Liquidity Requirements and Bank Deposits: Evidence from Ethiopia*

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Abstract

Liquidity requirements can stimulate deposit growth by increasing depositor repayment in bad states. A stylized model shows that such deposit growth may exceed the intermediation margin decline in the presence of high credit risk, hence stimulate lending and branching. Our empirical test exploits a large and unexpected policy change, which fostered the liquid assets of Ethiopian banks by 33% in one quarter of 2011. A representative panel of bank depositors shows deposit growth among wealthy and highly educated individuals. Bank balance-sheets and two sources of bank exposure to the policy highlight an increase in deposits, loans and branches.

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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 took place, increasing attention has been paid to promoting the resilience of banks and a variety of policies (Liquidity Coverage Ratio - LCR, Net Stable Funding Ratio - NSFR) have been promoted 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 these policies affect bank funding and whether they alter asset allocation. The power of the test is a key empirical constraint: most policies of liquidity regulation are announced quarters/years before the implementation and only gradually brought into operations. This makes it hard to track any behavioural change or, in any case, changes with enough 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 propose a novel insight on how liquidity requirements can affect bank stability and resilience: they can promote the supply of bank deposits by enhancing the safety of the banking system. Second, we focus on an emerging market (Ethiopia) presenting a unique policy change in liquidity requirements, which is both large and unexpected. In fact, not only did policy fostered the liquid assets of Ethiopia commercial banks by 33% in one quarter, but 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 two unique data sources which allow to explore the effects of such policy: 1) a representative panel of depositors from one bank, which permits to follow the same depositor four quarters before and after the policy; 2) bank balance-sheet data and a new map containing the universe of bank branches opened in Ethiopia until 2014. Our depositor-level results show that wealthy and educated individuals increase their deposits in the aftermath of the policy, which is in line with our bank-level evidence reporting a post-policy increase in deposits and overall balance sheet, followed by more lending and branching.

Beyond the local effect of this policy, studying an emerging market can be informative on the effect of liquidity requirements in general. First, it permits 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 bank's solvency may be questioned by depositors. Second, this work offers a perspective on the importance of liquidity requirements in countries which may be unable to offer deposit insurance. In fact, with the exception of North America and Europe, more than 50% of the countries in the world do not offer deposit insurance (Demirgüç-Kunt et al. (2014)), present risky financial systems (Caprio and Klingebiel (2002)) and may therefore find appropriate the adoption of liquidity regulation to stabilize their financial system.

Given the unique policy and source of variation, we introduce a stylized theoretical setting to track how a liquidity requirement can have an effect on deposits and lending in the presence of credit risk. The core insights of our model rely on the work of Farhi et al. (2009), Kashyap et al. (2014) and Calomiris et al. (2015). These papers have extensively analysed the role and effect of liquidity requirements in general settings, which are useful for our analysis. While our model is not a distinct theoretical contribution, it informs the empirical analysis and provides insights for empirical identification in this specific scenario. As a result, it includes some specific assumptions to generate a tractable solution and focus on the specific policy in analysis. The key finding that deposits can respond to liquidity requirements is due to the interaction between the lack of deposit insurance, bank limited liability and lending/deposit rates being exogenously determined Nosal and Rocheteau (2011). These three elements push banks to appropriate profits in the good states and pass losses on depositors in the bad states. Anticipating this, depositors lower their optimal deposit supply, which also shrinks bank size. However, if the central bank imposes a liquidity requirement, through a minimum level of safe asset holding in every state of the world, this moderates both profits and losses. It consequently increases depositor repayment in those bad states in which the bank would default, stimulating 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. Therefore, liquidity regulation is needed to create a commitment in holding safe assets.

Our empirical analysis contains two components. First, 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 significantly diverge afterwards and their deposit growth robustly increases. In addition to this, we find the strongest response among depositors that present a university degree. The second 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 and exploiting our theoretical setting to achieve identification. The first source is based on the 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, we exploit such heterogeneity to verify that banks with the comparatively larger increases reported the strongest inflow of deposits and intermediated more loans.

This country and policy provide the ideal laboratory to test our hypothesis. The implementation of such regulation was also unusual, yet 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 (ETB - local currency) of private sector lending by April 2011. Such bills are liquid because can be exchanged with liquidity by the central bank and because, given the lack of an interbank market, have de-facto recreated an interbank system by allowing banks to transfer liquidity claims. Such policy generated very large asset reallocations, with banks mobilizing 10% of their balance sheet and boosting their liquidity holding by 33% in 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 IMF,[1] argue that this policy is meant to collect government revenue to fund the construction of a national infrastructure (Grand Ethiopian Renaissance Dam). On the other hand, the 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 of state funding coming from an analogous financial repression initiatives in Connecticut in mid 1800 (Sylla et al. (1987)). As a result, though 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.

We are the first to show empirically that liquidity regulation can promote the inflow of bank deposits, profits, branch-installation and that enhanced bank safety is the channel through which this takes place. However, this issue has been difficult to study for a variety of reasons. To begin with, data availability on the banking industry, particularly in emerging markets, is a severe limit: except for a few, yet incomplete, sources (i.e., 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 only focused on 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 had access to the regulation documents and could interview senior executives for all private sector banks, which provided substantial

[1] Refer to IMF (2016), available at https://www.imf.org/external/pubs/ft/scr/2016/cr16322.pdf

[2] The title of the directive prescribing the policy change is "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".

insights on how this regulation affected their business. Regarding the available datasets, we track three key indicators of bank behaviour:

1) a representative panel of depositors from one bank, in which we follow the same depositor four quarters before and after the policy;

2) bank balance sheets with monthly frequency, which allow to observe the key modelling variables (safe assets, deposits, loans);

3) a new map covering over 90% of bank branches opened in Ethiopia between 2000 and 2015, including their city and region, telephone numbers and other information.

Our results indicate the existence of a deposit inflow as banks amass more liquid assets in response to the regulation. This also leads to more lending and an increase in branch-installation.

This paper participates to three different literatures. First, the empirical literature on the liquidity benefit of holding public bonds and liquidity requirements in general. Calomiris and Wilson (2004) gives evidence of New York banks in 1930s invested in liquid assets in order to signal their low risk and attract deposits. Krishnamurthy and Vissing-Jorgensen (2012) show that investors value the liquidity and safety of US 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 to store liquidity for financing future investments. Loutskina (2011) finds that securitization lowers bank 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 MBS premia generated by LCR 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 the their liquidity risk and the availability of deposit insurance.

Second, the paper also 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 to 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 that with more restrictive regulatory regimes are more exposed to banking crisis, but do not present necessarily poorly functioning banks. While through a cross-country and cross-bank analysis, Laeven and Levine (2009) show that the effects of financial regulation, both on liabilities and assets, depend remarkably on governance indicators and find a large heterogeneity in this respect. 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 the emergence of double-bank runs (both from borrowers and depositors) in the wake of the European interbank market freeze registered in 2007.

Third, this paper adds to the literature on branch expansion and financial access a relation with liquidity requirements. For example, we find that in response to the policy banks open more branches, especially in rural location. 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, which 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 raising income for individuals.

