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ABSTRACT

Interest in central bank digital currencies (CBDCs) has been burgeoning with 134 countries now exploring its implementation. In December 2022, India started its CBDC pilot program to continue its transition towards a digitized payments economy. This paper presents the first empirical analysis utilizing detailed transaction data to explore the dynamics between CBDCs and existing digital payment methods, as well as the implications of increased CBDC usage on traditional bank deposits. Our findings reveal that policies which increase transaction costs for current digital payment methods catalyze a substitution effect, bolstering CBDC adoption. Furthermore, an uptick in CBDC usage is associated with a notable decline in bank, cash, and savings deposits, suggesting potential paths to bank disintermediation. This study contributes critical insights into the evolving competition between digital currencies and established financial infrastructures, highlighting the transformative potential of CBDCs on the broader economy.

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1 Introduction

In recent years, Central Bank Digital Currencies (CBDCs) have emerged as a focal point of international discourse, primarily viewed as a pivotal tool for central banks to extend financial services more broadly. The trajectory of CBDC exploration has been remarkable, with the number of countries and currency unions investigating this digital innovation soaring from 35 in May 2020 to 134 by March 2024. Among these, 68 nations are in various stages of CBDC development, including pilot projects or full-scale launches. Notably, 11 of the G20 countries have initiated pilot programs, with India being a significant participant.[1] While the motivations behind CBDC exploration vary across nations, a key driving force is the pursuit of financial inclusion. The inherent digital nature of CBDCs positions them as an accessible, secure, and cost-effective transaction method, particularly for the unbanked and underbanked populations.

Although CBDCs may enhance financial inclusion, there also exists the potential for adverse effects on the financial system, particularly through their impact on banks. Indeed, the advent of CBDCs heralds a transformative shift in the financial sector, potentially re-defining the dynamics of monetary transactions and banking systems worldwide. At the heart of this transition lies a pressing inquiry: How will the introduction of a CBDC interact with existing payment systems and influence traditional bank deposits? This question gains urgency amidst concerns that CBDCs might precipitate a significant outflow of deposits from commercial banks, undermining their role in the financial ecosystem and potentially destabilizing the broader economy (Whited et al. (2023), Fernández-Villaverde et al. (2021), and Gross and Schiller (2021)). The reason being that CBDCs represent a digital form of central bank money that individuals and businesses can hold directly. Unlike traditional bank deposits, which are liabilities of commercial banks, CBDCs would be liabilities of the central bank. This direct holding is perceived as safer by the public, especially in times of financial uncertainty, because central banks are not subject to the same risks of failure as

[1]For an in-depth overview of country-specific CBDC initiatives, refer to https://www.atlanticcouncil.org/cbdctracker/.

commercial banks. As a result, in scenarios where trust in the commercial banking sector wanes, individuals and businesses might prefer to hold CBDCs instead of bank deposits, leading to a migration of funds away from commercial banks.

Further complicating this inquiry is the consideration of existing digital payment infrastructures. Many countries already boast efficient and widely adopted digital payment systems. The integration of CBDCs within these frameworks prompts a complex interplay: Will CBDCs complement or compete with established payment mechanisms?

Historically, the lack of empirical data on CBDC operations and their impact on financial markets and consumer behavior has left these important questions largely unanswered because concrete evidence remained elusive. However, as more countries venture into CBDC pilots or full implementations, a growing body of transactional data is beginning to illuminate these interactions. This paper aims to leverage such data from India to provide an empirical examination of the CBDC's role in a rapidly evolving digital financial landscape.

Specifically, we harness detailed transaction data from CBDCs in the retail sector, alongside monthly digital payment volumes from thousands of users in India, to analyze CBDC adoption. We first discuss how the CBDC has been rolled out and adopted—for instance, we show what user and region characteristics correlated with CBDC adoption. We then examine the impact of imposing a tax on existing digital payment methods on CBDC adoption. This analysis sheds light on the competitive dynamics between CBDCs and other payment mechanisms, contributing insights into strategies central banks might employ to enhance CBDC uptake. Amidst concerns regarding the potential for bank disintermediation resulting from increased CBDC usage, we also explore the implications for traditional bank deposit levels by analyzing monthly bank deposit data. This paper presents the outcomes of the inaugural empirical investigation into the interplay between CBDC adoption, alternative payment method utilization, and bank deposit trends.

The Reserve Bank of India (RBI), as the nation's central banking institution, is at the forefront of championing a transition towards a digitized economy. This ambitious move aims

at diminishing the operational costs associated with a cash-dominant economy, streamlining the current payments and settlement infrastructure, and broadening financial inclusion. In pursuit of these objectives, the RBI has introduced two digital payment solutions: the Unified Payments Interface (UPI) and the digital Rupee, which is a Central Bank Digital Currency (CBDC).

Launched in April 2016, UPI stands out as a user-friendly platform enabling transactions via QR codes and mobile applications. Its simplicity and efficiency have propelled its popularity, culminating in over 12 billion transactions in February 2024 alone. This robust growth trajectory positions UPI as a dominant force in India's payment landscape, with expectations for continued expansion. Conversely, the digital Rupee CBDC, unveiled in December 2022, remains in the nascent stages of its pilot program, poised for expansion across additional cities.

In a strategic shift in April 2023, the RBI introduced an interchange fee on certain UPI transactions, aiming to bolster revenue streams for service providers. This move marks a departure from UPI's initial design as a cost-free payment service, sparking discontent among its user base due to the imposition of what effectively amounts to a transaction tax.

Our study takes advantage of the introduction of this interchange fee to examine whether the imposition of such fees prompts users to migrate towards more economically viable alternatives, such as the CBDC. Through this analysis, we aim to provide a nuanced understanding of user preferences and the potential for digital payment methods to influence the broader trajectory of India's financial digitalization efforts.

We observe that the tax negatively influences UPI utilization, leading to a universal decline among users regardless of their income or educational backgrounds. To show that the decline is due to the introduction of the tax, we conduct a placebo test, and show that monthly cash transaction volumes remained unaffected by the tax, which aligns with expectations given that cash transactions were not the tax's target.

However, we find that usage of the CBDC, which serves as a direct and viable alternative

to UPI, saw an uptick post-tax implementation, among UPI users who were eligible for the digital Rupee. This effect appeared on both the intensive and the extensive margin, i.e., CBDC volume increased as well as the probability of new eligible users adopting CBDC for the first time. This effect was not uniform; rather, it displayed a significant degree of heterogeneity, with individuals of higher income and education levels showing a more pronounced shift towards CBDC adoption. This nuanced response underscores the CBDC's growing appeal as a competitive digital payment option in the face of increased transaction costs for conventional digital methods. Our results suggest that increasing transaction costs of a digital payment method can make CBDCs more attractive and improve adoption (Huynh et al. (2020) and León et al. (2023)).

Building on the findings of increased CBDC adoption subsequent to the UPI tax, our analysis extends to scrutinize its implications on bank deposits. We present empirical evidence illustrating a decline in bank deposits coinciding with the rise in CBDC usage following the implementation of the UPI tax. Notably, this downward trend extends to both savings and cash deposits, indicating a broader impact on the banking sector's deposit base.

It's crucial to underscore that the UPI tax, as formulated by the central bank, was not designed with the intent to influence CBDC adoption. This context frames our findings within the realm of unintended consequences, as we do not analyze the outcomes of a policy directly aimed at encouraging CBDC uptake. Nevertheless, the observed shift from UPI towards CBDC usage, prompted by the policy, manifests as an indirect yet significant influence on bank deposits.

In sum, this substitution effect unveils critical insights for policymakers, both within India and globally, spotlighting bank disintermediation as a tangible outcome in the era of CBDCs. For instance, countries like the United States, which stand on the cusp of introducing its own real-time payment system, FedNow, alongside contemplating the development of a CBDC, can experience similar effects. The United States' FedNow service, set to launch, represents a significant move towards modernizing payment systems by facilitating instant,

round-the-clock payments across the country. This development, coupled with the potential introduction of a U.S. CBDC, could mirror India's digital payment evolution, offering lessons on user adoption patterns, the interplay between new and existing payment systems, and the broader effects on bank deposits. The experience in India, particularly the observable shifts in consumer behavior following the implementation of taxes on digital transactions and the consequent increase in CBDC usage, sheds light on possible outcomes in the U.S. should similar policies or market conditions prevail. The substitution effect from traditional bank deposits to digital currencies, as witnessed in India, presents a cautionary tale for policymakers and financial institutions in the U.S., underscoring the importance of strategic planning and stakeholder engagement in mitigating potential risks of bank disintermediation.

2 Related Literature

Our paper is related to and contributes to four strands of the literature. First, the theoretical literature analyzing the effect that the introduction of CBDCs might have on financial stability in the banking system. Schilling et al. (2020) provides the first study on the CBDC trilemma, that is, the effects of CBDC on efficiency, financial stability, and price stability. Luu et al. (2023) find that CBDCs improve financial stability by reducing leverage and portfolio risks in the banking system. With a particular focus on financial stability, several studies examine the risks of bank runs in a system with CBDCs (Fernández-Villaverde et al. (2021), Ahnert et al. (2023), and Skeie (2021)). In particular, Fernández-Villaverde et al. (2021) find that, during a banking crisis, central banks can be more stable than commercial banks, leading people to substitute from bank deposits towards CBDCs ex-ante, and the central bank ultimately monopolizes deposits. Our results contribute to this topic by examining the impact that CBDC adoption has on the stability of commercial banks' deposit base. In particular, we show that higher CBDC usage leads to a decrease in bank deposits.

The second strand of literature that our paper contributes to is the role of banks when

CBDCs are adopted. Hemingway (2023), Chiu et al. (2022), Gross and Schiller (2021), Whited et al. (2023), and Chang et al. (2023) all develop theoretical models to analyze the impact of CBDCs on the banking sector and the degree of disintermediation that CBDCs bring. Chang et al. (2023) show that the substitution of bank deposits occurs only under a specific set of conditions and is more common among poorer households. Chiu et al. (2022) also find that interest-bearing CBDCs increase competition, leading to higher deposit rates. In fact, their results suggest that, in an increasingly cashless economy, a non-interest-bearing CBDC would actually increase bank intermediation. With higher deposit rates fueled by the introduction of a CBDC, Chang et al. (2023) finds richer households increase deposits to take advantage of these rates. On the other hand, Gross and Schiller (2021) develop a DSGE model that finds increasing disintermediation during financial crises where the stability of banks can not be trusted. Whited et al. (2023) develop and quantitatively estimate a model that finds that a non-interest-bearing CBDC reduces bank deposits at a high rate. Similarly, the Federal Reserve explores the benefits and risks of a retail CBDC in the US, and finds that a non-interest-bearing CBDC would be a substitute for deposits, leading to a decrease in aggregate deposits (Federal Reserve Board of Governors (2022)). We contribute to the literature by providing the first empirical experiment showing bank disintermediation after increasing CBDC usage. Our results in India suggest that the presence and adoption of CBDC, even a non-interest-bearing one, leads to disintermediation and lower bank deposits.

There is a growing body of literature that discusses the impact of UPI in India's growing digital payments economy. Dubey and Purnanandam (2023) find that digital payments can improve household income, business, and economic outcomes especially in regions with a lower commercial banking presence. Alok et al. (2024) find that UPI access allows for an increase in credit access, financial inclusion, and financial access. Our work further expands on the literature by understanding the effect of transaction fees and the presence of a close substitute in the form of a CBDC.

