Back to bank: the cost of digital currency and bank competition*

Lorenzo Spadavecchia† Jimmy Apaa Okello‡ Samuel N. Musoke§

Tuesday 6th February, 2024

Abstract

Abstract.

Keywords: Mobile Money, Financial Incusion, Digital Currency

JEL Codes: G21, E41, O11

*This paper has benefitted from discussions with and the suggestions of Adam Mugume, Nicolas Serrano-Velarde. Lorenzo Spadavecchia is extremely grateful to Nicola Limodio for continuous guidance, not only on this paper but also in the profession, and Markus Brunnermeier for hosting in the wonderful Department of Economics at Princeton University. Lorenzo Spadavecchia acknowledges generous funding from Rotary Foundation, BPM Lino Venini Foundation and LEAP. We thank ChatGPT for valuable research assistance. All errors are our own.

†Bocconi University. Email: `lorenzo.spadavecchia@unibocconi.it`

‡Bank of Uganda. Email: `JApaa@bou.or.ug`

§Bank of Uganda. Email: `Snmusoke@bou.or.ug`

1 Introduction

The dynamic landscape of digital payments is undergoing a transformative phase, with implications reaching far beyond transactional convenience. Within this context, we explore the intricate interactions between digital and traditional payment systems, focusing on the repercussions for bank lending and financial inclusion. A pivotal catalyst for our investigation is the ongoing debate on the potential introduction of Central Bank Digital Currencies (CBDCs), with raising questions about the ambiguous effects on the credit market (Andolfatto (2021), Agur et al. (2022)).

The global interest in CBDCs highlights the need for empirical investigations into their potential repercussions on the banking sector. While theoretical frameworks, as exemplified by Chiu et al. (2023), offer diverse perspectives on the consequences of CBDC introduction, empirical validations remain scarce. Our research aims to bridge this gap by delving into the nuanced dynamics between digital and traditional payment systems, shedding light on their impact on bank lending and financial inclusion.

We exploit an unexpected tax on Mobile Money introduced by the Ugandan government in July 2018 to study how a shock to the cost of digital currencies induces substitution with cash and bank deposits, eventually affecting bank liquidity and credit provision.

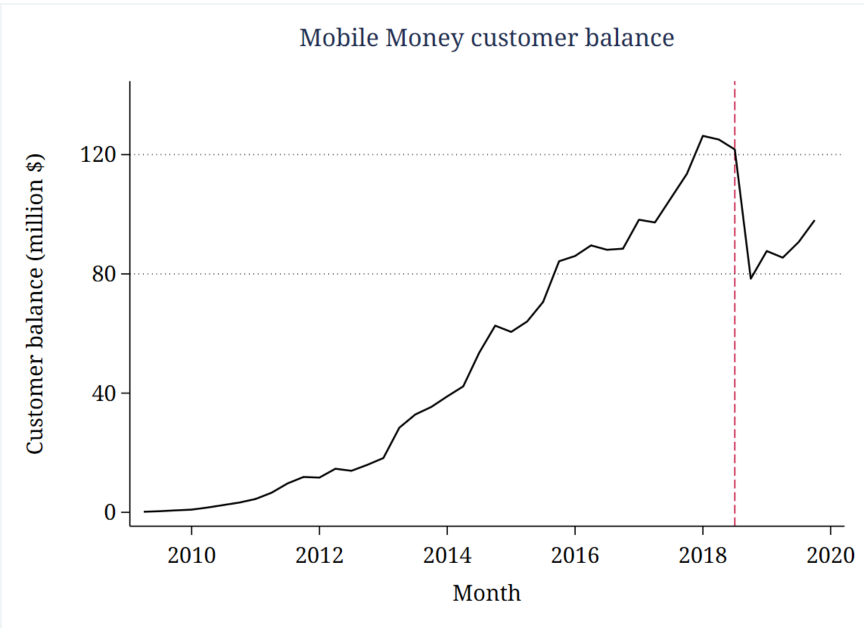
From a policy perspective, we also provide empirical evidence on the unintended consequences of digital currency taxation. Indeed, the palpable tension surrounding Mobile Money taxes across African nations[1] underscores a broader concern about the trade-offs inherent in the adoption of digital currencies. Mobile money has emerged as one of the most widespread digital payment systems (Demirguc-Kunt et al., 2018). Its diffusion resulted in tangible changes in various economic and financial indicators like risk-sharing (Jack and Suri (2011); Blumenstock et al. (2016)), remittances (Riley (2018); Aker et al. (2020)), lending (Suri et al., 2021) and savings (Breza et al., 2022), among others. De-

[1] In the last few years, taxes on mobile money transactions have increasingly been implemented in various African countries, with Uganda, Zimbabwe, Côte d'Ivoire, Kenya and the Republic of the Congo having implemented this tax prior to the Covid pandemic in 2020, while Tanzania, Cameroon and Ghana have done the same since.

spite these significant developments, research on the functioning and regulation of this technology remains limited. Positioning Mobile Money in competition with both cash for transactions and bank deposits for money storage, our conceptual framework elucidates its comparative advantages. Factors such as accessibility, cost-effectiveness, and ease of account opening underscore the potential dominance of Mobile Money in specific contexts. This framework forms the foundation for understanding the intricate substitution dynamics between digital and traditional payment systems. The interplay of these systems, influenced by geographic and economic factors, shapes the landscape of financial transactions and storage.

The tax had a detrimental effect on mobile money usage. We show in Figure 1 that in the quarter following the tax users withdrew the equivalent of 40 million US $ from the Mobile Money network.

Figure 1: Mobile Money customer balance



Notes: This figure plots the quarterly customer balance of mobile money, expressed in US $. It represents the value of mobile money detained by users.

Analyzing users' elasticity of substitution for Mobile Money with cash and deposits, contingent on their geographic location, elucidates a spatially heterogeneous impact of the tax. Urban areas, characterized by a higher density of ATMs and banks, witness a differential response, shaping variations in Mobile Money usage and deposit growth. Anticipated outcomes include differential effects on banks, manifesting in altered credit provision and potential rent transfers to specific borrower subgroups (Agarwal et al. (2018), Beck et al. (2018)).

Our conceptual framework centers on the substitution dynamics between digital and traditional payment systems. Mobile Money, positioned as a contender against cash and traditional bank deposits, leverages advantages in accessibility, cost-effectiveness, and ease of account opening. The spatially heterogeneous impact of Mobile Money taxes is examined through users' elasticity of substitution, considering variations in geographic contexts. Urban areas, with higher ATM and bank densities, witness distinct responses influencing Mobile Money usage and deposit growth. This framework forms the theoretical underpinning for understanding the nuanced interactions and competition between digital and traditional payment systems.

The envisaged mechanism entails users' responsiveness to Mobile Money taxes, driving changes in their payment preferences. The tax-induced shock is expected to trigger shifts in transactional behaviors. Consequently, the expected outcomes include alterations in the demand for traditional banking services and the growth trajectory of deposits. Moreover, the varying impact on urban and rural areas may result in divergent effects on bank lending, potentially influencing the credit market structure.

To empirically investigate the outlined mechanisms and expected outcomes, our research leverages a comprehensive dataset spanning multiple African countries. The dataset incorporates information on Mobile Money usage patterns, traditional banking transactions, and demographic variables. We employ a quasi-experimental design, leveraging the temporal variation introduced by the Mobile Money taxes. This approach allows us to isolate the tax-induced shock's impact on payment preferences and subsequent outcomes. Statistical analyses, including regression models and difference-in-differences estimators, form the backbone of our empirical methodology, providing robust insights into the complex dynamics between digital and traditional payment systems, and their implications for bank lending and financial inclusion.

Our research project intersects with multiple literature streams, each offering valuable insights into the multifaceted dimensions of digital payments, banking competition, and financial inclusion.

The recent surge in research on Central Bank Digital Currencies (CBDCs) has provided a theoretical lens to examine the implications of their introduction. Notable contributions include Chiu et al. (2023), Andolfatto (2021), and Agur et al. (2022), each offering unique perspectives on how CBDCs may influence competition in the financial sector. Keister and Sanches (2023) provide an extensive review, underscoring concerns about potential disintermediation of the banking system. These insights form a critical backdrop for our exploration of the real-world consequences of digital payment systems (Meaning et al. (2018), Brunnermeier et al. (2019), Brunnermeier and Niepelt (2019), Piazzesi and Schneider (2020), Duffie (2019), Sockin and Xiong (2023)).

The evolving landscape of FinTech and its impact on traditional finance has garnered attention from scholars exploring the regulatory environment and the dynamics of competition. Buchak et al. (2018) examine the role of technology in the decline of traditional banking, shedding light on the conditions favoring the expansion of shadow banking. Similarly, Erel and Liebersohn (2022) investigate the response of FinTech to financial services demand, emphasizing the expansion rather than the redistribution of financial services. These insights are crucial for understanding the broader context in which digital and traditional payment systems coexist (Beaumont et al. (2022), Ferrari et al. (2010)).

The burgeoning literature on the economic effects of instant payment systems, including the use of payment flows as indicators of repayment ability, adds a layer of complexity to our exploration. Contributions from Parlour et al. (2022), Di Maggio and Yao (2021), and Babina et al. (2022) provide insights into how payment systems are intricately linked with lending decisions and financial inclusion. This stream of literature enriches our understanding of the interconnectedness of digital payments and broader financial services (Higgins (2020), Bachas et al. (2018), Duarte et al. (2022), Sarkisyan (2023), Balyuk and Williams (2021), Dubey and Purnanandam (2023), Bian et al. (2023), Dupas et al. (2018)).

Drawing parallels with the literature on demonetization, our investigation into the Mobile Money tax-induced shock finds resonance with studies exploring policy changes that induce shifts in currency use. Chodorow-Reich et al. (2020) examine the consequences of demonetization, noting relative reductions in economic activity and shifts towards alternative payment technologies. Similarly, Crouzet et al. (2019) document how a cash contraction spurs the adoption of new payment technologies. These insights offer valuable context for understanding the potential ramifications of our identified tax-induced shock.

The extensive literature on the effects of Mobile Money provides a foundational understanding of its role in financial inclusion and transactional behavior. Pioneering studies by Jack and Suri (2011), Jack et al. (2013), and Jack and Suri (2014) highlight the transformative impact of Mobile Money on access to formal financial systems. Our research builds on this foundation, acknowledging the dual role of Mobile Money as both a facilitator of financial inclusion and a potential disruptor of traditional banking systems (Suri and Jack (2016), Suri (2017), Suri et al. (2021), Brunnermeier et al. (2023)).

The literature on liquidity, credit supply, and the impact of shocks on financial markets offers a theoretical and empirical foundation for our exploration. Khwaja and Mian (2008), Limodio (2022), and Choudhary and Limodio (2022) delve into the intricacies of liquidity shocks and their effects on credit provision. These insights inform our investigation into how the Mobile Money tax-induced shock might influence banks' credit supply.

Eventually, a rich body of literature explores the relationship between information asymmetries, credit provision, and the implications of data portability in the financial sector. Agarwal et al. (2018), Banerjee et al. (2021), and Beck et al. (2018) provide insights into the benefits of data portability and its role in enhancing credit provision. Our research contributes to this discourse by examining how shifts in payment systems might influence established relationships between banks and borrowers (Berlin and Mester (1999), Sette and Gobbi (2015)).

The rest of the paper is as follows. Section 2 offers details about the institutional aspects of the Ugandan mobile money tax, and provides an insight on a new bank-related technology, banking agents, that allow easier access to banks' services. Section 3 describes the data we use, comprehensive of a unique dataset on individual transactions of the whole Ugandan population of Mobile Money users, a dataset on individual banking agents, a dataset on the Central Bank's issuance of cash at local level, and a dataset on the universe of loans granted by private banks. Section 4 provides evidence on the substitution of Mobile Money with traditional payment and money storage systems. In Section 5 we show the effects of the Mobile Money tax induced positive liquidity shock to banks on the credit market. Section **??** concludes.

