
WORKING PAPER
N. 79
JUNE 2018

Liquidity Requirements and Bank Deposits: Evidence from Ethiopia

Nicola Limodio and Francesco Strobbe

This Paper can be downloaded without charge from The Social Science
Research Network Electronic Paper Collection:
<http://ssrn.com/abstract=3191928>

Liquidity Requirements and Bank Deposits: Evidence from Ethiopia*

Nicola Limodio[†] Francesco Strobbe[‡]

June 2018

Abstract

Liquidity requirements can stimulate deposit growth by increasing depositor repayment in bad states, which can also promote lending and branching. We study an unexpected policy change which fostered the liquid assets of Ethiopian banks by 33% in 2011, and present three findings in line with this hypothesis. First, a panel of bank depositors shows deposit growth among wealthy and highly educated individuals. Second, a survey reports higher deposits in branches opened after the policy and in university cities. Third, bank balance sheets and two sources of bank exposure to the policy highlight an increase in deposits, loans and branches.

JEL CODE: G21, G38, O16

Keywords: Banking, Liquidity Requirements, Financial Development

*We are grateful for useful suggestions to Franklin Allen, Oriana Bandiera, Thorsten Beck, Philip Bond, Emily Breza, Elena Carletti, Michele Costola, Charles Calomiris, Matthieu Chavaz, Decio Coviello, Stefan Dercon, Hans Degryse, Filippo De Marco, Luis Garicano, Alessandro Gavazza, Nicola Gennaioli, Maitreesh Ghatak, Doug Gollin, Charles Goodhart, Isaac Hacamo, Boyan Jovanovic, Ross Levine, Joseph Kaboski, Alex Karaivanov, Jan Pieter Krahnen, Michael Koetter, Shiva Makki, David Martinez-Miera, Lars Christian Moller, Francesco Nava, Gianmarco Ottaviano, Daniel Paravisini, Nicola Persico, Tarun Ramadorai, Ricardo Reis, Stefano Rossi, Farzad Saidi, Isabel Schnabel, Bernd Schwaab, Janis Skrastins, John Sutton, Emanuele Tarantino, Eric Verhoogen, Guillaume Vuilleme, Annette Vissing-Jorgensen, Xavier Vives, Shengxing Zhang, and seminar participants at the Aix-Marseille School of Economics, American Finance Association 2017 Conference, Bonn University, Belgrade YEC, DIW Berlin, Empirical Financial Intermediation Workshop, Greta CREDIT, LSE, Oxford Development Economics Conference, Petralia Workshop, Society for Economic Dynamics Conference and York-MMF-BoE Workshop. This project benefited from support from the World Bank Research Support Budget and the BAFFI CAREFIN Centre at Bocconi University. We thank Raeye Daniel, Michael Demissie, Sara Demsis, Cristiana Gentea, Edoardo Marchesi, Wollanssa Tadesse and Boris Turkin for superb research assistance. We also acknowledge editorial assistance by Emma Hoyle. We are responsible for all errors, and this work does not reflect the view of the World Bank or its Executive Directors and is not an official World Bank document.

[†]nicola.limodio@unibocconi.it, www.nicolalimodio.com, Corresponding Author, Bocconi University, Department of Finance, BAFFI CAREFIN, IGIER and LEAP, Via Roentgen 1, 20136 Milan, Italy.

[‡]Fstrobbe@worldbank.org, World Bank, 1818 H Street NW, 20433, Washington D.C., USA.

Introduction

Liquidity requirements are a key regulatory tool to strengthen the banking sector and its ability to absorb financial and economic shocks ([Bank for International Settlements \(2013\)](#)). Since the global financial crisis that started in 2009, increasing attention has been on promoting the resilience of banks, and a variety of policies have been introduced to regulate bank liquidity holding. Despite substantial theoretical work on this issue, the empirical literature on the effect of such policies is limited. For example, it is unclear how such regulation affects bank funding and whether it alters asset allocation. The power of the test is a key empirical constraint: most policies of liquidity regulation are announced quarters or years before the implementation and only gradually brought into operations. This makes it difficult to track any behavioural change or, in any case, changes with sufficient statistical power to study how lending and deposits respond.

In this paper, we provide three contributions to advance the empirical literature on liquidity requirements. First, we focus on a specific class of liquidity requirement policies, which link banks' liquid assets to their overall asset composition, and propose a novel mechanism through which these policies can affect bank stability and resilience. Such regulation can promote the supply of bank deposits by increasing the liquidity of bank assets and, therefore, grow the overall balance sheet of a bank. Second, we focus on an emerging market (Ethiopia) presenting a unique policy change in liquidity requirements that is both large and unexpected. In fact, not only did this policy foster the liquid assets of Ethiopian commercial banks by 33% in one quarter, but it was also announced less than one month before implementation. These elements offer ample power to test our hypothesis and verify how bank behaviour responds to liquidity requirements. Third, we analyse four unique data sources, which allow us to explore the effects of such a policy: 1) a representative panel of depositors from one bank, which permits us to follow the same depositor four quarters before and after the policy, 2) a survey of bank deposits at branch level, which shows the opening and deposit collection across different banks and cities over time, 3) bank balance sheets at high frequency and 4) a new map containing the universe of bank branches opened in Ethiopia until 2014. Our results can be summarized through three inter-related findings. First, depositor-level results show that wealthy and educated individuals increase their deposits in the aftermath of the policy. Second, in line with

depositor-level evidence, our branch-level analysis points toward significantly higher deposits in branches that opened after the policy in university cities. Third, the bank-level study points toward a post-policy increase in deposits and the overall balance sheet, followed by more lending and branching.

Beyond the local effect of this policy, studying an emerging market can be informative about the effect of liquidity requirements in general. First, it permits us to study liquidity requirements in isolation, given that neither capital requirements nor deposit insurance are in place in Ethiopia. This may be relevant because systemic shocks can affect both the stability of banks and the fiscal capacity of governments (Beck et al. (2017)), as the 2009 global financial crisis demonstrated. For these reasons, liquidity requirements may be particularly helpful when banks' solvency may be questioned by depositors. Second, our work offers a perspective on the importance of liquidity requirements in countries that may be unable to offer deposit insurance or alternative forms of financial regulation. In fact, with the exception of those in North America and Europe, more than 50% of countries in the world present risky financial systems (Caprio and Klingebiel (2002)), do not offer deposit insurance (Demirgüç-Kunt et al. (2014)) and may therefore choose to adopt liquidity regulation to stabilize their financial system.

The country and policy of Ethiopia provide the ideal laboratory to test our hypothesis. The implementation of such regulation was also unusual, but useful for the analysis. In mid-March 2011, the Ethiopian central bank (National Bank of Ethiopia (NBE)) approved a directive on liquidity requirements obliging all private commercial banks to start purchasing 0.27 newly created NBE bills for every Ethiopian birr of private sector lending by April 2011. Such bills are liquid both because they can be exchanged with liquidity by the central bank and because, given the lack of an interbank market, they have de facto recreated an interbank system by allowing banks to transfer liquidity claims. This policy generated very large asset reallocations, with banks mobilizing 10% of their balance sheet and boosting their liquidity holding by 33% in a few weeks. The reasons behind the introduction of this policy change are multiple. On the one hand, some national and international observers, for example the International Monetary Fund,¹ argue that this regulation is intended to collect government revenue to fund the construction of a national infrastructure (Grand Ethiopian Renaissance Dam). On the other hand, the

¹Refer to International Monetary Fund (2016), available at <https://www.imf.org/external/pubs/ft/scr/2016/cr16322.pdf>.

central bank argues that this policy intends to revive the local interbank market by allowing banks to trade liquidity claims.² The real reason is likely to embrace both of these arguments, and similar policies have been implemented in several countries over the past century (Edey and Hviding (1995)). For example, Yale University benefited from state funding due to an analogous financial repression initiative in Connecticut in mid-1800 (Sylla et al. (1987)). As a result, although it is not obvious whether and to what extent the policy maker anticipated the consequences of such liquidity regulation, it constitutes an ideal environment for our study.

Because the policy does not map exactly into the existing models of liquidity requirements, we introduce a stylized theoretical setting to track its effects and inform the empirical analysis. The core insights of our model rely on the work of Farhi et al. (2009), Kashyap et al. (2014) and Calomiris et al. (2015), who analysed the role and effect of liquidity requirements in general settings. Although we simplify many aspects of these models for tractability, we add a novel dimension in our analysis: banks decide how many branches to open in a given geography. This is key, because a liquidity requirement may not only change the deposits of existing customers, but also attract previously unbanked individuals and as a result lead to more branches and financial inclusion.

The key finding that deposits can respond to liquidity requirements is due to the interaction between the lack of deposit insurance and bank limited liability. Because a liquidity requirement moderates both profits and losses through a minimum level of safe asset holding in every state of the world, this increases depositor repayment in those bad states in which the bank would default and stimulates deposits. In cases of severely risky financial systems, we show that liquidity regulation can even lead to higher bank profits, if deposit growth exceeds the decline in the intermediation margin and loan provision. As a result, branch installation (as a proxy for financial development) also rises, as higher profitability leads to more branch opening and provision of additional loans. In our model, liquidity regulation is valuable because of the timing assumption: banks are unable to convince depositors of their safe asset holding because of limited liability. We believe that such assumption is particularly fitting to many emerging economies, especially those that experienced a meltdown of their financial system, as Ethiopia

²The directive prescribing the policy change is titled “Directives on the Establishment and Operations of a National Bank of Ethiopian Bills Market” and discusses its role in fostering “monetary, credit and financial conditions”.

did in 1990s ([Caprio and Klingebiel \(2002\)](#)). Therefore, liquidity regulation is needed to create a commitment in holding safe assets.

Our empirical analysis has three components. The first is a depositor-level analysis, in which we study how different terciles of the depositor distribution respond to the policy. We show that, while the deposit growth of three terciles was on a parallel trend before the policy, the third tercile starts to diverge significantly afterwards, and its deposit growth robustly increases. In addition, within the third tercile, we find the strongest response among depositors that present a university degree. The second element exploits a survey in which we collected data on branch level deposits and whether the corresponding city hosts a university. We find significantly higher deposits in bank branches that opened after the policy in cities with a university. The third piece of evidence emerges from a bank-level analysis, and because such requirements were not randomly assigned, the cross-sectional dimension of this treatment is challenging. We partially circumvent this problem by studying two sources of bank exposure to the policy and exploiting our theoretical setting to achieve identification. The first source is based on our model, which prescribes a supermodularity between liquidity and banking technology: following a liquidity requirement, banks with lower operational costs observe a larger increase in deposits and expand more rapidly. As a result, we focus on bank size as a sufficient statistic for banking technology and combine the large and unexpected time-series change generated by the regulation with cross-sectional variation in bank sizes (big versus small banks). The second source of bank exposure comes from the pre-policy share of liquid assets held by banks. While the average increase in liquidity was 33%, some banks experienced very large gains, even above 100%. Therefore, such heterogeneity allows us to verify that banks with the larger liquidity increases reported the strongest deposit inflow.

We are the first to show empirically that liquidity regulation can promote the inflow of bank deposits, branch-installation and that enhanced bank safety is the channel through which these take place. However, this issue has been difficult to study, for a variety of reasons. First, data availability on the banking industry, particularly in emerging markets, is a severe limit: except for a few, incomplete, sources (e.g. the Bankscope database), most banks are reluctant to publish any documentation that goes beyond the mere legal obligations. However, even when sources are available, they are – unsurprisingly – of low quality, generally incomplete, and

focused on only a few key financial variables, with limited details on branching and geographical outreach. Finally, as our model shows, liquidity regulation has a stronger effect on depositors in risky financial systems, with few countries presenting the simultaneous strong variation in the size of regulation combined with a risk-prone banking industry.

To address the data limitations previously mentioned for the Ethiopian case study, we have constructed a variety of unique databases through which we can track the whole financial system. Through confidential contacts with the NBE, we were given access to the regulation documents and were able to interview senior executives for all private sector banks and survey bank branches, which provided substantial insights into how this regulation affected their business. Regarding the available datasets, we track four key indicators of bank behaviour:

- 1) a representative panel of depositors from one bank, in which we follow 954 depositors through their individual account for four quarters before and after the policy;
- 2) a survey of bank deposits at branch level, in which we observe 792 branches in 249 cities and match this with the presence of a university in the city;
- 3) bank balance sheets with monthly frequency, which allow us to observe the key modelling variables (safe assets, deposits, loans);
- 4) a new map covering over 90% of bank branches opened in Ethiopia between 2000 and 2014, including their city and region, telephone numbers and other information.

This paper contributes to three different literatures. The first is the empirical literature on the liquidity benefit of holding public bonds and liquidity requirements in general. [Calomiris and Wilson \(2004\)](#) provides evidence of New York banks in the 1930s that invested in liquid assets to signal their low risk and attract deposits. [Krishnamurthy and Vissing-Jorgensen \(2012\)](#) show that investors value the liquidity and safety of United States Treasuries, and document this by analysing the spread between assets with different liquidity but similar safety and those with different safety but similar liquidity. [Gennaioli et al. \(2014\)](#) find that banks optimally choose to hold public bonds as a way of storing liquidity for financing future investments. [Loutskina \(2011\)](#) finds that securitization lowers banks' liquid asset holding and increases their lending ability by transforming illiquid loans into liquid funds. [Dagher and Kazimov \(2015\)](#) find that financial institutions relying on wholesale funding cut their credit more than retail-funded banks, and investigate the role of liquidity for this result. [Gete and Reher \(2017\)](#) study

the variation in mortgage-backed security premia generated by the liquidity coverage ratio and verify that this affects the composition of lenders and credit risk in the primary mortgage market. [Chavaz et al. \(2017\)](#) find that banks vary their deposit rate according to their liquidity risk and the availability of deposit insurance.