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

1 Theory

1.1 Economic Environment

The economy comprises a continuum of locations on the 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, while with $\beta = 0$, no branches are opened. Once 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 $R_G > 1$, while 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, 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 by 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 in order 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 by an intermediation margin, $\pi(s)$, which emerges as the difference between payments on liabilities and income on assets, times 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 only affect profits 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, 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 enough 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, $R_{DB} = sR_S + (1 - s)R_B$. Define $\widetilde{s}$ as the liquid asset level such that the bank is indifferent between repaying the market deposit rate, R_D, and liquidating its assets, $\widetilde{s} = (R_D - R_B)/(R_S - R_B)$, as $R_S > R_D > R_B$, which bounds $\widetilde{s} \in (0, 1)$. As a consequence, the following holds true:

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

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, $s \geq \widetilde{s}$; 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 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 $R_{DB} = \rho R_S + (1 - \rho)R_B \; if \; \rho < \widetilde{s}$ or $R_{DB} = R_D \; if \; \rho \geq \widetilde{s}$).

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 only in the first period and faces financial market imperfections, which 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 behavior 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 CRRA 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, while 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,

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

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 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 less branches, hence collects less deposits and gives less 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 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

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

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 the following

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

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 following effect,

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

it increases if liquidity regulation does not exceed a threshold $\widetilde{\rho} = \widetilde{\rho}(p)$ and decreases if it does. Such threshold is increasing in the probability of 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, we show that 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 $\widetilde{\rho} \simeq 0.33$. In the scenario in which this probability is brought to 15%, such a threshold correspondingly increases to $\widetilde{\rho} \simeq 0.5$, while if such a probability is reduced to 5%, the threshold follows to $\widetilde{\rho} \simeq 0.18$. In

[3] It 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 $\widetilde{s}$, which guarantees depositor repayment in any state, then imposing $\rho > \widetilde{s}$ leads to the opposite effect, as deposits do not increase given that there is no repayment increase, but the intermediation margin declines and this leads to lower profits, loans, and number of branches.

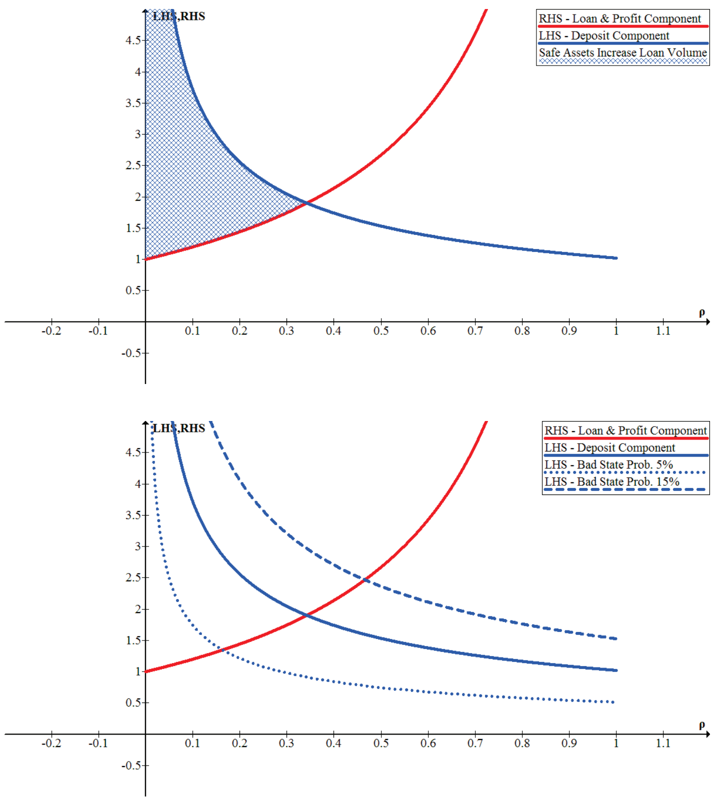
Appendix C, we report additional comparative statics with respect to both the probability of a bad state and other model parameters; however, this essential comparative statics on p shows how important the riskiness of the financial sector is for detecting a statistically significant effect.

These results can be summed up in the following proposition.

Proposition 1

There exists a threshold in the mandatory share of liquid assets, $\widetilde{\rho}(p)$, such that in the presence of unbranched locations, $\beta < 1, \forall \rho \leq \widetilde{\rho}(p)$ the total loan volume $L = \beta d(1-s)$, the 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 is increasing in the probability of a bad state, and hence decreasing in p.

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 (reported in blue), while the right-hand side is increasing (in 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 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 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 exhibitingη_L: 1) install more branches than the bank with η_H, $\beta(\eta_L)^* > \beta(\eta_H)^*$; 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: both banks want to open more branches, but the more efficient bank opens more 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

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

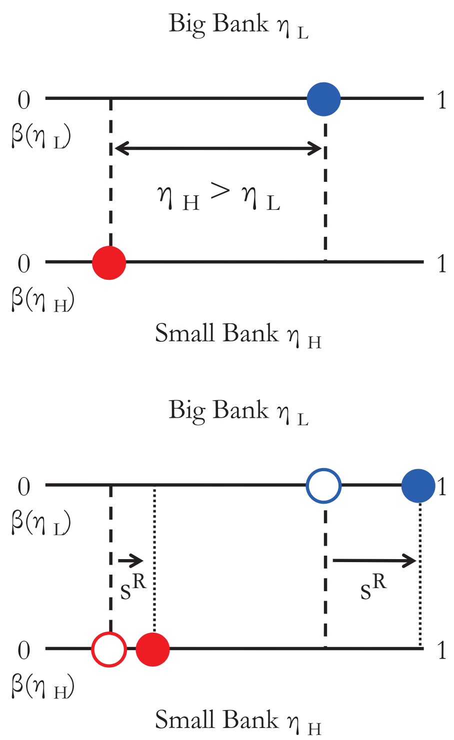
in which the variable of interest v_{it} for bank i at time t (ie., branches, deposits, loans...) is regressed over a bank and time fixed effects, ι_i and ι_t, and an interaction between the technological bank-specific parameter, η_i, and the liquidity regulation parameter, ρ_t. Proposition 2 predicts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

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

$$v_{it} = \iota_i + \iota_t + \sum_t c_t \cdot \eta_i \cdot \iota_t + u_{it}, \tag{1}$$

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 extensively use 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 $\forall t < \widetilde{t}$, with $\widetilde{t}$ representing the time period in which the liquidity regulation change takes place.

Figure 2: Size Heterogeneity and Identification



Notes: This figure graphically depicts one of the identification 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 lower pre-policy levels of liquidity experience a stronger deposit growth than banks with higher pre-policy levels of liquidity.

Figure 3 graphically depicts the essence of this alternative identification. The deposit function can be described by the positive and concave line (in blue) and assume this applies to all banks in the economy. In this simplified setting there two banks, a bank with pre-policy liquidity, described with the dotted line and small squares in red (Low-Liquidity Bank), and a bank with high pre-policy liquidity, reported with the dashed line and small triangles in green (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 experience 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, 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; 2) install more branches.