Finally, our work relates most closely to the literature on retail CBDCs. Many theoretical

models have been developed to study the adoption of a retail CBDC (Huynh et al. (2020), and León et al. (2023)). Huynh et al. (2020) show that central banks will need to lower transaction costs and improve consumer perceptions in order to incentivize CBDC adoption, especially in the presence of alternative digital payment methods. Similarly, León et al. (2023) build a model, and then calibrate it to survey data in Spain to find that a retail CBDC with no incentive policy is not likely to be adopted quickly. They find that retail CBDCs do not crowd out cash usage, but do compete with existing digital systems. Our results confirm these findings as an interchange fee on established alternative digital payment methods led to substitution away from these existing methods and towards CBDCs, with no effect on cash usage. Bijlsma et al. (2021) also use survey data from the Netherlands to show that most consumers would be interested in using CBDCs, and that the central bank can incentivize adoption through interest rates, and by communicating the details of CBDCs. To our knowledge, we provide the first empirical insight into CBDC transaction usage. Our study is unique as India has multiple digital payment methods available like UPI, and its payments economy is also cash dominated. We find an adverse effect on UPI usage after a tax is implemented, and substitution towards CBDC, in line with the results of León et al. (2023). Although the digital Rupee is not interest-bearing, our results do find that consumers with higher likelihood of understanding the intricacies of a CBDC adopt it more.

3 Background: Retail Payments, Digital Payments, and Digital Currency in India

India's payments economy is dominated by cash. In 2017, cash transactions accounted for 90% of total payment transaction volume.[2] Furthermore, the Reserve Bank of India (RBI), the central bank of India, found that cash is the preferred transaction method for regular expenses, and digital methods is the second preferred method. However, the costs

[2] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1973082.

of running a cash-reliant economy is significant—the RBI spent 49 billion Rupees printing cash, not including environmental, social, governance, and operational costs.[3] One of the main reasons India is exploring a digitized economy fueled by a digital payment system and a central bank digital currency (CBDC) is the high cost and inefficiency of their physical cash system. Thus, the RBI has introduced two revolutionary digital payment systems in the country: the Unified Payments Interface (UPI) and the digital Rupee CBDC (e₹).

3.1 Unified Payment Interface (UPI)

Launched in April 2016, UPI is a single-window mobile payment system developed by the National Payments Corporation of India (NPCI), an initiative of the RBI and the Indian Banks' Association (IBA) that operates as an umbrella organization for retail payments and settlement systems. The new payment system allows both customers and merchants to transfer money between bank accounts in a safe and no cost way. It eliminates the need to enter bank details or other sensitive information when initiating a transaction. Instead, users simply scan a QR code to transact. The system is revolutionary in India as users can link bank accounts to a mobile application to initiate transactions safely, and, thus, has been very successful in the digital payments space.

In fact, UPI is starting to fundamentally change the way Indians transact as adoption is burgeoning.[4] In February 2024, it processed over 12 billion transactions with an estimated value of over 18 trillion Rupees, up from just 2 million transactions in December 2016.[5] According to PwC's Indian payments handbook, 75% of digital retail payments in the 2022-23 fiscal year used UPI, and the figure is forecasted to grow to 90% by 2027.[6] In addition to high local adoption, UPI has gone global with six countries—Bhutan, France, Mauritius,

[3]See more about the costs of maintaining India's cash system in the RBI's note at https://www.rbi.org.in/Scripts/PublicationReportDetails.aspx?UrlPage=&ID=1218#CP3.
[4]See the IMF's note on India's digital payment economy at https://www.imf.org/en/News/Articles/2022/10/26/cf-how-indias-central-bank-helped-spur-a-digital-payments-boom.
[5]See more monthly statistics on UPI usage at the NPCI's website https://www.npci.org.in/what-we-do/upi/product-statistics.
[6]Read more at https://www.pwc.in/assets/pdfs/the-indian-payments-handbook-2022-2027.pdf.

Singapore, Sri Lanka, and the UAE—accepting it as a form of payment, with even more countries expected to become available in the future.[7]

UPI's growth has started the process of replacing cash as a method of payment. As of 2023, cash now accounts for less than 60% of total transaction volume, down from 90% in 2017. Furthermore, the RBI states that digital payments now make up more than 40% of all payments in India. High adoption and usage of this new payment method is clear, and it is even forecasted to continue growing in the next several years. The transition towards a digitized and cash-less payments system is well underway with the introduction of UPI, but the RBI takes it a step further with the introduction of a CBDC.

3.2 The Digital Rupee

The RBI started the process of launching its CBDC by first proposing an expansion of the definition of a "bank note" in the RBI Act, 1934 to include digital currencies in October 2021. The Cryptocurrency and Regulation of Official Digital Currency Bill, 2021 was subsequently introduced in the 2021 winter session of Parliament to "create a facilitative framework for creation of the official digital currency to be issued by the Reserve Bank of India (RBI)."[8] In a speech in July 2021, T. Rabi Shankar, the deputy governor of the RBI, defined a CBDC as a "legal tender issued by a central bank in a digital form," which "is the same as fiat currency and is exchangeable one-to-one with the fiat currency."[9] To further raise awareness and understanding of CBDCs, the RBI issued its CBDC concept note on October 7, 2022 detailing the motivations, objectives, design, technology and policy choices, and the benefits and risks of its CBDC, the digital Rupee (e₹).[10]

The RBI launched the retail pilot of the CBDC in four cities on December 1, 2022: Mumbai, New Delhi, Bengaluru, and Bhubaneswar. The pilot initially included four leading

[7] For updates on the list of countries, visit the NPCI's website at https://www.npci.org.in/who-we-are/group-companies/npci-international/list-of-countries.
[8] https://www.reuters.com/article/idUSKBN29Z0EG/.
[9] https://www.livemint.com/industry/banking/why-rbi-wants-a-digital-currency-11638806987714.html.
[10] The note is accessible at the RBI's website at https://www.rbi.org.in/Scripts/PublicationReportDetails.aspx?UrlPage=&ID=1218.

lenders: State Bank of India (SBI), ICICI Bank, Yes Bank, and IDFC First Bank. It was later expanded to more cities and banks, allowing for greater adoption. In the first two months, participating banks selected individuals or account holders for the trials. Later, it was relaxed and any customer could download the digital Rupee app, and connect their bank accounts. As of January 20, 2024, 4 million users and 400,000 merchants have been onboarded.[11]

The RBI made several design choices when launching the pilot, taking into account the features of each type of CBDC. The retail digital Rupee (e₹-R) would be legal tender and issued following the intermediate model (or two-tier model) where the RBI manages issuance and intermediaries like banks and other service providers manage the distribution. Users hold and transact the CBDC using a digital wallet on their phones, which is offered by the intermediary. The CBDC would also be non-renumerative, meaning that it would not bear interest, and would be token-based where each token acts just like a banknote and the holder is the owner. Users can transact with other users (P2P) or with merchants (P2M) through QR codes.[12] In essence, the retail digital Rupee is a non-interest-bearing, cash-like token issued by the central bank and distributed by commercial banks.

To operate the CBDC, the RBI has created and will manage a centralized system for processing, settling, and finalizing transactions, so that the digital Rupee can be used just like the physical Rupee. This digital payment system may seem very similar to other existing payment apps across the world, like UPI in India, but is different in two aspects: the payment infrastructure is created and managed by the central bank; and payments are made using central bank money and not the money created by the banking system. While the current proliferation of digital payment systems may negate the need for yet another retail payment instrument in the form of a CBDC, the digital Rupee does have advantages over other digital payment methods—it is central bank money, so it can reduce the settlement and counterparty risk while guaranteeing settlement finality. Furthermore, there are risks that the central bank

[11] Read more on the progress of the pilot program at https://www.thehindubusinessline.com/economy/world-economic-forum/rbi-in-no-rush-to-implement-cbdc-full-scale-says-governor-das/article67756853.ece.

[12] See the RBI's announcement of the pilot launch at https://www.rbi.org.in/scripts/BS_PressReleaseDisplay.aspx?prid=54773.

must take into account with the existing systems. For example, countries like Sweden, and China have seen near universal adoption of digital payment systems controlled by a few private companies, but this adoption could increase the overall risk to the financial system. Priyadarshini and Kar (2021) write that the increased adoption in these countries poses the risks "of monopolies, high entry barriers, potential misuse of data, safety and security of technology." Thus, there is a need for central banks to create a new digital payment infrastructure through CBDCs, and an important role of central banks to limit the market dominance of any one type of payment system. Even with the advantages of CBDCs, the RBI does not wish to replace the existing system. Instead, the central bank foresees a system where the digital Rupee complements UPI to provide consumers with more options, foster innovation in the digital transactions space, and create an efficient payments ecosystem.

One of the key features implemented by the RBI to popularise CBDC was allowing interoperability between the digital Rupee and UPI through merchant QR codes. Many merchants had already set up these QR codes for UPI transactions, so providing digital Rupee users with the ability to transact through these same codes allows for a seamless transition to CBDC and greater adoption.[13]

3.3 Introduction of the UPI Tax

In a change of policy, on April 1, 2023, the NPCI introduced an interchange fee on UPI payments exceeding ₹ 2,000.[14] For a transaction to qualify for the tax, it must be done using prepaid payment instruments (PPIs), and it must be a P2M transaction involving a certain group of merchants, where the merchants pay the fee. First, PPIs are wallets or other methods of payments that store the value being transacted. Digital wallets, smart cards, preloaded gift cards, and vouchers are examples of PPIs, but a UPI transaction that originates from

[13]See the NPCI's announcement of the interoperability feature at https://www.npci.org.in/PDF/npci/upi/circular/2023/UPI-OC-170-RBI%27s-Digital-Rupee-CBDC-and-UPI-Interoperability.pdf.

[14]The new policy was announced on March 29, 2023. View the press release at https://www.npci.org.in/PDF/npci/press-releases/2023/UPI-is-free-fast-secure-and-seamless-Every-month-over-8-billion-transactions-are-processed-free-for-customers-an pdf.

the user's bank account is not classified as a PPI transaction. Second, only transactions that involve a specific group of merchants will be taxed, such as digital merchants and merchants with a monthly inward UPI volume of more than ₹ 50,000. Crucially, the fee is paid by the merchants, and there is no additional fee for customers.

The interchange fee is charged to cover processing, and accepting fees. This tax is similar to the merchant discount rate applicable to credit cards. The RBI hopes that the tax can increase revenue for payment service providers and banks. The interchange fee is applicable in the range of 0.5-1.1% on different services. For example, fuel payments incur a fee of 0.5%, post office, telecom, utilities, agriculture, and education payments have a fee of 0.7%, and insurance, mutual fund, government, and railway payments incur 1%.[15]

After the announcement and implementation of the tax, many users were outraged, expressing their feelings on online surveys. LocalCircles is a free, online platform that allows people to connect with their communities for various aspects of urban daily life. In March 2024, just under a year after the introduction of the tax, the platform conducted a survey with over 34,000 participants from over 364 districts asking about further taxes on UPI transactions.[16] Since the introduction of the tax, 37% of users completed at least one transaction that was taxed. If the RBI were to further tax UPI, only 23% of users said they would tolerate it. In fact, 73% of users would stop using UPI altogether if more taxes were introduced. Most users adopted UPI due to its no-cost feature, so introducing a tax would be detrimental to their use, and they would either reduce or stop using UPI. While the interchange fee implemented in 2023 did not apply to all transactions, there were already companies that were charging convenience fees or sharing the burden of the interchange fees with customers. For example, the Indian Railway Catering and Tourism Corporation (IRCTC) started charging a convenience fee of ₹ 20 to users for using UPI. The days of a no-cost UPI were dwindling.

[15] Read more about the UPI tax at https://economictimes.indiatimes.com/wealth/spend/upi-merchant-transactions-ppi-which-upi-payments-will-attract-interchange-fee-will-you-have-to-bear-the-cost/articleshow/99087712.cms.

[16] See the results of the survey here https://www.localcircles.com/a/press/page/upi-transaction-fee.