Second, the present paper contributes to the literature on the relation between deposits and financial regulation. From a theoretical standpoint, [Diamond and Dybvig \(1983\)](#) were the first to associate depositor behaviour with financial institutions and regulation. [Calomiris and Kahn \(1991\)](#) highlight the discipline role of deposits and how this can change when financial regulation is introduced. [Allen et al. \(2015\)](#) discuss how financial regulation can affect deposit behaviour and consequently bank capital structure. The empirical literature on these topics is relatively limited, and our contribution is mostly directed to fill this gap. [Barth et al. \(2001, 2004\)](#) show that countries with more restrictive regulatory regimes are more exposed to banking crises, but do not present necessarily poorly functioning banks. Through a cross-country and cross-bank analysis, [Laeven and Levine \(2009\)](#) show that the effects of financial regulation on both liabilities and assets depend remarkably on governance indicators, and in this respect find a large heterogeneity. [Iyer, Jensen, Johannesen, Sheridan et al. \(2016\)](#) study a run on Danish banks that limited deposit insurance coverage, and find a differential reallocation of deposits across banks. [Iyer, Puri and Ryan \(2016\)](#) investigate the relation between depositors' response and solvency risk in India, by dissecting the behaviour of different depositor classes to these events. [Ippolito et al. \(2016\)](#) find an emergence of double-bank runs (from both borrowers and depositors) in the wake of the European interbank market freeze registered in 2007. In particular, because the deposit response of this policy occurs among wealthy and highly educated depositors, our work is linked to a literature on the role of financial literacy and sophistication. [Guiso and Jappelli \(2008\)](#) find that the poorly financially educated investors under-differentiate their portfolio, in line with the lack of readjustment to the policy that we find in Ethiopia. [Lusardi et al. \(2009b\)](#) and [Lusardi et al. \(2009a\)](#) find that financial literacy and sophistication are particularly low, among both old and young individuals, and that these correlate strongly with education outcomes. Consistent with our work, [Calvet et al. \(2009\)](#) find that financial wealth and education affect financial decisions (through under-diversification, inertia in risk taking, the disposition effect in stock holdings). [Guiso and Viviano \(2014\)](#) find

that highly financially literate individuals present a superior performance in financial decision-making during a banking crisis, even if with small magnitudes.

Third, our paper links the literature on branch expansion and financial access to liquidity requirements. For example, we find that, in response to this policy, banks open more branches, particularly in rural locations. This result is in line with the work of [Brown et al. \(2015\)](#), who find that, after a significant expansion, a major microfinance provider in Eastern Europe (ProCredit) was more likely to enter areas with relatively poor households, with account usage increasing among low- and middle-income households and the self-employed. These findings also resonate in the work of [Allen et al. \(2014\)](#), who study the expansion of Equity Bank in Kenya and its effect in previously under-served locations. In line with these results, [Bruhn and Love \(2014\)](#) show that the entry of Banco Azteca in Mexico helped to raise income for individuals.

In Section 1, we present the theoretical framework, first describing the economic environment and then investigating the bank decision problem. In Section 2, we discuss empirical evidence from the policy change in Ethiopia. In Section 3, we provide some robustness checks. Finally, Section 4 offers concluding remarks.

1 Theory

1.1 Economic Environment

The economy comprises a continuum of locations on a unit line, and each point is populated by a household engaging in a saving decision. The bank decides how many branches to open, $\beta \in [0, 1]$, which is costly, but allows it to reach a new locus and to interact with agents. If $\beta = 1$, then all locations are reached, whereas with $\beta = 0$, no branches are opened. When a branch is installed, the bank interacts with a depositor, who chooses how much to deposit, $d \geq 0$, given a remuneration $R_D \geq 1$. These liabilities are collected and allocated in two assets: a share in risky loans, $l \in [0, 1]$, and the remainder in a liquid asset, $s = 1 - l$. There exist two states $\sigma \in \{G, B\}$: in the good state, $\sigma = G$, which occurs with probability $p \in (\underline{p}, 1)$, the bank earns on risky loans a gross rate $R_G > 1$, whereas in the bad state, $\sigma = B$, which occurs with probability $1 - p$, the bank earns $R_B \in [0, 1)$. In contrast, the return on the liquid asset is

positive, deterministic, higher than the deposit rate, and lower than the expected loan return, $R_S \in [R_D, pR_G + (1 - p)R_B]$. Prices are given, and therefore if G occurs, the bank earns R_S on liquid assets and R_G on the remainder and pays R_D to depositors. Given the assumptions on the rates, the good state is always profitable and the bank always repays. However, if B occurs, given the liquid asset choice s and limited liability, the bank pays

$$R_{DB} = \min\{R_D, sR_S + (1 - s)R_B\},$$

the minimum between the deposit rate $R_D \geq 1$ and the return on the liquidated assets, composed of the sum of the gross return on liquid assets, sR_S , and the return on the risky assets, $(1 - s)R_B$.

This economy presents the following four stages:

- 1) the bank invests in financial development, deciding on the number of branches, β ;
- 2) households reached by a branch decide how much to deposit, d ;
- 3) the bank decides on the amount of liquid assets, s ;
- 4) the state σ is realized, the bank receives loan reimbursement, repays deposits and collects profits, and the household consumes the repaid deposits.

The timing of the game clarifies a key intuition for the role of liquidity regulation: given the structure of returns, the bank is not keen to hold any safe assets. Limited liability allows it to keep the profits in the good state, G , and to liquidate depositors with all that is collected in the bad state, B . Depositors anticipate this and, given the constant rates, limit their deposits in the banking system. If the bank could commit to hold an amount of safe assets always securing R_D , then deposits would be higher, and profits as well. However, in a single shot game, such commitment is not credible, and we delegate to liquidity regulation to solve this problem by imposing the amount of liquid and safe assets. Throughout this model, we shall switch off the possibility that prices change in response to agents' decisions: this can be interpreted as a price-taking assumption or introduced to be in line with the case studies we present in Section 2, in which prices are not the mechanism through which the policy affects the economy.

The game can be solved by backward induction. In terms of notation, capital letters refer to aggregate quantities at bank level, while lower-case letters refer to branch-specific quantities: l is the loan given in each branch, and $L = \beta l$ is the aggregate number of loans given by the bank (analogously, $S = \beta s$ and $D = \beta d$).

1.2 Bank and Liquid Assets

The profits of the bank are composed of an intermediation margin, $\pi(s)$, which emerges as the difference between payments on liabilities and income on assets, multiplied by the extensive margin given by the number of branches, β , and the intensive component being the amount of collected deposits in each branch, d .

At the last stage of the game, given that the extensive and intensive margins β and d are fixed, the bank can affect profits only by changing the intermediation margin and choosing the share of liquid assets to hold. The intermediation margin can be described by

$$\pi(s) = p[sR_S + (1 - s)R_G - R_D] + (1 - p)[sR_S + (1 - s)R_B - R_{DB}].$$

In the good state, which happens with probability p , the bank earns returns R_S on the share of liquid assets s and R_G on the remainder $1 - s$ and pays the deposit rate R_D ; in the bad state, it earns R_B and pays a deposit rate R_{DB} . In the good state, bank profits are always positive, and therefore the market deposit rate, R_D , is always repaid. However, in the bad state, this is not necessarily the case and the bank may default. Because of limited liability, the corresponding deposit rate can be described through the previously introduced $R_{DB} = \min\{R_D, sR_S + (1 - s)R_B\}$. Therefore, if the bank collects sufficient profits in the bad state, it repays depositors with the market rate R_D and keeps the positive profits $sR_S + (1 - s)R_B - R_D > 0$; however, in the opposite case, the bank passes its losses on to depositors and repays them with all the recovered assets, $R_{DB} = sR_S + (1 - s)R_B$. We define $\tilde{s}$ as the liquid asset level such that the bank is indifferent between repaying the market deposit rate, R_D , and liquidating its assets, $\tilde{s} = (R_D - R_B)/(R_S - R_B)$, as $R_S > R_D > R_B$, which bounds $\tilde{s} \in (0, 1)$. As a consequence, the

following holds true:

$$R_{DB} = \begin{cases} R_D & \text{if } s \geq \tilde{s}; \\ sR_S + (1-s)R_B & \text{if } s < \tilde{s}. \end{cases}$$

The deposit rate in the bad state, R_{DB} , equals the market deposit rate, R_D , if the liquid asset share exceeds the strictly positive threshold, $s \geq \tilde{s}$; otherwise, it is given by the liquidated assets.

Liquidity Regulation In the absence of regulation, the bank simply maximizes the intermediation margin with respect to the share of liquid assets s , in the absence of any constraint

$$\max_s \pi(s) = p[sR_S + (1-s)R_H - R_D] + (1-p)[sR_S + (1-s)R_B - R_{DB}],$$

which leads to a trivial solution of $s = 0$, given that $p \in (\underline{p}, 1)$ with $\underline{p} = (R_S - R_B)/(R_G - R_B)$, and passes all losses on to depositors in the bad state, $R_{DB} = R_B$. The timing of the game makes this intuition trivial, because in the last stage, depositors cannot punish the bank for this decision. The regulation that we study forces the bank to hold a level of safe assets $\rho > 0$, which adds to the previous problem the binding constraint $s^R = \rho$. Because the unregulated liquid assets equal zero, the regulation necessarily raises the deposit rate in the bad state (from $R_{DB} = R_B$ to $R_{DB} = \rho R_S + (1-\rho)R_B$ if $\rho < \tilde{s}$ or to $R_{DB} = R_D$ if $\rho \geq \tilde{s}$).

In the absence of a repeated game setting or other externalities, the bank has no private incentives to keep any liquid asset. Therefore, the post-regulation margin is defined as $\pi(\rho)$, decreasing in the liquidity regulation parameter ρ .

1.3 Depositor Problem

In each branched location, given β , a representative household faces a two-period problem, by deciding on consumption in period 1 (i.e., the present) and in period 2 (i.e., the future), given a vector of prices $\{R_D, R_B, R_S\}$, states $\sigma \in \{G, B\}$ with probabilities p and $1-p$ and the choice of the bank's liquid assets s . The household is endowed with income y in period 1 only and faces financial market imperfections that do not allow state-contingent transfers. Hence, consumption in period 2 is dependent on the state, which may be good, G , with savings being remunerated, R_D , or bad, B , with remuneration $R_{DB}(\rho)$. The solution is a vector $\{c_1, c_{2G}, c_{2B}\}$,

where each subscript number refers to the period, and G and B refer to the states of the future; such a consumption vector fully describes the deposit behaviour d . We are implicitly assuming that, when branched, a household always uses the banking system to deposit its savings, and several arguments in this respect have been raised in the literature. In the following problem, we adopt an additive and separable constant relative risk aversion utility function:

$$\begin{aligned} \max_{c_1, c_{2G}, c_{2B}} \quad & c_1^\alpha + \delta[p c_{2G}^\alpha + (1-p) c_{2B}^\alpha] \\ \text{s.t.} \quad & c_1 + \frac{c_{2G}}{R_D} = y \\ & c_1 + \frac{c_{2B}}{R_{DB}(\rho)} = y. \end{aligned}$$

Here, $\delta \in (0, 1)$ indicates the discount rate, $\alpha \in (0, 1)$ indicates the relative risk aversion parameter and p is the probability of the good state. The state-dependent budget constraints are standard, except that in the good state the discount rate is R_D , and in the bad state it is $R_{DB}(\rho)$. The following saving/deposit function in locations reached by branches β emerges:

$$d(\rho) = y - c_1 = \frac{\delta^{1/(1-\alpha)}[p R_D^\alpha + (1-p) R_{DB}(\rho)^\alpha]^{1/(1-\alpha)}}{1 + \delta^{1/(1-\alpha)}[p R_D^\alpha + (1-p) R_{DB}(\rho)^\alpha]^{1/(1-\alpha)}} y,$$

which is always positive and increasing in $R_{DB}(\rho)$, and hence in ρ . The full solution to the problem can be found in Appendix A.

1.4 Financial Development and Regulation

In the first period, the bank decides how many branches to install, given the intermediation margin in each location $\pi(\rho)$ (which depends negatively on the liquidity regulation parameter ρ), the deposit level $d(\rho)$ (which depends positively on ρ) and some convex cost of branch opening $c(\beta)$. Its convexity can be justified by the fact that branch coordination costs can be larger the further a branch is from the headquarters (the locus in zero).

This financial development problem can be written as

$$\max_{\beta \geq 0} \Pi = \pi(\rho) d(\rho) \beta - \eta \frac{\beta^2}{2}.$$

Note that in this setting, we introduce a new parameter η : this is a branch-opening technology parameter affecting both the average and marginal cost of branch opening. As is clear from the solution of the branch-maximization exercises, this technological parameter maps into the overall size of a bank, in terms of installed branches. In fact, given that the marginal branch profitability is $\pi(\rho)d(\rho)$, then this leads to the solution $\beta = [\pi(\rho)d(\rho)]/\eta$, with the overall profits being $\Pi = [\pi(\rho)d(\rho)]^2/2\eta$, loan volume $L = [\pi(\rho)/\eta]d(\rho)(1 - \rho)$, liquid asset holdings $S = [\pi(\rho)/\eta]d(\rho)\rho$ and deposits $D = [\pi(\rho)/\eta]d(\rho)$. As a result, it can be noted that a bank with a higher η parameter installs fewer branches and hence collects fewer deposits and gives fewer loans. From this point onward, we refer to η as a technology-induced parameter of bank size.

Liquidity Regulation as Safe Asset Purchase What happens to loan volume and branch installation when a positive shock to ρ occurs? Can such a liquidity regulation policy promote loan volumes and branch expansion? The liquidity regulation parameter, ρ , imposes a mandatory share of liquid and safe assets s , given that $s^R = \rho$. It is clear that loan volume can increase in the financial regulation parameter if and only if

$$\frac{\partial L}{\partial \rho} > 0 \rightarrow \epsilon_{d\rho} > \epsilon_{\pi\rho} + \epsilon_{l\rho}$$

that is, the elasticity of deposit mobilization exceeds the sum of the elasticity of the intermediation margin and loan share with respect to the regulation parameter ρ . As shown in Appendix B, the previous expression simplifies to

$$\frac{\alpha}{1 - \alpha} y A(\rho) > \frac{\rho}{1 - \rho} + \frac{1}{1 - \rho[(R_G - R_S)/(R_G - R_D)]}$$

with the expression on the left-hand side embedding the deposit component, with $A(\rho)$ decreasing in ρ because of concavity; in contrast, the right-hand side reports the profit component and is increasing in ρ . For given parameter values, it is possible to show that loan volume responds

to the regulation parameter with the effect

$$\frac{\partial L}{\partial \rho} = \begin{cases} \geq 0 & \rho \leq \tilde{\rho}, \\ < 0 & \rho > \tilde{\rho}; \end{cases}$$

that is, it increases if liquidity regulation does not exceed a threshold $\tilde{\rho} = \tilde{\rho}(p)$ and decreases if it does. Such a threshold increases in the probability of a bad state, $1 - p$. This result is intuitive: the deposit response to the regulation is higher the safer the financial system becomes because of the regulation. Hence, it follows that a risky financial system (with a high $1 - p$) experiences a stronger deposit response to liquidity regulation. This result is key to our empirical analysis and is the driver of the effects highlighted in Section 2. Note that given the definition of L and β , conditions for an increase in loans are sufficient for an increase in branches.³

The upper panel of Figure 1 shows the right- and left-hand-side expressions, with the shaded area indicating the region in which higher liquidity regulation promotes lending. In the lower panel, such a region increases in the probability of a bad state. In the main scenario, we set $1 - p$ to be 10% (solid line), which implies a threshold of $\tilde{\rho} \simeq 0.33$. In the scenario in which this probability is brought to 15%, such a threshold correspondingly increases to $\tilde{\rho} \simeq 0.5$, whereas if such a probability is reduced to 5%, the threshold is also reduced, to $\tilde{\rho} \simeq 0.18$. In Appendix C, we report additional comparative statics with respect to both the probability of a bad state and other model parameters; however, this essential comparative statics on p shows how important the riskiness of the financial sector is for detecting a statistically significant effect.