2 Institutional framework

2.1 Mobile Money Tax

Mobile money services were first introduced in Uganda by MTN in 2009 and, since then, the sector has seen significant growth. During the first year of operation, the number of registered accounts grew to 770,000 and the total value of transactions amounted to approximately UGX 133 billion (US$ 36 million) over the year.

After MTN, other mobile network operators (MNOs) soon introduced similar services. Within a decade, the number of registered, active accounts had surpassed 16 million and the total annual value of transactions had grown to UGX 73 trillion (US$ 20 billion). [2]

Figure B.1 in **??** reports the number of mobile money users and the volume and value of mobile money transactions in Uganda over the last 12 years. This growth is due, in part, to the accessibility of mobile money, enabled through a national network of roughly 212,500 registered mobile money agents who are markedly more prevalent than more traditional financial service providers, such as commercial banks.[3]

As the sector, and its turnover, has grown, governments are increasingly viewing mobile money as a convenient tax handle. This is especially true for governments facing

[2] Source: Bank of Uganda, 2021

[3] Surveys have indicated that whereas 54% of the population had a mobile money point-of-service within one kilometer of their home, just 16% per cent of the population had a point-of-service for a traditional bank (Bank of Uganda 2017).

pressures, both domestic and external, to increase domestic revenue mobilisation and reduce the reliance on aid and borrowing to fund public services. The resulting tax measures are often controversial and have drawn sharp criticism from those who fear that they will undermine the growth of nascent digital finance sectors and the development gains that (digital) financial inclusion is claimed to enable.[4]

Uganda presents an interesting case study of this trend. On 1 July 2018, the government introduced an especially contentious new tax of 1%[5] on the value of all mobile money transactions, aimed at mobilising more revenue from the telecommunications and financial sectors (Lees and Akol, 2021).

The mobile money tax legislation was initially drafted such that every stage of a mobile money transfer was taxed – depositing, sending, receiving, and withdrawing the money. These were identified as separate, and thus individually taxable, transactions. In effect, one transfer between two users might have been taxed up to four times.

Uganda currently has the foundations of a strong, well-structured system for policy development, providing for an orderly progression from an idea for change to the implementation of a final tax measure (Wales and Lees, 2020). Tax policy development in Uganda follows a series of distinct phases, closely linked to the annual budget cycle, as illustrated in Figure B.2. However, unanticipated expenditure requirements, and the rejection of several revenue-raising tax proposals, created pressure to find new sources of revenue late in the budget cycle. This led to surpass the standard steps required by the Ugandan legislation for law promulgation. These resulted in the introduction of a Mobile Money tax strongly advised by Ugandan President Yoweri Museveni[6]. The faster than usual process for the approval of this tax led to a lack of widespread citizen engagement and the tax proposal seemed largely absent from the general public discourse at the time. Indeed, the tax was unexpected by citizens, and as an indication of this, Figure B.3 shows Google search interest from Uganda in the terms "tax" and "mobile money" throughout

[4]See link

[5]After widespread public outcry and significant challenges in implementation, the tax rate was adjusted to 0.5 % and restricted to withdrawals in November 2018.

[6]The President wrote on his blog that the informal sector is "never taxed" and a tax on mobile money would ensure a "modest contribution"

2018. Search interest for "tax" and "mobile money" peak in the week starting 1 July 2018.

The introduction of the mobile money tax triggered immediate public outcry, with concerns about double taxation, financial inclusion, job losses, and the impact on the poor. Civil society, journalists, students, and activists organized protests, gaining international media attention.[7] In response, the President requested Parliament to amend the tax on July 12. Cabinet limited the tax to withdrawals, halving the rate. Despite delays, the Finance Committee supported the amendment for budgetary reasons. The Amendment Bill was implemented on November 17, following a series of events detailed in Figure B.4. As shown in 1, the tax had a huge impact on the usage of mobile money.

2.2 Agent Banking

In July 2017, Bank of Uganda passed a new regulation aimed at establishing a new tool through which commercial banks can operate: Agent Banking[8]. Agent banking is a banking model that involves the use of third-party agents, such as retail shops, to provide banking and financial services on behalf of traditional banks. This approach is particularly relevant in regions with limited access to physical bank branches, as it enables financial institutions to expand their reach and offer their services to underserved or remote areas. In Uganda, agent banking has gained momentum in recent years as a means to enhance financial inclusion and improve access to banking services, especially in rural and underserved areas. Agent banking services typically include cash deposits, cash withdrawals, balance inquiries, fund transfers, utility bill payments, and sometimes even account opening. The key feature of Agent Banking is that it does not require the opening of a bank account in order to perform operations such as depositing, withdrawing or transferring money. When depositing money, for example, the banking agent releases a receipt to the customer, who will use it to withdraw the money later on. While this tool has been long used by banks, in 2017 it was formalized through the creation of an

[7] A public opinion survey of nearly 3,000 people conducted in the second week of July found that 98% of respondents did not support or were strongly opposed to the mobile money tax (Whitehead, 2018).

[8] The Financial Institutions (Agent Banking) Regulations, 2017

inter-banks agency. The Agent Banking Company (ABC) was established in 2017 by Uganda Banker's Association (UBA) the umbrella organization for commercial banks in Uganda and Eclectics a pan-African technology company. Similar to the Mobile Money model, Agent Banking empowers commercial banks to appoint agents to provide banking services such as deposits, withdrawals and more on their behalf. Agents can be the local shopkeeper, kiosk owners, supermarket attendant or anyone in your community who has been authorized by your bank. The financial services currently offered through the ABC platform include cash deposits, cash withdrawals, bill payments and money transfers. The platform enables commercial banks to enhance customer experience, reduce the cost to serve and increase coverage while avoiding duplication of investment and effort. As at the end of 2021, there were 22 commercial banks with 20,108 agents enrolled on the platform. Between 2018 and 2021, agents on the platform cumulatively processed over 12 million transactions worth $ 4.3 billion.

In the analysis, we show the spur of banking agency after the introduction of the Mobile Money tax. We claim that the shock

3 Data

This section describes the datasets employed in this analysis and offers insights on the identification strategy by analysing the data on mobile money usage. In particular, the identification strategy verifies that the different elasticity of mobile money usage between urban and rural individuals lead to a differential exposure of banks to this shock, depending on their location. The main databases employed in this research are listed as follows:

1. Mobile Money transaction data. We have access to the universe of mobile money transactions from one of the two major companies in Uganda. MTN and Airtel share the mobile money market equally, have similar coverage and set extremely similar prices on mobile money transactions. We expect no major differences in individual level usage between the two comapnies, indeed it is estimated that at least 30% of the Ugandan

population with access to a a mobile phone has a SIM subscription with both operators.[9] For the only year 2018, we have access to more than 50 million transactions, divided by person-to-person transfers (P2P), cash-in (deposits) and cash-out (withdrawals). We are able to access both the sender, the receiver or the mobile money agent identifier, hence allowing us to reconstruct the whole network of mobile money transactions. We have access to the type of transaction, to its value in Ugandan Shillings (UGX), to the fees applied on the transactions, as well as on the time and day it was performed.

2. Mobile Money user location. Out of the 5.5 million mobile money users active before the introduction of the tax, we are able to identify the district of residence for a random sample of about 1.5 million users. This allows us to present evidence of heterogeneity in mobile money usage elasticity between urban and rural users.

3. Issuance of physical cash. The Central Bank of Uganda has also provided daily data on the issuance of cash to local private banks' branches for the years 2017-2022. Bank of Uganda has 10 offices spread throughout the Ugandan territory. Each of these offices provide cash on a daily basis to the major branch of private banks present in that area. We hence have a bank-location panel of cash issued. We use these data as a proxy of cash demand at the local level. Indeed, the only reason why banks request physical cash is to meet the demand of depositors withdrawing money.

4. Credit registry loan-level data. Our study employs detailed data on the commercial and household lending activities of banks. Uganda has a fully functional and comprehensive credit register that is maintained by the private credit bureau Compuscan Uganda CRB Ltd. under the supervision of the Bank of Uganda. The credit register ollects data on all new originated loans based on monthly reports from all commercial banks, microfinance deposit-taking institutions, and other credit institutions. We have access to the full dataset covering the period 2017-2023. For each granted loan we are able to identify both borrower-specific and loan-specific variables. We observe: i) the nature of the borrower, wether individual or business; ii) the type of loan (secured or unsecured); iii) the credit risk of the borrower); iv) the purpose of the loan (business, mortgage, school loan,

[9] National IT Survey Uganda (NITA), 2018. See link.

house restructuring, land purchase); v) for credit to individuals, we are able to identify the income of the borrower and her professional activity; for businesses, we are able to identify the sector of activity; vi) for all borrowers we identify the district of residency; vii) the day on which the loan was granted; viii) the rate of repayment as stated on the day of the granting; ix) the term/maturity of the loan.

5. Bank-level data on deposits. The Bank of Uganda provides monthly data on private institutions deposits. We are able to identify different types of deposits (demand, saving and time deposits).

6. Agent Banking Company individual agent's data. The Bank of Uganda has provided the details of deposits and withdrawals for each banking agent. We aggregate data at the district level. Data are available since April 2018.

7. Ugandan National Panel Survey. We employ household-level panel microdata from the Uganda Bureau of Statistics. These data provides information of a wide range of topics on households' income, savings, entrepreneurial activity, employment, education attainment, purchases (as well as type of payment used).

8. Geographical data on urban development and nighttime light intensity. We exploit the dataset introduced by Cattaneo et al. (2021) to create a district's measure of urban development. In this dataset, raster pixel are assigned a value ranging from 1 to 30, where 1 identify most urban areas and 30 most rural areas. The district's measure of urban development is hence constructed as the average of the pixel values in the district's itself. For the Mobile Money dataset we assign to each user the urban measure of the district where she resides, we then divide users in four quartiles depending on their measure of urbanity. We then construct a dummy that takes value 1 to identify the first quartile of most urban users (and 0 for the other three quartiles). As far as it concerns the bank-location data, we identify as urban those bank-locations in the first quartile of the rural distribution. As a robustness check, we also exploit the data on nighttime light intensity provided by the National Centers for Environmental Information. They provide pixels with value ranging from 0 (no light) to 63 (maximum light intensity), all over the globe. We construct a district's measure of light intensity by averaging nighttime light intensity

across all pixels contained in the district.

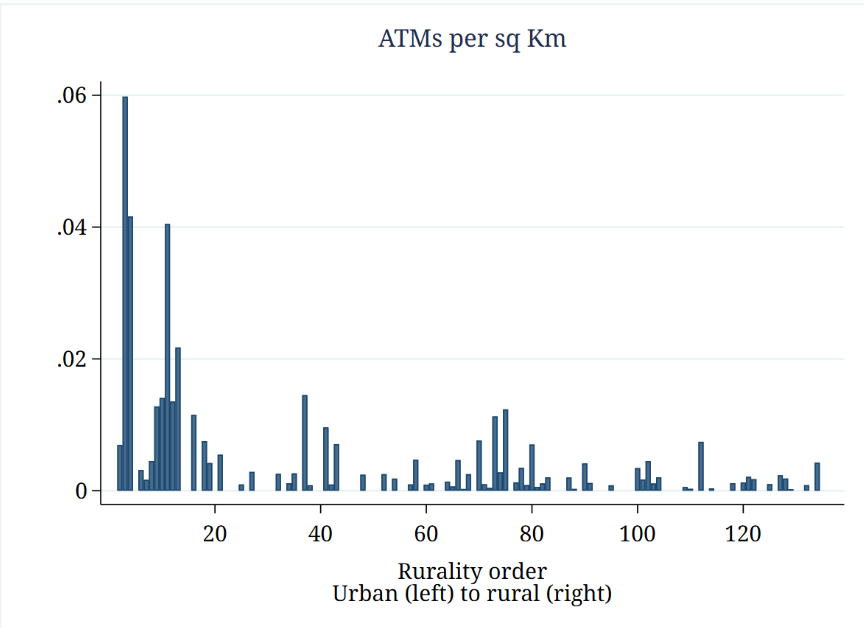
10. Individual Bank's ATMs and branches location. We obtained data for the location of all ATMs and branches of each bank.

