# The Impacts of Fast Retail Payments on Financial Institutions and Innovation

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**Abstract**

This paper examines how interoperable payments may affect innovation and competition in the market, focusing on the Unified Payments Interface (UPI) in India. We compare the number of innovations (measured by new functions introduced in their apps) and market share (measured by mobile transaction volume and value) between banks that are UPI members and those that are not. We find that UPI significantly increases mobile transaction, with the effect being larger for large banks. Additionally, UPI facilitates innovation among member banks, although a large fraction of this innovation is driven by fintech service providers. To further assess the impact, we estimate demand and innovation models for UPI. We find that both UPI and innovation significantly increase the demand for mobile transactions. Banks incur costs for innovation, with UPI innovations having lower costs compared to non-UPI innovations. We conduct counterfactual simulations to compare the impact of UPI with a scenario in which UPI is removed from the market. We find that UPI increases market share and innovation levels but also leads to increased market concentration.

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# 1 Introduction

Interoperability allows firms to reach large consumer bases rapidly and may change market structure and stimulate innovation in financial products. It may weaken the advantageous network effects of the largest firms while allowing smaller firms access to a much larger set of customers, which could spur innovation. This paper measures the impact of instant retail payment interoperability on innovation by, and competition between, financial service providers (FSPs) in the context of the Unified Payments Interface (UPI) in India.[1]

UPI, launched in April 2016, is one of the most successful interoperability payment systems. As of August 2023, UPI has surpassed 10 billion transactions. UPI also accounts for more than 75 percent of all retail digital transactions in India, with around 330 million unique users and over 70 million merchants actively utilizing UPI, employing 256 million QR codes across India.[2] As UPI grows, more innovations emerge in the space, such as AutoPay, which further facilitates insurance and investment payments.

We collect innovation measures by using bank app update histories from January 2015 to October 2023. We categorized an update as an innovation when the description pertained to new products related to credit, deposits, investments, and insurance, as well as new technologies related to UPI, user-friendly functions, and transaction and payment features. We also complemented this data with bank-level mobile banking transaction data available from the Reserve Bank of India.

We start by providing descriptive statistics of innovations and mobile banking transactions, measured in terms of value and volume, for UPI members (i.e., UPI

[1]Financial services providers are businesses that manage money on behalf of customers, including banks, credit unions, and other consumer finance companies; credit card companies, e-money issuers, and other payment institutions; insurance companies; and investment firms such as stock brokers, asset managers, portfolio managers, or investment advisers.

[2]See https://www.cnbctv18.com/technology/upi-transactions-payments-10-billion-for-first-time-in-august-digital-npci-17692301.htm.

service providers) relative to non-UPI members, before and after the introduction of UPI. Before UPI's introduction, both groups exhibit similar trends in innovations and mobile banking transactions. Afterward, UPI members consistently have higher levels of innovation and mobile banking transactions than non-UPI members, suggesting that UPI stimulates both innovation and demand.

We further quantify this effect using a difference-in-differences regression, comparing the treatment group (UPI members who joined UPI at that time) to the control group (the remaining members) before and after the introduction of UPI. We find that UPI increases the innovations of UPI members, with fintech providers (PhonePe and Paytm) showing higher innovations. UPI also increases mobile transaction volume for UPI members, both in terms of value and volume. Among large and small banks, the larger banks experience a significant increase in demand, suggesting that market concentration increases after UPI introduction.

UPI affects both innovation and demand, but innovation may also increase demand. To quantify the equilibrium effect of UPI, we further develop an empirical model. Consumers choose a bank for their mobile payment transactions based on their preference for the bank, whether it is a UPI member, and its cumulative innovations of different types. On the supply side, banks choose their levels of innovation (both UPI and non-UPI) to maximize their market share, while innovation incurs a marginal cost.

The estimates suggest that consumers value UPI functions and innovations. Both UPI and non-UPI innovations increase demand, but non-UPI innovations increase demand more than UPI innovations. Innovation is costly, and UPI innovations are associated with lower costs than non-UPI innovations.

We then simulate the counterfactual scenario without UPI and solve for the equilibrium innovations and market share with and without UPI. We compare the changes in consumer surplus, bank market share, market concentration, and innovation levels under these two scenarios. Because UPI innovations are associated with lower costs,

UPI results in a higher total number of innovations. Since UPI stimulates both demand and innovations, it increases consumer surplus and the average market share across banks. However, market concentration increases with UPI, which is consistent with our descriptive statistics.

Policymakers in lower-middle-income countries need to decide whether to invest in government-run payment systems that work with different banks and services. These investments can significantly impact the financial system, affecting factors such as competition between banks and technological progress. Our findings from UPI could offer valuable guidance for these decisions. By understanding how UPI affects competition and innovation, policymakers can better determine if investing in such systems could help them achieve their goals, particularly in terms of economic growth and financial inclusion.

**Related Literature.** The paper relates to several strands of the literature. First, this study contributes to the growing literature on the supply side of mobile money and cashless payments more generally (e.g., Economides and Jeziorski, 2017; Agarwal et al., 2020; Higgins, 2022; Brunnermeier et al., 2023).[3] This literature explores aspects such as demand-side heterogeneity for pricing, the impact on small businesses and other payment methods, coordination failures, and competition. However, the literature has not yet specifically addressed innovation and competition when innovation is endogenous.

We focus on the impact of interoperability on innovation and competition in the payment systems. Few empirical studies have looked into in this these aspects.[4] Most studies on financial innovation focus on how it affects household consumption or sav-

[3]On the demand side, the literature also quantifies the willingness to pay for mobile money (Aker et al. (2016); Economides and Jeziorski, 2017).

[4]Bourreau and Valetti (2015) and Bianchi et al. (2023) review the theoretical literature related to interoperability in the telecom and payment markets.

ings.[5] In terms of competition, Brunnermeier et al. (2023) shows that interoperability across mobile money operators reduces mobile money fees but also decreases network availability and financial inclusion. In addition, a small number of empirical studies (e.g., Faccio and Zingales, 2022; Genakos et al., 2018; Björkegren, 2022) examine network competition in Telecommunications, which also provides related insights into interoperable payment systems. Our framework is most related to that of Björkegren (2022), which considers the equilibrium choice of both demand adoption and supply investment.