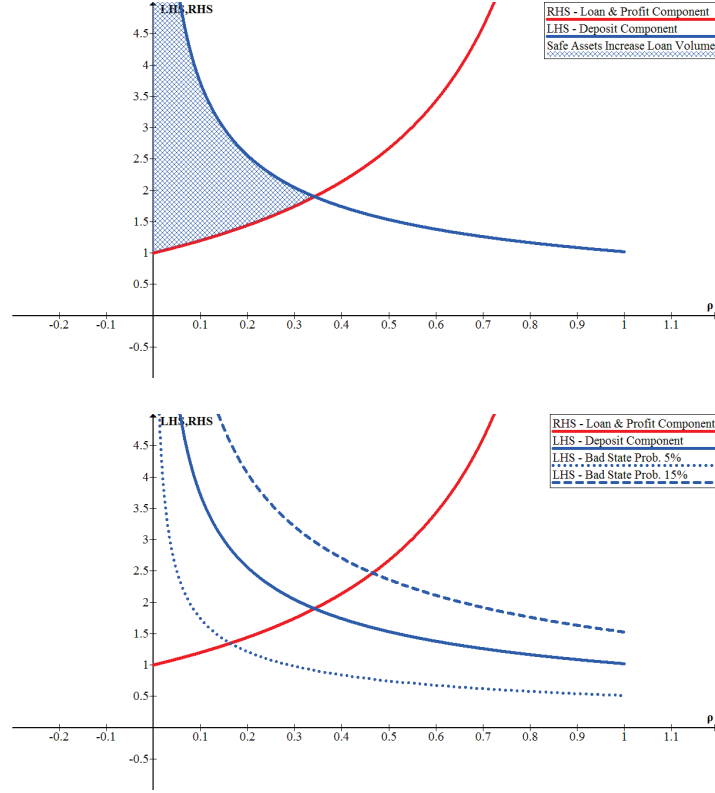
These results can be summed up in the following proposition.

Proposition 1

There exists a threshold in the mandatory share of liquid assets, $\tilde{\rho}(p)$, such that in the presence of unbranched locations, $\beta < 1$, $\forall \rho \leq \tilde{\rho}(p)$, the total loan volume $L = \beta d(1 - s)$, number of branches β , deposits per branch d , total deposits $D = \beta d$ and liquid assets S increase in the liquidity regulation parameter ρ . Such a threshold increases in the probability of a bad state, and hence decreases in p .

³It is also important to highlight that in the case that the financial system already presents a level of safe assets higher than or equal to $\tilde{s}$, which guarantees depositor repayment in any state, then imposing $\rho > \tilde{s}$ leads to the opposite effect because deposits do not increase, given that there is no repayment increase, but the intermediation margin declines, which leads to lower profits, loans and numbers of branches.

Figure 1: Loan Volume Increases in Liquid Assets



Notes: This figure plots the conditions under which loan volume increases in the regulated share of liquid assets. The x -axis reports the values of the liquid asset share parameter ρ , and the y -axis reports the values of the right- and left-hand-side variables. As is clear from the inequality, the left-hand side is decreasing in the parameter (blue), while the right-hand side is increasing (red). This figure assumes that the bank rates are in line with the model and calibrated with the Ethiopian economy, as from NBE (2011), and that the other parameters are in line with the literature: $R_G = 5/4$; $R_S = 21/20$; $R_B = 0$; $R_D = 1$; $\delta = 0.9$, $\alpha = 1/2$; $p = 0.9$; $y = 20$. The shaded area reports the regions in which the regulation determines an increase in loan volume. The upper panel reports the main picture with $p = 0.9$. The lower panel reports three cases: $p = 0.9$ (solid line), $p = 0.85$ (dashed line) and $p = 0.95$ (dotted line).

1.5 From Theory to Empirics

In the absence of an experimental setting for the application of this policy, we rely on two key modelling features to identify the effect of financial regulation.

1. A supermodularity that prescribes a stronger deposit growth for banks with a better banking technology. This implies that larger banks exhibit a stronger effect than smaller banks (presented in Section 1.5.1).
2. The heterogeneous effect of the policy on bank deposits depending on their pre-policy level of liquidity. This implies that banks with lower pre-policy liquidity experienced the largest post-policy gains in deposits (presented in Section 1.5.2).

1.5.1 Bank Technology and Size

Recalling the first-order condition $\beta = (\Pi/\eta)d$, both the equilibrium number of branches β and the response to the liquidity regulation policy $\partial\beta/\partial\rho > 0$ depend on the technology-induced parameter of bank size (i.e., η). This is a sufficient statistic for bank size because it characterizes both a level effect (i.e., the number of branches before the policy) and an impact effect (i.e., the response to the policy), and we carefully combine this cross-sectional analysis to the time-series analysis. Proposition 2 updates Proposition 1 and guides it to the data.

Proposition 2

The parameter of bank size η , measuring the technological endowment of the bank in terms of branch cost, affects negatively the optimal number of branches and the branch-installation response of the bank to liquidity regulation. If a set of banks is endowed with η_H and another set with η_L , with $\eta_H > \eta_L$, then the banks exhibiting η_L : 1) install more branches than the bank with η_H , $\beta(\eta_L)^* > \beta(\eta_H)^*$ and 2) respond to the liquidity regulation policy by opening more branches than the bank with η_H , $\partial\beta(\eta_L)^*/\partial\rho > \partial\beta(\eta_H)^*/\partial\rho$.

Therefore, all the predictions of Proposition 1 are differentially stronger for more efficient banks. This result is intuitive and is clarified in Figure 2. The more efficient bank makes more profits in every branch because it has lower branch installation costs, and therefore it opens more branches because more are profitable (level effect), $\beta(\eta_L) > \beta(\eta_H)$. This prediction stays true also after the policy shock: two banks want to open more branches, but the more efficient bank opens more branches because it makes more profits in each single branch,

$$\frac{\partial\beta^*(\eta_L)}{\partial\rho} > \frac{\partial\beta^*(\eta_H)}{\partial\rho}.$$

The results of Proposition 2 can be described through the encompassing empirical model

$$v_{it} = \iota_i + \iota_t + b \cdot \eta_i \cdot \rho_t + \epsilon_{it},$$

in which the variable of interest v_{it} for bank i at time t (e.g., branches, deposits, loans) is regressed over bank and time fixed effects, ι_i and ι_t , respectively, and an interaction between

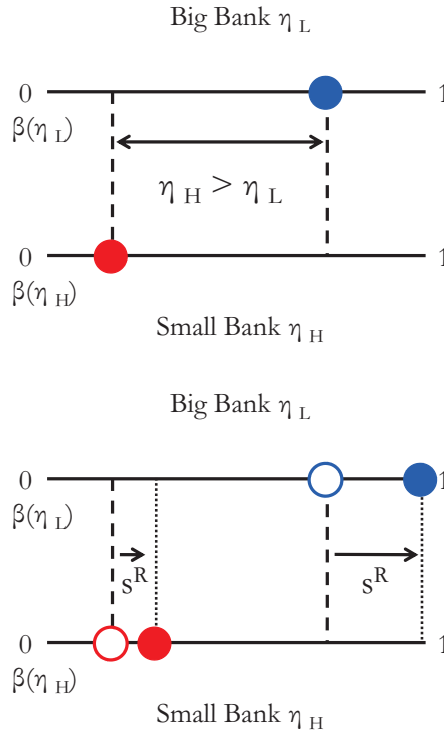
the technological bank-specific parameter, η_i , and the liquidity regulation parameter, ρ_t . Proposition 2 predicts that such interaction is negative because banks with a higher branch cost parameter grow less after the policy.

This model can be further generalized to test for the presence of parallel trends before the policy, leading to

$$v_{it} = \iota_i + \iota_t + \sum_t c_t \eta_i \times \iota_t + u_{it}, \quad (1)$$

in which the variable of interest v_{it} for bank i at time t is regressed over bank and time fixed effects, ι_i and ι_t and an interaction of time fixed effects with the bank-specific technological endowment for every period t , $\eta_i \cdot \iota_t$. Equation (1) is the empirical model that we use extensively in this paper. A particularly attractive feature is given by the interaction, c_t , which allows us to test whether banks with different technological endowments are on parallel trends before the policy, by verifying that c_t are not statistically different from zero $\forall t < \tilde{t}$, with $\tilde{t}$ representing the time period in which the liquidity regulation change takes place.

Figure 2: Size Heterogeneity and Identification



Notes: This figure depicts graphically one of the identifications in the empirical analysis. In the upper panel, we present the two banks assumed to be lying on two separate unit lines. One is bigger in equilibrium because it enjoys a low branch cost parameter η_L (i.e., Big Bank); the other is smaller because it enjoys a high parameter η_H (i.e., Small Bank). Here, there is a level effect in their respective branch number β , caused by the cost parameter. In the lower panel, our identification becomes clear: the time-series shock s occurs at the same time for all banks, but because of the cost parameter η , it affects the Big Bank differentially more.

1.5.2 Deposit Growth and Pre-Existing Liquidity

In Section 1.3, we present an important result: the deposit function, $d(\rho)$, is increasing and concave in the share of liquid assets, ρ . This offers an alternative source of identification: banks with low pre-policy levels of liquidity experience a stronger deposit growth than banks with high pre-policy levels of liquidity.

Figure 3 depicts graphically the essence of this alternative identification. The deposit function can be described by the positive and concave line (in blue), and we assume that this applies to all banks in the economy. In this simplified setting are two banks: a bank with pre-policy liquidity, indicated by the red dotted line and squares (low-liquidity bank); and a bank with high pre-policy liquidity, indicated by the green dashed line and triangles (high-liquidity bank).

If both banks are subject to the same requirement and increase their liquidity by the same amount, then the low-liquidity bank experiences much higher deposit growth than the high-liquidity bank. Graphically, this policy can be described as a shift from the pre-policy liquidity levels (vertical line with squares for low liquidity; vertical line with triangles for high liquidity) toward the new liquidity level (black line with circles). We can summarize these results in the following proposition.

Proposition 3

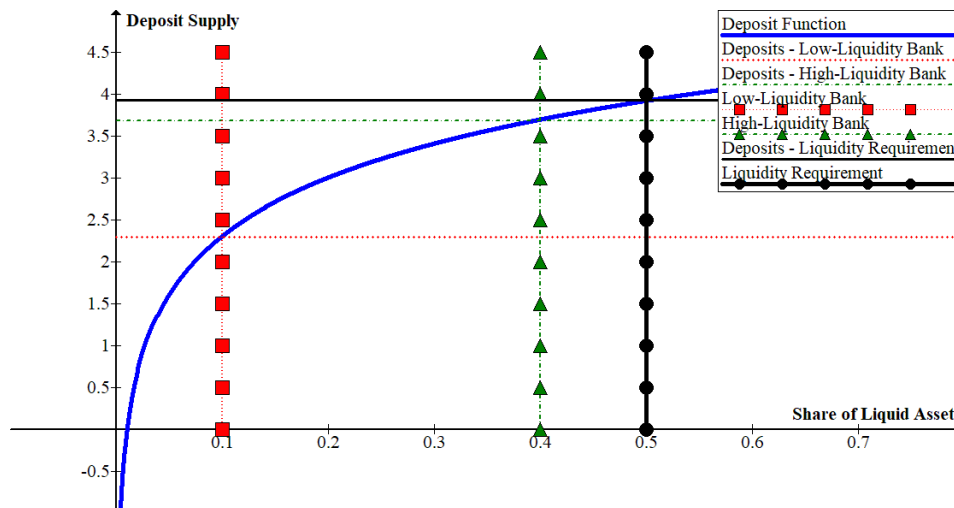
Suppose banks are endowed with heterogeneous pre-policy quantities of liquid assets, then banks with the lower amounts: 1) observe a large increase in deposits and 2) install more branches.

Therefore, all the predictions of Proposition 1 are differentially stronger for more banks that present a lower share of initial liquid assets, or alternatively, banks that experience a higher increase in the percentage of liquid assets after the policy. The results of Proposition 3 are summarized by the following model:

$$v_{it} = \iota_i + \iota_t + b \psi_i \times \rho_t + \epsilon_{it},$$

in which the variable of interest v_{it} for bank i at time t (ie., branches, deposits, loans...) is regressed over a bank and time fixed effects, ι_i and ι_t , and an interaction between the bank-specific increase in liquidity after the policy, ψ_i , and the liquidity regulation parameter that applies to all banks, ρ_t . Proposition 2 predicts that such interaction is positive because banks with a higher increase in liquidity grow more after the policy.

Figure 3: Liquidity Heterogeneity and Identification



Notes: This figure depicts graphically one of the identifications in this empirical analysis. Two banks face the same deposit supply function, indicated by the blue concave line. The low-liquidity bank, indicated by the red dotted line, holds a low level of pre-policy liquidity (small squares). The high-liquidity bank holds more liquidity and is indicated by the dashed green line (with small triangles). If the policy obliges both banks to raise their liquidity until the black line (with small circles), then both banks experience an increase in deposits. However, the bank with a low level of pre-policy liquidity experiences the largest increase.