4 Results on Mobile money and bank usage

4.1 Mobile Money

Our first assumption is that mobile money users are differentially affected by the introduction of the tax depending on the possibility of access to other means of payments. We exploit the density of ATMs in a given district as measure of access to mobile money alternatives. This measure is highly correlated with the level of urban development, as shown in Figure 2.

Figure 2: ATM density and urban development



Notes: This figure plots the number of ATMs per squared kilometer over the rurality index as proposed in Cattaneo et al. (2021). More urban districts show a higher density of ATMs.

While at the extensive margin we show that users in areas with high ATM density are more likely to keep using Mobile Money after the introduction of the tax, at the intensive margin of usage those individuals register the highest drop. We show that after the tax, the likelihood of using Mobile Money for an individual in low ATM density districts decreases by up to 70% (60% for individuals in high ATM density). But, conditional on using Mobile Money, the drop in usage (expressed in value transacted) is as high as 70% for individuals in low ATM density areas and 78% for individuals in high ATM density areas.

4.1.1 Extensive margin: individual level

We first present results from a simple difference-in-differences design. We interact a dummy Post Tax_t, that takes value 1 for observations after the introduction of the tax, with a indicator variable for individuals living in areas with high ATM density. We assign to each user the ATM density (calculated as number of ATMs over the districts area) of the district where she resides. We define High ATM density_d as a dummy indicating whether the users i in district d is in the highest 25 percentile of the users' distribution of ATM density. We use the subscript d as there are no users in the same district assigned a different value of the dummy variable.[10]

We collapse data over four months before and after the introduction of the tax (respectively February, March, April and May, and August, September, October, November). We do not include June and July due to the serious limitations of the observations in those months, as several glitches made it impossible to the mobile money company to collect the data. However, even including the available data from those two months, the results remain qualitatively similar. We are hence using two observations for each user: at time 0 (before the tax) and at time 1 (after the tax). This allows us to ease the interpretation of results. We do not include time fixed effect: while the results do not change, we prefer to keep this specification in order to show the generalized drop in mobile money usage. Indeed, the Post Tax_t dummy represents the time fixed effect.

We estimate the following regression:

[10]Similar results are obtained if we we assign to each user the urban index of the district where the individual resides as defined by Cattaneo et al. (2021). Indeed, there is a high correlation between urbanity index and ATM density.

$$Y_{idt} = \alpha_i + \gamma \text{Post Tax}_t + \beta \text{Post Tax}_t \times \text{High ATM density}_d + \epsilon_{idt} \tag{1}$$

where Y_{idt} is an indicator variable taking value 1 whether the individual i in district d has performed a transactions in period t, 0 otherwise. To note is that we are estimating the regression on the sample of individuals that performed a transactions in the pre-tax period: hence, Y_{i0} is always equal to 1. Results are presented in Table **??**.

Table 1: Extensive margin: performed transactions

	Extensive Margin				
	Active (1)	Sent (2)	Received (3)	Deposit (4)	Withdrawal (5)
Tax dummy$_t$	-0.374***	-0.730***	-0.708***	-0.491***	-0.399***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Tax dummy$_t$ × High ATM density$_d$	0.129***	0.127***	0.103***	0.129***	0.120***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
User FE	Yes	Yes	Yes	Yes	Yes
N. of users	1230473	496897	727099	1095198	1108445
Obs.	2460946	993794	1454198	2190396	2216890
Adj. R sq.	0.214	0.528	0.513	0.301	0.231
Mean Dep. Var. High ATM	0.755	0.396	0.394	0.638	0.721
Mean Dep. Var. Low ATM	0.626	0.270	0.292	0.509	0.601

Notes: In this table, we use the specification presented in Eq. 1 and we show how mobile money users in areas with high ATM density respond less to the introduction of the mobile money tax at the extensive margin, relatively to users in districts with low ATM density. Users in high ATM density areas are between 10% and 12% more likely to perform transaction after the tax, with respect to other users. We estimate the effect on the sample of users that were active before the tax. We provide results for being active at all, i.e. performing any type of transaction (1), and we also differentiate between different types of transactions. Column (2) show the effects on the likelihood of sending money, column (3) on receiving money, column (4) on depositing money, column (5) on withdrawing money. Standard errors are clustered at the individual level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

The γ represents the percentage drop in the number of users in low ATM density districts, while β is the differential effect on the number of users in high ATM density districts. Users in low ATM density areas are between 40% and 75% less likely to perform a given type of transactions, and urban users are more than 10% more likely to keep performing it after the tax.

While these results may appear to be in contrast with our hypothesis, it is to be noted that high ATM density areas are especially urban center, which register higher economic activity. It is hence not surprising that, at the extensive margin, urban users are more likely than rural users to remain within the system. Indeed, this measure is not indicative of the intensity of usage, as in this case it is sufficient to perform one only transaction to be identified as active.

4.1.2 Intensive margin: individual level

While the extensive margin provides a measure of the likelihood of remaining in the mobile money network, it is relevant to study the extent to which the technology is used by customers in the post-tax period. We here presents results of the same specification, using as outcome variable the average daily amount of a given type of transaction, the number of times and the share of days in which that type of transaction was performed. We however restrict the sample to those users that perform a given type of transaction both in the pre-tax and the post-tax period. The coefficient γ hence estimate the effect of the tax on individuals in low ATM density areas, for only those individuals that keep using mobile money for performing transactions of a given type. The β coefficient estimates the differential effect on users in high ATM density districts that keep using mobile money after the tax. Long story short, zeros are hence excluded. Table 2 present the results on the log average daily value of transactions. We hence interpret the coefficients as percentage change. We also show results for an additional measure, that we will further explore in next sections, which is the net deposits, i.e. the difference between deposits and withdrawals. This measures the net money that a given individual enter in the mobile money network. Since the difference between deposits and withdrawals can take negative value, we cannot log transform the outcome variable: we hence standardize it, and the interpretation changes accordingly. Again, we do not include time fixed effects in order to show the generalized negative impact of the tax on mobile money usage. As before, the Post Tax_t dummy represents the time fixed effect.

Table 2: Intensive margin: performed transactions

	Sent	Received	Deposits	Withdrawals	Net
	(1)	(2)	(3)	(4)	(5)
Tax dummy$_t$	-0.689***	-0.607***	-0.662***	-0.256***	-0.035***
	(0.006)	(0.004)	(0.003)	(0.002)	(0.000)
Tax dummy$_t$ × High ATM density$_d$	-0.103***	-0.117***	-0.040***	-0.060***	-0.004***
	(0.009)	(0.007)	(0.004)	(0.003)	(0.001)
User FE	Yes	Yes	Yes	Yes	Yes
N. of users	142522	225365	585690	691428	768061
Obs.	285044	450730	1171380	1382856	1536122
Adj. R sq.	0.438	0.349	0.407	0.448	0.225
Mean Dep. Var. High ATM	2900.033	2497.483	5883.921	5804.549	-220.917
Mean Dep. Var. Low ATM	2253.829	1849.746	4292.215	4178.469	-171.947

Notes: In this table, we use the specification presented in Eq. 1 and we show how mobile money users in high ATM density districts respond to the introduction of the mobile money tax at the intensive margin, relatively to users in low ATM density districts. High-ATM-density users transact between 4% and 12% less with respect to low-ATM-density users, after the tax. We estimate the effect on the sample of users that performed transactions of a given type before and after the tax. Column (1) show the effects on the amount of mobile money sent, column (2) on the amount received, column (3) on the amount deposited, column (4) on the amount withdrawn. For columns (1)-(4) outcome variables are the log of the average daily amount. In column (5) we use as outcome variable the standardized value of the difference between deposits and withdrawals. Standard errors are clustered at the individual level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table 2 shows that, conditional on keeping performing a transaction, high-ATM-density users reduce the average amount transacted daily by between 4% and 12%. These results are further confirmed by looking at the number of transactions and the share of days in which transactions are made. High-ATM-density users decrease significatively their usage at all levels. In Online Appendix A: Additional Tables, Tables A.1 and A.2 present results for the daily average number of transactions and for the share of days in which a type of transaction is performed.

We complement the analysis on the intensive margin adopting a difference-in-differences and an event study approach using monthly level data at the individual level. So, in this case, t will identify a month. Results from the following difference-in-differences are qualitatively similar to the ones already shown.

$$Y_{idt} = \alpha_i + \alpha_t + \beta \text{Post Tax}_t \times \text{High ATM density}_d + \epsilon_{idt} \tag{2}$$

In Online Appendix A: Additional Tables, Tables A.3, A.4 and A.5 we respectively show the results for the average daily value of transactions in a month, the log average daily number of transactions in a month, and the share of days in which a transaction is performed in a month.

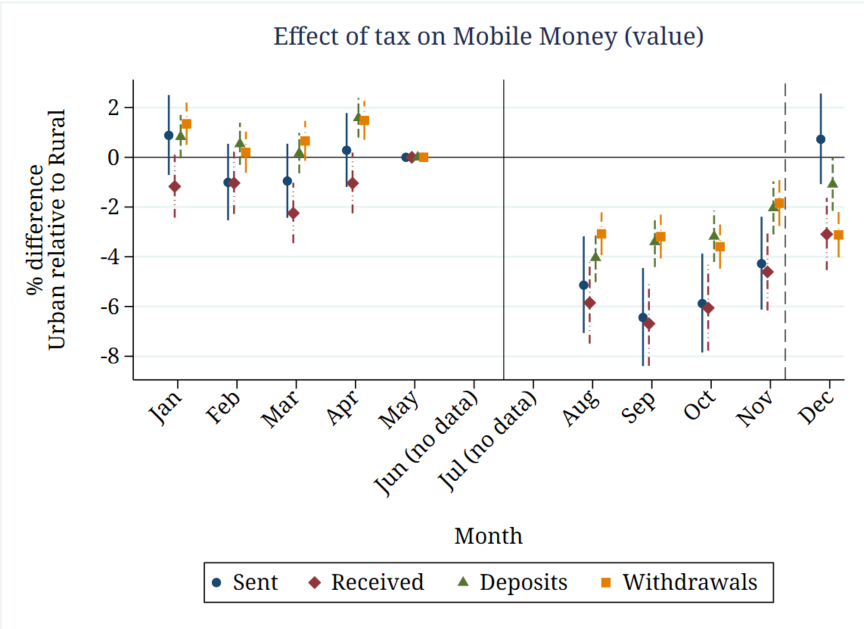
Below, in Figure 3 we show results for the following event study on the log average daily value transacted in a month.

$$Y_{idt} = \alpha_i + \alpha_t + \sum_{\tau=1,\tau\neq 5}^{T} \beta_\tau \text{Month}_\tau \times \text{High ATM density}_d + \epsilon_{idt} \tag{3}$$

We use May as the baseline category and exclude June and July from the analysis because of issue in data for that time period due to an IT change in the data collection system of Mobile Money operators. Outcome variables are the same as the ones listed above, we here only show the results on the log value of average daily transactions in a month.