Most importantly, the RBI states that the interchange merely affects UPI users and did not suggest that it was put into place to affect CBDC adoption. Regardless, at the time of the implementation, the CBDC pilot program had been live for four months. So, individuals who were eligible for CBDC and were UPI users now faced a crossroads: keep using UPI, reduce/stop using UPI or transition to this new relatively unknown CBDC payment system.

4 Data

The primary analysis of this paper hinges on three data sources: granular transaction data for retail CBDC, monthly UPI volume, and monthly deposit data at the branch level. The data comes from one of the top 3 commercial banks in India. The data sets allow us to observe monthly transaction volume across multiple channels, the demographics of the users, and branch-level bank deposits.

First, we have data on what districts became eligible for CBDC at each expansion stage—December 2022, January 2023, February 2023, May 2023, and June 2023. The data details what month a district had its first digital Rupee transaction. Figure 1 shows a map of India and the districts, in red, that became eligible during that month. Figure 2 displays a map of India and all the districts that are eligible at each expansion. Combined with data on district-level population and night light activity, we can better understand the characteristics of districts eligible during each expansion. Table 1 reports summary statistics on the districts that became eligible. The first month of the trial period featured 209 districts with the largest population and most night light activity relative to the districts that became eligible later in the pilot program. These districts also had the largest average number of bank branches and total deposits per branch. Relatively less districts were added to the program in the months of January, February, and May, with these districts being relatively smaller than those initially added in December. Finally, in June, the largest expansion was implemented with more locations, districts, and branches becoming eligible across the country. In our data,

we also identify users who never used CBDC and may have lived in districts that were not included in the pilot program. We have included these districts in Table 1 as Never Eligible for comparison. In particular, we identify 145 such districts with an average population and average night light activity significantly lower than those of the CBDC eligible districts. Our data indicates that the digital Rupee efforts were focused on larger districts with more activity, and more potential for adoption.

In our granular CBDC transaction data, we observe over 330,000 CBDC transactions from December 2022 to June 2023 for more than 22,000 users. The data details the transaction logs of the bank's customers, such as the timing, the type of transaction (loading wallets, transferring, and redeeming back to bank account), the quantity, and the recipient. Successful, pending, and failed transactions are all included in the log, but our analysis focuses solely on the successful transactions. Figure 3 shows the average monthly CBDC volume that a user transacted and the number of active users per month. A few trends are important to highlight. First, the number of active users is higher in the first two months of the pilot program, and drops before increasing significantly in June 2023 as CBDC eligibility is expanded to a greater part of the Indian population. Notably, the activity in the intermediate months of March and April is low. Second, the average total volume transacted per user steadily decreases. Despite the decrease, overall CBDC volume across all users increases in June 2023 as Figure 4 indicates. In March and April, CBDC activity is at its lowest, but picks up again in May and June.

In addition to CBDC transaction volume, we also observe monthly total UPI and cash transaction volumes for the CBDC users and a set of randomly sampled control users. Specifically, we have monthly volumes from October 2022 to June 2023 for UPI and cash transactions. Figure 4 reports both the total monthly CBDC volume and UPI volume across all users in our sample. UPI volume increases in 2023 but shows signs of a decline. Furthermore, the scale of the UPI transaction volumes is significantly larger than that of CBDC. The figure suggests that, while digital Rupee usage is increasing, UPI is still a far more popular method

of transacting.

Combining the CBDC, UPI and cash volume data, we observe more than 230,000 users. Of those, we have self-reported demographics for about 223,000 users. Table 2 reports summary statistics of the demographics for various subsets of our users. Roughly 6% of our users have used CBDC at least once in our sample and 34% have used UPI at least once. While our full sample is about 59% male, the subsamples of UPI and CBDC users are significantly more male dominated. In contrast, the subset of users who never used UPI and never used CBDC is more equal with a higher percentage of females and lower percentage of males. The two subsets of UPI and CBDC users are also slightly younger, on average, relative to our full sample. Notably, CBDC users have a significantly larger average annual income, roughly double that of our full sample and of the subset of UPI users. Education levels are self-reported by bank customers and are separated into multiple categories. In particular, UPI users and CBDC users are more educated relative to the full sample. The percentage of graduates and post graduates is higher for the subset of UPI and CBDC users. CBDC users are also more likely to have engineering, finance and computer degrees, relative to UPI users and the full sample. The demographics suggest that the people using CBDC during the trial period are more sophisticated with education levels that allow them to better understand the technology and mechanics behind CBDC, similar to the results in Bijlsma et al. (2021).

These same patterns emerge when we run a cross-sectional regression, testing the effect that user characteristics have on the probability of that individual being a CBDC user while controlling for the state of the individual's home branch. In Table 3, we find that being male increases the probability of being a CBDC user by 5.04 percentage points. Furthermore, it seems that being in the IQR of age, relative to the full sample, increases the likelihood of being a CBDC user. Having an annual income in the top quartile also increases the probability of being a CBDC user by 9.4 percentage points relative to those with incomes in the bottom quartile. Finally, being a UPI user or being a cash user increases the likelihood of being a CBDC user.

We see similar results with education level in Table 4, where the base category is Under Matriculate. In particular, having an engineering degree increases the probability of being a CBDC user by 31.3 percentage points, having a finance degree increases it by 35.1 percentage points, and having a computer degree increases the probability by 38.5 percentage points. The users with education levels that allow them to better understand CBDCs are more likely to adopt this new innovation.

Finally, we test if the demographics of the district that a user's home branch is located in has an effect on the user's likelihood of using the e-Rupee (Table 5). Consistent with the statistics in Table 1, banking in a district with the largest population and night light activity significantly increases the probability of being a CBDC user. In addition, if the district has more bank branches and more total bank deposits in the branch, the probability of being a CBDC user also increases.

Our demographics data also allows us to observe the pincode of where the user lives. In Figure 5, we plot the number of active CBDC users scaled by the population of the state on a map of the Indian states. The scale of the colors in the heatmap is relative to the values in June 2023. There is some activity present in December 2022, but it falls during the intermediate months of our sample before it increases significantly in June. The maps tell a similar story as our previous analysis—CBDC activity is relatively high in the early months before plateauing and subsequently exploding in the last two months.

In addition to user level data, we have deposit level data across all branches from the same commercial bank from October 2022 to June 2023. The data includes total deposits, savings deposits, and cash deposits. Total deposits are defined as the total amount in a bank account from all forms of deposit instruments—cash, savings, term deposits, bulk deposits and basic savings bank deposits. Savings deposits are defined as deposits in a savings account for fixed terms that earn a certain interest rate. Cash deposits are defined as cash deposited in one's bank account. With our data on CBDC eligibility by city, we can identify the branches that are eligible by the city that the branch is located in. Table 6 displays

summary statistics on the average deposits per branch based on when they became eligible for CBDC. The statistics suggest that the largest branches were eligible first, and relatively smaller branches are gradually included into the pilot program. The branches that were never eligible in our sample are the smallest in terms of deposits. Like with Table 1, there is a trend in the eligibility of CBDCs, where larger districts and banks are eligible first.

We primarily utilize the monthly volume data and the demographics of our users to explore users' response to the interchange fee in terms of their UPI, CBDC and cash transaction volumes. The demographics data is crucial as it allows us to exploit heterogeneous responses and changes in transaction trends. With our monthly branch deposit data, we can specifically test the hypothesis that CBDCs lead to a decrease in bank deposits.

5 Effect of UPI Tax on UPI and CBDC Payments

In an economy where multiple digital payment methods are available, can the RBI effectively manage the market share of each of these by implementing targeted policies? In this section we analyze the effect of the UPI tax on the usage of UPI and CBDC, and test if the tax truly had an adverse effect on UPI. In particular, we examine if UPI users who had the option to transition towards CBDCs chose to do so and substituted towards the new no-cost payment method. Through an event-study and differences-in-differences framework, we estimate the impact that the UPI tax had on users' UPI volume and CBDC volume with the following regression:

$$\log(y_{it}) = \alpha_{it} + \beta_0 \text{CBDC Eligible}_{it} + \beta_1 \text{Post} \times \text{CBDC Eligible}_{it} + \epsilon_{it}, \tag{1}$$

where y_{it} is the UPI, CBDC, cash, and total transaction volume for individual i at month t. Total transaction volume is computed as the sum of UPI, CBDC and cash transactions. The Post variable is an indicator variable that equals 1 for months including and after April 2023, and 0 otherwise. The CBDC Eligible$_{it}$ variable is an indicator variable that equals 1 when

individual i is eligible for CBDC use at month t, and acts as our treatment group. The control group, where CBDC Eligible$_{it}$ is 0, is composed of individuals i who are not yet eligible for CBDC at month t and does not include users who were never eligible for CBDC. This set up means that a user can be in the control group at $t = t_0$ and in the treatment group at $t = t_1$ where $t_0 < t_1$, which allows us to compare the usage of individuals before and after being treated. We are interested in the effect that the tax has on digital payment competition. Users who were never eligible do not have a choice to substitute, and thus are not included in our control group. We control for user and month by home branch state by income class fixed effects α_{it} to control for individual usage heterogeneity, and monthly trends based on a user's location and income level. Users are placed in an income class based on the decile that their reported income falls into.

We also explore the extensive margin of each payment method using a linear probability model. In particular, we estimate the following equation:

$$y_{it} = \alpha_{it} + \beta_0 \text{CBDC Eligible}_{it} + \beta_1 \text{Post} \times \text{CBDC Eligible}_{it} + \epsilon_{it}, \tag{2}$$

where y_{it} is the likelihood of using UPI, CBDC, or cash during month t, i.e. equals to 1 when user i uses the transaction method at least once in month t. All other variables stay the same as in Equation 1. In addition to testing the likelihood of using CBDC, we examine the probability that a user adopts CBDC for the first time. We estimate Equation 2 with y_{it} as an indicator for a user adopting CBDC for the first time—the variable equals 1 when user i has used CBDC at least once in months prior to, and including, month t, and 0 if the user has not adopted CBDC at all prior to, and including, month t.

In order to conduct a robustness check and to verify the parallel trends assumption, we run a time-series regression with the following equation:

$$\log(\text{UPI Volume}_{it}) = \alpha_{it} + \gamma_0 \text{CBDC Eligible}_{it} + \sum_{k \neq -1} \beta_k \mathbb{1}_{\{k=t\}} \times \text{CBDC Eligible}_{it}, \tag{3}$$

where $\mathbb{1}_{\{k=t\}}$ is an indicator variable that equals 1 for month t, and 0 otherwise. Month $t = 0$ is the month where the tax was implemented, so April 2023. Our sample covers December 2022 through June 2023, so we have monthly indicator variables for $t = -4, -3, ..., 2$ where $t = -4$ is December 2022 and $t = 2$ is June 2023. In our subsequent analysis, we normalize the coefficient for month $t = -1$ to 0. The variable of interest is β_k, which measures the differential effect on UPI usage during month k. Similarly, we estimate a linear probability model with the time-series specification as follows:

$$\text{UPI Likelihood}_{it} = \alpha_{it} + \gamma_0 \text{CBDC Eligible}_{it} + \sum_{k \neq -1} \beta_k \mathbb{1}_{\{k=t\}} \times \text{CBDC Eligible}_{it}, \tag{4}$$

where the dependent variable is now the likelihood of individual i using UPI during month t.