2 Empirics

2.1 Evidence from Ethiopia

In this section, we present empirical evidence on Ethiopia and the behaviour of local private banks, exploiting the introduction of a new liquidity regulation measure announced in mid-March 2011. On this date, the NBE issued a directive requiring all commercial banks to hold 27% of new loan disbursements in NBE bills from the beginning of April 2011.

Before analysing the policy, we provide some summary statistics on the key variable in this analysis and for the overall period. Table 1 reports the summary statistics for the total deposits and private sector lending and five variables relative to the overall assets. Ethiopian banks rely intensely on bank deposits, which are mostly retail deposits (unfortunately, a finer description than “total deposits” is not available in the data). Deposits are an important component of

these banks, and Panel A shows that they slightly exceed the amount of private sector lending and represent 67% of bank assets. Private sector loans are also very high, but are only around 40% of the bank total assets. A significant component lies in liquid assets (25%) and in the newly created NBE bills (9.8%).

The relevant aspect of studying the so-called 27% rule is given by the unique conditions of this shock: 1) it was unexpected and announced less than one month before implementation; 2) it caused a large accumulation of safe assets by banks in one quarter. The share of safe assets held by local banks passed from 21% to 28%, as shown in the next section, which corresponds to a 33% increase.

We first offer a simple test of compliance in which we run the following regression:

$$\Delta v_{it} = \iota_t + \beta \Delta Lending_{it} + u_{it},$$

in which the changes in the variables v (NBE bills and liquid assets) are regressed on changes in private sector lending for the period after the change in regulation. The policy prescribes that, for every Ethiopian birr that banks place in a new loan, they need to buy 0.27 NBE bills. Regrettably, the balance sheet information gives information only on the volume of lending, and as a result, we rely on the change in lending as an imperfect proxy for the new lending. Table 2 shows that we cannot reject compliance with the policy: column (1) shows that for every new birr of private sector lending, banks buy on average 0.21 NBE bills, which is not statistically different from 0.27. The existence of an effect of the policy on the overall level of liquid assets (cash, reserves, treasury bills, NBE bills, interbank holdings) can be verified through column (2), which shows that, as the purchase of NBE bills increases, so does the overall level of bank liquidity.

From a theoretical standpoint, this policy can be mapped as a positive shock to the s^R , which, combined with the above conditions 1) and 2), make it ideal for our analysis. It is also important to highlight that the NBE bills are not a profitable asset, because they pay a fixed remuneration of 3% per year, lower than the minimum deposit rate, 5%, or the average lending interest rate, 12% (NBE 2012).⁴

⁴Therefore, this policy, as well as mandating liquid assets, lowers the return on private sector lending, because banks are forced to purchase government bills with a negative remuneration for every loan. As a consequence, this piece of financial regulation also includes a lending tax, which would generate an effect against the one

To test the implications of Propositions 1, 2 and 3, we collected confidential data on the monthly balance sheet of all Ethiopian private banks between 2010 and 2013 and build a unique city-level map of Ethiopian branches, where for every bank, we know the cities in which all new branches have been opened, with the respective month and year between 2000 and 2014.

Propositions 1, 2 and 3 provide two fundamental elements to test the model: a shock to s^R promotes deposit growth; and cross-sectional variation in η (bank size) and ψ (bank pre-policy liquidity) characterizes a differential impact to the shock. Ethiopia is an exceptional context in which to test this model because, as well as a large time-series variation in s^R , we find a large cross-sectional variation in some characteristics associated with η and ψ .

Figure 4 presents the total assets of the 14 Ethiopian banks at the beginning of 2011, before the policy implementation, and there emerges a natural distinction between big and small banks. Indeed, there is a large discontinuity between the sixth bank, Bank of Abyssinia (BOA), with assets close to eight billion birr, and the seventh bank, Construction and Business Bank of Ethiopia (CBB), with assets below four billion birr. Therefore, we set the hypothesis that large banks are also endowed with a better technology (lower unit cost) than smaller banks: thus, larger banks match the η_L case and smaller banks match the η_H case. For this reason, given that the largest six banks are more than twice as large as the remaining eight, we classify the former banks as “more efficient” (hence presenting a lower cost of branch opening, η_L), and we define a dummy variable “Big Bank” taking unit value for all of these. The remaining are categorized as “less efficient” (embedding the parameter η_H). In Appendix D, we provide a direct test of our hypothesis and show that “big banks” are not just larger, but also present 40% lower administrative costs over assets and 45% lower administrative costs over personnel. This result, although not a comprehensive test of a variation due to η , provides some evidence consistent with our identification.

Figure 5 reports two panels. The upper panel shows the distribution of liquid assets held by Ethiopian banks in the quarter before the policy change (dashed blue line) and after (solid red line). Two interesting facts emerge. First, the median share of liquid assets before the policy

we highlight here. The lending tax would lower lending, whereas the “liquidity effect” should boost lending by attracting new deposits. In this context, the liquidity effect is stronger than the tax effect, which is very small. In fact, before the policy, a unit loan would deliver an average net 7% return (12% average lending rate minus 5% deposit rate), whereas after the policy, it would deliver the same gross return minus the net remuneration of these bills -2% multiplied by the amount of the purchased bills 0.27, hence $7\% - 0.27 \times 2\%$, which results in a 0.54% decline on lending returns. The small tax element was also confirmed during our extensive consultations with Ethiopian central bank executives and private bankers.

is 21%, which increases after the policy to 28%, and there is a median increase of 33% in one quarter. Second, the distribution of the liquid asset share held by the bank is almost entirely shifted rightward. The lower panel shows the percentage increase in the share of safe assets: its mean is 33%, but there is a very high variance. In particular, there exists a tail of banks that effectively double their held liquidity. This is crucial for testing the results of Proposition 3, and we use this last information, the percentage increase in the share of liquid assets, as a source of cross-sectional variation to test our hypothesis.

When both the time-series and cross-sectional variation is clear, we use the following data to test our propositions.

A. Main Results. In Section 2.2, we verify the predictions of Proposition 1, 2 and 3 on the following databases.

- * Depositor evidence. Using a representative panel of depositors from one bank, we observe a parallel trend in deposit growth across the terciles of depositors and a divergence after the policy. We further relate such growth to their education (Section 2.2.1).

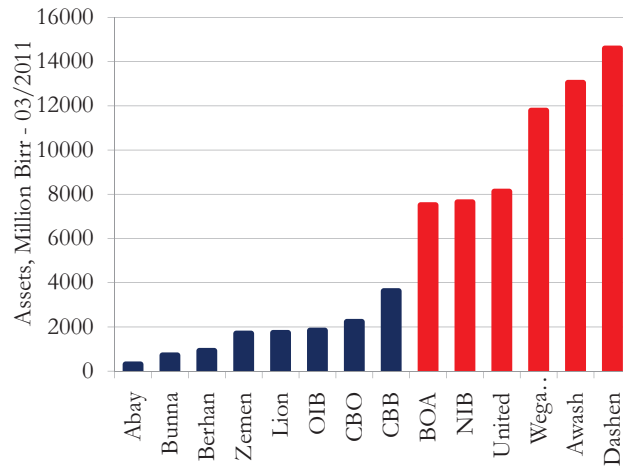
- * Branch evidence. Using a survey covering 792 bank branches across 249 Ethiopian cities, we verify that deposit level is higher in branches that opened after the policy and in cities that present a university.

- * Balance sheet evidence. Using monthly data, we verify that liquid asset purchases increase after the policy, that new deposits are collected in old branches, and that loan volume also increases (Section 2.2.3).

- * Branch map evidence. Using monthly data, we provide evidence that branch installation increases more markedly after the policy and in more cities their first branch is installed after the policy (Section 2.2.4).

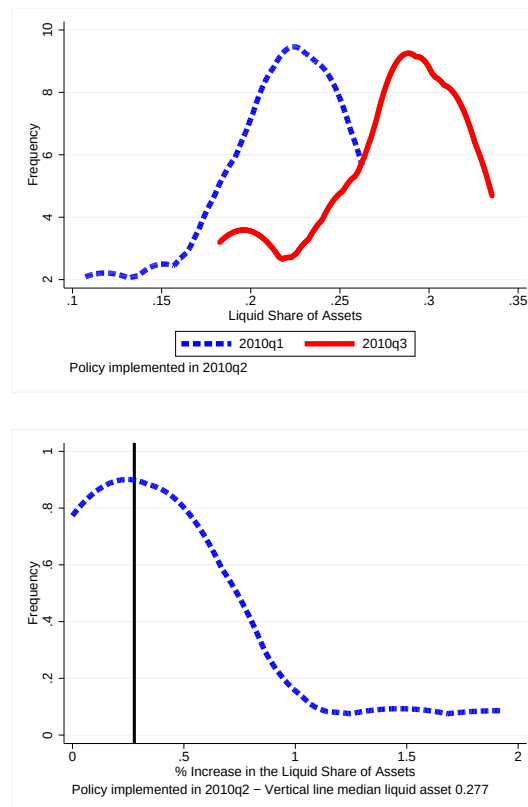
B. Robustness Checks. In Section 3, we explore a variety of factors that might confound our estimates, and we verify the soundness of our results.

Figure 4: Banks Assets and Size



Notes: This figure shows a bar chart reporting the total assets of all Ethiopian private banks at the beginning of 2011, one month before the introduction of the policy. There is an evident existence of a substantial discontinuity between the third largest bank, Wegagen Bank (denoted by Wega.), and the sixth largest Ethiopian bank (BOA), and also between the sixth and seventh largest banks, BOA and CBB. The six largest banks are shown in red and are those that we classify as big banks.

Figure 5: Bank Liquid Assets – Pre- and Post-Policy



Notes: This figure comprises two panels. The upper panels presents the distribution of the share of liquid assets held by Ethiopian banks in the quarter before the policy (dashed blue line) and a quarter after the policy (solid red line). The lower panel reports a distribution of the percentage increase in the share of liquid assets.

Table 1: Summary Statistics

	(1)	(2)	(3)	(4)	(5)
Variables	Obs.	Mean	S.D.	Min.	Max.
Panel A – Aggregates					
Ln Total Deposits	512	7.714	1.056	2.992	9.43
Ln Private Sector Lending	512	7.320	1.128	0.510	9.104
Panel B – Relative to Assets					
Deposits	512	0.673	0.095	0.125	0.807
Private Sector Lending	512	0.392	0.075	0.003	0.586
NBE Bills	512	0.098	0.072	0.000	0.248
Liquid Assets	512	0.252	0.068	0.107	0.795
Capital	512	0.142	0.086	0.000	0.835

Notes: This table reports the summary statistics for the main variables in the analysis. Panel A presents two variables described as the natural logarithm (Ln) of one plus their corresponding amount in Ethiopian birr. Total Deposits are defined as the sum of demand, savings and fixed deposits. Private Sector Lending collects the volume of loans extended to the private sector. Panel B reports all variables normalized by total assets. Liquid Assets are defined as the sum of other balance sheet variables (cash, treasury bills, reserves, NBE bills, interbank holdings). Obs. denotes the number of observations; S.D. denotes standard deviation.

Table 2: Compliance with NBE Bills

	(1)	(2)
Variables	Δ NBE Bills	Δ Liquid Assets
Δ Lending	0.208*** (0.039)	0.164*** (0.045)
Quarter-Year FE	Yes	Yes
Observations	378	378
Adj. R sq.	0.516	0.907
Mean Dep. Var.	31.73	52.93
S.D. Dep. Var.	93.31	615.02

Notes: This table shows the relation between the amount of NBE bills and liquid assets and private sector lending. Standard errors are clustered at bank level. Δ NBE Bills describes the changes in the volume of NBE bills in Ethiopian birr that a bank presents in its balance sheet. Δ Liquid Assets describes the changes in the volume of liquid assets held in a bank balance sheet. Liquid assets are defined as the sum of other balance sheet variables (cash, treasury bills, reserves, NBE bills, interbank holdings). The means and standard deviations (S.D.) of these variables are reported in the last two rows of the table. Δ Lending describes the changes in volume of Ethiopian birr of private sector lending registered in the bank balance sheet. *** indicates significance at the 1% level.

2.2 Main Results

2.2.1 Depositor Evidence

Through contacts with bank executives from one commercial bank, we were able confidentially to receive data on a representative panel of bank depositors. These are used by this particular bank to calibrate its operations (summarize deposits, target its marketing) and is described by the bankers as representative in terms of deposit distribution and other dimensions (jobs, geography). As a result, we can observe 954 depositors for eight quarters (four before and four after the policy) and study their deposit, which we use to calculate the quarterly deposit growth, and their main occupation as reported to the bank. This last variable is particularly useful, because from these activities, we can determine whether they hold a university degree and, in such case, code it with a dummy variable.

Our analysis proceeds as follows:

1. We study how different terciles of the deposit distribution behave over time and verify that depositors in only the third tercile react to the policy.
2. We verify that this deposit reaction is particularly strong among depositors in the third tercile and with a university degree.

The four quarters before the policy are useful for calculating the average deposit holding of an individual, and we assign each depositor to a tercile. Therefore, an individual i is assigned to the first tercile, $Tercile_1$, if his or her average deposit for the quarters between the third quarter of 2010 and the first quarter of 2011 place him or her in the lowest tercile of depositors, and analogously for $Tercile_2$ and $Tercile_3$. In terms of descriptive statistics, our panel presents a high quarterly deposit growth of 2.1%, with a large standard deviation (2.93), which is typical for emerging countries. Such growth rate is slightly higher for depositors in the second and third terciles, 6%; however, this is not statistically different from the other terciles. The first tercile holds 24% of the overall deposits of this bank, the second tercile 31% and the third tercile 45%. Our empirical model follows

$$v_{idt} = \iota_i + \iota_t + \sum_{d=2}^3 \iota_t \times Tercile_d + \epsilon_{idt},$$

in which we regress the deposit growth of individual i belonging to tercile d at quarter-year t over individual and quarter-time fixed effects, ι_i and ι_t , respectively, and an interaction between the time fixed effect and the dummy for the second and third terciles, $\sum_{d=2}^3 \iota_t \times Tercile_d$. As a result, while ι_t embeds the trend of deposit growth by depositors in the first tercile, the two interactions permit us to study these trends for depositors in the second and third terciles, $\iota_t \times Tercile_2$ and $\iota_t \times Tercile_3$, respectively. These are useful to test the parallel trend hypothesis and verify whether terciles react heterogeneously to the policy.