Therefore, all the predictions of Proposition 1 are differentially stronger for more bank 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

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

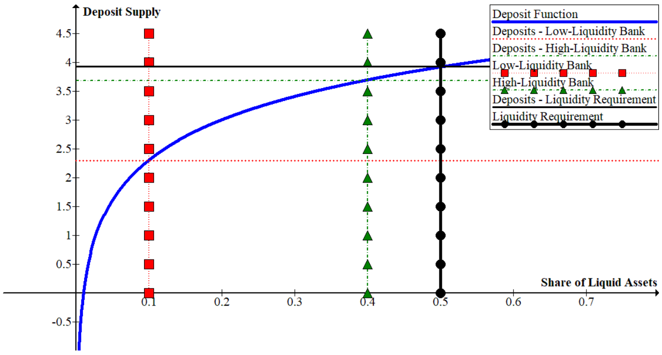
in which the variable of interest v_{it} for bank i at time t (ie., branches, deposits, loans...) is regressed over a bank and time fixed effects, ι_i and ι_t, and an interaction between the bank-specific increase in liquidity following the policy, ψ_i, and the liquidity regulation parameter that applies 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.

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 and introduced at the beginning of April. On this date, the NBE issued a directive requiring all commercial banks to hold 27% of new loan disbursements in NBE bills.

Figure 3: Liquidity Heterogeneity and Identification



Notes: This figure graphically depicts one 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 (reported with small squares). The high-liquidity bank holds more liquidity and is indicated by the dashed green line (reported with small triangles). If the policy obliges both banks to raise their liquidity until the black line (reported 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.

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. We can see that 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). We can see that deposits are an important component of these banks, from Panel A we can see 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 nature of this shock: 1) it was unexpected and announced less than a month before implementation; 2) it caused a large accumulation of safe-assets by banks in one quarter. The asset share of safe-assets held by local banks passed from 21% to 28%, as shown in the next subsection, 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 only gives information 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 and this 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), in which we observe 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, as they pay a fixed remuneration of 3% per year, lower than the minimum deposit rate, 5%, or the average lending interest, 12% (National Bank of Ethiopia 2012)[4].

In order to test the implications of Propositions 1, 2 and 3, we collect confidential data on the monthly balance sheet of all Ethiopian private banks between 2010 and 2013 and we build a unique city-level map of Ethiopian branches, where for every bank we know in which cities all new branches have been opened, with respective month and year between 2000 and 2015.

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 these 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, though 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 blu line) and after (full

[4]Therefore this policy as well as mandating liquid assets, also lowers the return on private sector lending, as 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 we highlight here. The lending tax would lower lending, while 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), while after the policy it would deliver the same gross return, minus the net remuneration of this bills -2% times the amount of the purchased bills0.27, hence $7\% - 0.27 \times 2\%$, this result 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.

red line). Two interesting facts emerge. First, the median share of liquid assets before the policy is 21%, which increase after the policy to 28% and the median increase of 33% in one quarter. Second, that the distribution of the liquid asset share held by the bank is almost entirely shifted right-ward. 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 tale 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.

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

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

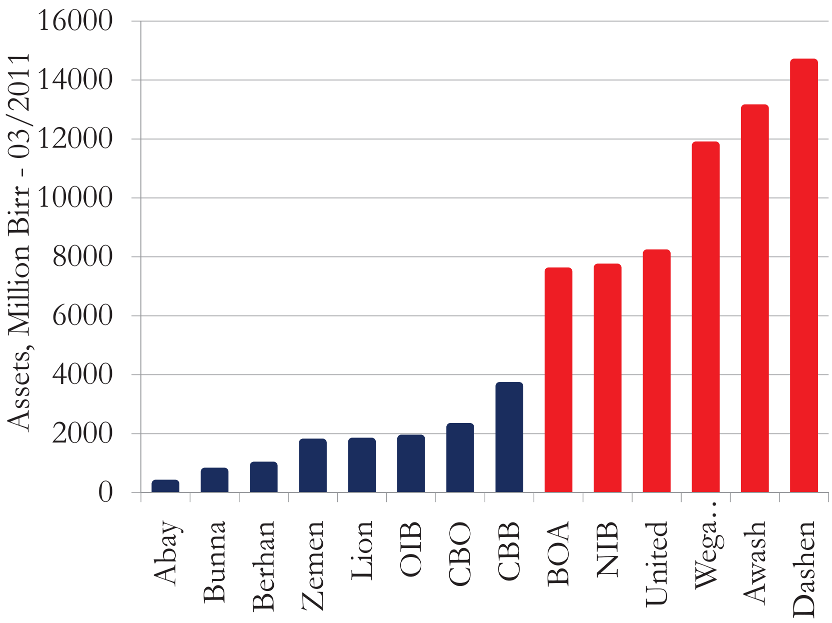
* Depositor evidence. Using a representative panel of depositors from one bank, we observe a parallel trend in deposit growth across the terciles of depositors and a divergence after the policy. We further relate such growth to their education (Section 2.2.1).

* 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 loan volume also increases (Section 2.2.2).

* Branch map evidence. Using monthly data, we give evidence that branch installation increases more markedly after the policy and more cities see their first branch installed after the policy (Section 2.2.3).

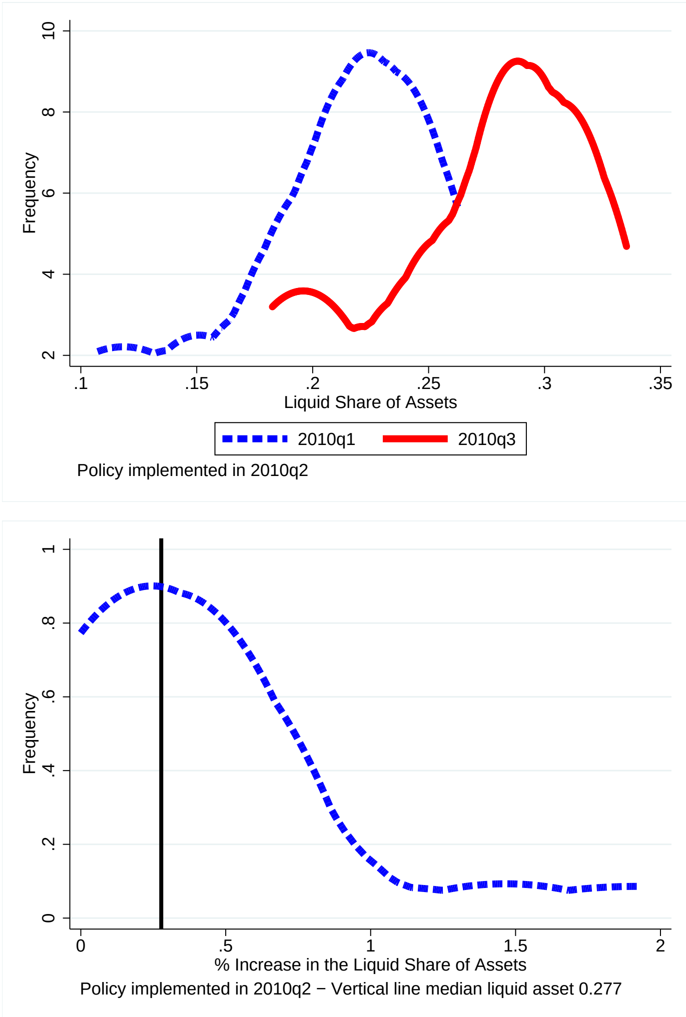
B. Robustness Checks. In Section 2.3 we explore a variety of factors which might confound our estimates and verify the soundness of our results.