We also examine heterogenous responses to the tax based on income and education. We separate our user sample into above and below median income to see the differential response for high-income individuals. Our data also provides us with the education levels of our users. We have categorized users who have engineering, finance (CA/ICWA/MBA/CFA), and computer degrees as sophisticated individuals who are more likely to understand the intricacies and details of a CBDC. To test the heterogenous effect, we estimate the following triple difference regression:

$$\begin{aligned} y_{it} = \alpha_{it} &+ \beta_0 \text{CBDC Eligible}_{it} + \beta_1 \text{Post} \times \text{CBDC Eligible}_{it} \\ &+ \beta_2 \text{CBDC Eligible}_{it} \times \text{Char}_i + \beta_3 \text{Post} \times \text{CBDC Eligible}_{it} \times \text{Char}_i + \epsilon_{it}, \end{aligned} \tag{5}$$

where Char_i is an indicator variable that is 1 when individual i falls has characteristic Char.

We would like to understand if UPI users complement their UPI usage with CBDC or substitute towards CBDC after the fee, so the regressions are run on the subsample of users who have used UPI at least once prior to the tax. Table 7 reports the coefficients of Equation 1, where our coefficient of interest is β_1. Column 1 reports the estimates for the

differential effect on UPI volume. We find that, after the tax is implemented, users who are eligible for CBDC decreased their UPI usage by an average of 6.5%.[17] The coefficient is statistically significant at the 1% level and negative, indicating a drop in UPI usage after the tax. In addition, column 1 of Table 8 shows that the likelihood of using UPI in the months after the tax decreases by 0.76 percentage points. In Figure 6, we plot the estimates of β_k in Equation 4, and we see that there is no difference in UPI usage trends prior to the tax, so UPI usage for both the treatment and control group are on parallel trends. After the tax, there is an economically significant difference in UPI usage, particularly in month 1 or May 2023, where users who are eligible for CBDC use UPI less. Similarly, we see that the likelihood of using UPI is on parallel trends prior to the tax, and subsequently decreases in month 1 after the tax (Figure 7). Our results suggest that UPI users are less likely to use the transaction method and decrease their total volume after the tax is implemented.

To rule out the possibility that there was a general drop in transacting, we run a placebo test with cash volume as the dependent variable in Equation 1 and Equation 2. We report the results in Table 7 for the intensive margin and Table 8 for the extensive margin. We do not expect there to be any differential effect on cash volume as the UPI tax was not targeting cash transactions. In both tables, no coefficient is significantly different from 0, confirming that our results regarding a drop in UPI usage is truly due to the implementation of the interchange fee. Furthermore, our estimates also match the results of the LocalCircles survey discussed in Section 3.3 where users are likely to reduce UPI usage after taxes are implemented. So, we are confident that the NPCI's implementation of the UPI interchange fee had an adverse effect on UPI usage.

The digital Rupee, with its interoperability with UPI, and its digital nature, is a viable alternative method of transaction for these users. We test if making UPI less appealing increases the competition of digital payment methods, and increases CBDC usage, in line with the results in Huynh et al. (2020) and León et al. (2023). The users in our treatment

[17] Calculated through $\exp(-0.0673) - 1 \approx -0.065$.

group are eligible for CBDC, so they have the choice and ability to transition towards the digital Rupee. In column 2 of Table 7, we report the estimates of Equation 1 with CBDC volume as the dependent variable. We find that, after the tax, CBDC volume increases by an economically significant average of 0.51%. Users who can substitute towards CBDC do make the change. We also find that the likelihood of using CBDC increases by an average of 0.09 percentage points for these users (Table 8). Furthermore, we find greater adoption as the probability of new CBDC users using it for the first time increases by 0.25 percentage points (Table 9). On both the intensive and extensive margins, UPI users who are eligible for CBDC choose to increase their usage of the digital Rupee, but the magnitudes are small.

To understand why the differential effect may not be large, we examine the heterogenous response to the UPI tax. In Table 10, we report estimates for income heterogeneity. In particular, we find that income does not change a UPI user's decision to reduce usage as the coefficient for Post $\times$ CBDC Eligible$_{it}$ $\times$ Above Median Income is not statistically different from 0. Furthermore, our placebo test with cash yields no economically significant coefficient, further confirming that the decline is caused by the interchange fee. More importantly is the heterogeneous effect on CBDC volume. We find that users with above median income increased their CBDC volume after the tax by an economically significant average of 1.48% over below median income users. Furthermore, the statistically insignificant coefficient of Post $\times$ CBDC Eligible$_{it}$ suggests that below median income users did not choose to transition some of their transactions towards CBDC.

We next examine the heterogenous effect based on education. Like with income, we find no heterogeneity in the response on UPI usage as all users, regardless of education level, reduced their usage after the tax. Our results suggest that the RBI's decision to add the interchange fee had an adverse effect on all UPI users regardless of income level and education. Again, our placebo test with cash shows no statistically significant coefficient. With CBDC, we find a larger response for users who are sophisticated as they increased their CBDC usage by a statistically significant average of 69.42% relative to users who are not

sophisticated after the tax. The users who are more likely to understand the design, details, and economics of the digital Rupee substituted away from the UPI and towards the CBDC, similar to the results of Bijlsma et al. (2021).

With the interoperabilty design of UPI and CBDC, and the no-cost feature of CBDCs, UPI users who had the option to transition towards CBDC did substitute their transaction volume, and were more likely to be first time users of the CBDC. The RBI's policy to tax UPI had an adverse effect on UPI use, but did have the indirect effect of incentivizing the CBDC as usage on both the extensive and intensive margin increased. These results match the conclusions of Huynh et al. (2020), who found that "transaction cost is the main characteristic that can make" CBDCs enticing to consumers who already use other payment methods. While UPI users are using CBDC more, we find that UPI is still the more popular transaction method as the total volume across all three methods (UPI, CBDC, and cash) is decreasing after the tax. In column 4 Table 7, we find that total volume decreased by 6.09%, and find that all users decreased total volume regardless of income and education. These initial results suggest that CBDC is an option that many consider as a viable substitute to the ever-popular UPI even though it is still a new and untested payment method. If the central bank would like to increase adoption, our results suggest that policies targeted against existing digital payment systems can incentivize users to substitute.

6 Adoption of CBDC Effect on Bank Deposits

The literature surrounding the effect of CBDCs on bank intermediation hypothesize that the adoption of CBDCs will lead to a decrease in bank deposits (Whited et al. (2023), Chang et al. (2023), Gross and Schiller (2021), Federal Reserve Board of Governors (2022), Fernández-Villaverde et al. (2021)). Although the UPI tax was not originally related to CBDC, we find that UPI users substituted away from UPI towards CBDC as an unintended result of the tax. So, we study the implications that this increase in CBDC usage and adoption had an

bank deposits. Through a similar event study framework, we empirically test the literature's hypothesis. Formally, we estimate the following specification:

$$\log(y_{bt}) = \alpha_{bt} + \beta_0 \text{Post} + \beta_1 \text{CBDC Eligible}_{bt} + \beta_2 \text{Post} \times \text{CBDC Eligible}_{bt} + \epsilon_{bt}, \tag{6}$$

where y_{bt} is the total deposits, cash deposits and savings deposits of bank branch b at month t. In the data, total deposits is the sum of all forms of deposit instruments. Savings deposits are defined as fixed term deposits that earn an interest rate. The Post variable is a dummy that equals 1 for months including and after April 2023. The $\text{CBDC Eligible}_{bt}$ is a dummy that equals to 1 when bank branch b's city becomes eligible for CBDC in month t. The control group is the set of branches b that are not yet eligible at month t or are never eligible. We control for month and branch state fixed effects to control for time trends and state-wise heterogeneity in deposits. As a robustness check, we run two different regressions: one with just branch state fixed effects, and another with both month and branch state fixed effects.

We also estimate a time-series regression to ensure that any differential effect is not driven by general trends in deposits. We estimate the following specification

$$\log y_{bt} = \alpha_{bt} + \gamma_0 \text{CBDC Eligible}_{bt} + \sum_{k \neq -1} \beta_k \mathbb{1}_{k=t} \times \text{CBDC Eligible}_{bt}, \tag{7}$$

where $\mathbb{1}_{k=t}$ is an indicator variable that equals 1 for month t, and 0 otherwise. Our set up is similar to that of our analysis on transaction volumes, where $t = -4$ is December 2022, $t = 2$ is June 2023, and our coefficient for month $t = -1$ is normalized to 0.

We first study changes in total deposits after the tax, during a time where CBDC usage and adoption is increasing. In Table 12, we display the estimates of the coefficients to Equation 6. As a robustness check, we run two separate regressions, from least restrictive to most restrictive in terms of controls. In column 1, we only include bank branch state fixed effects and find that the total deposits of CBDC eligible bank branches decrease by a

statistically significant average of 5.59% relative to branches that were not eligible for CBDC.[18] With state and month fixed effects, the deposits decrease by an economically significant average of 3.73%. In both cases, we see that deposits decrease after the tax is implemented. In Figure 8, we plot the estimates of β_k in Equation 7. In the period prior to the tax, we see that the treatment and control group are on parallel trends, but, after the tax, a significant difference emerges as the total deposits of the treatment group are lower than those of the control group. The effect is most pronounced in months 1 and 2 after the tax (May and June 2023). Combined with the results from Section 5, we see that an increase in CBDC usage and a decrease in total bank deposits following the introduction of the tax. There seems to be a substitution towards the CBDC, away from deposits in commercial banks, confirming the hypothesis of the literature.

To ensure that our results for total deposits are robust, we examine the differential effect on savings deposits and cash deposits. In table 13, we report the estimates of the effect on savings deposits. After the UPI tax, CBDC eligible branches see an economically significant average drop in savings by 2.54% when controlling for month and branch state fixed effects. Figure 9 also confirms that the treatment and control group are on parallel trends prior to the tax. After the tax, we see that there is a statistically significant drop in months 0 and 1 at the 10% level. Similarly, in Table 14, our estimates suggest that cash deposits in CBDC eligible branches dropped by an economically significant average of -4.88% after the tax when controlling for state and month fixed effects. In Figure 10, we further confirm that the treatment and control group are on parallel trends, and find that, at the 5% level, there is an economically significant drop in cash deposits in months 1 and 2. With both savings and cash deposits, our results are robust for different sets of controls, and find similar results of drops in deposits after the UPI tax.

Across total deposits, savings deposits, and cash deposits, CBDC eligible bank branches experience a decrease in deposits after the UPI tax and an uptick in CBDC usage. However,

[18] Calculated through $\exp(-0.0575) - 1 \approx -0.0559$.

our work is limited by the fact that the RBI did not intend to incentivize CBDC through the tax. We find an indirect and unintended effect where UPI users who have the option to substitute do so, but our result lacks the presence and analysis of a policy that explicitly increases CBDC adoption. Despite the limitation, our results do confirm the hypothesis of the literature that when there is an increase in CBDC usage, there is a decrease in deposits.

7 Conclusion

This paper provides the first empirical examination of CBDC transaction usage and its effect on bank deposits. Our unique CBDC transaction data, monthly UPI and cash volumes, and monthly bank deposit data enables us to test various hypotheses. We consider the competition between CBDC and other digital payment methods and how adverse policies on one affect the usage of another. Our branch-level deposit data also allows us to empirically test the hypothesis that CBDCs can reduce bank deposits.

First, we find that a tax on a digital payment method like the UPI decreases its usage regardless of income and education heterogeneity. Because the tax makes the CBDC seem like a more attractive and costless method of transacting, our results show that UPI users with the choice to substitute do so, with high income and high education users substituting more. Our work agrees with the findings of the literature that transaction costs and the competition with existing payment methods are important factors in the adoption CBDCs. For central banks that would like to see greater CBDC adoption, we find that policies discouraging the usage of existing digital payment methods and lowering transaction costs can lead to higher CBDC usage.