After this initial test, we unpack this result by presenting the regression

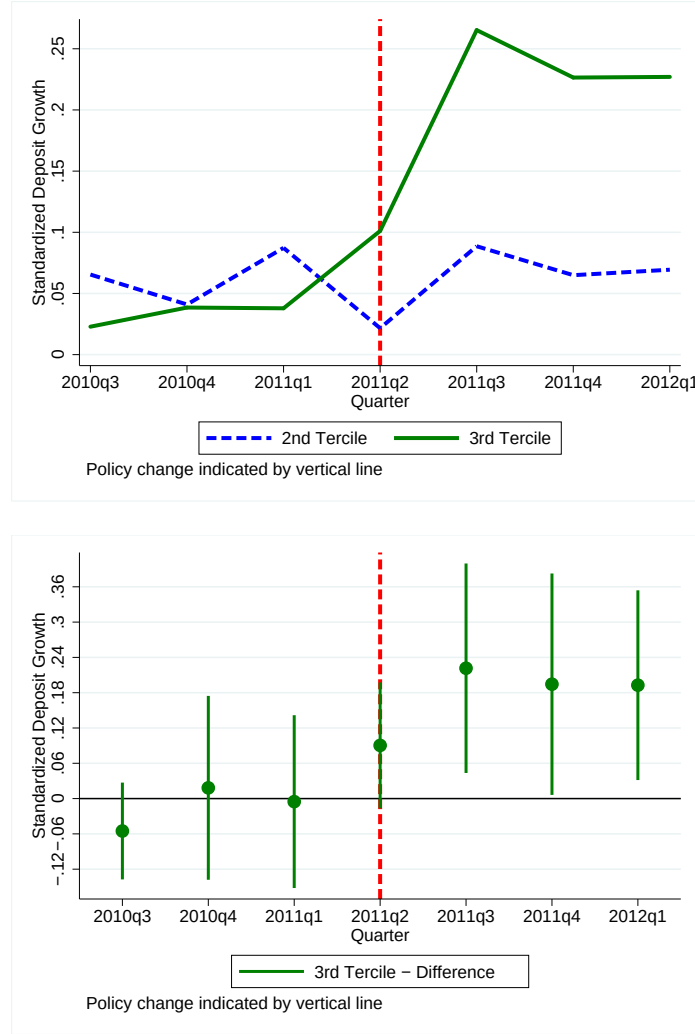
$$v_{idt} = \iota_i + \iota_t + \beta_2 Tercile_2 \times Policy_t + \beta_3 Tercile_3 \times Policy_t + \epsilon_{idt},$$

in which we introduce a dummy variable taking unit value for all quarters after the policy introduction, $Policy_t$, and interact this with the second and third terciles. Beyond summarizing the previous result, this is useful in studying whether the deposit growth varies according to whether a depositor holds a university degree. To do so, we introduce a dummy variable that takes unit value for all individuals whose job can be unequivocally associated with a university degree,⁵ $University_i$, and this variable is interacted with the others. It is important to highlight that very few depositors are classified as holding a university degree, 5.6%. This is in line with the figures at country level on the share of individuals with a university degree, 6.1%.

Figure 6 plots the coefficients of the previous specification, in which the excluded group is the first tercile. The upper panel shows the evolution of the standardized deposit growth across terciles, while the lower panel shows the difference between the third tercile and the others, including the 95% confidence interval. Both pictures are useful in verifying that the second and third terciles are evolving on parallel trends before the policy, whereas from the policy onward, we observe a steady and statistically significant increase in the deposit growth of “wealthy depositors” belonging to the third tercile. This increase is relatively large: it averages 16% of a standard deviation, is statistically different from zero but is relatively dispersed, as the lower panel reports.

⁵The following jobs are coded with a 1 in the University Dummy: Medical Doctor, Architect, Engineer, Lawyer, Agronomist, Professor and Scientist. The job “Business Owner” does not contain sufficient details and hence is coded with a zero.

Figure 6: Policy Change and Trends – NBE Bills and Liquid Assets



Notes: This figure plots the coefficients of the trend in deposit growth exhibited by the second and third terciles compared with the first tercile (upper panel) and the difference between the third and the other terciles (lower panel). To simplify the interpretation of the coefficient, we standardize deposit growth. In the upper panel, the dashed blue line indicates the coefficient of deposit growth for the second tercile, while the solid green line reports the coefficient for the third tercile. The policy is implemented in the second quarter of 2011 and is indicated by the dashed red vertical line. As indicated by both panels, the pre-trend between the first, second and third terciles are not statistically different from zero before the policy, whereas there is an increase in deposit growth by the third tercile. The standard errors are clustered at individual level.

Table 3 refines and unpacks this result by presenting the previous regressions with a $Policy_t$ dummy replacing the quarter-time fixed effects. Column (1) summarizes the results of Figure 6: the standardized deposit growth of individuals in the second tercile does not statistically differ from those in the first tercile, while that of depositors in the third tercile is 16% of a standard deviation higher. Column (2) adds an element of sophistication by introducing the dummy $University_i$. In this case, the excluded category are individuals in the first tercile and without a university degree. The first two rows confirm the results from column (1), while the remaining three rows present two interesting results. First, all the point estimates of the interaction between the Tercile, Policy and University dummies are positive, as could

be expected for sophisticated depositors after the policy change. Second, the highest deposit growth is recorded among depositors belonging to the third tercile and with a university degree: their deposit growth increases by a further 30% of a standard deviation.

These results are in line with this policy injecting trust into the financial system and show that sophisticated depositors (wealthy and educated) are those responding more favourably to this.

Table 3: Policy Change, Deposit Growth and University

	(1)	(2)
Variables	Standardized Deposit Growth	
<i>Tercile 2 × Policy</i>	0.031 (0.051)	0.026 (0.052)
<i>Tercile 3 × Policy</i>	0.166*** (0.052)	0.153*** (0.053)
<i>Tercile 1 × Policy × University Degree</i>		0.052 (0.148)
<i>Tercile 2 × Policy × University Degree</i>		0.081 (0.153)
<i>Tercile 3 × Policy × University Degree</i>		0.295** (0.135)
Individual FE	Yes	Yes
Quarter-Year FE	Yes	Yes
Observations	7,632	7,632
Adj. R sq.	0.082	0.083
Mean Dep. Var.	0.021	0.021
S.D. Dep. Var.	2.932	2.932

Notes: This table reports ordinary least squares (OLS) estimates; the unit of observation is the individual depositor, and depositor and quarter-time fixed effects (FE) are included. Standard errors are clustered at individual level. Deposit growth varies at quarterly level and is defined as follows: the difference between the natural logarithm of deposits in quarter t minus the natural logarithm of the deposits at $t - 1$. This is then standardized, and hence we subtract 0.0.21 and divide by 2.932. The means and standard deviations (S.D.) of deposit growth are reported in the last two rows of the table. This variable is regressed over the *Policy* variable, which is a dummy taking unit value for all quarters after 2011q2, a dummy for each tercile of the deposit distribution and a dummy taking unit value if a depositor holds a job characterized by a university degree. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

2.2.2 Branch Evidence

In order to verify how the deposit behaviour changed at branch level, we partnered with the National Bank of Ethiopia and conducted a survey of bank branch managers. We contacted the universe of bank branches in Ethiopia until the end of 2016 (3,301 branches) and for 792 of them (24%) we were able to conduct a 30 minute interview between in 2017. The key variables that we collected were the amount of deposits at branch level and the year in which the branch was opened.

In line with the theoretical model and the depositor-level evidence, we expected that branches opened after the policy change would collect more deposits. In order to proxy for the proportion of sophisticated depositors, we coded the location of Ethiopian universities in the branch survey. As a result, we can verify whether branches that opened after the policy change in cities with a university (hence a pool of more sophisticated depositors) collected more deposits than branches opened in cities without a university.

The key empirical analysis is built around the following model

$$v_{jbct} = \iota_b + \iota_c + \iota_t + \beta \textit{After Policy}_t \times \textit{University}_c + \epsilon_{jbct},$$

in which the natural logarithm of deposits held by branch j of bank b in city c that opened in year t is regressed over bank, city and time fixed effects, respectively ι_b, ι_c and ι_t . The key variable of interest, $\textit{After Policy}_t \times \textit{University}_c$, is an interaction between a dummy taking unit value for all branches that opened from the year of the policy change (2011) onward, $\textit{After Policy}_t$, and a dummy taking unit value in cities hosting a university, $\textit{University}_c$.

The coefficient β measures the difference in the level of deposits between branches that opened after the policy in cities hosting a university, and hence presenting a pool of depositors who may react to the policy, and those cities that do not present a university. Bank, city and year fixed effects are important, because control for the fact that: a) some banks may hold higher or lower deposits regardless of the policy (more or less popular/trusted); b) cities present different level of deposits, as GDP may vary widely across the country and c) branches opened in certain years may present different levels of deposits in an idiosyncratic manner.

The previous set of fixed-effects highlights that we are running a difference-in-difference analysis. Our first difference compares two branches that are opened in the same city, with one existing before the policy and the other being opened after the policy, as picked up by the dummy, *After_Policy_t*. The second difference compares two branches that were opened in the same post-policy year, but across different cities, with one presenting a university and the other not, *University_c*. The combination of the respective time-series and cross-sectional variation permits to pass a variety of concerns empirical concerns and we introduce a variety of additional fixed effects to account for some of these.

Table 4 reports the results of this section. Column (1) presents the baseline specification and shows that branches opened after the policy in university cities present 24% higher deposits than branches opened in the same period in non-university cities. Given that this is a level-difference and recorded over a 4 year period (2011-2014), this translates in deposits with a higher yearly growth of 5.5% (in a confidence interval between 0.4% and 9.9%). Column (2) adds to the previous set of fixed effects also a control for bank-year fixed effects, that controls for possible differing trends in deposit growth across banks and over time. The point estimate is unaffected. In Column (3), we further control for the unobserved heterogeneity that leads a bank to open a branch in a city. In this case the point estimate grows from 24% to 44%, with an annualized deposit growth of 9.5% (in a confidence interval between 5.5% and 13.1%). Finally, in column (4) I include all fixed effects and find results in line with column (3). Overall these results are in line with the depositor-level analysis and present evidence of responses to a safer bank, especially among highly-educated depositors.

2.2.3 Balance Sheet Evidence

Bank Size: Quarterly Variation

The policy change creates a large exogenous variation in the aggregate s^R , and from the point of view of the theoretical model, this leads to more liquid assets, which stimulate deposits and consequently lending. Because private banks are equally affected by the policy, but respond differentially based on their parameter η , we can produce a variety of tests to study Propositions 1 and 2 empirically. In this section, we offer the following tests: first, we verify that NBE bills were indeed purchased as the policy prescribes and that the policy was not applied differently

between big and small banks; second, we report the quarter evolution of the main aggregates, removing bank-specific effects and seasonal fluctuations, showing the presence of a discontinuity at the policy change introduction, differentially stronger for larger banks. All of these tests provide empirical support for the balance sheet predictions and offer quantitative evidence in favour of our model.

Table 4: Branch Deposit, Policy and University

	(1)	(2)	(3)	(4)
Variables	Branch Deposit - Natural Log			
After Policy $\times$ University	0.241** (0.119)	0.238* (0.142)	0.445*** (0.0995)	0.483*** (0.118)
City FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Bank x Year FE		Yes		Yes
City x Bank FE			Yes	Yes
Obs.	792	792	792	792
Adj. R sq.	0.584	0.582	0.529	0.513
Mean Dep. Var.	13.11	13.11	13.11	13.11
S.D. Dep. Var.	1.095	1.095	1.095	1.095

Notes: This table reports ordinary least squares (OLS) estimates; the unit of observation is a branch. Standard errors are clustered at city level. Branch deposit measures the natural logarithm of the deposits recorded in a survey conducted in 792 branches across 249 cities in Ethiopia. This variable is regressed over the *Policy* variable, which is a dummy taking unit value for all years from 2011 onward. University takes unit value for all Ethiopian cities that presented a university in 2011 and afterward. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

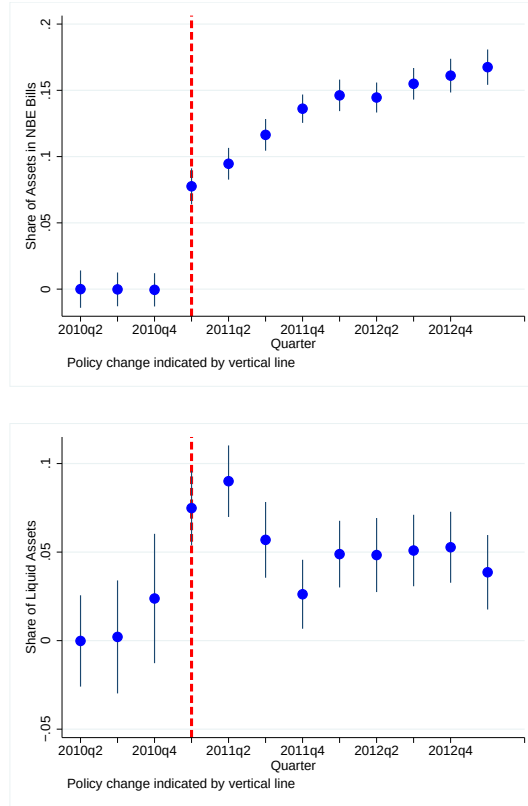
In presenting this test, we explore all available time-series information, rather than simply presenting a pre-post-estimation, as clarified in equation (1). For this reason, we verify how deposits, lending, NBE bills and liquid assets move during all the available quarters and whether a differential trend is registered for big banks. To tighten the empirical exercise with the theoretical model, we regress the logarithm of real deposits and loans, while we report the NBE bills and safe assets as shares of the total assets of the bank. In fact, the variable s^R in the model is the share of assets held in safe assets, and hence the policy change affects this variable rather than simply the log flow of safe assets.

The theoretical model predicts a discontinuity around the introduction of the policy, stronger for large banks, and a long-term effect following the discontinuity. For this reason, we estimate the following model:

$$v_{iqy} = a + \sum_{qy=1}^{13} b_{qy} \cdot d_{qy} + \sum_{qy=1}^{13} c_{qy} \cdot d_{qy} \cdot \text{Big Bank}_i + \iota_i + \iota_{iq} + \epsilon_{iqy}, \quad (2)$$

where the variable v_{iqy} is regressed on a dummy variable d_{qy} , which takes unit value for each quarter qy of the 13 available, an interaction of this dummy with the *Big Bank* dummy variable, a bank fixed effect ι_i , and a bank-quarter fixed effect ι_{iq} to account for seasonality. The coefficients c_{qy} are the core of this estimation and report the average differential evolution of the variable v_{iqy} for big banks. Note that, while in equation (1) the sign of the interaction term was negative because the theoretical model measured η , here the interactions are expected to be positive, because *Big Bank* measures the inverse of η . This difference stays across all empirical exercises.