The remainder of this paper is organized as follows. Section 2 outlines the background of UPI, Section 3 discusses the data used for the analysis, Section 4 shows the descriptive statistics, Section 5 describes the empirical model, Section 6 presents the model estimates and the counterfactual equilibrium of no UPI. Finally, Section 7 concludes the paper. Additional technical details and robustness checks are available in the appendices.

# 2 Background

Digital payments in India rely on the UPI, which connects participants across the payment ecosystem, linking merchants and users and facilitating interbank transactions and digital payments. The system has become the backbone of India's cashless economy, enabling real-time transactions.

UPI is a payment infrastructure developed by NPCI that enables interoperability between a specific group of banks, known as "UPI member" banks in all UPI documentation provided by NPCI (the body responsible for UPI). As of August 2024, there are more than 450 UPI members. Some of these member banks also offer UPI-

[5] Jack and Suri (2014) shows that M-PESA, an innovation in remittances, impacts consumption in response to income shocks by improving risk sharing. Breza et al. (2020) finds that receiving payroll through mobile money leads to increased account use and savings and helps users learn to avoid illicit fees. Suri et al. (2021) finds that new digital loans improve household resilience.

enabled mobile applications. These banks are referred to as "PSP & member" banks. Not all member banks have their own mobile applications, making this distinction important. Customers of any UPI member bank can link their bank accounts through any mobile application provided by PSP & member banks. They can then send or receive money between their linked bank account and any other account at a UPI member bank.

In late 2016, a non-bank company called PhonePe partnered with a UPI member (and PSP) bank, Yes Bank, to become a third-party app provider. Customers of any UPI member bank could link their accounts to the PhonePe application and transfer money to other UPI member bank customers or make other payments through PhonePe (e.g., transferring money from their bank account to their PhonePe wallet). The leading UPI apps include PhonePe, Google Pay, and Paytm, which together account for 96.5% of the total UPI transaction count.[6,7]

**Adoption.** UPI has been growing strongly over the past years. Several key events that facililate the adoption include the impact of the 2016 Indian banknote demonetisation and Covid-19 on digital payments in India. As of August 2023, UPI has surpassed 10 billion transactions. UPI also UPI also accounts for more than 75 percent of all retail digital transactions in India, with around 330 million unique users and over 70 million merchants actively utilizing UPI, employing 256 million QR codes across India.[8]

**Innovation.** UPI has developed new innovations and features beyond its initial role as a payment app. It now also involves functions such as insurance payments

[6]See https://inc42.com/buzz/with-96-share-phonepe-google-pay-paytm-dominated-upi-transaction-count-in-december/.

[7]Google Pay started as Tez and was rebranded as Google Pay in 2017. PhonePe and Paytm launched their UPI-based services in 2016 and 2017, respectively.

[8]See https://www.cnbctv18.com/technology/upi-transactions-payments-10-billion-for-first-time-in-august-digital-npci-17692301.htm.

and investment purposes. Several innovations have emerged, such as UPI Autopay, which allows payments to be processed automatically on the payment date, further facilitating insurance payments. Investors can also use UPI as a payment method for investments.

# 3 Data

Our analysis combines several different sources of data, each of which is described below.

**Mobile Banking Transactions.** We obtain both volume and value data of mobile banking transactions from statistics provided by the Reserve Bank of India for the period from October 2015 to Setepmebr 2023.

We show that mobile banking transactions are a good measure of UPI transaction value, as they exhibit a high correlation with the dataset provided by PhonePe over time in Appendix A.

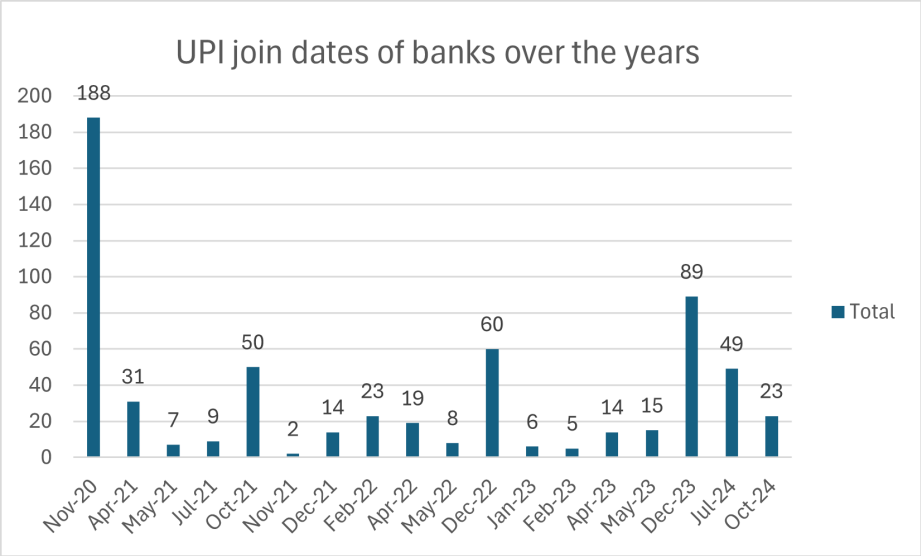
**Innovation.** We measure innovation using the update history and descriptions of mobile banking apps associated with each bank and FSP from January 2015 to October 2023.[9] We categorize a relevant update as an innovation when the update description pertains to new products related to credit, deposits, investments, and insurance, as well as new technologies related to UPI, user-friendly functions, and transaction and payment features.

Not all banks have available update history. In total, we have data on about 218 banks and 2 financial service providers (FSPs), of which 32 are UPI members and 188 are non-members.

[9]The update history is shown for both the Android and Apple Stores. We focus on the India store and obtain the information from data.ai.

**UPI Membership.** Using the list provided by the National Payments Corporation of India (NPCI), we identify whether banks are UPI members.[10] We then create an indicator that takes the value of 1 only for periods after the bank's UPI join date, and 0 for all prior periods. The UPI join date for each bank is determined using the Wayback Machine's archived snapshots of NPCI's List of Banks Live on UPI webpage, which periodically captures the membership list to track when each bank joined the UPI network.[11] However, the web archive only contains information from November 2020 onwards. Therefore, any bank that appears in the November 2020 archive is deemed to have joined UPI as of November 2020.

Figure 1: Distribution of UPI Join dates




Note: Figure 1 plots the histogram of months of UPI join dates that we collect from the Wayback Machine. Banks that appear in the November 2020 archive are deemed to have joined UPI as of November 2020.

[10] PhonePe and Paytm are also considered UPI members, and they are defined as Fintech Service Providers (FSPs).