Second, we test the effect that CBDCs have on bank deposits. Results in the literature suggest that increased CBDC usage can lead to bank disintermediation and lower deposits. With CBDC usage increasing after the UPI tax, we look at the differential effect on bank deposits. Our results suggest that bank deposits, savings and cash deposits all decrease after

the UPI tax when CBDC usage increases, providing the first empirical confirmation of these theories. However, our result may be limited by the fact that the UPI tax was not originally meant to improve CBDC adoption; instead, we observe the unintended effect of incentivizing CBDC usage. We welcome future studies that consider policies directly affecting CBDC use that will further confirm these hypotheses.

We show that central bank policies on digital payments impact not just the usage of these methods and CBDCs but also affect bank deposits. Bank disintermediation will become an important issue that policy makers will need to consider when implementing their CBDCs.

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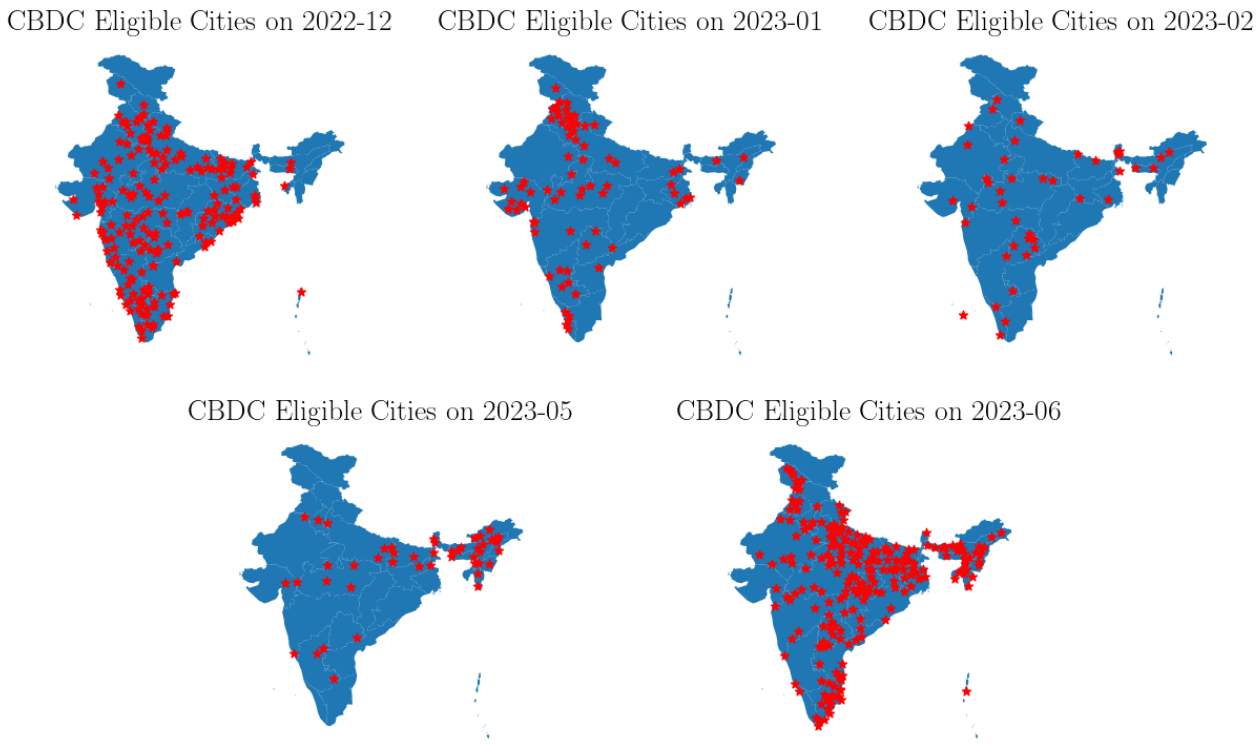
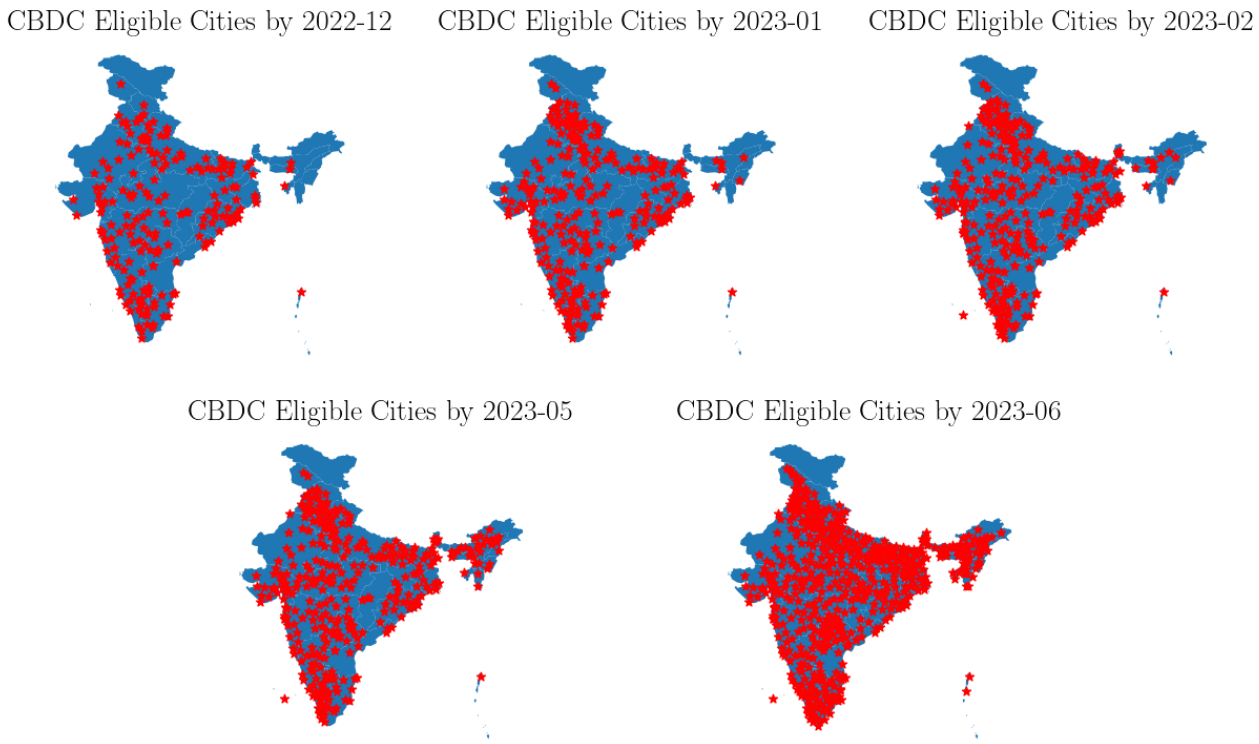
Figure 1: New CBDC Eligible Districts at Each Expansion



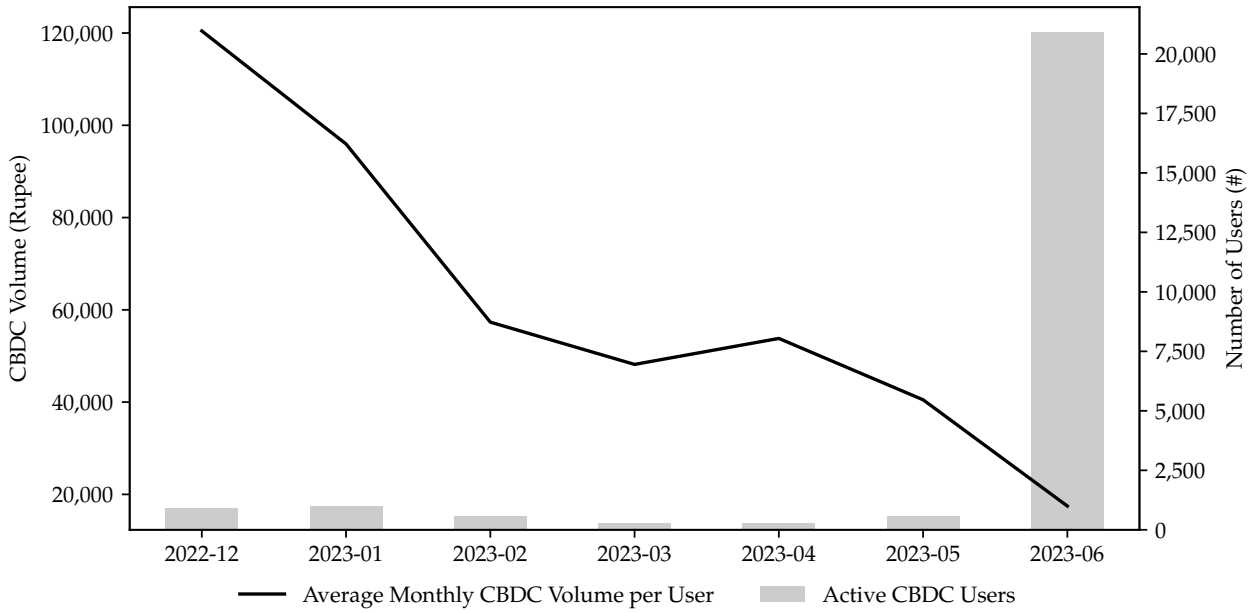
The pilot program expanded to new districts in December 2022, January 2023, February 2023, May 2023, and June 2023. The figure plots which districts became eligible at each expansion stage in red.

Figure 2: All CBDC Eligible Districts at Each Expansion



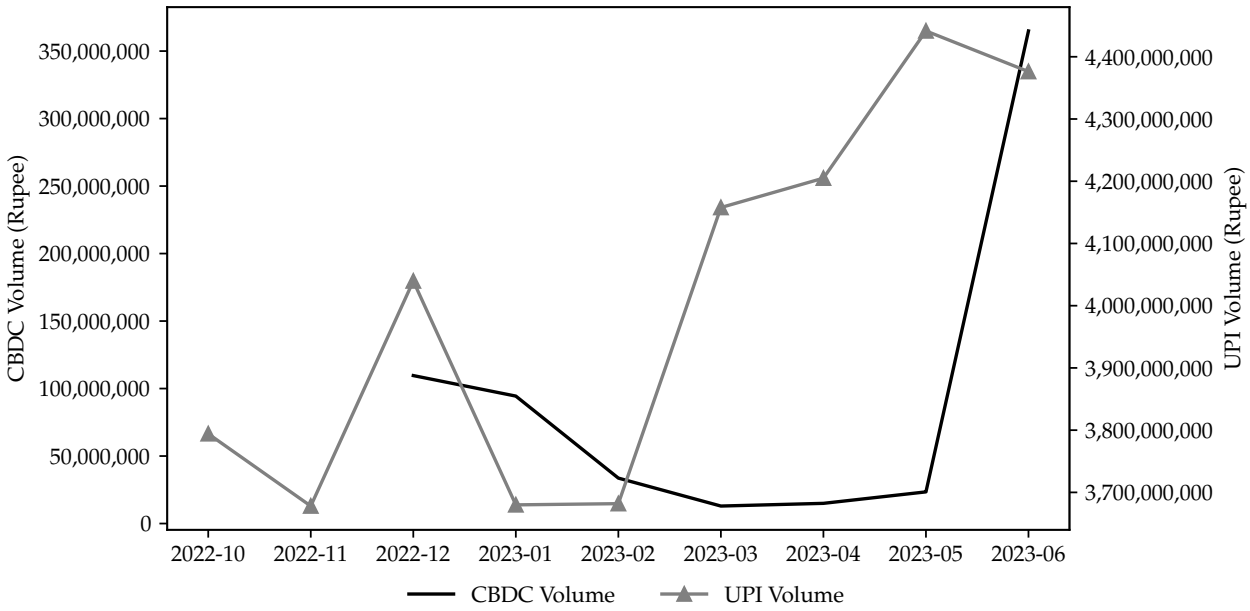
The figure shows the cumulative eligibility of districts in December 2022, January 2023, February 2023, May 2023, and June 2023 in red.