Figure 7: Policy Change and Trends – NBE Bills and Liquid Assets



Notes: This figure plots the coefficients of the overall trend in the asset share of NBE bills (upper panel) and the asset share of overall liquid assets (lower panel) over all quarters available in the data. As is evident, there occurs an important discontinuity around the policy introduction (vertical dashed red line), and all banks start purchasing a large amount of NBE bills, with a significant increase in the amount of overall safe assets. As is evident from Table 5, big and small banks do not purchase statistically different quantities of such assets.

Table 5: Liquidity Requirements, Bank Size and Banking

Variables	(1) Total Deposits Ln Mill. Birr	(2) Private Lending Ln Mill. Birr	(3) NBE Bills Asset Share	(4) Liquid Assets Asset Share
Big Banks				
Big Bank $\times$ Quarter 2	0.0774 (0.0469)	0.0935** (0.0364)	0.0000 (0.0004)	0.00246 (0.0116)
Big Bank $\times$ Quarter 3	0.0841 (0.171)	0.00917 (0.291)	-0.000716 (0.00101)	0.00881 (0.0280)
Big Bank $\times$ Quarter 4	0.112 (0.251)	-0.0190 (0.376)	-0.00197 (0.00265)	0.0610 (0.0519)
Big Banks and Post-Policy				
Big Bank $\times$ Quarter 5	0.254 (0.174)	0.262* (0.139)	-0.0133 (0.0196)	-0.00574 (0.0264)
Big Bank $\times$ Quarter 6	0.360** (0.165)	0.296* (0.146)	-0.0164 (0.0188)	-0.00451 (0.0314)
Big Bank $\times$ Quarter 7	0.455** (0.164)	0.357** (0.155)	-0.0179 (0.0202)	-0.0133 (0.0347)
Big Bank $\times$ Quarter 8	0.535*** (0.177)	0.428** (0.173)	-0.0134 (0.0180)	-0.0226 (0.0341)
Big Bank $\times$ Quarter 9	0.622*** (0.179)	0.487** (0.190)	-0.00819 (0.0227)	-0.00775 (0.0294)
Big Bank $\times$ Quarter 10	0.658*** (0.189)	0.519** (0.204)	-0.0195 (0.0205)	-0.00476 (0.0312)
Big Bank $\times$ Quarter 11	0.716*** (0.204)	0.572** (0.215)	-0.0261 (0.0224)	-0.0329 (0.0375)
Big Bank $\times$ Quarter 12	0.788*** (0.212)	0.622** (0.233)	-0.0359 (0.0225)	-0.0383 (0.0344)
Big Bank $\times$ Quarter 13	0.845*** (0.219)	0.699** (0.249)	-0.0322 (0.0238)	-0.0400 (0.0365)
Quarter-Year FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Observations	512	512	512	512
Adj. R sq.	0.951	0.875	0.893	0.384
Mean Dep. Var.	7.751	7.295	0.0940	0.252
S.D. Dep. Var.	1.574	1.150	0.0736	0.0703

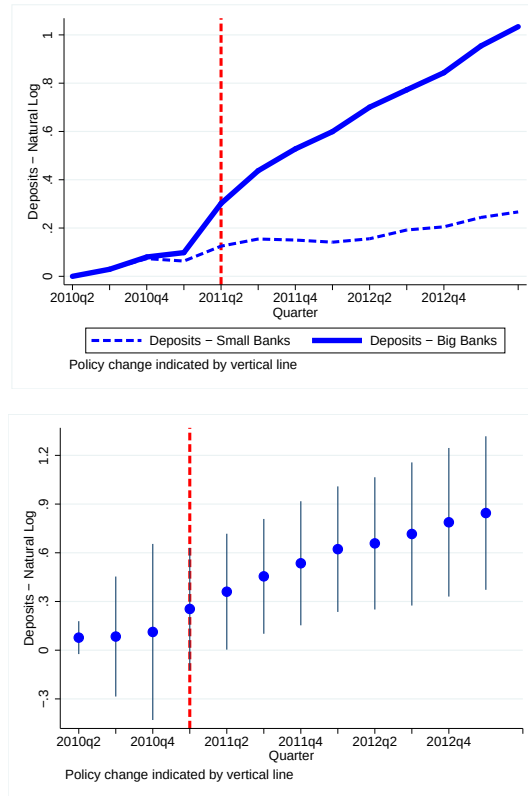
Notes: This table reports OLS estimates; the unit of observation is bank level, and bank and quarter $\times$ year fixed effects (FE) are included. Standard errors are clustered at bank level. Total Deposits is a variable aggregating demand, saving and time deposits at bank level; it is continuous and measured in million (Mill.) birr. Private Lending embodies lending to the private (no

financial sector, no public sector, regions, cooperatives) at bank level; it is continuous and measured in million birr. NBE Bills is the amount of bills issued by the NBE at bank level; it is continuous and measured as a share of total bank assets. Liquid Assets are defined as the sum of other balance sheet variables (cash, treasury bills, reserves, NBE bills, interbank holdings); it is continuous and as a share of bank assets. The means and standard deviations (S.D.) of these variables are reported in the last two rows of the table. All of these variables are regressed over 13 quarter dummy variables, which span all the months in our data. The policy change occurs in Quarter 5 (April, May and June 2011). Figures 8 and 9 plot all the coefficients over time. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

In Figure 7, we present the average trend in the quantity of NBE bills (upper panel) and overall liquid assets (lower panel) as a share of overall assets for all banks. The upper panel shows that, before the policy change, there were no such bills in the economy (all banks held exactly zero of such bills), whereas after the policy change, these bills represent 15% of bank assets. However, liquidity does not increase in a one-to-one proportion, as banks change the composition of their liquid assets; in fact, the lower panel shows that the overall liquidity as a share of assets increases by 5–8 percentage points, in line with Figure 5. The effects of this policy on deposits and loans are shown in Figures 8 and 9. These report the evolution of deposits and loans, respectively; in both figures, the upper panel reports the evolution of both big and small banks, while the lower panel reports their difference including the 95% confidence interval. In both cases, we cannot reject the parallel trends before the policy, whereas the trends in both deposits and loans start to diverge significantly after the policy. Table 5 reports the coefficients for the difference for deposits, loans, NBE bills and liquid assets between big and small banks. Comparing these coefficients is important to verify three points: 1) we cannot reject parallel trends, as graphically reported, while such trends divert after the policy; 2) big and small banks do not accumulate a statistically different quantity of NBE bills and liquid assets; 3) the point estimate of the post-policy increase in deposits is higher than the increase in lending, in line with the fact that such additional deposits are key for financing additional lending.

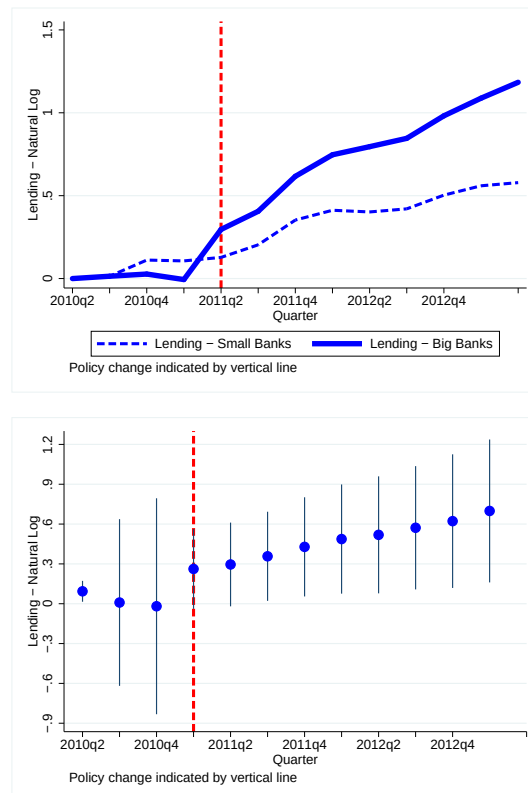
Therefore, consistent with the theoretical model, an increase in safe asset holding by all banks generates a differential expansion in deposits and loans, stronger for larger banks.

Figure 8: Policy Change and Trends – Deposits



Notes: This figure plots the coefficients of the overall trend exhibited by small and large banks for the natural logarithm of deposits (upper panel) and the difference and 95% confidence interval (lower panel) over all quarters available in the data. Big banks are reported with a blue solid line, while small banks are reported with a blue dashed line. The policy is announced in mid-March 2011 and implemented in April 2011 (vertical red dashed line). As is evident, there occurs an important discontinuity around the policy introduction (Quarter 5).

Figure 9: Policy Change and Trends – Lending



Notes: This figure plots the coefficients of the overall trend exhibited by small and large banks for the natural logarithm of private sector lending (upper panel) and the difference and 95% confidence interval (lower panel) over all quarters available in the data. Big banks are reported with a blue solid line, while small banks are reported with a blue dashed line. The policy is announced in mid-March 2011 and implemented in April 2011 (vertical red dashed line). As is evident, there occurs an important discontinuity around the policy introduction (Quarter 5).

Bank Pre-Policy Liquidity

In this section, we combine the large time-series variation in liquidity requirements with the larger cross-sectional variation in the percentage increase in the share of liquid assets that each bank accumulated after the policy change. As shown in Figure 5, given that some banks increased their share of liquid assets by 20–30% and others by 100% or more, we can exploit this margin in this analysis. Proposition 3 shows that banks with the strongest increase in liquid assets are also those with more deposits and lending in response.

The empirical equation can be described by

$$v_{it} = \iota_i + \iota_t + b \text{ Policy}_t \times \text{Liquidity Increase}_i + \epsilon_{it},$$

in which v_{it} embodies a variable by bank i at time t (deposits and loan), which is regressed on bank and time fixed effects, a dummy taking unit value for all quarters after the policy (Policy_t) and a variable that measures the cross-sectional change in the share of liquid assets ($\text{Liquidity Increase}_i$).

Table 6 shows that the prescriptions of Proposition 3 cannot be rejected. Column (1) reports that, after the policy, banks that had increased their liquid asset share by one standard deviation increased their deposits by 0.633 percentage points (8.2%). This is in line with an increase in liquid and safe asset holding by banks, generating an increase in banks' deposit supply. Analogously, column (2) reports lending increases as well, but by a smaller extent, 0.505 percentage points (6.8%), given that a part of the deposit growth satisfies the liquidity requirement. This is interesting because, in response to a higher liquidity requirement, the overall lending increases because of the larger balance sheet generated by the increase in deposits.

Table 6: Liquidity Requirements, Liquidity Increase and Banking

	(1)	(2)
Variables	Deposits	Private Lending
	Ln Mill. Birr	Ln Mill. Birr
Policy $\times$ Liquidity Increase	0.633*** (0.0827)	0.505*** (0.102)
Quarter-Year FE	Yes	Yes
Bank FE	Yes	Yes
Observations	512	512
Adj. R sq.	0.964	0.953
Mean Dep. Var.	7.715	7.320
S.D. Dep. Var.	1.057	1.129

Notes: This table reports OLS estimates; the unit of observation is bank level, and bank and quarter $\times$ year fixed effects are included. Standard errors are clustered at bank level. Deposits is a variable aggregating demand, saving and time deposits at bank level; it is continuous and measured in the natural logarithm (Ln) of million (Mill.) birr. Private Lending embodies lending to the private (no financial sector, no public sector, regions, cooperatives) at bank level; it is continuous and measured in the natural logarithm of million birr. Policy is a dummy taking unit value from the quarter in which the policy is implemented onward. Liquidity Increase describes the bank-level percentage increase in the amount of share of liquid assets held by each bank. The means and standard deviations (S.D.) of these variables are reported in the last two rows of the table. *** indicates significance at the 1% level.

2.2.4 Evidence from a Branch Map of Ethiopia

In this section, we present further evidence on a key feature of Propositions 1, 2 and 3, where we show that this new liquidity requirement induces branch expansion. To test this hypothesis, we construct a map of all branches in Ethiopia, where for each bank, we know all the branches installed and their region and city of introduction with the month and year of opening. Our map covers 2,023 branches installed by all 14 banks registered until 2013 and opened between 2000 and 2014.

In this analysis, we want to verify two features: 1) that the overall number of branches increases as the liquidity effect kicks in, as the model predicts; 2) that new branches are more “rural”. We measure rurality by measuring the distance in kilometres from the bank headquarters.

For this reason, we collapse our branch-level database to a panel at bank level with months and year. Our test is a typical difference-in-difference specification

$$v_{imy} = a + b \cdot Policy_{my} \times Bank\ Variation_i + \iota_i + \iota_m + \iota_y + \epsilon_{iy}, \quad (3)$$

where the two measures of branch expansion in consideration (number of branches and kilometres from the headquarters), v_{imy} , are regressed over bank, month and year fixed effects, ι_i , ι_m and ι_y , respectively, and the interaction between a policy dummy taking unit value after April 2011, the introduction of the policy and the two sources of bank variation studied in this paper (big bank and the percentage increase in the share of liquid assets).

Table 7 presents the key results on branch expansion. Columns (1) and (2) summarize the results by comparing the variation between big and small banks. In both cases, after the policy, big banks increase their branch expansion significantly more. Column (1) reports that this effect amounts to 0.586 percentage points over the three years after the policy, which corresponds to a 5.37% increase per year. Column (2) gives a measure of the “rurality” of these new branches, which increases by 12% over a three-year period, 3.85% per year. Columns (3) and (4) replicate these results by considering the percentage increase in liquidity as a source of cross-sectional variation. Column (3) shows that, after the policy change, banks that increased their liquidity by one standard deviation experienced a 13% increase in their installed branches over a three-year period, 4.16% per year. Analogously, we observe an increase in distance by 16% over three years, 5.07% per year.