[11] See https://www.npci.org.in/what-we-do/upi/live-members for the list of UPI members.

### 3.1 Summary Statistics

Table 1 presents the summary statistics of. Regarding innovation, the upper panel of Table 1 shows that Fintech service providers have the highest average, with 3.66 innovations per month. UPI members also exhibit higher levels of innovation, averaging 0.28 innovations per month compared to 0.08 for non-members. We also list detailed innovations in each category, including UPI-related and non-UPI-related innovations (loans, savings, insurance, investments, card payments, bill payments, tax payments, recharge, technology, and convenience).

For mobile banking transactions, the lower panel of the innovation and mobile banking datasets. Table 1 indicates that we compiled a panel dataset comprising a total of 662 banks. UPI members have larger transaction values and volumes compared to non-UPI members.[12]

## 4 Reduced-Form Evidence

To understand how UPI affects mobile transactions and innovations, we compare these outcomes for UPI and non-UPI members before and after the introduction of UPI.

Figure 2 plots the average total mobile transaction value each quarter for UPI and non-UPI members, respectively. After the introduction of UPI, UPI members have experienced a greater increase in total transaction value compared to non-UPI members, especially after 2020. Similar findings are shown for the mobile transaction volume, as indicated in Figure 3.

We plot the quarterly average innovation for UPI and non-UPI members over time, excluding the FSP innovation, in Figure 4. The innovations from UPI and non-UPI members diverge after the introduction of UPI, especially after 2018. UPI

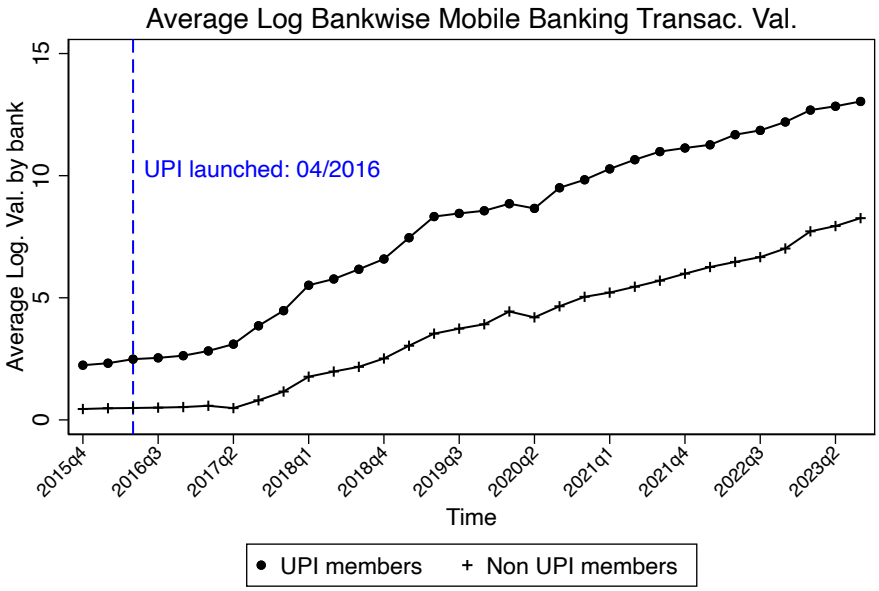
[12]We exclude a few outliers, mostly large banks with missing data from July 2023 to September 2023.

Table 1: Summary Statistics

| | Fintech | | UPI members | | Non-UPI members | |
|---|---|---|---|---|---|---|
| | Mean | S.D | Mean | S.D | Mean | S.D |
| *Innovations* | | | | | | |
| # of Innovation | 3.656 | 4.468 | 0.282 | 1.1005 | 0.080 | 0.562 |
| # of Banks | 2 | | 89 | | 129 | |
| *Innovations in Detail* | | | | | | |
| UPI-Related | 0.198 | 0.493 | 0.016 | 0.134 | 0.003 | 0.057 |
| Loan | 0.005 | 0.072 | 0.010 | 0.106 | 0.003 | 0.058 |
| Saving | 0.120 | 0.371 | 0.004 | 0.070 | 0.001 | 0.037 |
| Insurance | 0.115 | 0.393 | 0.004 | 0.068 | 0.001 | 0.035 |
| Investment | 0.099 | 0.377 | 0.015 | 0.131 | 0.006 | 0.084 |
| Card Payment | 0.537 | 0.744 | 0.057 | 0.251 | 0.015 | 0.130 |
| Bill Payment | 0.703 | 0.933 | 0.039 | 0.210 | 0.010 | 0.103 |
| Tax Payment | 0.693 | 0.935 | 0.038 | 0.206 | 0.009 | 0.102 |
| Recharge | 0.818 | 0.983 | 0.074 | 0.290 | 0.027 | 0.168 |
| Technology | 0.172 | 0.465 | 0.011 | 0.111 | 0.003 | 0.052 |
| Convenience | 0.193 | 0.578 | 0.013 | 0.117 | 0.004 | 0.064 |
| # of Banks | 2 | | 89 | | 129 | |
| *Mobile Banking* | | | | | | |
| Value (Rs) | - | - | $3.36 \times 10^{10}$ | $2.15 \times 10^{11}$ | $2.08 \times 10^{8}$ | $2.18 \times 10^{9}$ |
| Volume | - | - | $1.10 \times 10^{13}$ | $7.99 \times 10^{13}$ | $6.19 \times 10^{10}$ | $1.43 \times 10^{12}$ |
| # of Banks | - | - | 207 | | 434 | |