Figure 4: Banks Assets and Size



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

Table 1: Summary Statistics

Variables	(1) Obs.	(2) Mean	(3) St. Dev.	(4) Min	(5) 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	.510	9.104
Panel B - Relative to Assets					
Deposits	512	.673	.095	.125	.807
Private Sector Lending	512	.392	.075	.003	.586
NBE Bills	512	.098	.072	0	.248
Liquid Assets	512	.252	.068	.107	.795
Capital	512	.142	.086	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 of one plus their corresponding amount in Ethiopian Birr. Total deposits is 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).

Table 2: Compliance with NBE Bills

	(1)	(2)
Variables	Δ NBE Bills	Δ Liquid Assets
Δ Lending	0.208***	0.164***
	(0.039)	(0.045)
Quarter-Year FE	Yes	Yes
Obs.	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. Delta NBE bills describes the changes in the volume of NBE bills in Ethiopian Birr that a bank presents in its balance sheet. Delta 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 of these variables are reported in the last tow rows of the table. Delta Lending describes the changes in volume of Ethiopia Birr of private sector lending registered in the bank balance sheet. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

2.2 Main Results

2.2.1 Depositor Evidence

Through contacts with bank executives from one commercial bank, we were able to confidentially receive data on a representative panel of bank depositors. This is 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 8 quarters (4 before and 4 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 back out 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 only depositors in 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 to calculate 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 average deposit for the quarters between the third quarter of 2010 and the first quarter of 2011 place him in the lowest tercile of depositors. 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

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

in which we regress the deposit growth of individual i belonging to tercile d at quarter-year t over an individual and quarter-time fixed effects, ι_i and $+\iota_t$, and an interaction between the time fixed effect and the dummy for the second and third tercile, $\sum_{d=2}^{3} \iota_t \cdot Tercile_d$. As a result, while ι_t embeds the trend of deposit growth by depositors in the first tercile, the two interactions permit to study these trends for depositors in the second and third tercile, $\iota_t \cdot Tercile_2$ and $\iota_t \cdot Tercile_3$. 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 following 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 tercile. Beyond summarizing the previous result, this is useful in studying whether the deposit growth varied according to whether a depositor holds a university degree. In order to do so we will introduce a dummy variable which takes unit value for all individuals whose job can be unequivocally associated to 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. Its upper panel shows the evolution of the standardized deposit growth across terciles, while the lower panel presents 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 tercile are evolving on parallel trends before the policy, while 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

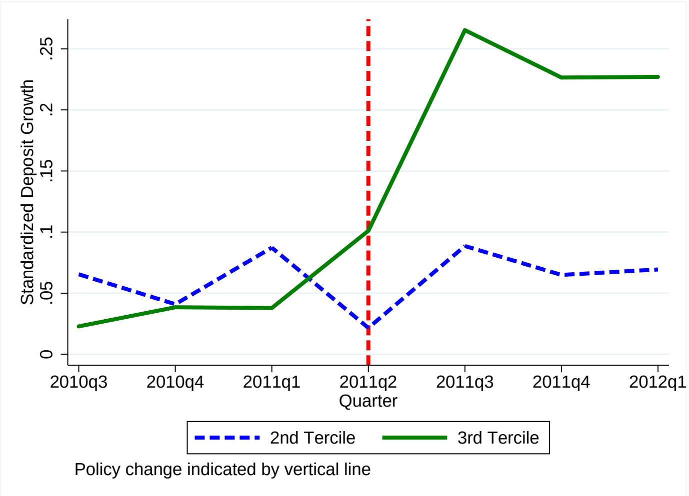
[5] The following jobs are coded with a one in the University Dummy: Medical Doctor, Architect, Engineer, Lawyer, Agronomist, Professor and Scientist. The job "Businessman" does not contain enough details and hence is coded with a zero.

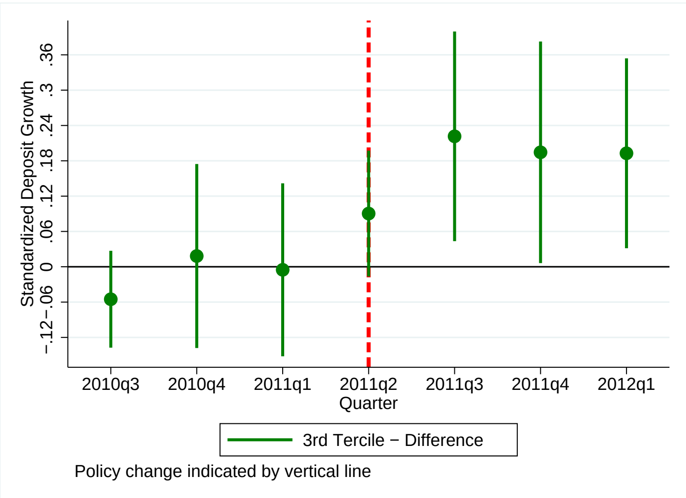
a standard deviation, is statistically different from zero but is relatively dispersed as the lower panel reports.

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) introduces 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 it 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 in the financial system and show that sophisticated depositors (wealthy and educated) are those responding more favorably to this.

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 to 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 blue dashed line indicates the coefficient of deposit growth for the second tercile, while the green full line reports the coefficient for the third tercile. The policy is implemented in the second quarter of 2011 and is indicated by the red and dashed vertical line. As indicated by both panels, the pre-trend between the first, second and third tercile are not statistically different from zero before the policy, while we observe an increase in deposit growth by the third tercile. The standard errors are clustered at individual level.

Table 3: Policy Change, Deposit Growth and University

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

Notes: This table reports OLS estimates; the unit of observation is the individual depositor and depositor and quarter-time fixed effects 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, hence we subtract 0.0.21 and divide by 2.932. The means and standard deviations of deposit growth are reported in the last tow 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 Balance Sheet Evidence

Bank Size - Quarterly Variation

The policy change creates a large exogenous variation in the aggregates^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 the subsection 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.