Figure 3: Monthly Average CBDC Volume and User Activity



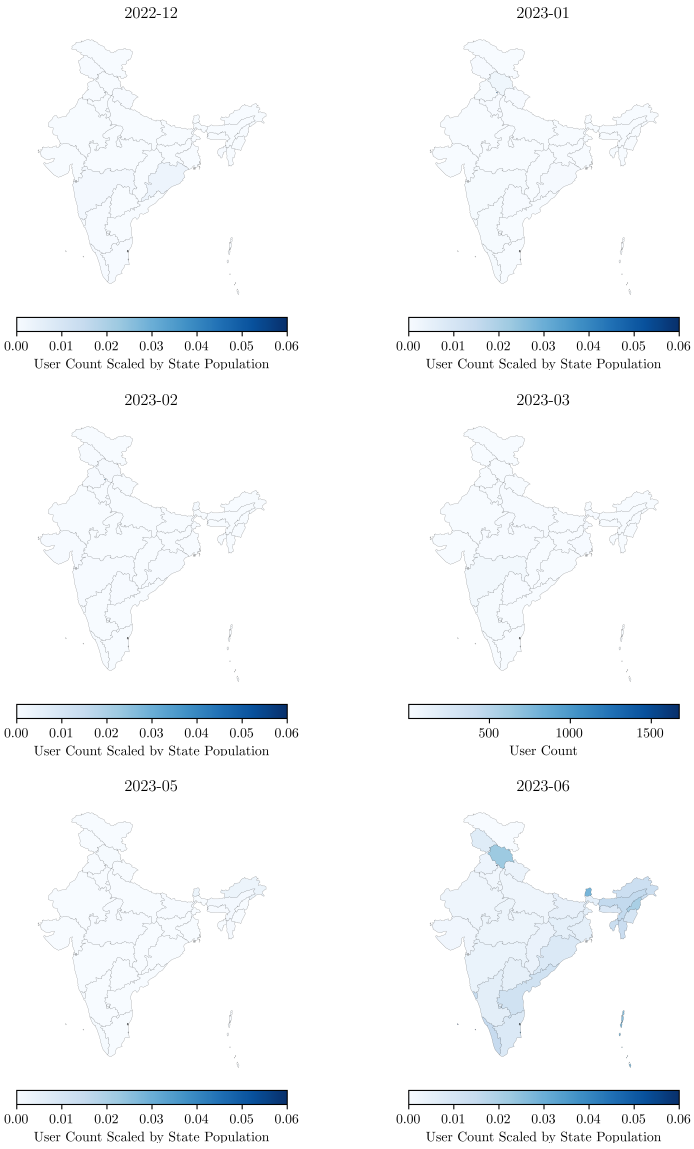
The figure displays the average monthly CBDC volume per user and the number of active CBDC users from December 2022 to June 2023.

Figure 4: Total Monthly Transaction Volume



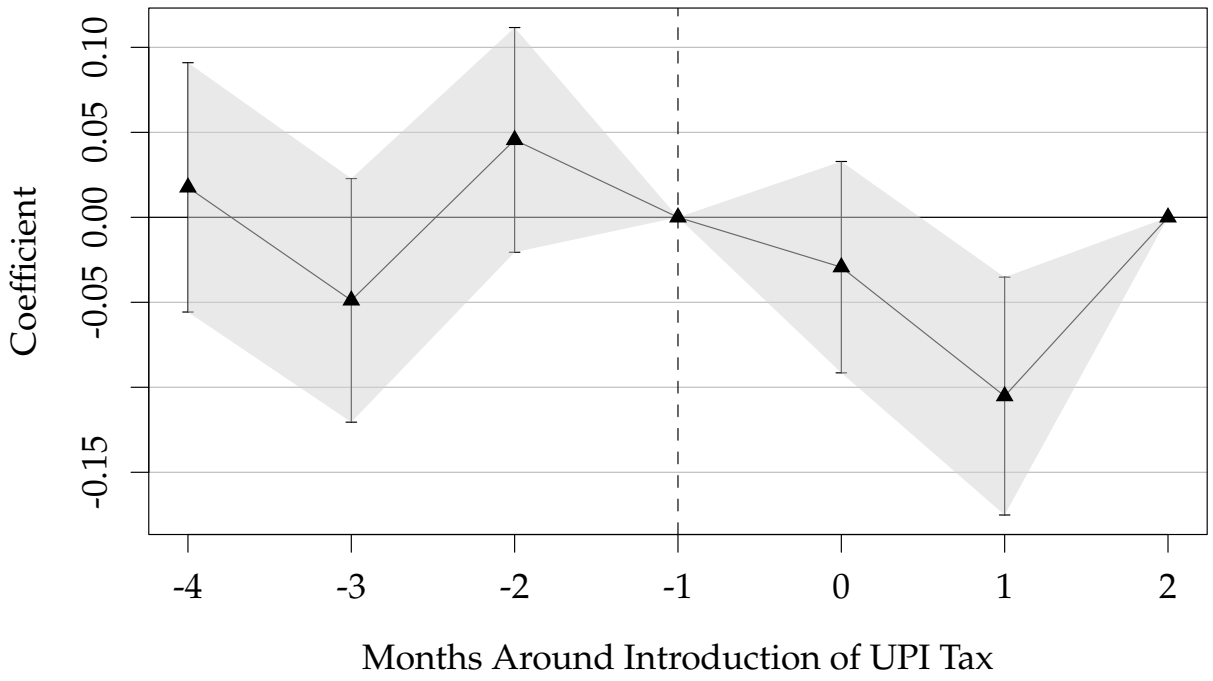
The figure displays the CBDC and UPI total monthly transaction volume across all users in our sample from December 2022 to June 2023.

Figure 5: Active CBDC User Count Scaled by State Population



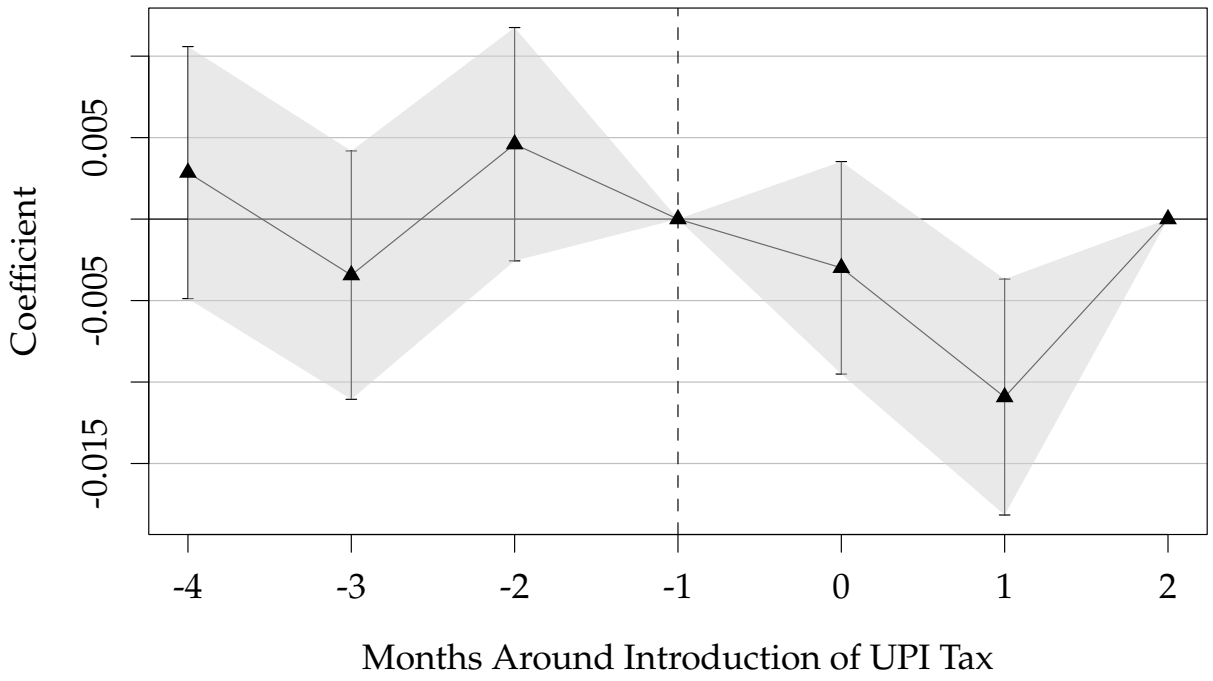
The figure shows the number of active CBDC users scaled by the state population that they live in for our sample.

Figure 6: Transaction Volume After UPI Tax



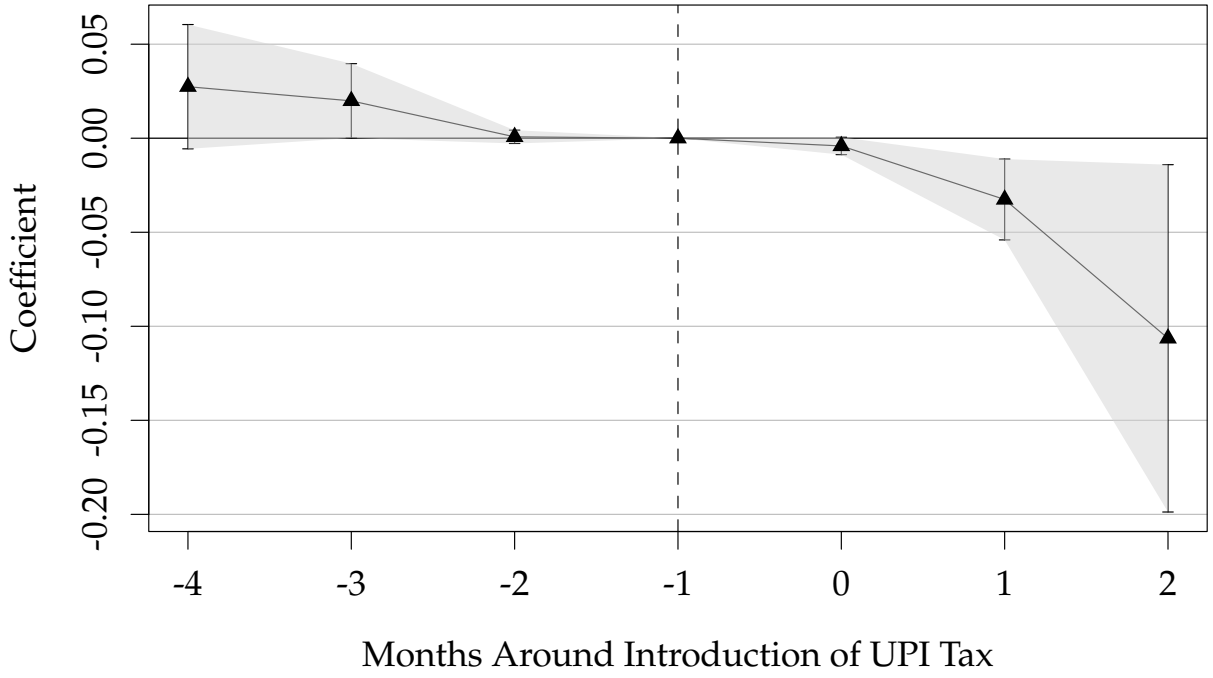
The figure shows the difference in log UPI volume after the UPI tax is implemented. Specifically, the figure plots β_k from Equation 3.