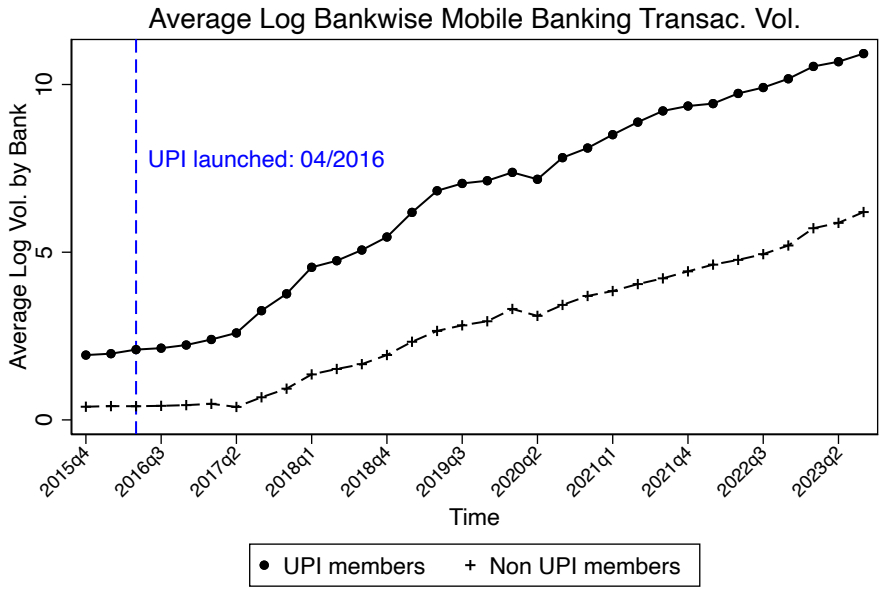
Note: Table 1 presents the summary statistics of the innovation and mobile banking datasets, respectively. The upper panel shows the number of innovations for each type of member (fintech service providers [PhonePe, Paytm], UPI members, non-UPI members) and their associated counts. The lower panel displays the mobile banking volume and value for UPI members and non-UPI members; this dataset does not include fintech service providers.

Figure 2: Mobile Banking Transaction (Value)




Note: Figure 2 displays the average quarterly mobile banking total value over time since January 2015 for UPI and non-UPI members, respectively.

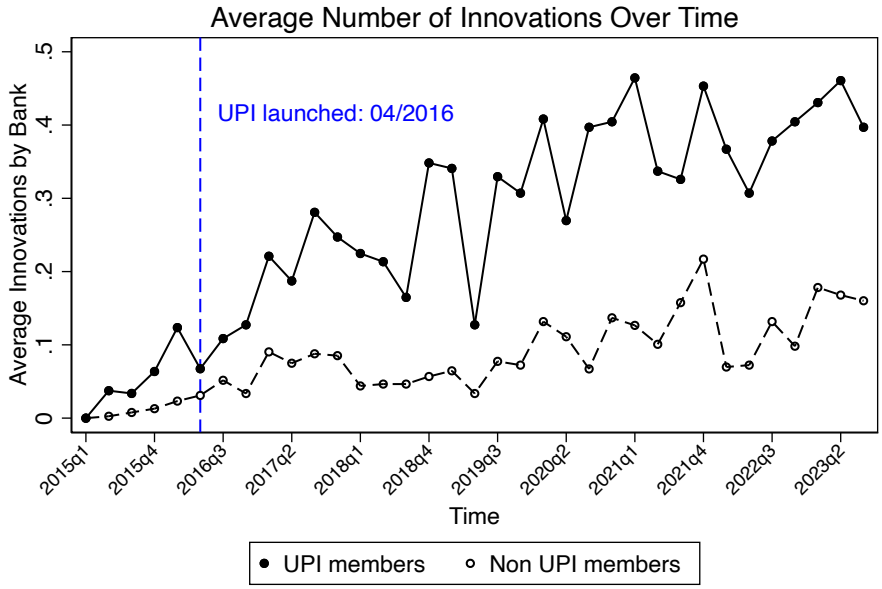
Figure 3: Mobile Banking Transaction (Volume)




Note: Figure 3 displays the average quarterly mobile banking volume over time since January 2015 for UPI and non-UPI members, respectively.

members have a higher average innovation rate than non-UPI members.

Figure 4: Innovation Over Time




Note: Figure 4 displays the average quarterly number of innovations over time since January 2015 for UPI and non-UPI members, respectively.

## 4.1 Differences-in-Differences

We estimate the effect of UPI on mobile banking transactions and innovations using a difference-in-differences specification by comparing UPI members and non-UPI members before and after the UPI introduction, as follows:

$$Y_{jt} = \beta \times UPI_{jt} \times Post_t + \omega_j + \delta_t + \epsilon_{jt}, \tag{1}$$

where $Y_{jt}$ is the outcome variable for bank (or FSP) $j$ in month $t$, $UPI_j$ indicates whether bank (or FSP) $j$ has joined UPI in month $t$, and $Post_t$ indicates whether month $t$ is after the introduction of UPI. We also control for bank fixed effects $\omega$ and month fixed effects $\delta$.

Table 2: The Impact of UPI on Mobile Transaction Value

| | (1) | (2) | (3) |
|---|---|---|---|
| | All Banks | Large Banks | Small Banks |
| UPI × Post | 391.642*** | 425.029*** | 0.167** |
| | (111.707) | (121.099) | (0.078) |
| Month fixed effect | ✓ | ✓ | ✓ |
| Bank fixed effect | ✓ | ✓ | ✓ |
| Observations | 62,976 | 31,200 | 31,776 |
| Adj R-squared | 0.467 | 0.467 | 0.293 |

Note: Table 2 reports the estimates from Equation 1, using the mobile transaction value (in 100K) as the dependent variable. Robust standard errors, clustered at the financial institution level, are reported in parentheses. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table 3: The Impact of UPI on Mobile Transaction Volume

| | (1) | (2) | (3) |
|---|---|---|---|
| | All Banks | Large Banks | Small Banks |
| UPI × Post | 148.258*** | 157.133*** | 0.006*** |
| | (43.096) | (44.879) | (0.002) |
| Month fixed effect | ✓ | ✓ | ✓ |
| Bank fixed effect | ✓ | ✓ | ✓ |
| Observations | 62,976 | 31,200 | 31,776 |
| Adj R-squared | 0.342 | 0.343 | 0.204 |

Note: Table 3 presents the estimates from Equation 1 using the mobile transaction volume (in 100K) as the dependent variable. Robust standard errors, clustered at the financial institution level, are reported in parentheses. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table 2 presents the results using mobile transaction value (in 100K) as the outcome variable. On average, the introduction of UPI increased total transaction value for banks. In Column 2 of Table 2, we further explore heterogeneous effects between large and small banks, where large banks are defined as those whose average monthly transaction volume during the pre-UPI period exceeds the median of the distribution. The results are stronger for larger banks. We also find similar results for mobile transaction volume, as shown in Table 3.

Table 4 presents the estimates using innovation as the outcome variable. We find that the introduction of UPI is associated with an increase in innovation of 0.099. Additionally, in Column 2 of Table 4, we include an interaction between Fintech firms and the post-period indicator, which shows that their innovation increases by 1.844 after the introduction of UPI.