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 reports the 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, hence the policy change affects this variable, rather than just 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

$$v_{iqy} = a + \sum_{qy=1}^{13} b_{qy} \cdot d_{qy} + \sum_{qy=1}^{13} c_{qy} \cdot d_{qy} \cdot Big\ Bank_i + \iota_i + \iota_{iq} + \epsilon_{iqy}, \tag{2}$$

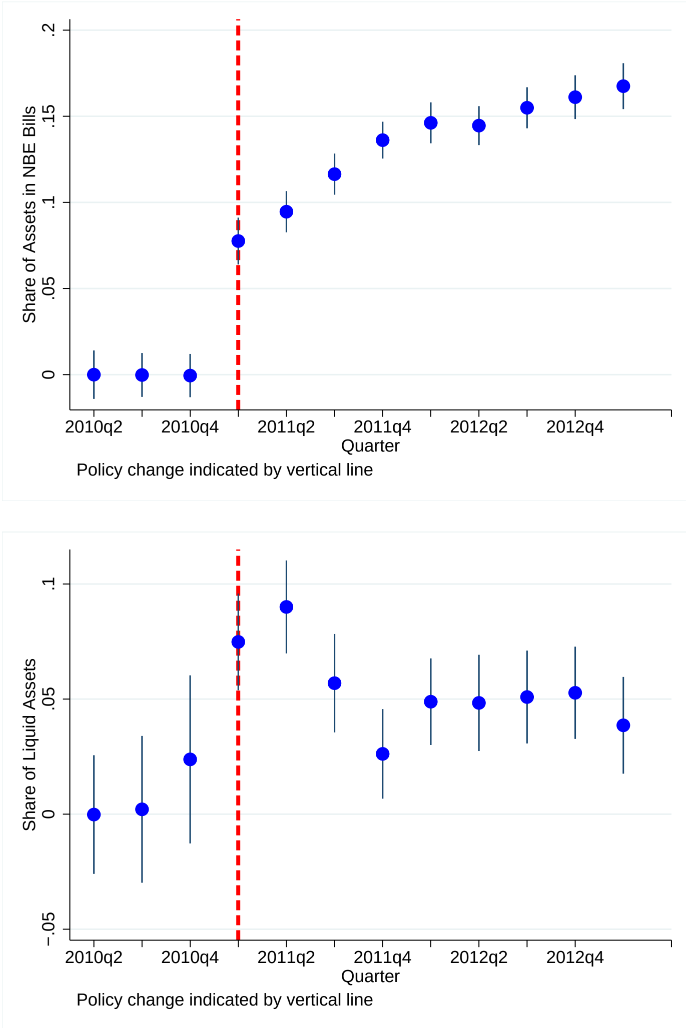
where the variable v_{iqy} is regressed on a dummy variable d_{qy}, which takes unit value for each quarter qy of the 13 available, an interaction of this dummy with the Big Bank dummy variable, a bank fixed effect ι_i, and a bank-quarter fixed effect ι_{iq} to account for seasonality. The coefficients 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 the big bank dummy measures the inverse of η. Such difference stays across all empirical exercises.

Table 4: Liquidity Requirements, Bank Size and Banking

Variables	(1) Deposits Ln Mill. Birr	(2) Lending Ln Mill. Birr	(3) NBE bills Asset Share	(4) Liquid assets Asset Share
	Big Banks			
Big Bank × Quarter 2	0.0774	0.0935**	0	0.00246
	(0.0469)	(0.0364)	(4.35e-10)	(0.0116)
Big Bank × Quarter 3	0.0841	0.00917	-0.000716	0.00881
	(0.171)	(0.291)	(0.00101)	(0.0280)
Big Bank × Quarter 4	0.112	-0.0190	-0.00197	0.0610
	(0.251)	(0.376)	(0.00265)	(0.0519)
	Big Banks and Post-Policy			
Big Bank × Quarter 5	0.254	0.262*	-0.0133	-0.00574
	(0.174)	(0.139)	(0.0196)	(0.0264)
Big Bank × Quarter 6	0.360**	0.296*	-0.0164	-0.00451
	(0.165)	(0.146)	(0.0188)	(0.0314)
Big Bank × Quarter 7	0.455**	0.357**	-0.0179	-0.0133
	(0.164)	(0.155)	(0.0202)	(0.0347)
Big Bank × Quarter 8	0.535***	0.428**	-0.0134	-0.0226
	(0.177)	(0.173)	(0.0180)	(0.0341)
Big Bank × Quarter 9	0.622***	0.487**	-0.00819	-0.00775
	(0.179)	(0.190)	(0.0227)	(0.0294)
Big Bank × Quarter 10	0.658***	0.519**	-0.0195	-0.00476
	(0.189)	(0.204)	(0.0205)	(0.0312)
Big Bank × Quarter 11	0.716***	0.572**	-0.0261	-0.0329
	(0.204)	(0.215)	(0.0224)	(0.0375)
Big Bank × Quarter 12	0.788***	0.622**	-0.0359	-0.0383
	(0.212)	(0.233)	(0.0225)	(0.0344)
Big Bank × Quarter 13	0.845***	0.699**	-0.0322	-0.0400
	(0.219)	(0.249)	(0.0238)	(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 × year fixed effects 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 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 of these variables are reported in the last tow 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% levels, respectively.

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

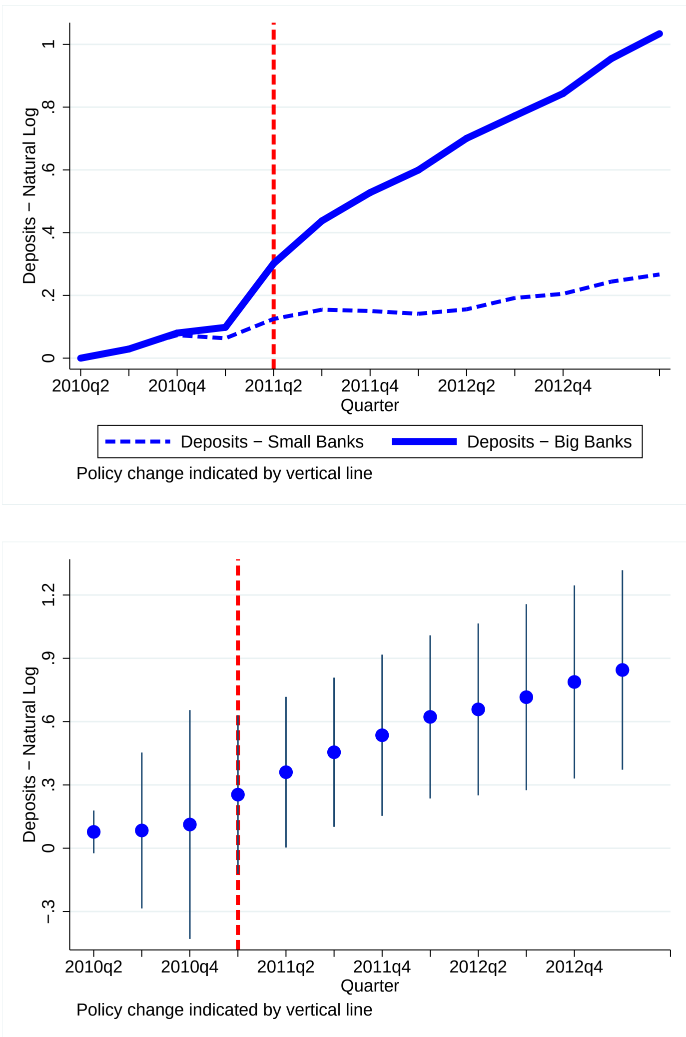


Notes: This figure plots the coefficients of the overall trend in the asset share of NBE bills (upper panel) and the asset share of overall liquid assets (lower panel) over all quarters available in the data. As is evident, there occurs an important discontinuity around the policy introduction (vertical 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 4, big and small banks do not purchase statistically different quantities of such assets.