Figure 7: Transaction Likelihood After UPI Tax



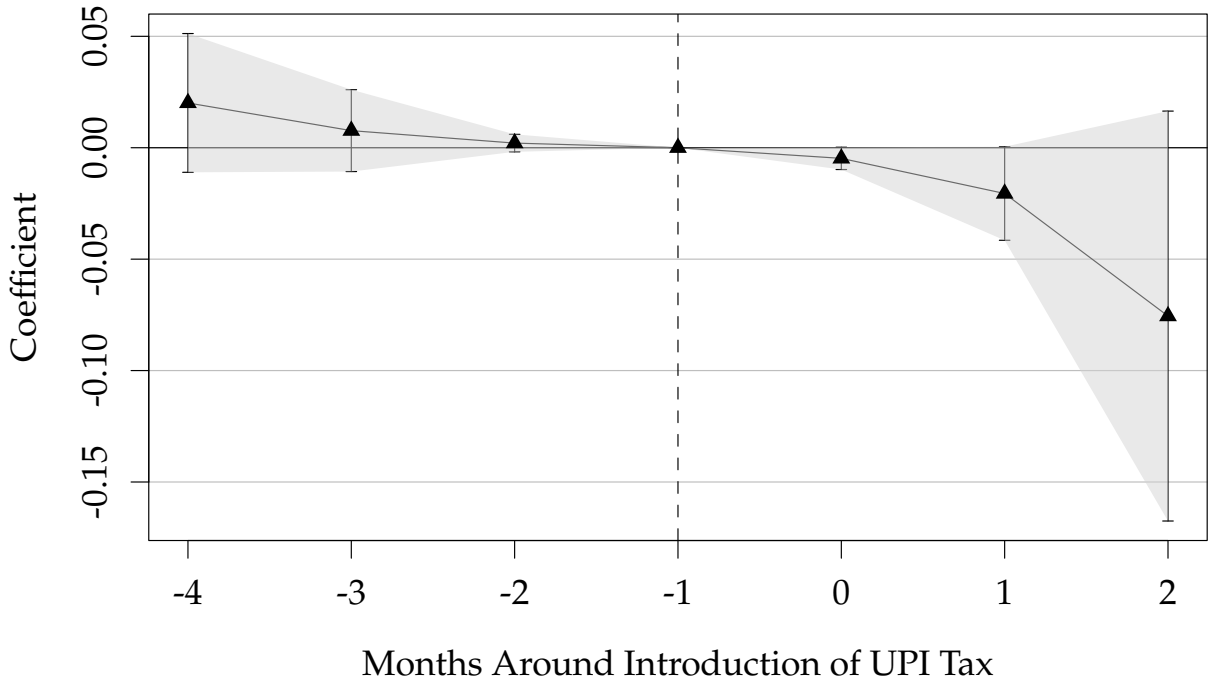
The figure shows the difference in log UPI volume after the UPI tax is implemented. Specifically, the figure plots β_k from Equation 4.

Figure 8: Bank Total Deposits UPI Tax



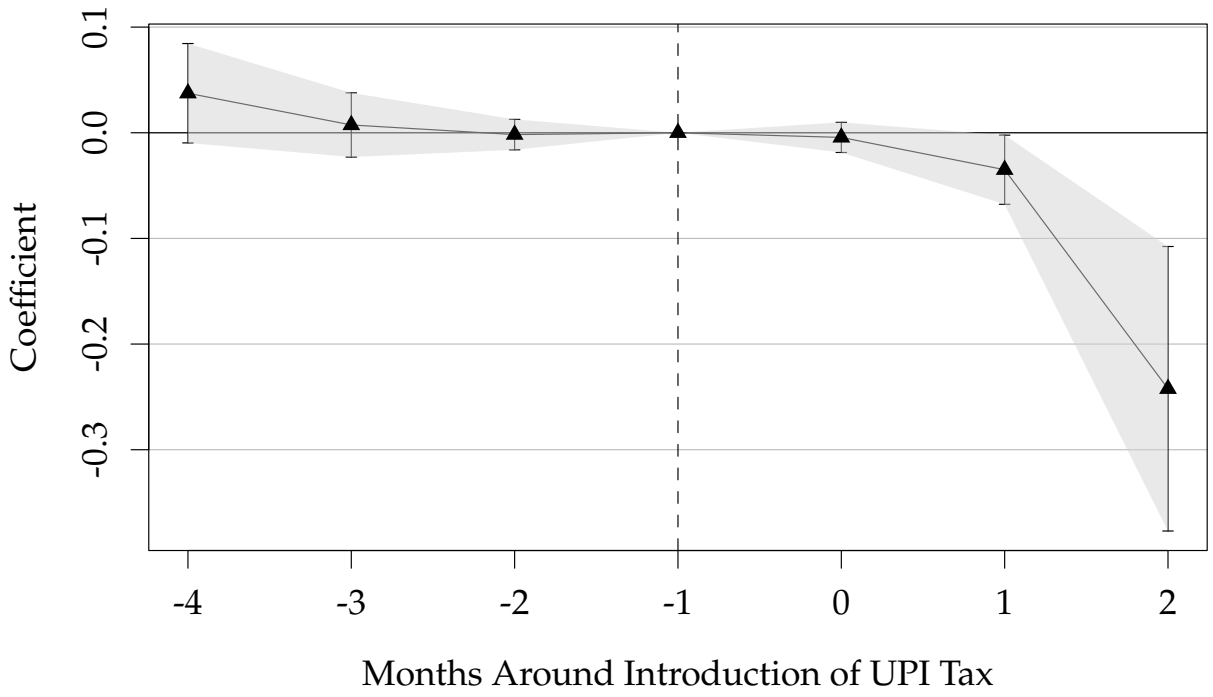
The figure shows the difference in log bank total deposits after the UPI tax is implemented. Specifically, the figure plots β_k from Equation 7.

Figure 9: Bank Savings Deposits UPI Tax



The figure shows the difference in log bank savings deposits after the UPI tax is implemented. Specifically, the figure plots β_k from Equation 7.

Figure 10: Bank Cash Deposits UPI Tax



The figure shows the difference in log bank cash deposits after the UPI tax is implemented. Specifically, the figure plots β_k from Equation 7.

Table 1: Summary Statistics of Districts Eligible for CBDC

The table reports descriptive statistics for districts that became eligible for CBDC at every expansion stage for our sample. We also include some summary statistics for the districts in our sample that were never eligible for CBDC. The first column displays the month of the CBDC expansion. The second column displays the number of districts added. The third column displays the average total population of those districts. The fourth column displays the average night light activity in each district. The fifth column displays the average count of bank branches in each district. The sixth column displays the average total deposits, in billions of Rupees, in each bank branch in each district.

Month Eligible for CBDC	Number of Districts	Total Population	Night Lights	Bank Branch Count	Total Bank Deposits (Billions of Rupee)
2022-12	209	2,492,617.4	766.5	74.5	12,311.2
2023-01	76	1,662,886.6	422.8	50.7	5,379.24
2023-02	42	1,142,303.9	194.0	31.6	2,776.71
2023-05	47	1,099,174.8	178.8	24.7	2,320.8
2023-06	237	1,316,511.7	221.2	27.4	2,400.05
Never Eligible	145	589,379.9	74.9	10.8	821.94

Table 2: User Summary Statistics

The table reports descriptive statistics of the users in our sample. Panels A and B display self-reported demographics for different subsets of users. Panel C displays the usage of CBDC, UPI and cash. The first column displays statistics for our full sample. The second column displays statistics for users who used UPI at least once in our sample. The third column displays statistics for users who never used UPI in our sample. The fourth column displays statistics for users who used CBDC at least once in our sample. The fifth column displays statistics for users who never used CBDC in our sample. The sixth column displays statistics for users who never used UPI and never used CBDC in our sample.

	Full Sample	UPI User	Non-UPI User	CBDC User	Non-CBDC User	Neither UPI nor CBDC User
Panel A: User Characteristics						
% Male	59.45	67.96	55.10	80.71	58.17	54.10
% Female	39.12	31.81	42.87	19.27	40.32	43.79
Average Age	39.15	37.12	40.15	38.90	39.17	40.17
Average Annual Income (Rupee)	247,609.48	278,562.36	228,431.48	554,321.93	226,400.79	208,522.47
Panel B: Education						
% Under Matriculate	10.31	4.27	13.39	0.65	10.89	13.91
% Matriculate	11.77	10.34	12.50	3.04	12.30	12.89
% Graduate	8.07	10.44	6.85	23.73	7.12	6.16
% Post Graduate	1.99	2.85	1.54	7.70	1.64	1.31
% Medical Graduate	0.18	0.29	0.13	0.09	0.19	0.13
% Engineering Graduate	0.55	1.00	0.32	3.09	0.39	0.22
% Law Graduate	0.05	0.08	0.04	0.20	0.04	0.03
% CA/ICWA/MBA/CFA	0.17	0.26	0.12	1.07	0.12	0.08
% Computer Degree	0.08	0.15	0.04	0.54	0.05	0.03
% Other Professional Degree	0.35	0.36	0.35	0.64	0.34	0.34
Panel C: Transaction Method Usage						
% CBDC User	5.71	9.17	3.93	100.00	0.00	0.00
% UPI User	33.86	100.00	0.00	54.40	32.61	0.00
% Cash User	14.83	17.75	13.34	23.99	14.28	13.78
Average Total CBDC Vol (Rupee)	1,742.81	2,674.59	1,265.64	30,539.09	0.00	0.00
Average Total UPI Vol (Rupee)	161,387.76	476,539.49	0.00	253,461.06	155,815.31	0.00
Average Total Cash Vol (Rupee)	78,983.25	204,757.88	14,574.65	23,328.92	82,351.56	15,019.12
N	223,459.00	75,658.00	147,801.00	12,749.00	210,710.00	141,988.00

Table 3: Probability of Being a CBDC User by User Characteristics

The table displays probability estimates of a user being a CBDC user based on self-reported gender, age, and income, and past usage of UPI and cash, which include home branch state fixed effects, defined as the state where a user's home branch is located. *t*-statistics are shown in parenthesis. Standard errors are clustered at the home branch state level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	CBDC User (1/0)				
	(1)	(2)	(3)	(4)	(5)
Male (1/0)	0.0504***				
	(17.38)				
Age Quartile 2		0.0651***			
		(13.16)			
Age Quartile 3		0.0563***			
		(8.323)			
Age Quartile 4		0.0235***			
		(4.613)			
Annual Income Quartile 2			-0.0417***		
			(-9.339)		
Annual Income Quartile 3			-0.0258***		
			(-4.630)		
Annual Income Quartile 4			0.0938***		
			(9.179)		
UPI User (1/0)				0.0541***	
				(6.124)	
Cash User (1/0)					0.0443***
					(5.104)
N	220,276	223,459	179,303	223,459	223,459
R-squared	0.01	0.02	0.05	0.02	0.01
Home Branch State FE	Yes	Yes	Yes	Yes	Yes

Table 4: Probability of Being a CBDC User by User Education

The table displays probability estimates of a user being a CBDC user based on self-reported education level relative to users who are under matriculate. Home branch state fixed effects are included, defined as the state where a user's home branch is located. *t*-statistics are shown in parenthesis. Standard errors are clustered at the home branch state level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	CBDC User (1/0)
	(1)
Matriculate	0.0119***
	(7.540)
Graduate	0.1624***
	(18.56)
Post Graduate	0.2143***
	(13.99)
Medical Graduate	0.0218*
	(1.757)
Engineering Graduate	0.3134***
	(15.30)
Law Graduate	0.2168***
	(5.955)
CA/ICWA/MBA/CFA	0.3510***
	(11.08)
Computer Degree	0.3847***
	(14.14)
Other Professional Degree	0.0960***
	(7.676)
N	74,883
R-squared	0.13
Home Branch State FE	Yes