We also explore different categories and find that innovation increases particularly in areas related to UPI, card payments, recharge, and technology. The remaining categories are discussed in Appendix B.2.1.

# 5 Empirical Model

We next develop a model to further understand the effect of UPI. We allow consumer demand of mobile banking transaction to depend on whether the bank is an UPI member and its different types of innovations.

## 5.1 Demand

The indirect utility of using mobile transaction service of bank $j \in J_t$ at month $t$ is as the following:

$$\begin{aligned} U_{ijt} &= \eta_j + \rho \times UPI_{jt} + \boldsymbol{I}\alpha + \xi_{jt} + \varepsilon_{ijt} \\ &= \delta_{jt} + \varepsilon_{ijt}. \end{aligned}$$

Table 4: The Impact of UPI on Main Innovation Categories

| | UPI | Card Payment | Recharge | Technology | Total |
|---|---|---|---|---|---|
| UPI × Post | 0.017*** | 0.021** | 0.019 | 0.007* | 0.099* |
| | (0.006) | (0.010) | (0.012) | (0.004) | (0.052) |
| Fintech × Post | 0.195*** | 0.319*** | 0.366* | 0.025 | 1.844* |
| | (0.028) | (0.101) | (0.210) | (0.076) | (0.989) |
| Month fixed effect | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank fixed effect | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 23,320 | 23,320 | 23,320 | 23,320 | 23,320 |
| Adj R-squared | 0.077 | 0.143 | 0.171 | 0.050 | 0.201 |

Note: Table 4 presents the estimates from Equation 1, using the number of innovations, both overall and by category, as the dependent variable. The UPI variable is a binary indicator equal to 1 if a bank has joined UPI, and 0 otherwise. Fintech is a binary indicator for PhonePe and Paytm. Robust standard errors, clustered at the financial institution level, are reported in parentheses. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

where $\eta_j$ denotes the bank-specific intercept, which could represent brand preference for each bank, and $UPI_j$ indicates whether bank $j$ is a UPI member at month $t$, $\boldsymbol{I}$ is a vector of four other types of cumulative innovation, We categorize innovations into UPI-related innovations and other types, including savings, insurance, convenience, and loans. $\xi$ represents the unobserved preferences of each bank and month, and $\varepsilon$ is the error term that follows a type 1 extreme value distribution. With this assumption, we can express the probability of bank $j$'s market share in month $t$ as follows:

$$s_{jt} = \frac{\exp \delta_{jt}}{1 + \sum_{k \in J_t} \exp \delta_{kt}}.$$

We define each month as a market because we do not have bank-region data. Additionally, mobile payment transactions are typically not constrained by the consumer's location.

## 5.2 Supply

On the supply side, banks decide whether to innovate; innovation increases market share, but is also costly. We simplify the model that firm consider the following objectives when choosing the number of innovations:

$$\pi_{jt}(I_{jt}) = s_{jt}(1 - c_{jt}) \times \Delta I_{jt}.$$

We do not assume that firms maximize profit, as we do not observe any prices or revenues for each bank. Therefore, we assume that banks maximize market share by choosing their current level of innovation $\Delta I_{jt} = I_{jt} - I_{j,t-1}$. However, since each innovation costs firms $c_{jt}$, firms will not innovate indefinitely.[13] Based on this, we can obtain the innovation levels for each bank in each month as $I^*_{jt} = \arg\max_I \pi_{jt}(I)$. We currently do not allow banks to choose whether to join UPI, as we do not have the exact timing for when each bank joins UPI. However, with better data, this could potentially be considered.

[13]We assume the cost also increases with market share, which aligns with our finding that larger banks do not necessarily innovate more, resulting in a better fit.

## 5.3 Estimation

We describe the estimation procedure, starting with the demand side and then discussing the supply side.

### 5.3.1 Demand Estimation

We define the maximum monthly total mobile transaction value observed in the data as the market size and then calculate the market share of each bank for each month, $s_{jt}$. Our empirical results are not sensitive to this definition of market size or to whether we use value or volume.

To mitigate outliers from affecting the innovation estimates, we capped each cumulative count of innovations at the 97th percentile for each respective type of innovation throughout the period.[14] We then estimate the demand function using the standard inversion.

### 5.3.2 Supply Estimation

We focus on 57 banks that have innovated in any type during the sample period. Since other non-UPI-related innovations have similar estimates for the demand function, we group them together as non-UPI innovations. We account for two different costs of innovation: UPI-related innovation cost and non-UPI-related innovation cost, denoted as $\boldsymbol{c} = (c_{UPI}, c_{NUPI})$.

We classify these banks into three clusters using k-means clustering, based on two types of innovations: The High UPI Innovation Group has relatively high UPI-type innovation; the Low Innovation Group consists of banks with low levels of both types of innovation; and the High Non-UPI Innovation Group represents banks with high

[14]The 97th percentiles are 6 for UPI, 4 for loans, 1 for savings, 1 for insurance, 5 for investments, 16 for card payments, 10 for bill payments, 10 for tax payments, 17 for recharges, 3 for technology, and 4 for convenience-related innovations.

non-UPI-type innovation. See Appendix C for a list of the banks in each group. We allow the costs to be different for each cluster.[15]

We solve for the optimal level of cumulative innovation for each firm and each month and match that with the data using the method of moments estimator.

$$E_{j,t}\begin{bmatrix} f^{UPI}(\boldsymbol{c}) \\ f^{NUPI}(\boldsymbol{c}) \end{bmatrix} = E_{j,t}\begin{bmatrix} \Delta I_{j,t}^{UPI}(\boldsymbol{c}) \\ \Delta I_{j,t}^{NUPI}(\boldsymbol{c}) \end{bmatrix} = \mathbf{0}. \tag{2}$$

We find the cost estimates that best match the moment conditions in Equation 2. In practice, we use the generalized method of moments with the identity matrix and calculate standard errors using the delta method.

# 6 Results

We present and discuss the estimates. We then use these estimates to understand the counterfactual innovation and market share without UPI.

## 6.1 Demand Estimates

Table 5 displays the demand estimates. We find that consumers are more likely to choose a bank if it is a UPI member. In addition, consumers value both UPI innovations and non-UPI innovations, with UPI innovations having a greater coefficient in increasing consumer utility.