These two specifications, however, come with no ease interpretation. Hence, it is worthwhile to spend a few words describing the structure of the dataset and the meaning of the estimated coefficients. Also in this case we are estimating the intensive margin, this means that we observe no value (missing) for when no transaction is made by the user. Users can however potentially transact every month. The first issue hence derives by the fact that users might be different in the timing of their transactions (i.e. user i might transact in April and August, while user j might transact in May, September and November). Including individual fixed effects hence controls for patterns of transactions: we are hence estimating the effect within individuals that make transactions in the same months. Months fixed effects instead clear out month specific differences. For the difference-in-differences, the β represents the average effect of the tax on otherwise similar high-ATM-density users with respect to low-ATM-density users. The β_τ's in the event study, instead, represent the average difference in the outcome of otherwise similar high-ATM-density users with respect to low-ATM-density users within a given month. Figure B.5 also shows results for the average number of transactions and the share of days. In both figures, we already express the y-axis in percentage change.

Figure 3: Differential effect of the tax on users in high ATM density districts



Notes: This figure plots the coefficients β of the event study described in Eq. 3. We use as outcome variable the log of average daily value of mobile money transactions in a month at the individual level. We differentiate between type of transactions. We already express the y axis in terms of % change. We use May as the baseline month. Data for June and July are excluded due to issues with data collection. Standard errors are clustered at the individual level, and the figure reports 95% confidence interval.

4.2 Banking agents: Adoption of a new banking technology at district level

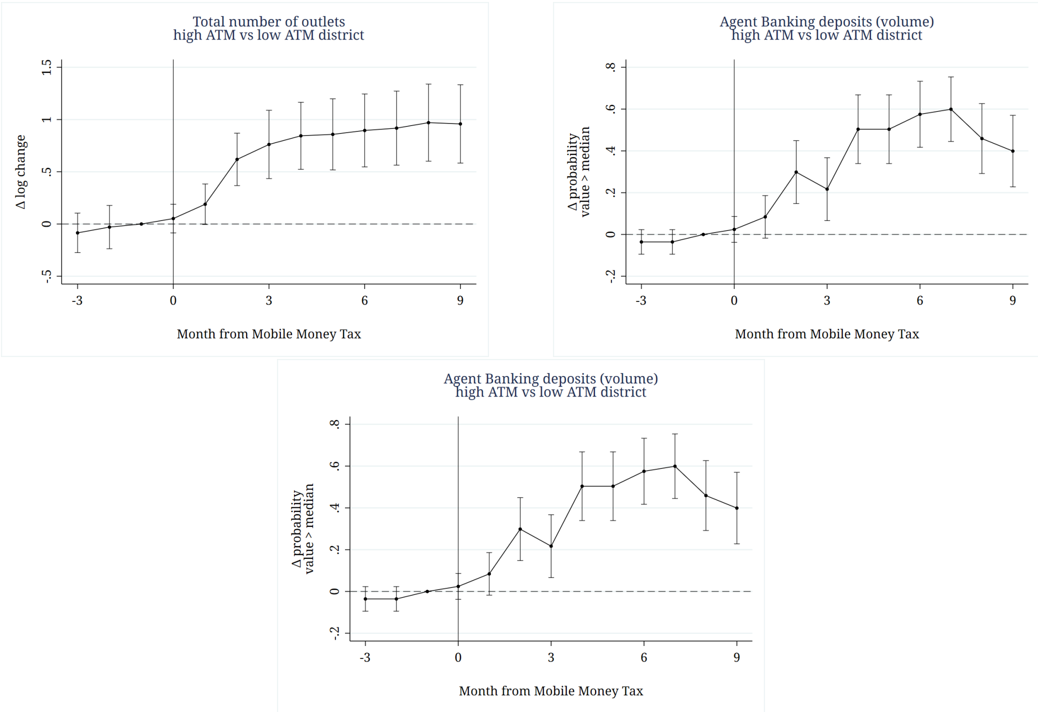
The introduction of the Mobile Money tax made it less convenient to use Mobile Money with respect to other techologies that facilitate the exchange of money. Corroborating the findings of Crouzet et al. (2019), we show that the adoption of Banking Agents increased persistently as a response to the contraction registered by mobile money after the tax. As explained, banking agents are a technology that allows the execution of bank-related activity, such as transactions, in the fashion of branchless banking. The adoption of this technology is highly demand driven: indeed, it is not the bank who decides where to open a new banking agents. Like mobile money agents, it is merchants or individuals themselves who decide whether to start offering this service. While the bear the fixed costs needed to start such activity, the earn a fee on each transaction they perform for the bank.

In this subsection, we present evidence that the spread of banking agents spurred after the introduction of the mobile money tax. This is particularly true in districts with ATM density. These results are justified by the complementary that might arise between banking agents and ATMs. Indeed, banking agents have more incentive to open where the users are already acquainted to the banking system or where there is a pervasive access to ATMs, that facilitate the withdrawal and deposit of cash.

We first propose an event study to show the differential increase between high and low ATM-density districts in the number of new banking agents, and in the value and volume of deposits. We show the results of the following in Figure 4:

$$Y_{dt} = \alpha_d + \alpha_t + \sum_{\tau=-3,\tau\neq-1}^{10} \beta_\tau \text{Month}_\tau \times \mathbf{1}\left[\text{High ATM density}\right]_d + \epsilon_{dt} \tag{4}$$

Figure 4: Banking agents: high- vs low-ATM density



Notes: In this panel we plot the coefficients of Eq. 4, where we use as outcome variable the log number of banking agents (top left), a dummy for banking agents' deposits volume (top right) and value (bottom) above median. All outcome variables are at the district level. The plotted coefficient represents the differential between high- and low-ATM density district, with respect to the reference period. We use as reference the month before the introduction of the mobile money tax. Standard errors are clustered at the bank level and we report 90% confidence intervals.

In Table 3 we present results from the following difference-in-differences:

$$Y_{dmy} = \alpha_d + \alpha_{my} + \beta \text{Post Tax}_{my} \times \mathbf{1}\left[\text{High ATM density}\right]_d + \epsilon_{dmy} \tag{5}$$

where the observations are the district d, month m in year y level. The outcome Y is either the volume and value of deposits to banking agents. We use three different specification outcome variable in order to overcome the issue related to the presence of zeros as described in Chen and Roth (2023): as suggested in the paper, we express the outcome variable in level, log, or as a dummy indicating values above and below the median.

Table 3: Banking agents deposits

	Volume			Value		
	Δ Level ('000) (1)	Δ Log (2)	Δ Pr > median (3)	Δ Level ('000) (4)	Δ Log (5)	Δ Pr > median (6)
Tax dummy$_t$ $\times$ High ATM density$_c$	0.323**	2.164***	0.390***	0.098*	6.748***	0.395***
	(0.142)	(0.369)	(0.064)	(0.050)	(1.271)	(0.066)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1495	1495	1495	1495	1495	1495
Adj. R sq.	0.484	0.683	0.528	0.500	0.664	0.539
Mean Dep. Var.	0.076	1.098	0.146	0.023	4.863	0.157

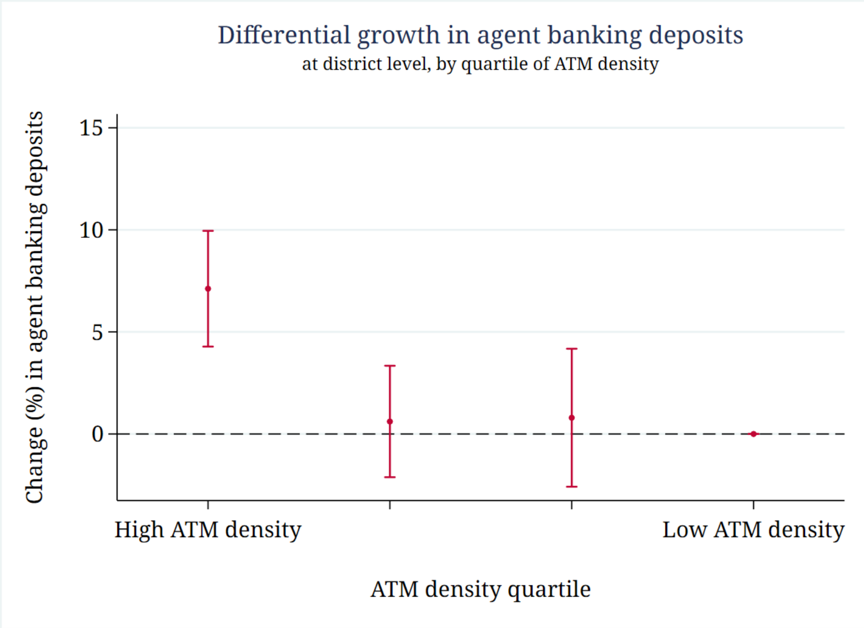
Notes: This table reports the coefficients of Eq. 5. The outcome variables are the number and the value of deposits made by customers to Banking Agents. They are expressed in level, log, or as a dummy indicating whether the value is below or above the median as proposed in Chen and Roth (2023). Time and district FEs are included. Standard errors are clustered at the district level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

We also show results by quartile of ATM density, exploiting the following specification:

$$Y_{dmy} = \alpha_d + \alpha_{my} + \sum_{i=1}^{4} \beta_i \mathbf{1}_i \left[\text{ATM density}_d\right] \times \text{Post}_{my} + \epsilon_{dmy} \tag{6}$$

where our unit of observation is the district and where we control for time and district FEs. The reference category is the group of district in the lowest quartile of ATM density distribution.

Figure 5: Differential effect of the tax on cash issued in urban branches



Notes: This figure reports the coefficients of Eq. 6. The outcome variable is the monthly (log) value of deposits to banking agents in a given district. The unit of observation is the district. We include district and time FEs. The omitted category of reference is the group of districts in the lowest quartile of the ATM-density distribution. Standard errors are clustered at the district level. We include indicate significance at the 90% confidence interval.

4.3 Increased usage of banking

In this subsection, we present evidence at the bank level. We confirm the results in the previous subsection, by showing that the number of agents increases more for those banks with a higher share of ATMs. Again, this corroborate the hypothesis that banking agents benefit from the presence of other bank-related technologies. Being the individual merchant who decides with which bank to open the banking agent, we show that more pervasive banks are the ones registering the higher growth in banking agents. This reinforces the usage of ATMs themselves: we show that after the mobile money tax the value of ATM withdrawals for a given bank increases in the pervasiveness of its ATMs.

We estimate the following:

$$Y_{bqy} = \alpha_b + \alpha_{qy} + \beta \text{Post Tax}_{qy} \times \mathbf{I}\left[\text{ATM market share}\right]_b + \epsilon_{bqy} \tag{7}$$

where the unit of observation is bank b in quarter q in year y. The coefficient β express the differential change in the outcome after the tax for districts in the highest quartile of the ATM density distribution with respects to all other districts. The independent variable ATM market share$_b$ is defined at the bank level in the pre-policy period. It is interacted with a post-policy dummy. Bank and time FEs are included, hence all individual terms are absorbed. We report the results in Table 4, and also include the results when using as independent variable the market share of bank's ATMs.