Table 5: Probability of Being a CBDC User by User Home Branch District

The table displays probability estimates of a user being a CBDC user based on the statistics of the district of their home branch, which include home branch state fixed effects, defined as the state where a user's home branch is located. *t*-statistics are shown in parenthesis. Standard errors are clustered at the home branch state level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	CBDC User (1/0)			
	(1)	(2)	(3)	(4)
Population Quartile 2	0.0002			
	(0.0640)			
Population Quartile 3	0.0043			
	(1.405)			
Population Quartile 4	0.0163***			
	(2.974)			
Night Lights Quartile 2		0.0047***		
		(3.447)		
Night Lights Quartile 3		0.0116***		
		(3.843)		
Night Lights Quartile 4		0.0244***		
		(4.162)		
Total Bank Deposits Quartile 2			0.0009	
			(0.5423)	
Total Bank Deposits Quartile 3			0.0099***	
			(3.459)	
Total Bank Deposits Quartile 4			0.0259***	
			(4.435)	
Total Bank Branches Quartile 2				0.0057***
				(3.101)
Total Bank Branches Quartile 3				0.0120***
				(3.093)
Total Bank Branches Quartile 4				0.0242***
				(4.523)
N	223,432	223,432	223,432	223,432
R-squared	0.00	0.00	0.01	0.00
Home Branch State FE	Yes	Yes	Yes	Yes

Table 6: Bank Summary Statistics

The table reports descriptive statistics of the banks in our sample and their average deposits across different subsets based on when the city of the branch becomes eligible for CBDC. The first column displays statistics for the full sample. The second column displays statistics for banks eligible for CBDC December 2022. The third column displays statistics for banks eligible for CBDC January 2023. The fourth column displays statistics for banks eligible for CBDC February 2023. The fifth column displays statistics for banks eligible for CBDC May 2023. The sixth column displays statistics for banks eligible for CBDC June 2023. The seventh column displays statistics for banks that were never eligible for CBDC. The reported branch deposit levels are in billions of Rupees, and are updated as of November 2022.

	Full Sample	Eligible 2022-12	Eligible 2023-01	Eligible 2023-02	Eligible 2023-05	Eligible 2023-06	Never Eligible
Average Total Deposits (Billions of Rupee)	130.00	331.49	183.50	149.11	166.16	154.43	71.60
Average Savings (Billions of Rupee)	51.41	108.48	76.88	75.85	89.37	78.37	31.25
Average Cash (Billions of Rupee)	7.17	19.72	6.70	7.55	9.72	7.66	3.88
N	29,966.00	5,257.00	1,243.00	450.00	450.00	2,019.00	20,547.00

Table 7: Transaction Volume After UPI Tax

The table reports the effect of the UPI tax on UPI, CBDC, cash and total transaction volume, and the estimates of the coefficients of Equation 1. Column 1 reports the coefficients for the effect on log UPI volume. Column 2 reports the coefficients for log CBDC volume. Column 3 reports the coefficients for log cash volume. Column 4 reports the coefficients for log total volume. For all the volume variables, the nonzero values have been winsorized at the 1% level. *t*-statistics are shown in parenthesis. Standard errors are clustered at the user level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	Log UPI Volume	Log CBDC Volume	Log Cash Volume	Log Total Volume
	(1)	(2)	(3)	(4)
CBDC Eligible$_{it}$	0.0550**	0.0913***	-0.0109	0.0618***
	(2.371)	(8.312)	(-0.6184)	(2.658)
Post × CBDC Eligible$_{it}$	-0.0673***	0.0051**	-0.0191	-0.0628**
	(-2.675)	(1.978)	(-1.001)	(-2.481)
N	420,665	420,665	420,665	420,665
R-squared	0.66	0.30	0.39	0.65
Month × Bank Branch State × Income Class FEs	Yes	Yes	Yes	Yes
User FE	Yes	Yes	Yes	Yes

Table 8: Transaction Likelihood After UPI Tax

The table reports the effect of the UPI tax on the likelihood of using UPI, CBDC, and cash, and the estimates of the coefficients of Equation 2. Column 1 reports the coefficients for the effect on the likelihood of using UPI. Column 2 reports the coefficients for the likelihood of using CBDC. Column 3 reports the coefficients for the likelihood of using cash. *t*-statistics are shown in parenthesis. Standard errors are clustered at the user level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	UPI Likelihood (1/0)	CBDC Likelihood (1/0)	Cash Likelihood (1/0)
	(1)	(2)	(3)
CBDC Eligible$_{it}$	0.0046*	0.0119***	-0.0010
	(1.936)	(8.763)	(-0.6781)
Post × CBDC Eligible$_{it}$	-0.0076***	0.0009***	-0.0013
	(-2.977)	(3.114)	(-0.7755)
N	420,665	420,665	420,665
R-squared	0.56	0.30	0.43
Month × Bank Branch State × Income Class FEs	Yes	Yes	Yes
User FE	Yes	Yes	Yes

Table 9: Likelihood of Becoming a CBDC User After UPI Tax

The table reports the effect of the UPI tax on the likelihood of a user becoming a CBDC user, and the estimates of the coefficients of Equation 2. *t*-statistics are shown in parenthesis. Standard errors are clustered at the user level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	CBDC User Likelihood (1/0)
	(1)
CBDC Eligible$_{it}$	0.0104***
	(7.472)
Post × CBDC Eligible$_{it}$	0.0026***
	(9.377)
N	420,665
R-squared	0.48
Month × Bank Branch State × Income Class FEs	Yes
User FE	Yes

Table 10: Income Heterogeneity in Transaction Volume After UPI Tax

The table reports the heterogenous effect of the UPI tax on UPI, CBDC, cash and total transaction volume based on income, and the estimates of the coefficients of Equation 5. Column 1 reports the coefficients for the effect on log UPI volume. Column 2 reports the coefficients for log CBDC volume. Column 3 reports the coefficients for log cash volume. Column 4 reports the coefficients for log total volume. For all the volume variables, the nonzero values have been winsorized at the 1% level. *t*-statistics are shown in parenthesis. Standard errors are clustered at the user level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	Log UPI Volume	Log CBDC Volume	Log Cash Volume	Log Total Volume
	(1)	(2)	(3)	(4)
CBDC Eligible$_{it}$	0.0974***	0.0068	-0.0090	0.1001***
	(2.774)	(0.6945)	(-0.3653)	(2.827)
Post × CBDC Eligible$_{it}$	-0.0939**	-0.0032	-0.0215	-0.0915**
	(-2.422)	(-1.356)	(-0.8119)	(-2.348)
CBDC Eligible$_{it}$ × Above Median Income (1/0)	-0.0759	0.1513***	-0.0035	-0.0685
	(-1.621)	(7.366)	(-0.0996)	(-1.460)
Post × CBDC Eligible$_{it}$ × Above Median Income (1/0)	0.0473	0.0147***	0.0042	0.0511
	(0.9281)	(3.034)	(0.1123)	(0.9973)
N	420,665	420,665	420,665	420,665
R-squared	0.66	0.30	0.39	0.65
Month × Bank Branch State × Income Class FEs	Yes	Yes	Yes	Yes
User FE	Yes	Yes	Yes	Yes

Table 11: Education Heterogeneity in Transaction Volume After UPI Tax

The table reports the heterogenous effect of the UPI tax on UPI, CBDC, cash and total transaction volume based on education, and the estimates of the coefficients of Equation 5. Column 1 reports the coefficients for the effect on log UPI volume. Column 2 reports the coefficients for log CBDC volume. Column 3 reports the coefficients for log cash volume. Column 4 reports the coefficients for log total volume. For all the volume variables, the nonzero values have been winsorized at the 1% level. *t*-statistics are shown in parenthesis. Standard errors are clustered at the user level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	Log UPI Volume	Log CBDC Volume	Log Cash Volume	Log Total Volume
	(1)	(2)	(3)	(4)
CBDC Eligible$_{it}$	0.0581**	0.0804***	-0.0085	0.0649***
	(2.488)	(7.400)	(-0.4789)	(2.774)
Post × CBDC Eligible$_{it}$	-0.0691***	-0.0031	-0.0185	-0.0660***
	(-2.732)	(-1.154)	(-0.9698)	(-2.592)
Post × Sophisticated (1/0)	-0.0397	-0.0941***	0.0441	-0.0447
	(-0.2489)	(-3.781)	(0.2380)	(-0.2789)
CBDC Eligible$_{it}$ × Sophisticated (1/0)	-0.2271	0.7504***	-0.1772	-0.2361
	(-1.394)	(5.043)	(-1.106)	(-1.433)
Post × CBDC Eligible$_{it}$ × Sophisticated (1/0)	0.1295	0.5272***	-0.0286	0.2252
	(0.7071)	(8.844)	(-0.1465)	(1.234)
N	420,665	420,665	420,665	420,665
R-squared	0.66	0.30	0.39	0.65
Month × Bank Branch State × Income Class FEs	Yes	Yes	Yes	Yes
User FE	Yes	Yes	Yes	Yes

Table 12: Total Bank Deposits After UPI Tax

The table reports the effect of the UPI tax on bank branch total deposits, and the estimates of the coefficients of Equation 6. Column 1 reports the coefficients where we include just bank branch state fixed effects. Column 2 reports the coefficients where we include bank branch state and month fixed effects. The nonzero values of total deposits have been winsorized at the 1% level. *t*-statistics are shown in parenthesis. Standard errors are clustered at the branch level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	Log Bank Total Deposits (Rupee)	
	(1)	(2)
Post	0.0014	
	(0.1991)	
CBDC Eligible$_{bt}$	0.4333***	0.4429***
	(20.56)	(20.46)
Post × CBDC Eligible$_{bt}$	-0.0575***	-0.0380***
	(-6.930)	(-4.320)
N	68,586	68,586
R-squared	0.12	0.12
Bank Branch State FE	Yes	Yes
Month FE		Yes

Table 13: Bank Savings Deposits After UPI Tax

The table reports the effect of the UPI tax on bank branch savings deposits, and the estimates of the coefficients of Equation 6. Column 1 reports the coefficients where we include just bank branch state fixed effects. Column 2 reports the coefficients where we include bank branch state and month fixed effects. The nonzero values of savings deposits have been winsorized at the 1% level. *t*-statistics are shown in parenthesis. Standard errors are clustered at the branch level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	Log Bank Savings Deposits (Rupee)	
	(1)	(2)
Post	0.0114*	
	(1.660)	
CBDC Eligible$_{bt}$	0.1871***	0.1902***
	(8.835)	(8.731)
Post × CBDC Eligible$_{bt}$	-0.0351***	-0.0257***
	(-4.449)	(-3.034)
N	68,586	68,586
R-squared	0.07	0.07
Bank Branch State FE	Yes	Yes
Month FE		Yes

Table 14: Bank Cash Deposits After UPI Tax

The table reports the effect of the UPI tax on bank branch cash deposits, and the estimates of the coefficients of Equation 6. Column 1 reports the coefficients where we include just bank branch state fixed effects. Column 2 reports the coefficients where we include bank branch state and month fixed effects. The nonzero values of cash deposits have been winsorized at the 1% level. *t*-statistics are shown in parenthesis. Standard errors are clustered at the branch level, and significance level is denoted by the asterisks, where *** = 1%, ** = 5%, and * = 10%.

	Log Bank Cash Deposits (Rupee)	
	(1)	(2)
Post	0.0126	
	(1.172)	
CBDC Eligible$_{bt}$	0.4017***	0.4089***
	(13.82)	(13.68)
Post × CBDC Eligible$_{bt}$	-0.0552***	-0.0500***
	(-4.394)	(-3.727)
N	68,586	68,586
R-squared	0.09	0.09
Bank Branch State FE	Yes	Yes
Month FE		Yes