Table 7: Branches and Liquidity

	(1)	(2)	(3)	(4)
Variables	Ln Num. of Branches	Ln Distance in Km	Ln Num. of Branches	Ln Distance in Km
Policy $\times$ Bank Variation	0.586*** (0.166)	1.021** (0.450)	0.471*** 0.471***	1.423*** 1.423***
Bank Variation	Big Banks		Percentage Liquidity Increase	
Bank FE	Yes	Yes	Yes	
Time FE	Yes	Yes	Yes	
Observations	518	518	518	518
Adj. R sq.	0.891	0.660	0.882	0.663
Mean Dep. Var.	3.447	8.558	3.447	8.558
S.D. Dep. Var.	1.034	1.720	1.034	1.720

Notes: This table reports OLS estimates. The unit of observation is bank level, and bank, month and year fixed effects (FE) are included. Standard errors are clustered at bank level. The number of branches (Num. of Branches) is defined as the cumulative number of branches installed by a bank, while the distance from the headquarters (Distance in Km) is the cumulative number of kilometres of the branches installed by a bank. Their means and standard deviations (S.D.) are reported in the final two rows of the table. These variables are regressed over the interaction of a Policy dummy taking unit value after April 2011 and two sources of Bank Variation. In columns (1) and (2), we use the Big Bank dummy; while in columns (3) and (4), we use the percentage increase in the share of liquid assets after the policy. The adjusted R^2 (Adj. R sq.) of these regressions is also reported. *** and ** indicate significance at the 1% and 5% level, respectively.

3 Robustness Checks

In this section, we explore possible alternative explanations that might be related to the policy change and invalidate our inference. We structure this in two subsections:

1. Identifying Assumption (Section 3.1) – in which we rule out that macroeconomic changes taking place at the same time as our policy change are responsible for the results.
2. Robustness to Alternatives (Section 3.2) – in which we study a variety of other margins that may confound our results.

3.1 Identifying Assumption

The results presented in Tables 5 and 6 are robust to time-series shocks that affect all banks with the same intensity. However, some economic variables may affect heterogeneously banks by either their size (Table 5) or their liquidity holding (Table 6). Therefore, the main results of this work may be driven by a contemporaneous macroeconomic shock rather than the policy change.

To rule out this possibility, we proceed in the following way. First, we identify a set of macroeconomic variables to study for Ethiopia: gross domestic product (GDP) per capita growth, export as a share of GDP, foreign direct investment (FDI) as a share of GDP, and inflation. Second, we offer the following test:

$$v_{it} = \iota_i + \iota_t + b \textit{Policy}_t \times \textit{Cross Section}_i + c \textit{Macro}_t \times \textit{Cross Section}_i + \epsilon_{it},$$

in which we regress the logarithm of deposits (Table 8) and lending (Table 9) over bank and quarter-year fixed effects, ι_i and ι_t , respectively, then the interaction between the dummy taking unit value for all quarters after the implementation of the policy, $\textit{Policy}_t$, and the cross-sectional variation across banks, $\textit{Cross Section}_i$. This variable is the *Big Bank* dummy in Panel A and the *Liquidity Increase* continuous variable in Panel B. Finally, we add an interaction between the macroeconomic variables previously described and the cross-sectional variable. These will absorb macroeconomic changes that affect banks heterogeneously depending on their cross-sectional variation.

Table 8 and Table 9 report the results of our new model for deposits and lending, respectively. In each of these tables, Panel A exploits *Big Bank* as a source of cross-sectional variation, while Panel B uses the *Liquidity Increase* compared with the pre-policy case. In all cases, the coefficient of interest, $\textit{Policy}_t \times \textit{Cross Section}_i$, is positive, significant and in line with the previous results. We can see that in both Table 8 and Table 9, *Big Bank* seems to change non-trivially in its point estimate, pointing toward a possible heterogeneous effect of macroeconomic variables depending on bank size. In contrast, *Liquidity Increase* is relatively unaffected by the interactions in its point estimate.

3.2 Robustness to Alternatives

The most important feature, which has not been previously addressed, is the destination of the funds collected by the NBE through this new bill. One powerful argument regarding the effects observed in Figure 6 on deposits and loans could be the following. This liquidity regulation drained substantial resources from the banking system and placed them in long-term investment in some geographical areas to which big banks had a comparative advantage in terms of access. In a sense, leaving aside the liquidity asset increase verified in Figure 5, this hypothesis would identify the regulation policy as an indirect transfer of resources from small to big banks. We believe this is implausible for two reasons. First, the Ethiopian government relies heavily on its state-owned bank the Commercial Bank of Ethiopia, which is the largest in the country, not affected by the policy and profitable: in 2011/12, it amassed 8 billion birr of profits, corresponding to roughly 400 million United States dollars.

Table 8: Deposits, Liquidity Requirements and Macroeconomic Shocks

Variables	(1)	(2)	(3)	(4)
Deposits Ln Mill. Birr				
Panel A – Big Banks				
Policy × Big Bank	0.404*** (0.123)	0.348*** (0.117)	0.511*** (0.108)	0.583*** (0.120)
Macro Variable × × Big Bank	Yes	Yes	Yes	Yes
Panel B – Liquidity Increase				
Policy × Liquidity Increase	0.678*** (0.0731)	0.679*** (0.0737)	0.633*** (0.0828)	0.630*** (0.0852)
Macro Variable × × Liquidity Increase	Yes	Yes	Yes	Yes
Macro Variables	GDP Growth Per Capita	Export % of GDP	FDI % of GDP	Inflation CPI
Observations	512	512	512	512
Mean Dep. Var.	7.715	7.715	7.715	7.715
S.D. Dep. Var.	1.057	1.057	1.057	1.057

Notes: This table reports OLS estimates; the unit of observation is bank level, and bank and quarter $\times$ year fixed effects are included. Standard errors are clustered at bank level. Deposits is a variable aggregating demand, saving and time deposits at bank level; it is continuous and measured in the natural logarithm (Ln) of million (Mill.) birr. Policy is a dummy taking unit value from the quarter in which the policy is implemented onward. In Panel A, we exploit the Big Bank dummy as a source of cross-sectional variation across banks; while in Panel B, we exploit Liquidity Increase, which describes the bank-level percentage increase in the amount of share of liquid assets held by each bank. In each panel, the corresponding unit of cross-sectional variation is interacted with the four macro variables reported in the row “Macro Variables”: the growth of GDP per capita, export as a share of GDP,

FDI as a share of GDP and inflation measures through the changes in the consumer price index (CPI). The means and standard deviations (S.D.) of deposits are reported in the last two rows of the table. *** indicates significance at the 1% level.

If there had to be a redistribution of resources, then the two state-owned banks (the Commercial Bank of Ethiopia and the Development Bank of Ethiopia) might have been the recipients rather than private commercial banks. Second, if the argument given above is true, we should observe a special increase in credit and branches in those regions that were particularly targeted for long-term investment. The region that has mostly been attractive to long-term investment projects is Benishangul-Gumuz, which hosts the construction site of the Grand Ethiopian Renaissance Dam. In Figure 9, the upper panel shows the branch installation and total employment by medium-scale enterprises compared with the national average. As is evident, it is difficult to argue that such a region has been the destination of most attention, and for this reason, we believe that our claim concerning the mechanism of enhanced bank safety cannot be dismissed.

Table 9: Lending, Liquidity Requirements and Macroeconomic Shocks

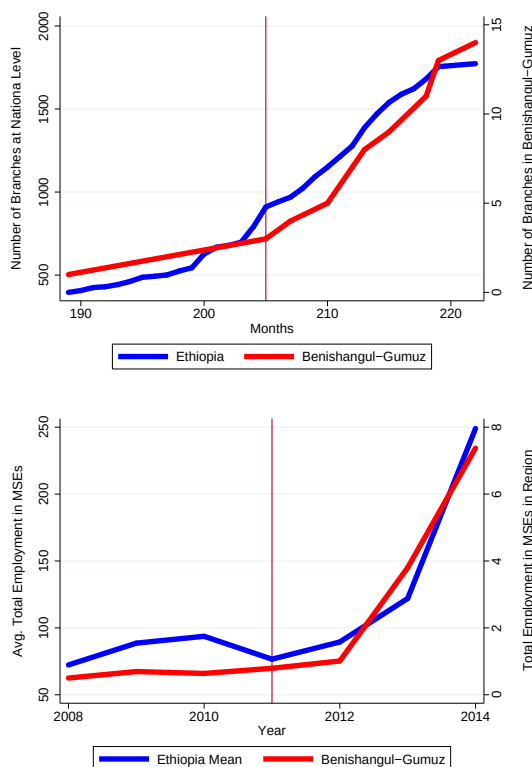
Variables	(1)	(2)	(3)	(4)
	Lending Ln Mill. Birr			
Panel A – Big Banks				
Policy × Big Bank	0.402*	0.339***	0.461**	0.525***
	(0.219)	(0.106)	(0.178)	(0.194)
Macro Variable × × Big Bank	Yes	Yes	Yes	Yes
Panel B – Liquidity Increase				
Policy × Liquidity Increase	0.540***	0.543***	0.507***	0.505***
	(0.101)	(0.102)	(0.103)	(0.104)
Macro Variable × × Liquidity Increase	Yes	Yes	Yes	Yes
Macro Variables	GDP Growth Per Capita	Export % of GDP	FDI % of GDP	Inflation CPI
Obs.	512	512	512	512
Mean Dep. Var.	7.320	7.320	7.320	7.320
S.D. Dep. Var.	1.129	1.129	1.129	1.129

Notes: This table reports OLS estimates; the unit of observation is bank level, and bank and quarter $\times$ year fixed effects are included. Standard errors are clustered at bank level. Private lending embodies lending to the private (no financial sector, no public sector, regions, cooperatives) at bank level; it is continuous and measured in the natural logarithm (Ln) of million (Mill.) birr. Policy is a dummy taking unit value from the quarter in which the policy is implemented onward. In Panel A, we exploit the Big Bank dummy as a source of cross-sectional variation across banks; while in Panel B, we exploit Liquidity Increase, which describes the bank-level percentage increase in the amount of share of liquid assets held by each bank. In each panel, the corresponding unit of cross-sectional variation is interacted with the four macro variables reported in the row “Macro Variables”: the growth of GDP per capita, export as a share of GDP, FDI as a share of GDP and inflation measures through the changes in the consumer price

index (CPI). The means and standard deviations (S.D.) of deposits are reported in the last two rows of the table. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

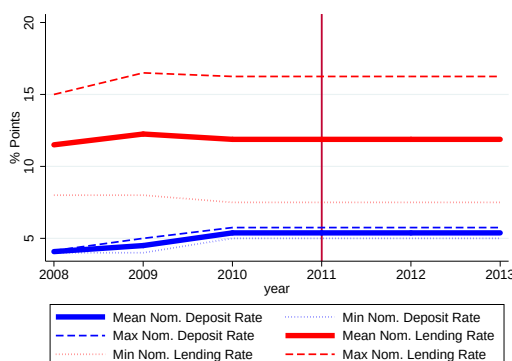
Another argument against the safe-asset nature of these bills may be that they lock increasing liquidity in the central bank and do not allow banks to use this to address liquidity shortfall. This is most likely not the case for two reasons: 1) banks can use this bill to trade liquidity claims among themselves and smoothen idiosyncratic shocks; 2) the central bank redeems this bill for liquidity, as article 7 of the directive prescribes.

Figure 10: Regional Heterogeneity



Notes: This figure reports the monthly evolution of branch opening in the upper panel and the yearly total employment by medium-scale enterprises in the lower panel for the region Benishangul-Gumuz (red) and the other Ethiopian regions (blue). As is clear in both panels, there is no detectable difference between the rest of Ethiopia and Benishangul-Gumuz, which has been the centre of substantial long-term investment in recent years. The upper panel reports the number of branches, while the lower panel gives the number of employees (in thousands). The red vertical line marks the month and year of the policy change (April 2011) in the upper panel and the year of the policy change (2011) in the lower panel.

Figure 11: Policy Change and Prices: Lending and Deposit Rates

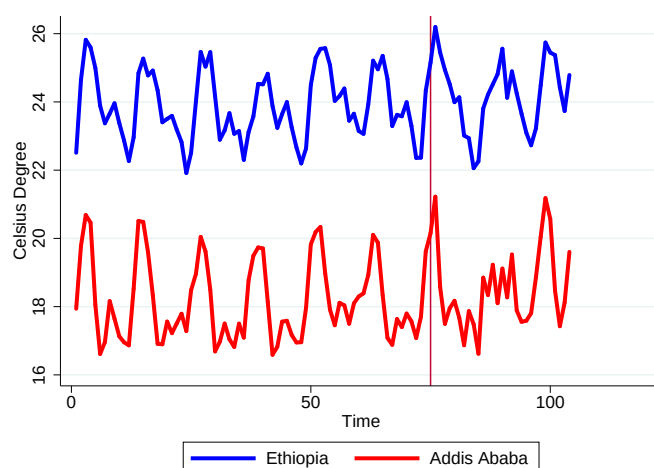


Notes: This figure reports the monthly evolution of the average nominal (Nom.) deposit rate (blue) and lending rate (red), with their respective minimum and maximum rates. The sources are the 2012, 2013 and 2014 annual reports of the NBE. As described in the text, there is no detectable change in either of the rates in response to the policy change.

Another core element that has been omitted in the analysis is the price response of the policy. The theoretical model took prices as given and was silent on the ways in which the lending and deposit rates could respond to a shock in s^R . This might create alternative channels through which the liquidity regulation shapes the economic problem. For example, if the lending rate in the good state, R_G , grew in response to the policy (or if the deposit rate R_D correspondingly declined), then the branch expansion effect could be entirely due to an increased profitability of the banking system, with liquid assets being a negligible component of the story. We decided to leave prices constant in the model because of anecdotal evidence from Ethiopian bankers on the lack of a price response due to competitive pressure, which was then confirmed in our data collection exercise. In fact, Figure 10 presents the mean lending and deposit rates with their respective minimum and maximum rates as published by the NBE (2013). Although some changes occurred in mid-2009, it is noticeable that, over the period of the policy (2011–2013), rates are generally constant, at least in the first moment of their distributions and the respective supports. This is in line with the theoretical model, in which market prices were left constant over the policy change.