Table 4: ATM withdrawals and number of agents

	ATM withdrawals (billion)			Number agencies ('000)		
	Level (1)	Log (2)	Log (3)	Level (4)	Log (5)	Log (6)
Post Tax × **I**[ATM Market share]	0.034**	0.028**		1.309**	0.658***	
	(0.015)	(0.012)		(0.481)	(0.186)	
Post Tax × Market share of urban ATMs			0.003***			0.056***
			(0.000)			(0.007)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	263	263	263	264	264	264
Adj. R sq.	0.981	0.984	0.991	0.639	0.679	0.738
Mean Dep. Var.	0.025	0.025	0.025	0.007	0.007	0.007

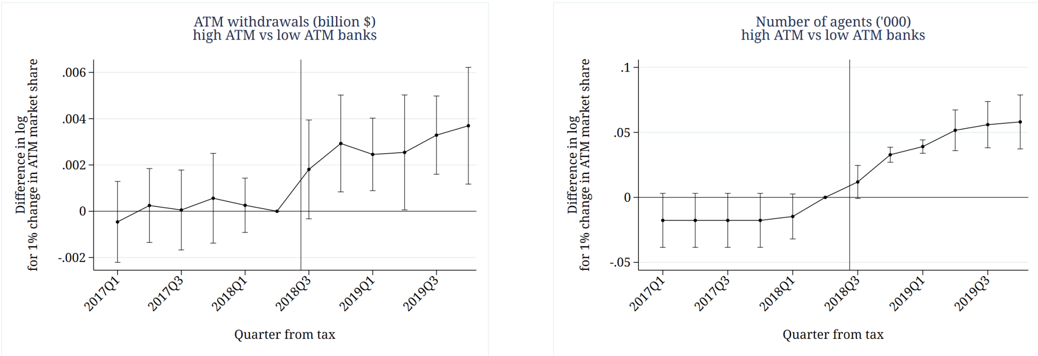
Notes: This table reports the coefficients of Eq. 7. The outcome variables are the value of ATM withdrawals (in billion UGX) and the number of banking agents. The unit of observation is the private bank at quarterly level. We control for bank and time FEs. Standard errors are clustered at the bank level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Eventually, we also provide event study evidence exploiting the following:

$$Y_{bt} = \alpha_b + \alpha_{qy} + \sum_{\tau=-6,\tau\neq-1}^{6} \beta_\tau \text{Quarter}_\tau \times \text{ATM Market share}_b + \epsilon_{bqy} \tag{8}$$

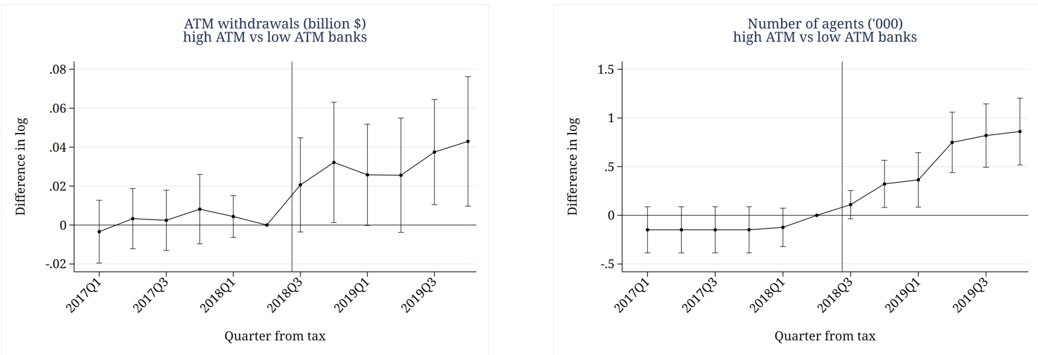
We show the results in Figure 6. We interpret the coefficient as the differential change in the log outcome for 1% higher ATM market share, with respect to the quarter before the introduction of the mobile money tax. In Figure 7

Figure 6: Bank's ATM market share, ATM withdrawals and banking agents



Notes: In this panel we plot the coefficients of Eq. 8, where we use as outcome variable the log number of banking agents (right) and the value of ATM withdrawals. All outcome variables are at the bank level. The plotted coefficient represents the differential change in the outcome for 1% higher ATM market share, with respect to the reference period. We use as reference the quarter before the introduction of the mobile money tax. Standard errors are clustered at the bank level and we report 90% confidence intervals.

Figure 7: Bank's ATM market share, ATM withdrawals and banking agents



Notes: In this panel we plot the coefficients of Eq. 8, where we use as outcome variable the log number of banking agents (right) and the value of ATM withdrawals. All outcome variables are at the bank level. In this case, we use as independent variable a dummy indicating whether the bank is in the highest quartile of the ATM market share distribution. The plotted coefficient represents the differential change in the outcome for banks with high relatively to banks with low ATM market share, with respect to the reference period. We use as reference the quarter before the introduction of the mobile money tax. Standard errors are clustered at the bank level and we report 90% confidence intervals.

4.4 Cash

We present evidence that district with high ATM density present an increased demand of physical cash. These results further corroborates the hypothesis that mobile money is substituted by bank deposits and cash after the introduction of the tax. Banks are used for money storage through banking agents, ATMs register an increase in withdrawals, and physical cash is now used for transaction.

We use data from issuance of cash from the Central Bank to private banks. While data on cash withdrawals at the individual branch do not exist, we exploit data at the bank-district level. We use data from 29 banks in 10 different districts. We define the bank-district pairs as branches. We use monthly data spanning from 2017 to 2022.

We exploit the following difference-in-differences specification, where we include the interactions between the post tax dummy and a dummy identifying those districts in the highest quartile of the ATM density distribution. This means that all branches within the same district will register the same ATM density. We exploit the following difference-in-differences:

$$\mathrm{Y}_{bdmy} = \alpha_{bd} + \alpha_{my} + \beta \text{Post Tax}_{my} \times \mathbf{1}[\text{High ATM density}]_d + \epsilon_{bdmy} \tag{9}$$

where the outcome variable is the growth rate of the value of notes issued to bank b in district d. Our preferred specification contains bank-district-month FE that account for seasonality, bank-district FE that allow comparison of the same branch, and time FEs that allow comparison between branches within the same period.

Table 5: Cash issuance

	Log cash withdrawn	
	(1)	(2)
Post Tax_t × High ATM density $_d$	0.304***	0.231***
	(0.061)	(0.055)
Branch FE	Yes	Yes
Time FE	Yes	Yes
District × Month FE		Yes
Obs.	2622	2622
Adj. R sq.	0.543	0.542
Mean Dep. Var.	21.745	21.745

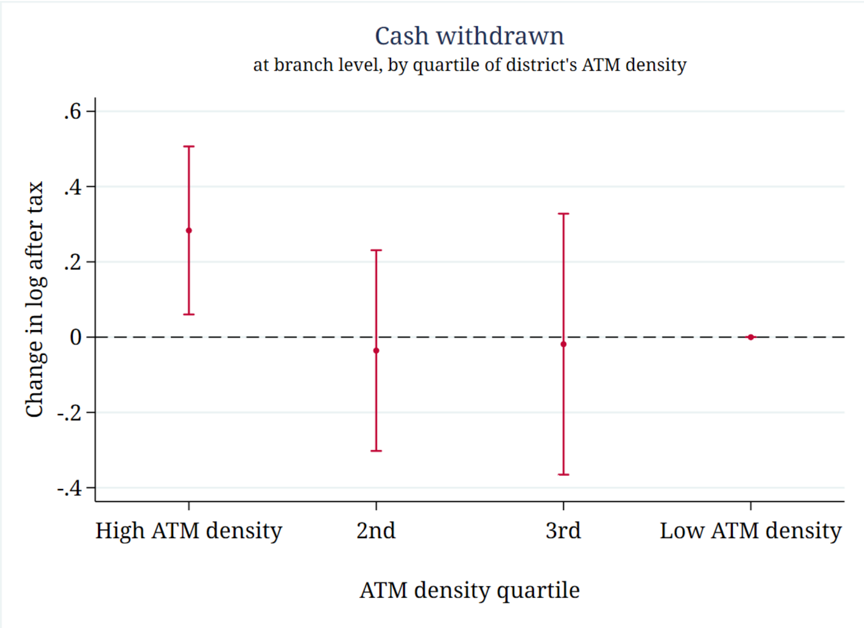
Notes: This table reports the coefficients of Eq. 9. The outcome variable is the log value of cash issued by the Central Bank to private banks. The unit of observation is the private bank-district pair, that we define as branch. We control for branch and time FEs in column (1), and add branch-month FEs in column (2) to account for seasonality. Standard errors are clustered at the district level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Figure 8 shows the difference in the log of cash issued at the bank-district level. We plot the coefficients of an equation similar to Eq. 6:

$$Y_{bdqy} = \alpha_{bd} + \alpha_{qy} + \sum_{i=1}^{4} \beta_i \mathbf{1}_i \text{ATM density quartile}_d \times \text{Post}_{qy} + \epsilon_{bdqy} \tag{10}$$

The coefficient represent the change in log cash withdrawn after the policy at the branch level after, with respect to the group of branches in the districts in the lowest quartile of ATM density distribution.

Figure 8: Differential effect of the tax on cash issued in urban branches



Notes: This figure reports the coefficients of Eq. 10. The outcome variable is the log value of cash issued by the Central Bank to private banks. The unit of observation is the private bank-district pair, that we define as branch. We include branch FE and quarter FE. Standard errors are clustered at the district level. We include 95% confidence interval.

5 Results on Credit

The imposition of the mobile money tax has engendered a multifaceted economic transformation. The discernible outcome of the tax has been a substantial reduction in the usage of mobile money services, precipitating a noteworthy exodus of funds from the mobile money system. Users, reacting strategically to the tax burden, have exhibited a pronounced reduction of the usage of mobile money, likely in favor of other means of payment, such as cash.

The consequence of this shift has been twofold: a surge in traditional banking activities and heightened liquidity within the banking sector. As shown in Section 4.2, the surge in banking agents has emerged as a profitable alternative to mobile money services. This has led to a discernible increase in both the number of banking agents and volume/value of deposits to banking agents.

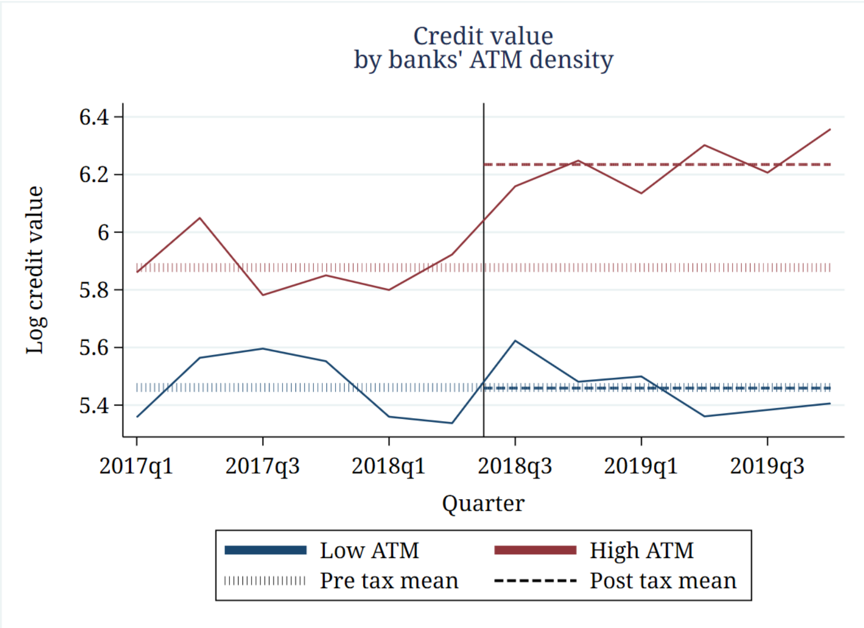
However, the newfound liquidity within the banking system is likely to be exceptionally volatile. Individuals, while utilizing banking agents for secure fund storage, overwhelmingly favor cash for transactions, a behavior validated by a concurrent rise in ATM withdrawals. This liquidity volatility has prompted banks to adopt risk management strategies in their lending practices.

Our results show that banks have selectively increased lending to established customers with a demonstrated low risk of default. Conversely, lending to new customers, particularly those perceived as high risk, has contracted. To mitigate the potential risk of defaults, banks have raised interest rates for high-risk borrowers and shortened repayment terms. This cautious lending approach aligns with theoretical frameworks outlined in Berger and Bouwman (2015), illustrating how banks adapt their lending behavior in response to external shocks.

This intricate interplay between taxation, user behavior, and banking dynamics highlights the nuanced challenges within the financial ecosystem. Furthermore, the ongoing public discourse surrounding the mobile money tax introduces an element of uncertainty. The prevailing uncertainty in tax policy may influence user behavior Gulen and Ion (2016)and potentially lead to a reversion to mobile money. This complex landscape underscores the need for adaptive financial policies that can navigate the evolving dynamics of user preferences and regulatory frameworks.

