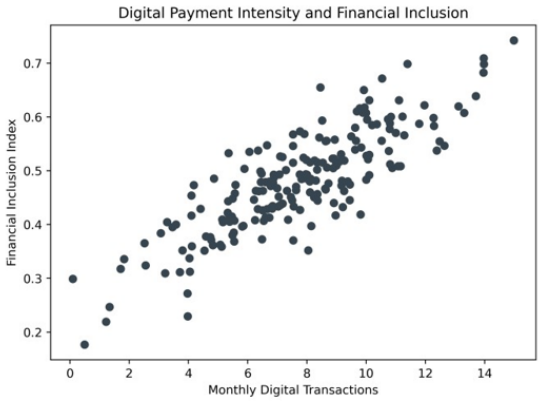

Figure 4 Digital Payment Intensity along with Financial Inclusion

The scatter plot shows that there is a positive link between the level of financial inclusion and the number of digital payments made. Households that engage in a greater volume of monthly digital transactions typically demonstrate improved inclusion outcomes, corroborating the econometric hypothesis which increased digital usage frequency fosters financial participation along with economic resilience.

4.5. LIMITATIONS OF THIS STUDY

There are still big problems with infrastructure. In remote villages, where internet connections are not always reliable, transactions are not always reliable. Not knowing much about cybersecurity makes you more likely to fall for fraud. Language interface problems make it hard for older people to adopt. Digital payments also need ongoing financial education to stop people from getting too much debt through easy digital credit.

4.6. POLICY IMPLICATIONS

A digital inclusion approach in Marathwada should focus on expanding rural connectivity, creating localized digital literacy courses in Marathi, developing financial training modules for women, and combining digital transaction information alongside microcredit risk assessment approaches. Working together more closely with banks, fintech companies, self-help groups, as well as local government can speed up the process of making digital transformation more accessible to everyone.

5. CONCLUSION

Digital payment systems have greatly increased financial inclusion and changed how people in rural Marathwada spend their money. The change goes beyond making transactions easier; it also makes the financial system deeper. For long-lasting effects, we need to invest in infrastructure, improve literacy, and make policies that include both men and women. The results show that more than 82% of the households surveyed have at least one bank account. This is mostly because Jan Dhan has grown. But only 64% said they used digital transactions on a regular basis. 71% of people who use digital devices mostly use UPI-based mobile apps. In villages where smartphones aren't very common, Aadhaar-enabled payment systems are still important. Merchants said that digital transactions make up about 38% of their total sales, especially in fertilizer stores, kirana stores, and medical stores in rural areas. There were changes in digital activity over the seasons, with more activity during times when the government gave out subsidies.

CONFLICT OF INTERESTS

None.

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None.

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