Third, climate might be problematic if the policy change occurred over periods of extensive temperature fluctuations, which might have affected the agricultural and/or industrial productivity and hence financial markets. Ethiopia is a country close to the Equator, with a heterogeneous climate and diverse altitudes, and all of these characteristics make it suitable for important temperature fluctuations, which might be related to our study. From an analysis of average monthly temperatures for Ethiopia and its capital city, Addis Ababa, between 2005 and 2013, as shown in Figure 12, we observe that, although there is some substantial cyclical variation in temperature, there does not seem to be an exceptional increase in either the level or the volatility of temperatures over the period of the policy change.

Figure 12: Climate and Policy Change



Notes: This figure reports the monthly average temperature in Ethiopia (blue) and Addis Ababa (red) between January 2005 and August 2013. The policy change occurs in April 2011, reported as Time 75 in the figure, and there does not seem to be any response to weather changes. The data source is the Berkeley Earth project (<http://berkeleyearth.org>). Alternative measures of temperatures were used from the National Oceanic and Atmospheric Administration's National Climatic Data Center and are highly correlated with the current values (0.72 for Addis Ababa and 0.6 for Ethiopia) and highlight similar differences.

Table 10: Largest Disasters in Ethiopia

	(1)	(2)
Type	Date	Total Deaths
Flood	13 August 2006	364
Flood	5 August 2006	498
Epidemic	September 1988	7,385
Drought	June 1987	367
Epidemic	January 1985	1,101
Drought	May 1983	300,000
Epidemic	January–December 1981	990
Drought	December 1973	100,000
Epidemic	January 1970	500
Drought	July 1965	2,000

Notes: This table reports the most important disasters in Ethiopia between 1960 and 2015, from the most recent to the oldest. In recent years, Ethiopia has not experienced any disaster that could be related to the policy introduction. The data source is EM-DAT, <http://emdat.be>.

In addition, natural disasters might lead to a change in the marginal value of public/private infrastructure and affect financial markets. The year of the policy change, 2011, was indeed

marked by one of the most severe droughts in Eastern Africa in the past 60 years,⁶ and this may be a reason for concern. As clarified by Figure 13, this disaster affected mostly Somalia, Kenya and Ethiopia. However, this might be a limited concern for this study because, while Somalia was hit in the most densely populated region of the country (around its capital city, Mogadishu), Ethiopia was hit in a low-density and predominantly rural area, as clarified by the lower panel of Figure 13. In particular, according to some controversial relief statistics, the number of Ethiopians affected by this disaster was between a few hundred and 700,000, which is a sizeable number, but limited relative to the 2011 population of 89.39 million. In Table 10, we report a list of the major disasters that have occurred in Ethiopia since 1960, and verify that this drought does not qualify as a disaster in the Emergency Events Database (EM-DAT) definition.⁷

Last but not least, alternative policy changes might have contemporaneously affected bank behaviour. In this period, the introduction of interest-free banking (IFB)⁸ is the most important regulation. This measure is intended to allow Muslim Ethiopians to have a deposit account and to invest in other financial products complying with Islamic principles and not “making money with money”. However, because by law all deposits in Ethiopia are remunerated at least an annual 5%, this prevented the use of banking services by the almost 33% of Ethiopians who profess Muslim faith. As a result, this measure could have been a major confounder. For example, the simultaneous increase in deposits that we observe may be mostly due to new Muslim customers, who might have been the driver of the effects. Even if this could be a fascinating hypothesis, we exclude the theory that IFB is effectively responsible for any of the effects that we report. Despite 2011 marking the legalization of IFB in Ethiopia, only one bank announced operations toward IFB at the end of 2013, which is the last part of our sample. A few other banks officially launched IFB products only in 2014 and 2015.⁹ The reluctance

⁶Refer to the BBC article “Horn of Africa sees ‘worst drought in 60 years’”, 28 June 2011, available at <http://www.bbc.co.uk/news/world-africa-13944550>.

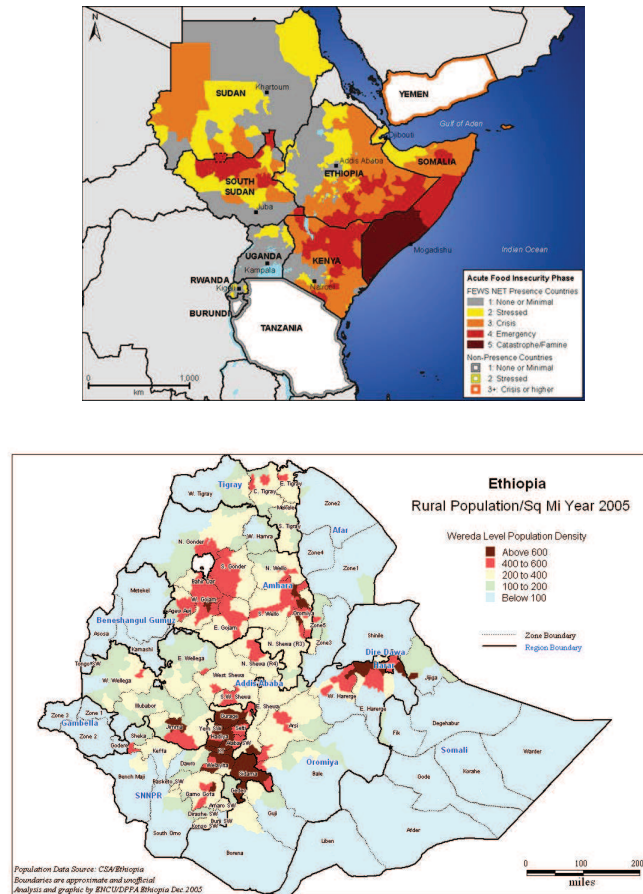
⁷The EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters and defines a disaster as an event satisfying at least one of the following characteristics: 10 or more people reported killed; 100) or more people reported affected; declaration of a state of emergency; call for international assistance.

⁸For more information, refer to the NBE directive available at <http://www.nbe.gov.et/pdf/directives/bankingbusiness/sbb-51-11.pdf>.

⁹The first bank to offer IFB was Oromia International Bank in September 2013, and the state-owned Commercial Bank of Ethiopia announced operations at the end of October 2013. Successively, Wegagen Bank, United Bank and Abay Bank announced the offer of IFB in 2014, and the other banks are moving in this direction but have not yet implemented such products. For more information, refer to the October 2013 and May 2014 issues of *Addis Fortune*, a major Ethiopian business magazine:

behind this initiative is mainly given by the higher costs of operating these financial products, because the bank needs to purchase directly the investment good on behalf of the firm, which then progressively repays it.

Figure 13: Drought and Population Density in Ethiopia in 2011



Notes: The upper panel shows a picture of the 2011 Eastern African drought and the intensity at which countries were affected. The picture is based on the Famine Early Warning System (FEWS) and is freely available at https://en.wikipedia.org/wiki/File:FEWS_Eastern_Africa_July-September_projection.png. The lower panel shows a map of the population density in Ethiopia constructed by the Central Statistical Agency of Ethiopia (CSA). Comparing the two pictures, it emerges that the areas most affected by the drought were low-population-density areas, mostly in the Somali and Oromia regions.

4 Conclusion

In this paper, we show that liquidity requirements can stimulate deposit growth by increasing depositor repayment in bad states. We present a stylized model to guide our empirical analysis and show that such deposit growth may exceed the intermediation margin decline in the presence of high credit risk, and hence stimulate lending and branching. The model is useful in offering

<http://addisfortune.net/articles/commercial-bank-to-launch-interest-free-banking/> and <http://addisfortune.net/articles/interest-grows-in-interest-free-banking/>.

two sources of cross-sectional variation along which banks are affected: 1) bank technology, which can be summarized by size as a sufficient statistic, and 2) the heterogeneous increase in liquid asset holding by banks.

We analyse a unique policy change that permits us to test our hypothesis, namely, there was a large and unexpected liquidity requirement in Ethiopia that fostered the liquid assets of Ethiopian banks by 33% in one quarter of 2011. Our analysis relies on four unique sources of data: a representative panel of bank depositors, a survey of branch-level deposits, bank balance sheets at high frequency and a branch map covering the universe of bank branches.

Depositor-level data highlight that, whereas the three terciles of the deposit distribution were evolving on parallel trends before the policy, the third tercile diverges significantly after the policy and increases its deposit growth. We further investigate this growth and find that such increase is particularly large among depositors in the third tercile and holding a university degree. This may be interpreted as an index of sophistication and ability to factor in new financial information. Branch-level data clarifies that branches opened after the policy change in university cities collected significantly more deposits than branches opened before the policy and branches opened in cities without a university. This is consistent with the depositor-level analysis and points toward a key role of sophistication in this setting. The remaining two datasets are useful for verifying that this policy presented a heterogeneous effect on banks. Those that were either larger or experienced a larger increase in their post-policy liquidity, also reported larger increases in deposits, lending and branching.

These results shed light on an alternative role of liquidity requirements that has received little empirical consideration. Our findings are particularly interesting for emerging markets, which share many similarities with Ethiopian financial institutions and characteristics. This mechanism may also apply to financial systems in high-income countries, which encounter temporary systemic shocks that simultaneously weaken the credibility of government guarantees (i.e., deposit insurance) and the solvency of banks.

References

Allen, F., Carletti, E., Cull, R., Qian, J., Senbet, L. W., Valenzuela, P. et al.: 2014, Improving access to banking: Evidence from kenya, *Technical report*, CEPR Discussion Papers.

- Allen, F., Carletti, E. and Marquez, R.: 2015, Deposits and bank capital structure, *Journal of Financial Economics* **118**(3), 601–619.
- Bank for International Settlements: 2013, Basel iii: The liquidity coverage ratio and liquidity risk monitoring tools, *Basel Committee on Banking Supervision* .
- Barth, J. R., Caprio, G. and Levine, R.: 2004, Bank regulation and supervision: what works best?, *Journal of Financial intermediation* **13**(2), 205–248.
- Barth, J. R., Caprio Jr, G. and Levine, R.: 2001, Banking systems around the globe: Do regulation and ownership affect performance and stability?, *University of Chicago Press* pp. 31–96.
- Beck, T., Carletti, E. and Goldstein, I.: 2017, 11 financial regulation in europe: Foundations and challenges, *Economics without Borders* p. 470.
- Brown, M., Guin, B. and Kirschenmann, K.: 2015, Microfinance banks and financial inclusion, *Review of Finance* **20**(3), 907–946.
- Bruhn, M. and Love, I.: 2014, The real impact of improved access to finance: Evidence from mexico, *The Journal of Finance* **69**(3), 1347–1376.
- Calomiris, C. W., Heider, F. and Hoerova, M.: 2015, A theory of bank liquidity requirements, *Mimeo* .
- Calomiris, C. W. and Kahn, C. M.: 1991, The role of demandable debt in structuring optimal banking arrangements, *The American Economic Review* pp. 497–513.
- Calomiris, C. W. and Wilson, B.: 2004, Bank capital and portfolio management: The 1930s capital crunch and the scramble to shed risk, *The Journal of Business* **77**(3), 421–455.
- Calvet, L. E., Campbell, J. Y. and Sodini, P.: 2009, Measuring the financial sophistication of households, *American Economic Review* **99**(2), 393–98.
- Caprio, G. and Klingebiel, D.: 2002, Episodes of systemic and borderline banking crises, *Managing the real and fiscal effects of banking crises, World Bank Discussion Paper* **428**, 31–49.
- Chavaz, M., Rostom, M. and Slutzky, P.: 2017, Depositors attention and bank risk: Evidence from uk offshore accounts, *Working Paper* .

- Dagher, J. and Kazimov, K.: 2015, Banks liability structure and mortgage lending during the financial crisis, *Journal of Financial Economics* **116**(3), 565–582.
- Demirgüç-Kunt, A., Kane, E. J. and Laeven, L.: 2014, Deposit insurance database, *NBER (wp 20278)* .
- Diamond, D. W. and Dybvig, P. H.: 1983, Bank runs, deposit insurance, and liquidity, *Journal of political economy* **91**(3), 401–419.
- Edey, M. and Hviding, K.: 1995, An assessment of financial reform in oecd countries, *OECD Economics Department Working Papers, No. 154* .
- Farhi, E., Golosov, M. and Tsyvinski, A.: 2009, A theory of liquidity and regulation of financial intermediation, *The Review of Economic Studies* **76**(3), 973–992.
- Gennaioli, N., Martin, A. and Rossi, S.: 2014, Sovereign default, domestic banks, and financial institutions, *The Journal of Finance* **69**(2), 819–866.
- Gete, P. and Reher, M.: 2017, Non-banks and lending standards in mortgage markets. the spillovers from liquidity regulation., *Working Paper* .
- Guiso, L. and Jappelli, T.: 2008, Financial literacy and portfolio diversification.
- Guiso, L. and Viviano, E.: 2014, How much can financial literacy help?, *Review of Finance* **19**(4), 1347–1382.
- Ippolito, F., Peydró, J.-L., Polo, A. and Sette, E.: 2016, Double bank runs and liquidity risk management, *Journal of Financial Economics* **122**(1), 135–154.
- Iyer, R., Jensen, T., Johannesen, N., Sheridan, A. et al.: 2016, The run for safety: Financial fragility and deposit insurance, *Working Paper* .
- Iyer, R., Puri, M. and Ryan, N.: 2016, A tale of two runs: Depositor responses to bank solvency risk, *The Journal of Finance* **71**(6), 2687–2726.
- Kashyap, A. K., Tsomocos, D. P. and Vardoulakis, A. P.: 2014, How does macroprudential regulation change bank credit supply?, *NBER (wp 20165)* .

- Krishnamurthy, A. and Vissing-Jorgensen, A.: 2012, The aggregate demand for treasury debt, *Journal of Political Economy* **120**(2), 233–267.
- Laeven, L. and Levine, R.: 2009, Bank governance, regulation and risk taking, *Journal of financial economics* **93**(2), 259–275.
- Loutskina, E.: 2011, The role of securitization in bank liquidity and funding management, *Journal of Financial Economics* **100**(3), 663–684.
- Lusardi, A., Mitchell, O. S. and Curto, V.: 2009a, Financial literacy among the young: Evidence and implications for consumer policy, *Technical report*, National Bureau of Economic Research.
- Lusardi, A., Mitchell, O. S. and Curto, V.: 2009b, Financial literacy and financial sophistication among older americans, *Technical report*, National Bureau of Economic Research.
- Sylla, R., Legler, J. B. and Wallis, J. J.: 1987, Banks and state public finance in the new republic: The united states, 1790–1860, *The Journal of Economic History* **47**(2), 391–403.