In this section, we exploit data from the Uganda credit registry to study the behavior of banks in lending. We first show that in the first year and a half following the mobile money tax, lending from banks who were more exposed to liquidity shock increases by the equivalent of US $ 100 million. We identify these banks as the ones with the highest ATM density. As shown in previous results in Section 5, banks with the higher share of ATMs are also the ones experience the highest increase in banking agents, and hence in banking agents' deposits. Figure 9 plots the log of credit granted by banks with high and low ATM market share, before and after the introduction of the mobile money tax. We see an increase in the total level of lending in the quarters following the tax for banks with high ATM share.

Figure 9: Differential effect of the tax on cash issued in urban branches



Notes: This figure reports the coefficients of Eq. 10. The outcome variable is the log value of cash issued by the Central Bank to private banks. The unit of observation is the private bank-district pair, that we define as branch. We include branch FE and quarter FE. Standard errors are clustered at the district level. We include 95% confidence interval.

We propose an analysis adopting the methods proposed by Khwaja and Mian (2008) for estimating the bank-lending channel. Our data have the following structure: for each bank, district and quarter we manage to identify those loans provided to customers with or without credit history and who are defined are low or high risk. The credit registry is comprehensive, and banks share customers' information. Hence, we manage to identify those customers who had previous credit relations with any bank. We hence study the distributional effect of the tax on credit by banks using the following regression:

$$Y_{bdt} = \alpha_b + \alpha_{dt} + \text{Post Tax}_t \times \mathbf{I}\left[\text{ATM market share}\right]_b + \epsilon_{bdt} \tag{11}$$

where Y_{bdt} is the outcome variable defined at bank b in district d at time t. The independent variable is the interaction between a post-policy dummy and an indicator variable taking value 1 for those banks in the upper quartile of the distribution of ATMs market share. We include bank and district-time FEs.

The regression is run for different groups of borrowers separately. In Table 6 we report the results for the log amount of loans provided by banks

Table 6: Log amount lent

	w/ Credit history		w/o Credit History	
	Low risk (1)	High risk (2)	Low risk (3)	High risk (4)
Tax dummy$_{qy}$ $\times$ $\mathbf{I}\left[\text{ATM share}\right]_b$	0.152**	-0.027	-0.023	-0.043***
	(0.063)	(0.037)	(0.026)	(0.013)
Bank FE	Yes	Yes	Yes	Yes
District-Time FE	Yes	Yes	Yes	Yes
N. of banks	26	22	26	21
Adj. R sq.	0.372	0.329	0.357	0.141
Mean Dep. Var.	0.251	0.059	0.189	0.034

Notes: This table reports the coefficients of Eq. 11. The outcome variable is the log amount lent by private banks. Observations are defined at the bank, district, time level. We include bank and district-time FEs. Standard errors are clustered at the district level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

We then provide evidence for the interest rate in Table 7 and the term of repayment in Table 8.

Table 7: Interest rate on loans

	w/ Credit history		w/o Credit History	
	Low risk (1)	High risk (2)	Low risk (3)	High risk (4)
Tax dummy$_{qy}$ $\times$ $\mathbf{I}$[ATM share]$_b$	0.681	5.130**	-2.966	3.588***
	(4.063)	(1.905)	(2.004)	(0.699)
Bank FE	Yes	Yes	Yes	Yes
District-Time FE	Yes	Yes	Yes	Yes
N. of banks	26	22	26	21
Adj. R sq.	0.892	0.725	0.831	0.750
Mean Dep. Var. High ATM	22.690	26.240	23.460	26.964

Notes: This table reports the coefficients of Eq. 11. The outcome variable is the interest rate applied on loans provided by private banks. Observations are defined at the bank, district, time level. We include bank and district-time FEs. Standard errors are clustered at the district level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table 8: Log term of repayment

	w/ Credit history		w/o Credit History	
	Low risk (1)	High risk (2)	Low risk (3)	High risk (4)
Tax dummy$_{qy}$ $\times$ $\mathbf{I}$[ATM share]$_b$	-2.240***	-0.875	-2.223***	-0.803**
	(0.654)	(0.543)	(0.638)	(0.327)
Bank FE	Yes	Yes	Yes	Yes
District-Time FE	Yes	Yes	Yes	Yes
N. of banks	26	22	26	21
Adj. R sq.	0.923	0.719	0.907	0.691
Mean Dep. Var.	5.966	5.874	6.138	6.179

Notes: This table reports the coefficients of Eq. 11. The outcome variable is the log term of repayment of loans provided by private banks. Observations are defined at the bank, district, time level. We include bank and district-time FEs. Standard errors are clustered at the district level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

6 Conclusions

References

Agarwal, S., S. Chomsisengphet, C. Liu, C. Song, and N. S. Souleles (2018): "Benefits of relationship banking: Evidence from consumer credit markets," *Journal of Monetary Economics*, 96, 16–32.

Agur, I., A. Ari, and G. Dell'Ariccia (2022): "Designing central bank digital currencies," *Journal of Monetary Economics*, 125, 62–79.

Aker, J. C., S. Prina, and C. J. Welch (2020): "Migration, money transfers, and mobile money: Evidence from Niger," in *AEA Papers and Proceedings*, vol. 110, 589–93.

Andolfatto, D. (2021): "Assessing the impact of central bank digital currency on private banks," *The Economic Journal*, 131, 525–540.

Babina, T., G. Buchak, and W. Gornall (2022): "Customer data access and fintech entry: Early evidence from open banking," .

Bachas, P., P. Gertler, S. Higgins, and E. Seira (2018): "Digital financial services go a long way: Transaction costs and financial inclusion," in *AEA Papers and Proceedings*, American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203, vol. 108, 444–448.

Balyuk, T. and E. Williams (2021): "Friends and family money: P2p transfers and financially fragile consumers," *Available at SSRN 3974749*.

Banerjee, R. N., L. Gambacorta, and E. Sette (2021): "The real effects of relationship lending," *Journal of Financial Intermediation*, 48, 100923.

Beaumont, P., H. Tang, and E. Vansteenberghe (2022): "The role of fintech in small business lending," *Available at SSRN 4260842*.

Beck, T., H. Degryse, R. De Haas, and N. Van Horen (2018): "When arm's length is too far: Relationship banking over the credit cycle," *Journal of Financial Economics*, 127, 174–196.

Berger, A. N. and C. Bouwman (2015): *Bank liquidity creation and financial crises*, Academic Press.

Berlin, M. and L. J. Mester (1999): "Deposits and relationship lending," *The Review of Financial Studies*, 12, 579–607.

Bian, W., L. W. Cong, and Y. Ji (2023): "The Rise of E-Wallets and Buy-Now-Pay-Later: Payment Competition, Credit Expansion, and Consumer Behavior," Tech. rep., National Bureau of Economic Research.

Blumenstock, J. E., N. Eagle, and M. Fafchamps (2016): "Airtime transfers and mobile communications: Evidence in the aftermath of natural disasters," *Journal of Development Economics*, 120, 157–181.

Breza, E., M. Kanz, and L. F. Klapper (2022): "Learning to navigate a new financial technology: Evidence from payroll accounts," Tech. rep., National Bureau of

Economic Research.

Brunnermeier, M. K., H. James, and J.-P. Landau (2019): "The digitalization of money," Tech. rep., National Bureau of Economic Research.

Brunnermeier, M. K., N. Limodio, and L. Spadavecchia (2023): "Mobile Money, Interoperability and Financial Inclusion," Tech. rep.

Brunnermeier, M. K. and D. Niepelt (2019): "On the equivalence of private and public money," *Journal of Monetary Economics*, 106, 27–41.

Buchak, G., G. Matvos, T. Piskorski, and A. Seru (2018): "Fintech, regulatory arbitrage, and the rise of shadow banks," *Journal of financial economics*, 130, 453–483.

Cattaneo, A., A. Nelson, and T. McMenomy (2021): "Global mapping of urban–rural catchment areas reveals unequal access to services," *Proceedings of the National Academy of Sciences*, 118, e2011990118.

Chen, J. and J. Roth (2023): "Logs with zeros? Some problems and solutions," *The Quarterly Journal of Economics*, qjad054.

Chiu, J., S. M. Davoodalhosseini, J. Jiang, and Y. Zhu (2023): "Bank market power and central bank digital currency: Theory and quantitative assessment," *Journal of Political Economy*, 131, 1213–1248.

Chodorow-Reich, G., G. Gopinath, P. Mishra, and A. Narayanan (2020): "Cash and the economy: Evidence from India's demonetization," *The Quarterly Journal of Economics*, 135, 57–103.

Choudhary, M. A. and N. Limodio (2022): "Liquidity risk and long-term finance: Evidence from a natural experiment," *The Review of Economic Studies*, 89, 1278–1313.

Crouzet, N., A. Gupta, and F. Mezzanotti (2019): "Shocks and technology adoption: Evidence from electronic payment systems," .

Demirguc-Kunt, A., L. Klapper, D. Singer, and S. Ansar (2018): *The Global Findex Database 2017: Measuring financial inclusion and the fintech revolution*, World Bank Publications.

Di Maggio, M. and V. Yao (2021): "Fintech borrowers: Lax screening or cream-skimming?" *The Review of Financial Studies*, 34, 4565–4618.

Duarte, A., J. Frost, L. Gambacorta, P. Koo Wilkens, and H. S. Shin (2022): "Central banks, the monetary system and public payment infrastructures: lessons from Brazil's Pix," *Available at SSRN 4064528*.

Dubey, T. S. and A. Purnanandam (2023): "Can Cashless Payments Spur Economic Growth?" *Available at SSRN 4373602*.

Duffie, D. (2019): "Digital currencies and fast payment systems: Disruption is coming," in *Asian Monetary Forum, May, mimeo*.

Dupas, P., D. Karlan, J. Robinson, and D. Ubfal (2018): "Banking the unbanked? Evidence from three countries," *American Economic Journal: Applied Economics*, 10, 257–297.

Erel, I. and J. Liebersohn (2022): "Can FinTech reduce disparities in access to finance? Evidence from the Paycheck Protection Program," *Journal of Financial Economics*, 146, 90–118.

Ferrari, S., F. Verboven, and H. Degryse (2010): "Investment and usage of new technologies: Evidence from a shared ATM network," *American Economic Review*, 100, 1046–1079.

Gulen, H. and M. Ion (2016): "Policy uncertainty and corporate investment," *The Review of Financial Studies*, 29, 523–564.

Higgins, S. (2020): "Financial Technology Adoption: Network Externalities of Cashless Payments in Mexico," *American Economic Review forthcoming.*

Jack, W., A. Ray, and T. Suri (2013): "Transaction networks: Evidence from mobile money in Kenya," *American Economic Review*, 103, 356–361.

Jack, W. and T. Suri (2011): "Mobile money: The economics of M-PESA," Tech. rep., National Bureau of Economic Research.

——— (2014): "Risk sharing and transactions costs: Evidence from Kenya's mobile money revolution," *American Economic Review*, 104, 183–223.

Keister, T. and D. Sanches (2023): "Should central banks issue digital currency?" *The Review of Economic Studies*, 90, 404–431.

Khwaja, A. I. and A. Mian (2008): "Tracing the impact of bank liquidity shocks: Evidence from an emerging market," *American Economic Review*, 98, 1413–1442.

Lees, A. and D. Akol (2021): "There and back again: the making of Uganda's mobile money tax," .

Limodio, N. (2022): "Terrorism financing, recruitment, and attacks," *Econometrica*, 90, 1711–1742.

Meaning, J., B. Dyson, J. Barker, and E. Clayton (2018): "Broadening narrow money: monetary policy with a central bank digital currency," .