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), while 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 points, in line with Figure 5. The effects of this policy on deposits and loans are presented by Figures 8 and 9. Both report the evolution of deposits and loans respectively, in both cases the upper panel reports the evolution of both big and small banks, while the lower panel their difference including the 95% confidence interval. In both cases, we cannot reject the parallel trends before the policy, while the trends in both deposits and loans start to significantly diverge after the policy. Table 4 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 accumulate a nost 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.

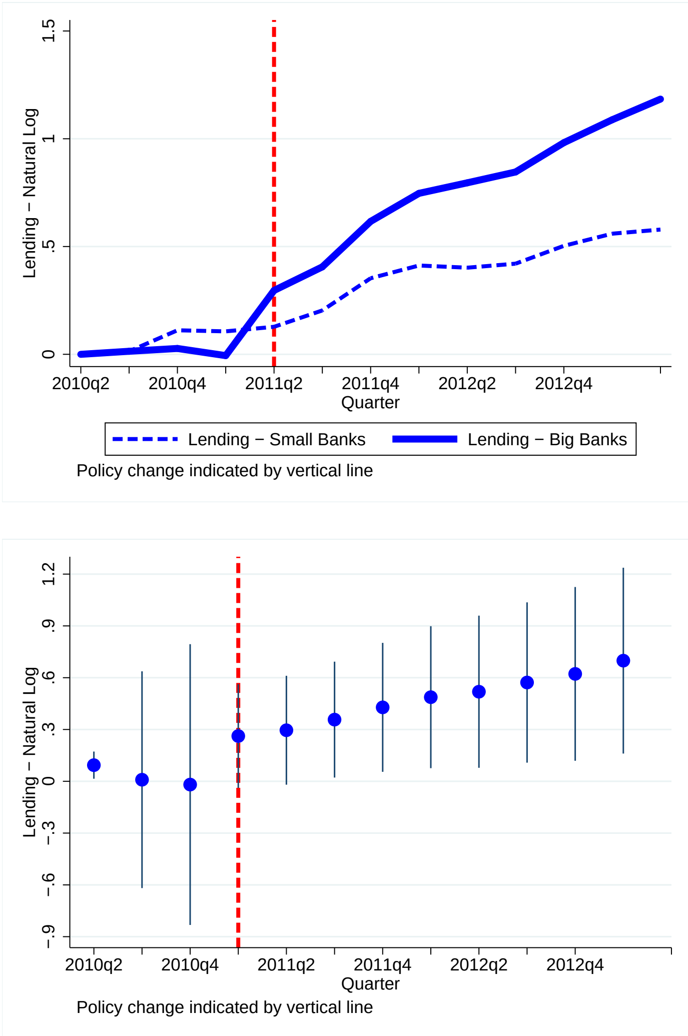
Therefore, consistently with the theoretical model, an increase in safe asset holding by all banks generates a differential expansion in deposits and loans, stronger for larger banks.

Figure 8: Policy Change and Trends - Deposits



Notes: This figure plots the coefficients of the overall trend exhibited by small and larger 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 using a solid line, while small banks are reported with a dashed line. The policy is announced in mid-March 2011 and implemented in April 2011 (shown by the vertical red 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 larger 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 using a solid line, while small banks are reported with a dashed line. The policy is announced in mid-March 2011 and implemented in April 2011 (shown by the vertical red line). As is evident, there occurs an important discontinuity around the policy introduction (Quarter 5).

Bank Pre-Policy Liquidity

In this subsection, 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

$$v_{it} = \iota_i + \iota_t + b \cdot Policy_t \times Liquidity\ \ Increase_i + \epsilon_{it}$$

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 ($Liquidity\ Increase_i$).

Table 5 shows that the prescriptions of Proposition 3 cannot be rejected. Column (2) shows that after the policy banks that increased their liquid asset share by one standard deviation saw an increase in their deposits by 0.633 points (8.2 percent). This is in line with an increase in liquid and safe asset holding by banks generating an increase in banks deposit supply. Analogously, Column (3) shows lending increases as well, but by a smaller extend 0.505 points (6.8 percent), 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 5: Liquidity Requirements, Liquidity Increase and Banking

	(1)	(2)
Variables	Deposits	Lending
	Ln Mill. Birr	Ln Mill. Birr
Policy × Liquidity Increase	0.633***	0.505***
	(0.0827)	(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 × 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 of million 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 of these variables are reported in the last tow rows of the table. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

2.2.3 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. In order to test this hypothesis, we construct a map of all branches in Ethiopia, where for each bank we know all the branches installed, 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) the overall number of branches increases as the liquidity effect kicks in, as the model predicts; 2) new branches are more "rural". We measure rurality by measuring the distance in kilometers from the bank headquarter

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

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

where the two measures of branch expansion in consideration (number of branches and kilometers from the headquarter), v_{imy}, are regressed over bank, month and year fixed effects, $\iota_i, \iota_m, \iota_y$, 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 percent increase in the share of liquid assets).

Table 6 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 we observe that after the policy big banks increase significantly more their branch expansion. Column (1) states that this effect accounts to 0.586 points over the 3 years after the policy, which corresponds to a 5.37% increase per year. While column (2) gives a measure of the "rurality" of these new branches, which increases by 12% over a three year period, or 3.85% per year. Columns (3) and (4) replicate these results by considering the percent increase in liquidity as a source of cross-sectional variation. In column (3), we observe 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, or 4.16% per year. Analogously, we observe an increase in distance by 16% over three years or 5.07% per year.

Table 6: Branches and Liquidity

Variables	(1) Ln Num. of Branches	(2) Ln Distance in Km	(3) Ln Num. of Branches	(4) Ln Distance in Km
Policy × Bank Variation	0.586***	1.021**	0.471***	1.423***
	(0.166)	(0.450)	0.471***	1.423***
Bank Variation	Big Banks		Percent Liquidity Increase	
Bank FE	Yes	Yes	Yes	
Time FE	Yes	Yes	Yes	
Obs.	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 are included. Standard errors are clustered at bank level. The number of branches is defined as the cumulative number of branches installed by a bank, while the distance from the headquarter is the cumulative number of kilometers of the branches installed by a bank. Their means and standard deviations are reported in the final two rows. 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 percent increase in the share of liquid assets following the policy. The adjusted R^2 of these regressions is also reported. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

3 Robustness Checks

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

1. Identifying Assumption - in which we rule out that macroeconomic changes taking place at the same time with our policy change are responsible for the results:

2. Robustness to Alternatives - in which we study a variety of other margins that may confound our results.

3.1 Identifying Assumption

The results presented in Tables 4 and 5 are robust to time-series shocks that affect all banks with the same intensity. However it could be argued that some economic variables may affect heterogeneously banks by either size (Table 4) or their liquidity holding (Table 5). Therefore, the main results of this work may be driven by a contemporaneous macroeconomic shock, rather than the policy change.