## 6.2 Supply Estimates

Table 6 displays supply cost estimates. UPI innovations consistently show a lower cost than non-UPI innovations across different groups. The costs of both UPI and

[15]Based on our clustering, High UPI Innovation Group has an average of 2.019 units of UPI-type and 1.483 units of non-UPI-type innovation, Low Innovation Group has an average of 0.477 units of UPI-type and 1.131 units of non-UPI-type innovation, and High Non-UPI Innovation Group has an average of 0.169 units of UPI-type and 0.354 units of non-UPI-type innovation.

Table 5: Demand Estimates

| | (1) | (2) |
|---|---|---|
| UPI | 0.005*** | 0.001** |
| | (0.000) | (0.014) |
| UPI Innovations | 0.248*** | 0.097** |
| | (0.000) | (0.039) |
| Non-UPI Innovations | 0.048*** | 0.051*** |
| | (0.000) | (0.000) |
| Bank fixed effect | ✓ | ✓ |
| Observations | 5,527 | 5,527 |
| Objective Value | $3.2 \times 10^{-26}$ | $2.2 \times 10^{-27}$ |

Note: Table 5 presents the demand estimates. Robust standard errors, clustered at the financial institution level, are reported in parentheses. In Column 1, non-UPI innovations include card payment, bill payment, tax payment, and recharge. In Column 2, non-UPI innovations include all non-UPI-related innovations. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table 6: Cost Estimates

| | $c^{UPI}$ | $c^{NUPI}$ |
|---|---|---|
| Cluster 0 | 0.243 | 0.573 |
| High UPI Innovation Group | (0.002) | (0.005) |
| Cluster 1 | 0.398 | 0.936 |
| Low Innovation Group | (0.055) | (0.109) |
| Cluster 2 | 0.225 | 0.528 |
| High Non-UPI Innovation Group | (0.060) | (0.202) |

Note: Table 6 displays the estimates of UPI innovation costs and non-UPI innovation costs for each group, clustered based on their innovation levels in the data.

non-UPI innovations are highest for the group that innovates the least (i.e., the low innovation group).

## 6.3 Counterfactual Simulations

Using the model estimates, we simulate the equilibrium innovations and market share under the scenarios with and without UPI. In the latter case, we set the variable $UPI = 0$, and banks do not invest in UPI innovations.

We solve the counterfactual innovation for each type and for each bank $j$ until iteration $n$ when

$$|I_{j,n} - I_{j,n-1}| < \varepsilon$$

for $\varepsilon = 0.02$.

Table 7 displays the percentage change in market outcomes. We find that con-

Table 7: Counterfactual Innovation and Market Share Changes

| | |
|---|---|
| Δ% Consumer Surplus | -1.318% |
| Δ% Market Share | -0.459% |
| Δ% HHI | -0.099% |
| Δ% UPI Innovations | -100.000% |
| Δ% Non-UPI Innovations | 58.896% |
| Δ% Total Innovations | -32.913% |

Note: Table 7 displays the percentage change in market outcomes in the counterfactual scenario of no UPI, relative to the case with UPI.

sumer surplus decreases by 1.3%.[16] Banks generally lose market share on average, though by a smaller magnitude, about 0.01%. The HHI decreases without UPI, suggesting that UPI increases market concentration.

In terms of innovation levels, UPI innovations would be zero (a 100% decrease) without UPI. There are some substitutions toward non-UPI innovations, so non-UPI innovations increase. However, the increase is smaller than the decrease in UPI innovations, leading to a decrease in total innovations of 32.9%.

Table 8 further separates the equilibrium market outcomes by large and small banks, where large banks are defined as those with an average market share greater than the median of its distribution. Under this definition, there are 29 large banks and 28 small banks. We find that large banks experience a significant decrease in total

[16] Consumer surplus is calculated based on the standard equation as follows:

$$CS_t = \log\left(1 + \sum_{j \in \mathcal{J}_t} \exp \delta_{jt}\right)$$

We do not measure it in dollar value because UPI transactions do not involve prices.

Table 8: Counterfactual Innovation and Market Share Changes by Firm Size

| | Large Banks | Small Banks |
|---|---|---|
| Δ% Consumer Surplus | -1.313% | -2.861% |
| Δ% Market Share | -0.456% | -0.948% |
| Δ% UPI Innovations | -100.000% | -100.000% |
| Δ% Non-UPI Innovations | 72.421% | 40.000% |
| Δ% Total Innovations | -36.066% | -26.694% |

Note: Table 8 displays the percentage change in market outcomes in the counterfactual scenario of no UPI, relative to the case with UPI, respectively for large banks and small banks, while large banks are defined as those with a market share greater than the median of its distribution.

innovations, while small banks see a smaller decrease in market share. Conversely, small banks experience a larger decrease in market share compared to large banks.

# 7 Conclusion

Many lower-middle-income country governments have recently invested in interoperable retail payment switches. Theoretically, a key benefit of this investment is the reduction of network advantages held by large FSPs, which could alter competition and lead to increased innovation, ultimately resulting in better outcomes for consumers. This could enhance financial inclusion by expanding the digital financial services market. However, investing in an interoperable switch is costly. Insights from the natural experiment of UPI provide empirical evidence—currently lacking in credibility—on the direction and magnitude of these impacts, which can aid in the cost-benefit analysis of fast retail payment systems.

# References


Agarwal, S., Qian, W., Ren, Y., Tsai, H.-T. T., and Yeung, B. Y. (2020). The real impact of fintech: Evidence from mobile payment technology. *Available at SSRN 3556340*.

Aker, J. C., Boumnijel, R., McClelland, A., and Tierney, N. (2016). Payment mechanisms and antipoverty programs: Evidence from a mobile money cash transfer experiment in niger. *Economic Development and Cultural Change*, 65(1):1–37.

Bianchi, M., Bouvard, M., Gomes, R., Rhodes, A., and Shreeti, V. (2023). Mobile payments and interoperability: Insights from the academic literature. *Information Economics and Policy*, 65:101068.

Björkegren, D. (2022). Competition in network industries: Evidence from the rwandan mobile phone network. *The Rand journal of Economics*, 53(1):200–225.

Bourreau, M. and Valetti, T. (2015). Competition and interoperability in mobile money platform markets: What works and what doesn't? *Communications & Strategies*, (99):11.

Breza, E., Kanz, M., and Klapper, L. F. (2020). Learning to navigate a new financial technology: Evidence from payroll accounts. Technical report, National Bureau of Economic Research.

Brunnermeier, M. K., Limodio, N., and Spadavecchia, L. (2023). Mobile money, interoperability, and financial inclusion. Technical report, National Bureau of Economic Research.