Parlour, C. A., U. Rajan, and H. Zhu (2022): "When fintech competes for payment flows," *The Review of Financial Studies*, 35, 4985–5024.

Piazzesi, M. and M. Schneider (2020): "Credit lines, bank deposits or CBDC? competition and efficiency in modern payment systems," *Unpublished, Stanford University.*

Riley, E. (2018): "Mobile money and risk sharing against village shocks," *Journal of Development Economics*, 135, 43–58.

Sarkisyan, S. (2023): "Instant Payment Systems and Competition for Deposits," .

Sette, E. and G. Gobbi (2015): "Relationship lending during a financial crisis," *Journal of the European Economic Association*, 13, 453–481.

Sockin, M. and W. Xiong (2023): "Decentralization through tokenization," *The Journal of Finance*, 78, 247–299.

Suri, T. (2017): "Mobile money," *Annual Review of Economics*, 9, 497–520.

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

Suri, T. and W. Jack (2016): "The long-run poverty and gender impacts of mobile money," *Science*, 354, 1288–1292.

Wales, C. J. and A. Lees (2020): "Report on the tax policy-making process in Uganda," Tech. rep., ODI Advisory Report.

Whitehead, A. (2018): "Uganda social media and mobile money taxes survey report," *Whitehead Communications, Kampala.*

Back to bank:

the cost of digital currency and bank competition

Online Appendix

Online Appendix A: Additional Tables

A.1 Mobile Money

A.1.1 Intensive margin: individual level

Table A.1: Intensive margin: average daily number of transactions

	Sent	Received	Deposits	Withdrawals
	(1)	(2)	(3)	(4)
Tax dummy$_t$	-0.491***	-0.452***	-0.435***	-0.253***
	(0.003)	(0.002)	(0.002)	(0.001)
Tax dummy$_t$ × High ATM density$_d$	-0.086***	-0.092***	-0.015***	-0.048***
	(0.005)	(0.004)	(0.003)	(0.002)
User FE	Yes	Yes	Yes	Yes
N. of users	142522	225365	585690	691428
Obs.	285044	450730	1171380	1382856
Adj. R sq.	0.429	0.318	0.408	0.447
Mean Dep. Var. High ATM	0.070	0.049	0.131	0.108
Mean Dep. Var. Low ATM	0.059	0.044	0.131	0.096

Notes: In this table, we use the specification presented in Eq. 1 and we show how urban mobile money users respond to the introduction of the mobile money tax at the intensive margin, relatively to rural users. Urban users perform between 2% and 6% less daily transactions with respect to rural users, after the tax. We estimate the effect on the sample of users that performed transactions of a given type before and after the tax. Column (1) show the effects on the number of transactions sent to another user, column (2) on the number of transactions received, column (3) on the number of deposits, column (4) on the number of withdrawals. Outcome variables are the log of the average daily amount. Standard errors are clustered at the individual level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table A.2: Intensive margin: share of days for transaction

	Sent	Received	Deposits	Withdrawals
	(1)	(2)	(3)	(4)
Tax dummy$_t$	-0.031***	-0.019***	-0.033***	-0.022***
	(0.000)	(0.000)	(0.000)	(0.000)
Tax dummy$_t$ × High ATM density$_d$	-0.010***	-0.006***	-0.005***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)
User FE	Yes	Yes	Yes	Yes
N. of users	156967	237653	601693	707320
Obs.	313934	475306	1203386	1414640
Adj. R sq.	0.552	0.402	0.476	0.538
Mean Dep. Var. High ATM	0.083	0.052	0.114	0.104
Mean Dep. Var. Low ATM	0.066	0.045	0.100	0.091

Notes: In this table, we use the specification presented in Eq. 1 and we show how urban mobile money users respond to the introduction of the mobile money tax at the intensive margin, relatively to rural users. Urban users transact about 0.5% less days with respect to rural users, after the tax. We estimate the effect on the sample of users that performed transactions of a given type before and after the tax. Column (1) show the effects on the share of days in which the user sent mobile money, column (2) on the share of days in which the user received mobile money, column (3) on the share of days in which the user deposited mobile money, column (4) on the share of days in which the user withdrew mobile money. Outcome variables are the log of the average daily amount. Standard errors are clustered at the individual level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table A.3: (Log) average daily value of transactions

	Sent	Received	Deposits	Withdrawals
	(1)	(2)	(3)	(4)
Tax dummy$_t$	-0.495***	-0.339***	-0.543***	-0.209***
	(0.003)	(0.003)	(0.002)	(0.001)
Tax dummy$_t$ × Urban$_c$	-0.034***	-0.037***	-0.034***	-0.037***
	(0.006)	(0.005)	(0.003)	(0.003)
User FE	Yes	Yes	Yes	Yes
Month FE	No	No	No	No
N. of users	434262	663043	1145494	1192352
Obs.	1667485	2398051	5797682	6327527
Adj. R sq.	0.494	0.408	0.452	0.446
Mean Dep. Var. Urban	1.1e+04	6630.113	1.1e+04	9155.623
Mean Dep. Var. Rural	8736.667	5446.040	8670.581	7235.526

Notes: In this table, we use the specification presented in Eq. 2 and we show how urban mobile money users respond to the introduction of the mobile money tax at the intensive margin, relatively to rural users. In this case, we are using individual-month level data, and we are exclusively employing observed transactions, i.e. we are excluding zeros and hence estimating the intensive margin. Are outcome variable, we are using the log of the average daily value transacted in a month at the individual level. Urban users transact about 3.5% less with respect to rural users, after the tax. Column (1) show the effects on the value of transactions sent to another user, column (2) on the value of transactions received, column (3) on the value of deposits, column (4) on the value of withdrawals. Outcome variables are the log of the average daily amount. Outcome variables are the log of the average daily amount. Standard errors are clustered at the individual level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table A.4: (Log) average daily number of transactions

	Sent	Received	Deposits	Withdrawals
	(1)	(2)	(3)	(4)
Tax dummy$_t$	-0.338***	-0.239***	-0.312***	-0.235***
	(0.002)	(0.001)	(0.001)	(0.001)
Tax dummy$_t$ × Urban$_c$	-0.039***	-0.027***	-0.024***	-0.028***
	(0.003)	(0.002)	(0.002)	(0.001)
User FE	Yes	Yes	Yes	Yes
Month FE	No	No	No	No
N. of users	434262	663043	1145494	1192352
Obs.	1667485	2398051	5797682	6327527
Adj. R sq.	0.449	0.308	0.491	0.397
Mean Dep. Var. Urban	0.132	0.079	0.180	0.134
Mean Dep. Var. Rural	0.111	0.073	0.179	0.122

Notes: In this table, we use the specification presented in Eq. 2 and we show how urban mobile money users respond to the introduction of the mobile money tax at the intensive margin, relatively to rural users. In this case, we are using individual-month level data, and we are exclusively employing observed transactions, i.e. we are excluding zeros and hence estimating the intensive margin. Are outcome variable, we are using the log of the average daily number of transactions in a month at the individual level. Urban users transact about 3.5% less with respect to rural users, after the tax. Column (1) show the effects on the number of transactions sent to another user, column (2) on the number of transactions received, column (3) on the number of deposits, column (4) on the number of withdrawals. Outcome variables are the log of the average daily amount. Outcome variables are the log of the average daily amount. Standard errors are clustered at the individual level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Table A.5: Share of days in a month in which transaction type is made

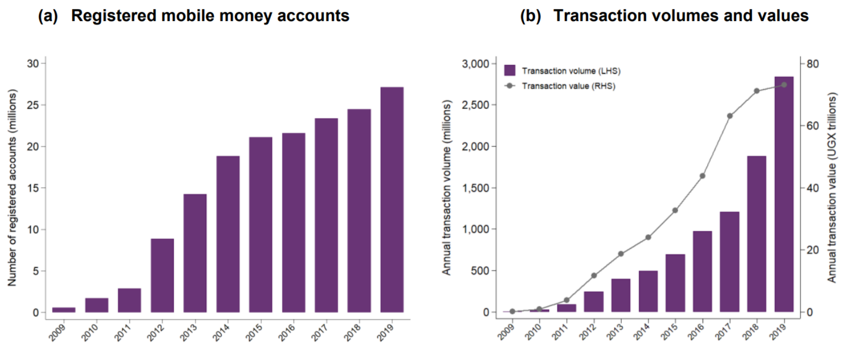
	Sent	Received	Deposits	Withdrawals
	(1)	(2)	(3)	(4)
Tax dummy$_t$	-0.034***	-0.018***	-0.033***	-0.024***
	(0.000)	(0.000)	(0.000)	(0.000)
Tax dummy$_t$ × Urban$_c$	-0.007***	-0.003***	-0.005***	-0.005***
	(0.000)	(0.000)	(0.000)	(0.000)
User FE	Yes	Yes	Yes	Yes
Month FE	No	No	No	No
N. of users	434262	663043	1145494	1192352
Obs.	1667485	2398051	5797682	6327527
Adj. R sq.	0.498	0.377	0.520	0.474
Mean Dep. Var. Urban	0.102	0.071	0.131	0.120
Mean Dep. Var. Rural	0.089	0.066	0.121	0.110

Notes: In this table, we use the specification presented in Eq. 2 and we show how urban mobile money users respond to the introduction of the mobile money tax at the intensive margin, relatively to rural users. In this case, we are using individual-month level data, and we are exclusively employing observed transactions, i.e. we are excluding zeros and hence estimating the intensive margin. Are outcome variable, we are using the share of days in a month in which the individual perfomed a given type of transaction. Urban users transact about 3.5% less with respect to rural users, after the tax. Column (1) show the effects on the share of days in which the user sent mobile money, column (2) on the share of days in which the user received mobile money, column (3) on the share of days in which the user deposited mobile money, column (4) on the share of days in which the user withdrew mobile money. Outcome variables are the log of the average daily amount. Standard errors are clustered at the individual level. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Online Appendix B: Additional Figures