In order to rule out this possibility, we proceed in the following way. First, we identify a set of macroeconomic variables to study for Ethiopia: GDP per capita growth, Export as a share of GDP, FDI as a share of GDP, Inflation. Second, we offer the following test

$$v_{it} = \iota_i + \iota_t + b\, Policy_t \times Cross\ Section_i + c\, Macro_t \times Cross\ Section_i + \epsilon_{it}$$

in which we regress the logarithm of deposits (Table 7) and lending (Table 8) 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, $Policy_t$, and the cross-sectional variation across banks, $Cross\ Section_i$. 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 heterogeneously banks depending on their cross-sectional variation.

Tables 7 and 8 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 to the pre-policy case. In all cases the coefficient of interest, $Policy_t \times Cross Section_i$, is positive, significant and in line with the previous results. We can see that in both Table 7 and 8 the big bank dummy seems to change non-trivially in its point estimate, pointing toward a possible heterogeneous effect of macroeconomic variables depending on bank size. On the contrary, we observe the liquidity increase variable being 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 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 heavily relies on its state-owned bank, CBE, which is the largest in the country, not affected by the policy and profitable -- in 2011/12, it amassed eight billion birr of profits, corresponding to roughly 400 million US dollars (USD).

Table 7: Deposits, Liquidity Requirements and Macroeconomic Shocks

	(1)	(2)	(3)	(4)
Variables	Deposits Ln Mill Birr			
Panel A - Big Banks				
Policy × Big Bank	0.404***	0.348***	0.511***	0.583***
	(0.123)	(0.117)	(0.108)	(0.120)
Macro Variable × × Big Bank	Yes	Yes	Yes	Yes
Panel B - Liquidity Increase				
Policy × Liquidity Increase	0.678***	0.679***	0.633***	0.630***
	(0.0731)	(0.0737)	(0.0828)	(0.0852)
Macro Variable × × Liquidity Increase	Yes	Yes	Yes	Yes
Macro Variable	GDP Growth per capita	Export % of GDP	FDI % of GDP	Inflation CPI
Obs.	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 × 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 of million 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 of deposits are reported in the last tow rows of the table. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

If there had to be a redistribution of resources, then the two state-owned banks (CBE and the Development Bank of Ethiopia, DBE) might have been the recipients, rather than private commercial banks. Secondly, 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 (GERD). In Figure 9, we can observe in the upper panel the branch installation and total employment by medium-scale enterprises compared to 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 through enhanced bank safety cannot be dismissed.

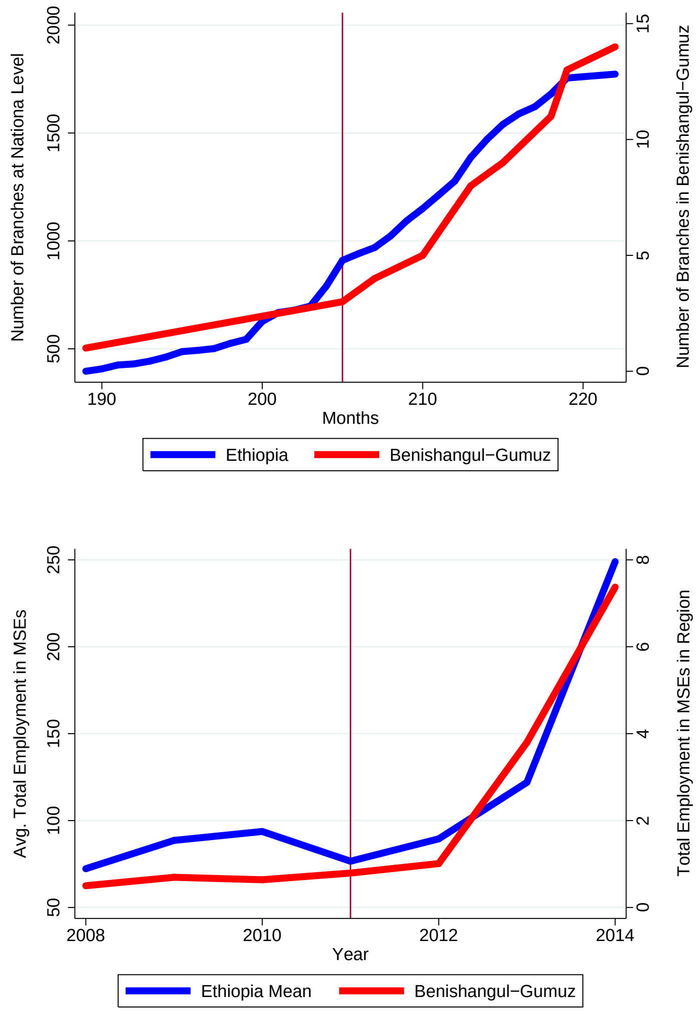
Table 8: Lending, Liquidity Requirements and Macroeconomic Shocks

	(1)	(2)	(3)	(4)
Variables	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 Variable	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 × 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 of million 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 of deposits are reported in the last tow rows of the table. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

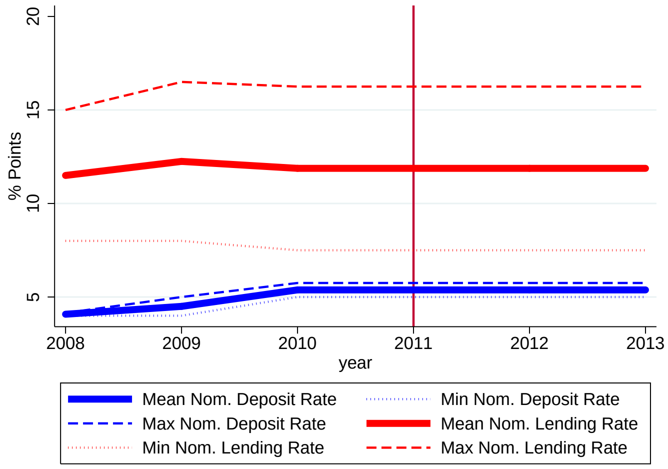
Another argument against the safe-asset nature of these bills could argue that they lock increasing liquidity in the central bank and do not allow banks to use this to address liquidity shortfall. This is most likely not the case for two reasons: 1) banks can use this bill to trade liquidity claims among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

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 (in blue) and the other Ethiopian regions (in red). 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 the last 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

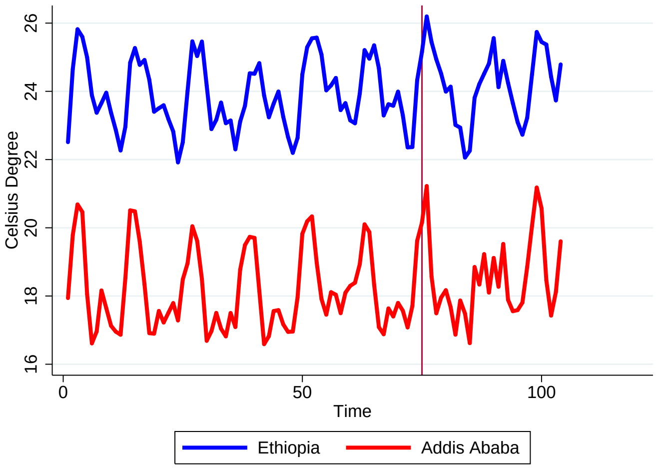


Notes: This figure reports the monthly evolution of the average nominal deposit rate (blue) and lending rate (red), with their respective minimum and maximum rates. The sources are the 2012, 2013, and 2014 Annual Reports of the NBE. As described in the text, there is no detectable change in either rate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

Thirdly, climate might be considered problematic, if the policy change occurred over periods of extensive temperature fluctuations, which might affect the agricultural and/or industrial productivity and hence financial markets. Ethiopia is a country with an heterogeneous climate, close to the equator and with diverse altitudes, 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 (blue) and Addis Ababa (red) between 2005 and 2013, as shown in Figure 11, we observe that while 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, Time 75, and there does not seem to be any response to weather changes. The data come from the Berkeley Earth project (http://berkeleyearth.org). Alternative measures of temperatures were used from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC), which are highly correlated with the current values (0.72 for Addis Ababa and 0.6 for Ethiopia) and highlight similar differences.