Economides, N. and Jeziorski, P. (2017). Mobile money in tanzania. *Marketing Science*, 36(6):815–837.

Faccio, M. and Zingales, L. (2022). Political determinants of competition in the mobile telecommunication industry. *The Review of Financial Studies*, 35(4):1983–2018.

Genakos, C., Valletti, T., and Verboven, F. (2018). Evaluating market consolidation in mobile communications. *Economic Policy*, 33(93):45–100.

Higgins, S. (2022). Financial technology adoption: Network externalities of cashless payments in mexico. *Pdf, Northwestern University. https://seankhiggins.com/assets/pdf/higgins_jmp. pdf.*

Jack, W. and Suri, T. (2014). Risk sharing and transactions costs: Evidence from kenya's mobile money revolution. *American Economic Review*, 104(1):183–223.

Suri, T., Bharadwaj, P., and Jack, W. (2021). Fintech and household resilience to shocks: Evidence from digital loans in kenya. *Journal of Development Economics*, 153:102697.

# A UPI Measures

To check that mobile banking transaction volume from the RBI is a good measure for UPI transactions, we compare it with the UPI transaction volume data from PhonePe, which is publicly available from PhonePe Pulse.[17] We analyze the correlation over time between these two datasets and find that the correlation is 0.99.

Figure A.1: Comparison of Mobile Banking Transaction Volume vs. UPI Volume

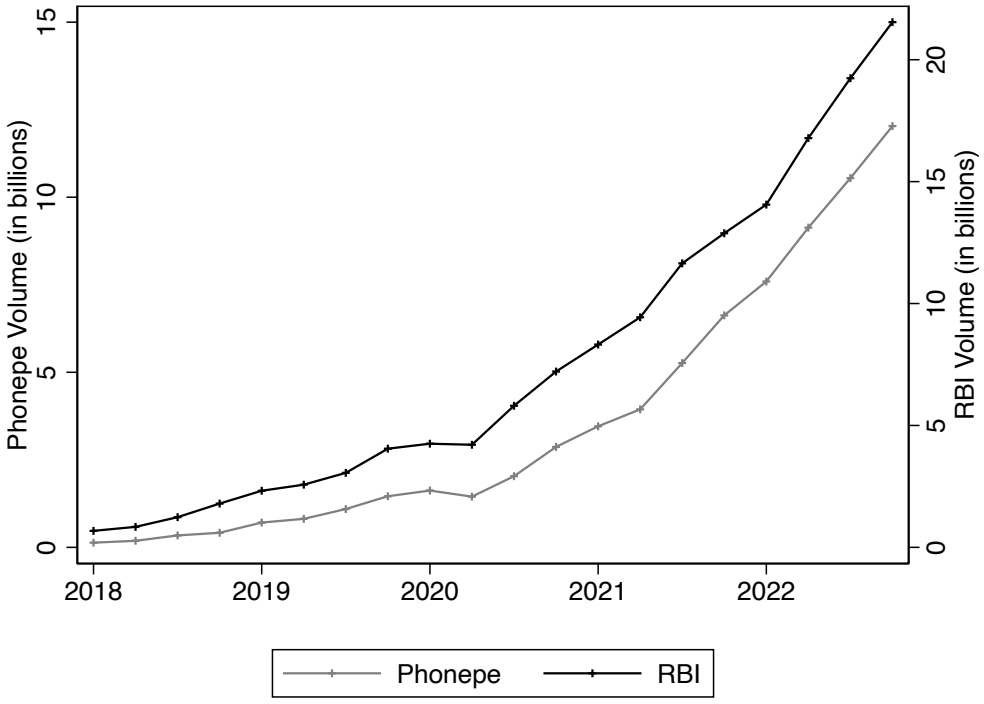



Figure A.1 compares the aggregate mobile banking transaction volume from the RBI (aggregated across banks) with the aggregate UPI transaction volume from PhonePe Pulse (aggregated across regions).

[17] See https://www.phonepe.com/pulse/.

# B Alternative Specification

## B.1 Transaction Value and Volume

Table A.1 and Table A.2 show the results using an alternative UPI indicator that captures whether a bank has ever been a UPI member.

Table A.1: Alternative Specification: The Impact of UPI on Mobile Transaction Value

| | (1) | (2) | (3) |
|---|---|---|---|
| | All Banks | Large Banks | Small Banks |
| UPI × Post | 196.305*** | 264.478** | 0.110*** |
| | (58.022) | (79.977) | (0.035) |
| Month fixed effect | ✓ | ✓ | ✓ |
| Bank fixed effect | ✓ | ✓ | ✓ |
| Observations | 62,976 | 31,200 | 31,776 |
| Adj R-squared | 0.461 | 0.464 | 0.290 |

Note: Table A.1 reports the estimates from Equation 1, using the mobile transaction value (in 100K) as the dependent variable. Robust standard errors, clustered at the financial institution level, are reported in parentheses. Significance levels: *(p < 0.10), **(p < 0.05), ***(p < 0.01).

Table A.2: Alternative Specification: The Impact of UPI on Mobile Transaction Volume

| | (1) | (2) | (3) |
|---|---|---|---|
| | All Banks | Large Banks | Small Banks |
| UPI × Post | 677.778*** | 921.154*** | 0.004*** |
| | (19.769) | (27.235) | (0.001) |
| Month fixed effect | ✓ | ✓ | ✓ |
| Bank fixed effect | ✓ | ✓ | ✓ |
| Observations | 62,976 | 31,200 | 31,776 |
| Adj R-squared | 0.336 | 0.340 | 0.198 |

Note: Table A.2 reports the estimates from Equation 1, using the mobile transaction volume (in 100K) as the dependent variable. Robust standard errors, clustered at the financial institution level, are reported in parentheses. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

## B.2 Innovation

### B.2.1 Other Innovation Categories

Table A.3 examines the impact of UPI on innovation in areas related to loans, savings, insurance, investment, bill payments, tax payments, and convenience. The impact of UPI on these categories is small.