B.1 Mobile Money and Tax

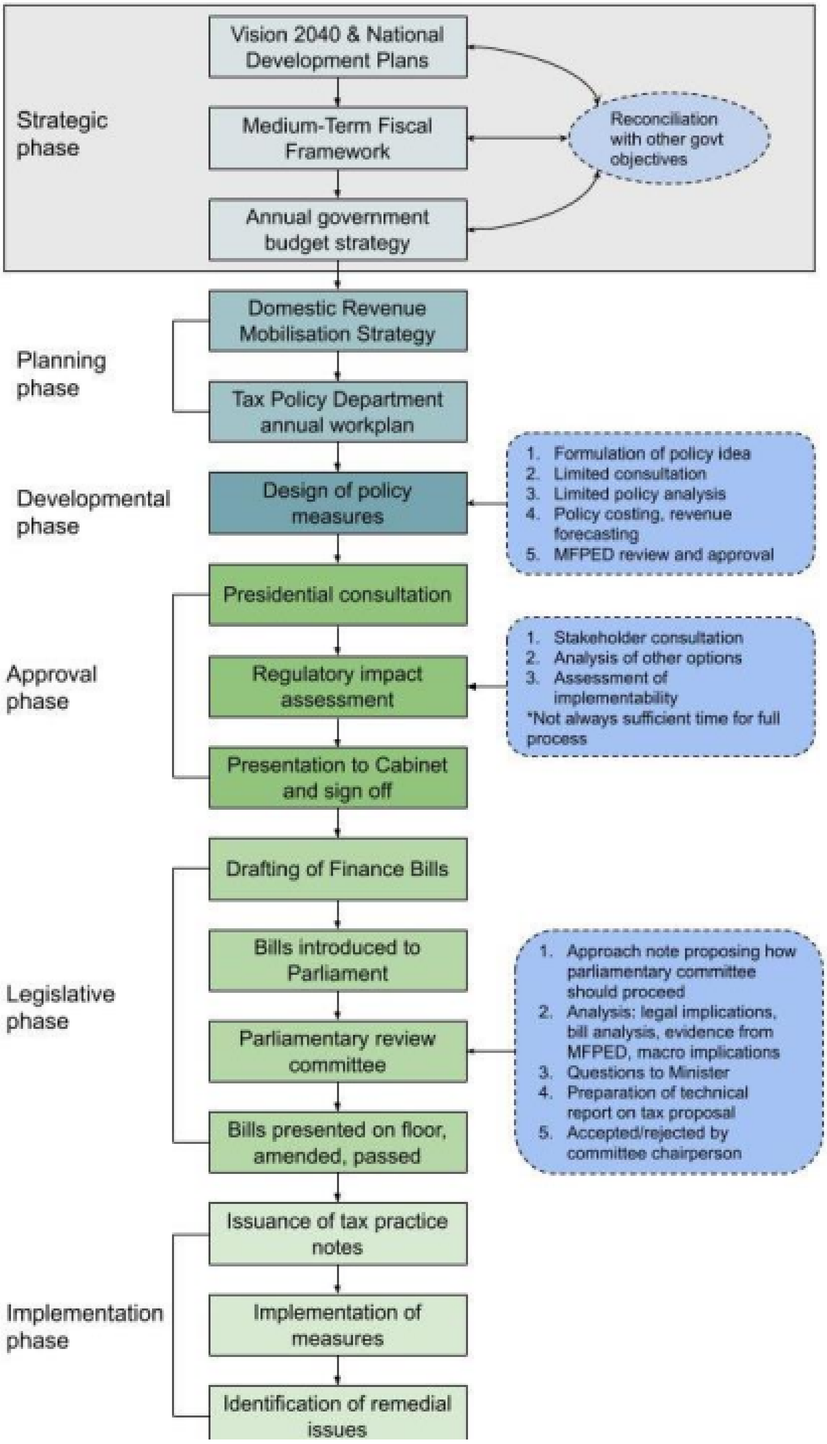
Figure B.1: Mobile volume in Uganda



Source: authors' calculations using data from the Bank of Uganda (2021).

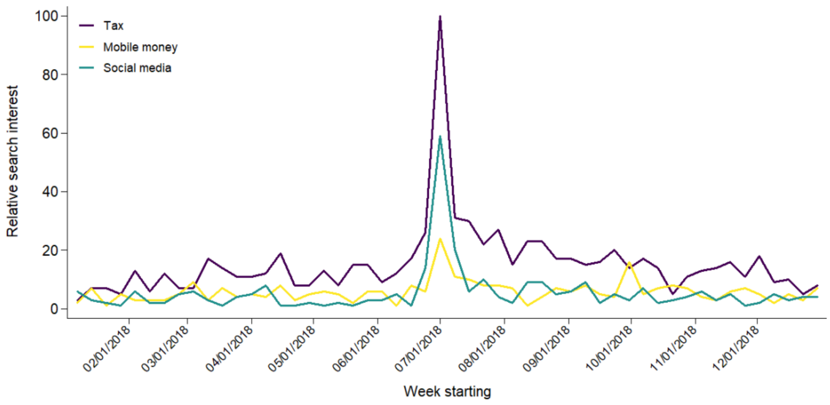
Notes: In Panel (a) we report the total number of registered users over time. In Panel (b) we show the volume (bars) and the value (line) of Mobile Money transactions in Uganda.

Figure B.2: General Tax process



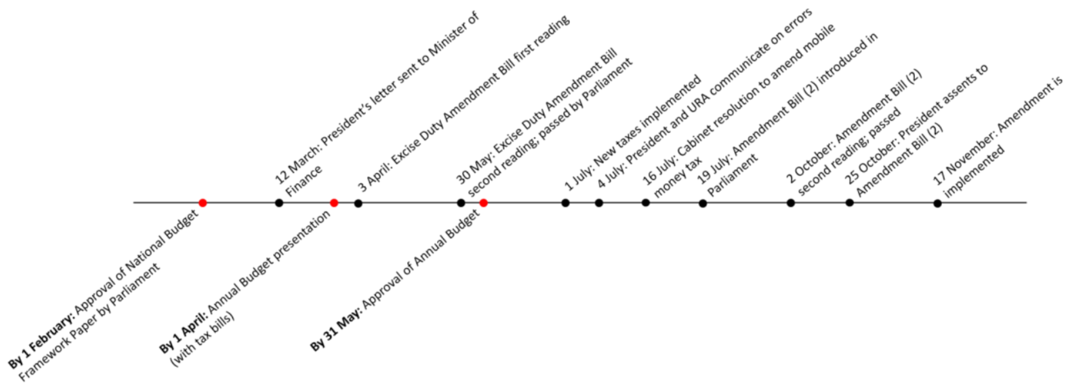
Notes: This figure presents the process for new tax approval in Uganda. As shown, there are multiple steps. These were not followed for the introduction of the mobile money tax.

Figure B.3: Google Trend for Mobile Money Tax



Notes: Google Trends gives the relative popularity of a search query for a defined location and time period. The data is indexed to 100, where 100 indicates the maximum search interest across the terms, time period, and geographical area. We assume that search indicators provide representative information about the behaviours of the literate and internet-enabled segment of the population (who may be more likely to be mobile money users). There is relatively limited interest in these terms before July, even in May when the Mobile Money tax proposals were discussed in Parliament.

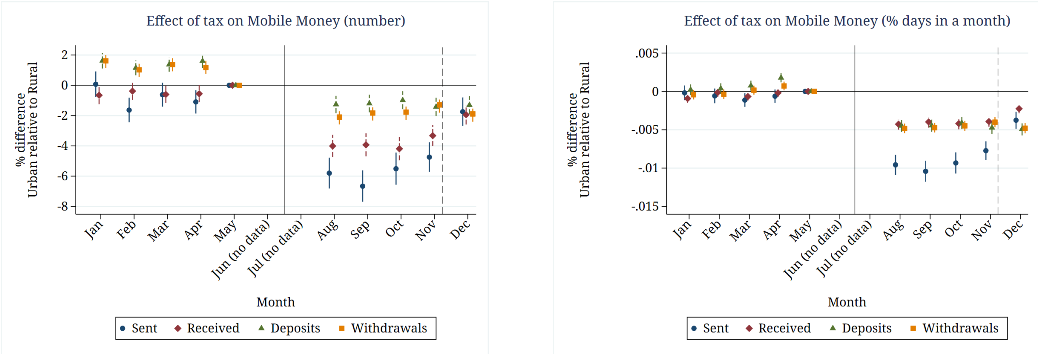
Figure B.4: Mobile Money Tax process



Notes: This figure reports the steps that led to the introduction of the Mobile Money tax in Uganda. Compared to Figure B.2, we see how the process for the introduction of this tax was extremely simplified.

B.2 Mobile Money

Figure B.5: Differential effect of the tax on urban areas

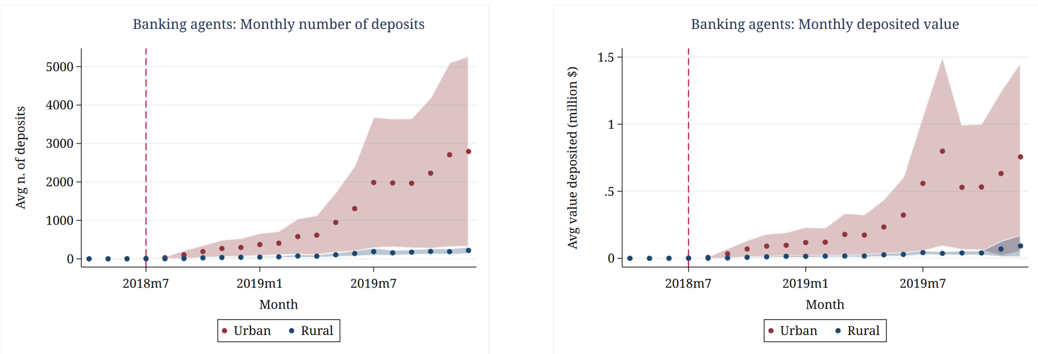


Notes: This figure plots the coefficients β of the event study described in Eq. 3. We use as outcome variable the log of the average number of mobile money transactions in a month at the individual level (left panel) and the share of days in which a given type of transaction is performed by the individual (right panel). We differentiate between type of transactions. In the left panel, we already express the y axis in terms of % change. We use May as the baseline month. Data for June and July are excluded due to issues with data collection. Standard errors are clustered at the individual level, and the figure reports 95% confidence interval.

B.3 Banking Agents

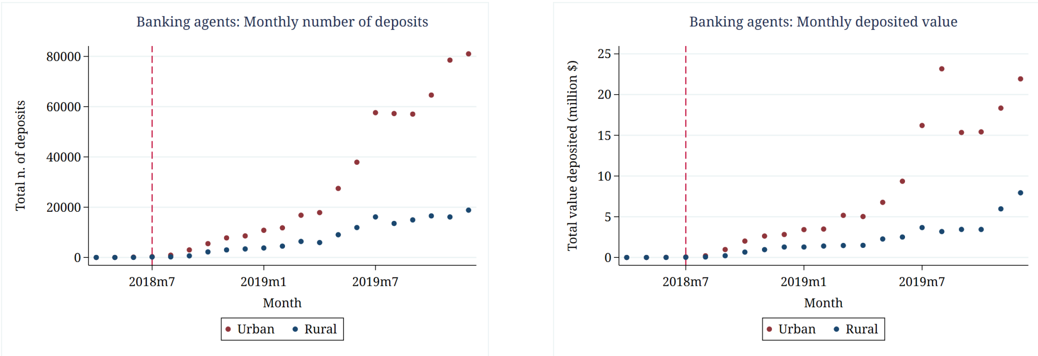
We show the time series of aggregate agent banking deposits at monthly level. While almost no activity is detected before July 2018, deposits start rising after this date.

Figure B.6: Monthly average banking agents deposits



Notes: In this panel we present the mean number of deposits (left) and the mean value of deposits (right) to banking agents in a given month. We define as Urban the first quartile of districts in the rurality index distribution. We define as Rural all remaining districts. We include confidence intervals at the 90%.

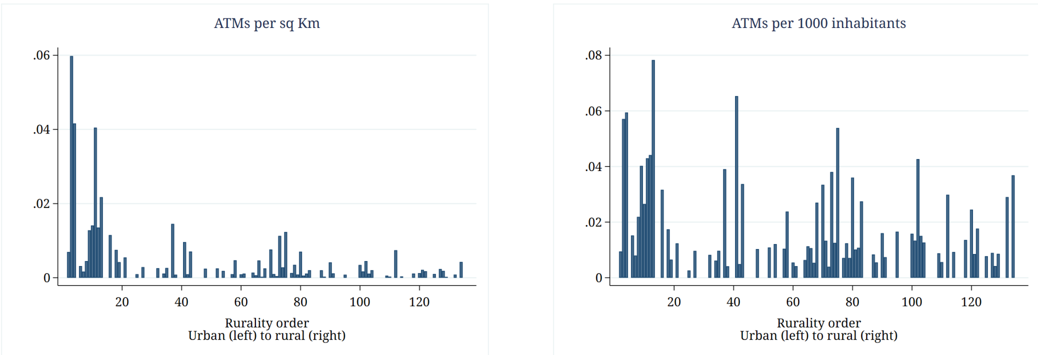
Figure B.7: Monthly total banking agents deposits



Notes: In this panel we present the total number of deposits (left) and the total value of deposits (right) to banking agents in a given month. We define as Urban the first quartile of districts in the rurality index distribution. We define as Rural all remaining districts.

B.4 Rurality and ATM density

Figure B.8: ATMs density by rurality



Notes: In this panel we present the density of ATMs per squared meters and per 100'000 inhabitants of districts. We order distrcts by their rurality index, where lower values indicate a more urban district.

Online Appendix C - Theoretical Framework