Table 9: 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

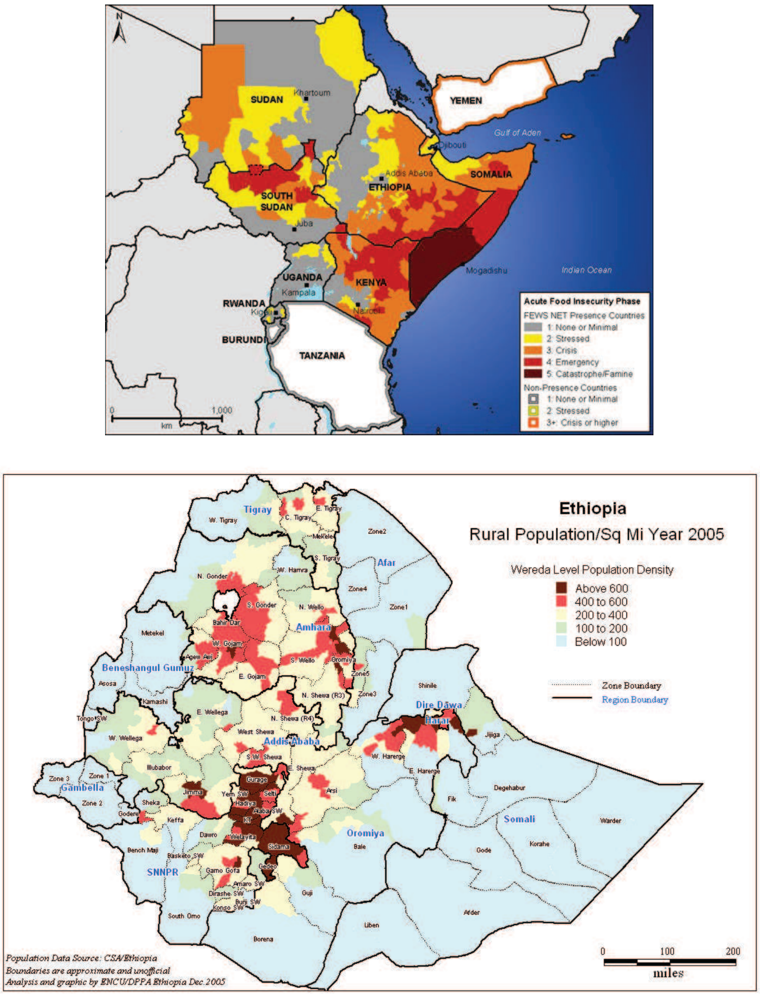
Notes: This table reports the most important disasters in Ethiopia between 1960 and 2015, from the most recent to the oldest. In recent years, Ethiopia has not experienced any disaster that could be related to the policy introduction. The data source is EM-DAT, http://emdat.be.

In addition to this, 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 Eastern Africa has experienced in the past 60 years,[6]and this may be a reason for concern. As clarified by Figure 12, 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

[6]Refer 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.

(around the capital city Modagishu), Ethiopia was hit in a low-density and predominantly rural area, as clarified by the lower panel of Figure 12. In particular, according to some controversial relief statistics, the number of Ethiopians affected by this disaster was between a few hundred and 700,000,[7]which is a sizeable number, but limited relative to the 2011 population of 89.39 million. In Table 9, we also 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.[8]

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 Oromiya region.

Last but not least, alternative policy changes might have contemporaneously affected bank behaviour. In this period, the introduction of interest-free banking (IFB)[9] is the most important

[7]Refer to the Huffington Post article "Ethiopia: Hunger During Worst Drought In 60 Years", 17 August 2011, available at http://www.huffingtonpost.com/2011/08/17/ethiopia-hunger-drought_n_928989.html.

[8]The EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) and defines a disaster as an event satisfying at least one of these characteristics: * Ten (10) or more people reported killed. * Hundred (100) or more people reported affected. * Declaration of a state of emergency. * Call for international assistance.

[9]For more information on this refer to the NBE directive available here http://www.nbe.gov.et/pdf/directives/bankingbusiness/sbb-51-11.pdf.

regulation. This measure is meant to allow Muslim Ethiopians to have a deposit account, and invest in other financial products, complying with Islamic principles and not "making money with money". Because by law all deposits in Ethiopia are remunerated at least an annual 5%, this prevented the use of banking services by almost 33% of Ethiopians, which profess Muslim faith. As a result, this measure could have been a major confounder. For example, the simultaneous increase in deposits 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 IFBs are effectively responsible for any of the effects we report. Despite 2011 marked 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 [10]. The reluctance behind this initiative is mainly given by the higher costs of operating these financial products, as the bank needs to directly purchase the investment good on behalf of the firm, which then progressively repays back.

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, hence stimulate lending and branching. The model is useful in offering two sources of cross-sectional variation along which banks are affected: 1) bank technology, which can be summarized by size as a sufficient statistic; 2) the heterogeneous increase in liquid asset holding by banks.

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

Depositor-level data highlight that while 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. The remaining two dataset are useful to verify that this policy presented

[10]The first bank to offer IFB was Oromia International Bank in September 2013, while the state-owned Commercial Bank of Ethiopia announced operations at the end of October 2013. Successively, Wegagen International Bank, United Bank and Abay Bank announced the offer of IFBs in 2014, while the other banks are moving in this direction but have not yet implemented such products. For more information on this refer to the issue of October 2013 and May 2014 of Addis Fortune, a major Ethiopian business magazine: http://addisfortune.net/articles/commercial-bank-to-launch-interest-free-banking/ and http://addisfortune.net/articles/interest-grows-in-interest-free-banking/

an heterogeneous affect on banks. Those that were either larger or experienced a larger increase in their post-policy liquidity, also reports larger increases in deposits, lending and branching.

These results shed light on an alternative role of liquidity requirements which received little empirical consideration. Our findings are particularly interesting for emerging markets, which share many financial institutions and characteristics in line with Ethiopia. At the same time, this mechanism may also apply to financial systems in high-income countries, which encounter temporary systemic shocks which 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.

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* .

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.

Nosal, E. and Rocheteau, G.: 2011, *Money, payments, and liquidity*, MIT press.

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.