Table A.3: The Impact of UPI on Other Innovation Categories

| | Loan | Saving | Insurance | Investment | Bill Payment | Tax Payment | Convenience |
|---|---|---|---|---|---|---|---|
| UPI × Post | 0.004 | 0.003 | 0.002 | 0.004 | 0.010 | 0.011 | 0.003 |
| | (0.004) | (0.003) | (0.002) | (0.004) | (0.009) | (0.009) | (0.003) |
| Fintech × Post | -0.003 | 0.123*** | 0.045 | 0.094** | 0.273 | 0.262 | 0.141*** |
| | (0.005) | (0.035) | (0.116) | (0.042) | (0.170) | (0.162) | (0.051) |
| Month fixed effect | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank fixed effect | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 23,320 | 23,320 | 23,320 | 23,320 | 23,320 | 23,320 | 23,320 |
| Adj R-squared | 0.021 | 0.053 | 0.046 | 0.031 | 0.174 | 0.175 | 0.063 |

Note: Table 4 presents the estimates from Equation 1, using the number of innovations by category, as the dependent variable. The UPI variable is a binary indicator equal to 1 if a bank has joined UPI, and 0 otherwise. Fintech is a binary indicator for PhonePe and Paytm. Robust standard errors, clustered at the financial institution level, are reported in parentheses. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

### B.2.2 Alternative Specification

Table A.4 and Table A.5 show the results using an alternative UPI indicator that captures whether a bank has ever been a UPI member.

Table A.4: Alternative Specification: The Impact of UPI on Main Innovation Categories

| | UPI | Card_payment | Recharge | Technology | Total |
|---|---|---|---|---|---|
| UPI × Post | 0.012*** | 0.028*** | 0.032*** | 0.007*** | 0.129*** |
| | (0.003) | (0.007) | (0.009) | (0.002) | (0.036) |
| Fintech × Post | 0.203*** | 0.322*** | 0.366* | 0.027 | 1.860* |
| | (0.028) | (0.106) | (0.214) | (0.077) | (1.011) |
| Month fixed effect | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank fixed effect | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 23,320 | 23,320 | 23,320 | 23,320 | 23,320 |
| Adj R-squared | 0.076 | 0.143 | 0.171 | 0.049 | 0.201 |

Note: Table A.4 presents the estimates from Equation 1, using the number of innovations, both overall and by category, as the dependent variable. The UPI variable is a binary indicator of whether a bank has ever joined UPI. Fintech is a binary indicator for PhonePe and Paytm. Robust standard errors, clustered at the financial institution level, are reported in parentheses. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

Table A.5: Alternative Specification: The Impact of UPI on Other Innovation Categories

| | Loan | Saving | Insurance | Investment | Bill_payment | Tax_payment | Convenience |
|---|---|---|---|---|---|---|---|
| UPI_live × Post | 0.004** | 0.003** | 0.003*** | 0.004 | 0.017*** | 0.016*** | 0.005* |
| | (0.002) | (0.001) | (0.001) | (0.003) | (0.005) | (0.005) | (0.003) |
| Fintech × Post | -0.002 | 0.124*** | 0.045 | 0.095** | 0.273 | 0.263 | 0.140*** |
| | (0.004) | (0.036) | (0.115) | (0.043) | (0.174) | (0.167) | (0.052) |
| Month fixed effect | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bank fixed effect | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 23,320 | 23,320 | 23,320 | 23,320 | 23,320 | 23,320 | 23,320 |
| Adj R-squared | 0.020 | 0.053 | 0.046 | 0.031 | 0.174 | 0.175 | 0.063 |

Note: Table A.5 presents the estimates from Equation 1, using the number of innovations by category as the dependent variable. The UPI variable is a binary indicator of whether a bank has ever joined UPI. Fintech is a binary indicator for PhonePe and Paytm. Robust standard errors, clustered at the financial institution level, are reported in parentheses. Significance levels: *($p < 0.10$), **($p < 0.05$), ***($p < 0.01$).

# C Innovation Groups

Table A.6, Table A.7, and Table A.8 provide lists of banks that are clustered into different groups based on innovation levels.

Table A.6: High UPI Innovation Group

| |
|---|
| AIRTEL PAYMENTS BANK |
| ARYAVART BANK |
| AXIS BANK LTD |
| CANARA BANK |
| DBS BANK INDIA LIMITED |
| DEUTSCHE BANK |
| FEDERAL BANK LTD |
| HDFC BANK LTD |
| ICICI BANK LTD |
| IDBI BANK LTD |
| INDIAN BANK |
| INDIAN BANK - ALLAHABAD BANK TILL 31032020 |
| NSDL PAYMENTS BANK |
| RBL BANK LIMITED |
| SOUTH INDIAN BANK |
| STATE BANK OF INDIA |
| UCO BANK |

Table A.7: Low Innovation Group

| |
|---|
| ABHINAV SAHAKARI BANK LTD, DOMBIVALI |
| ACCOUNTANT GENERALS OFFICE EMPLOYEES CO-OP BANK |
| AGRASEN BANK |
| BANK OF MAHARASHTRA |
| CENTRAL BANK OF INDIA |
| CITY UNION BANK |
| COMMERCIAL CO-OP BANK LTD, KOLHAPUR |
| DHANLAXMI BANK LIMITED |
| ESAF SMALL FINANCE BANK |
| FINCARE SMALL FINANCE BANK |
| FINO PAYMENTS BANK |
| HSBC |
| INDIA POST PAYMENTS BANK LIMITED |
| INDIAN OVERSEAS BANK |
| JAMMU |
| KASHMIR BANK |
| KALUPUR COMM CO-OP BANK LTD |
| KARNAVATI CO-OP BANK LTD |
| MAHARASHTRA MANTRALAYA |
| ALLIED OFFICES CO-OP BANK |
| PAYTM PAYMENTS BANK LIMITED |
| PUNJAB |
| SIND BANK |
| SBM BANK (MAURITIUS) LTD |
| SBM BANK INDIA LTD |
| SHREE WARANA BANK LTD, WARANANAGAR |
| SHRI VEERSHAIV CO-OP BANK LTD |
| UDUPI CO-OP TOWN BANK LTD |
| UJJIVAN SMALL FINANCE BANK LIMITED |
| VIKAS SOUHARDA CO-OP BANK LTD |

Table A.8: High Non-UPI Innovation Group

| |
|---|
| AU SMALL FINANCE BANK LIMITED |
| BANK OF BARODA |
| CITI |
| DCB BANK LTD |
| DEVELOPMENT CREDIT BANK LTD |
| IDFC FIRST BANK LTD |
| INDUSIND BANK LTD |
| KARUR VYSYA BANK LTD |
| NKGSB CO-OP BANK LIMITED |
| PUNJAB NATIONAL BANK |
| STANDARD CHARTERED BANK |
| UNION BANK OF INDIA |
| YES BANK LIMITED |