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Bank Deposits and Liquidity Regulation: Evidence from Ethiopia

Nicola Limodio* Francesco Strobbe†

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Abstract

The regulation of bank liquidity can create a commitment device on repaying depositors in bad states, if deposit insurance is absent. A theoretical model shows that liquidity regulation can: 1) stimulate a deposit inflow, moderating the limited liability inefficiency; 2) promote lending and branching, if deposit growth exceeds the intermediation margin decline. Our empirical test exploits an unexpected policy change, which fostered the liquid assets of Ethiopian banks by 25% in 2011. Exploiting the cross-sectional heterogeneity in bank size and bank-level databases, we find an increase in deposits, loans and branches, with no decline in profits.

JEL code: G21, G32, O16, O55

Keywords: Banking, Liquidity Risk, Financial Development, Ethiopia

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Introduction

Deposits are a major source of bank funding and a key element in financing credit. At the same time, they shape the quality of credit through various channels: forcing liquidation (Diamond and Dybvig, 1983), monitoring risk (Calomiris and Kahn, 1991) and affecting the optimal capital structure of banks (Allen, Carletti and Marquez, 2015), among others. In this paper, we study how deposits respond to the regulation of bank liquidity, defined as the mandatory holding of safe assets (cash, government bonds, etcetera). Our banking model highlights how liquidity regulation can affect depositors' behaviour and we exploit a unique policy change in an emerging market to assess empirically this mechanism.

In particular, we restrict our attention to liquidity regulation in the absence of deposit insurance. We do this for two reasons. First, because though there exists a consensus on financial regulation when deposit insurance is in place (Beck, Carletti and Goldstein, 2016), less is known when deposit insurance is absent. With the exception of North America and Europe, more than 50% of the countries in the world are in this condition (Demirgüç-Kunt, Kane and Laeven, 2014). Second, because this became particularly relevant after the 2009 global financial crisis and the 2010-2012 European debt crisis, which demonstrated that systemic shocks can affect both the stability of banks and the fiscal capacity of governments. In such cases, liquidity regulation can be particularly important given that: 1) deposit insurance may be perceived as not credible; 2) banks' liquidity and solvency may be questioned by depositors.

To pursue this question, our paper focuses on a specific regulatory episode in an emerging market (Ethiopia), which offers the ideal environment for three reasons: 1) it does not present deposit insurance; 2) it exhibits an unexpected policy change that increased the bank liquidity holding by 25% in one quarter of 2011; 3) its local banks are risky and enjoy a limited credibility by depositors on their liquidity (in the '90s Ethiopia experienced a severe banking crisis and bank runs as Caprio and Klingebiel (2002) discuss). These factors local savers cautious in their deposits (Bachas et al, 2017).

Our theoretical model is based on the interaction between the lack of deposit insurance and banks' limited liability. These two 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, 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 paper is conceptually related to the work of Calomiris, Heider and Hoerova (2015), who develop a theory of bank liquidity requirements, showing both the effect on deposits and credit allocation in a more general setting. At the same time, these results are also in line with the literature showing the liquidity benefit of holding public bonds (Holmstrom and Tirole (1998), Krishnamurthy and Vissing-Jorgensen (2012), Gennaioli, Martin, and Rossi (2014)).

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. Such policies have been implemented in several countries over the past century (Edey and Hviding, 1995). 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. In addition to this, the power of the test is generally a sizable problem: most liquidity regulation policies 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 depositors' reactions. 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.

For this reason, we investigate a unique case study that addresses the previous concerns. In mid-March 2011, the National Bank of Ethiopia (NBE) approved a directive on liquidity requirements, obliging all private commercial banks to start purchasing 0.27 government bonds for every unit of private sector lending by April 2011. While it could be questioned whether this is a liquidity regulation, as these bonds may be far from liquid and risk-free; we believe this is not the case for two reasons. First, such bills can be exchanged with liquidity by the central bank (article 7 of the directive). Second, given the lack of an interbank market, these bills have de-facto recreated an interbank system by allowing banks to transfer liquidity claims. This policy generated very large asset reallocations, with banks mobilizing 10% of their balance sheet in few weeks and boosting their liquidity holding by 25%.

Because such requirements were not randomly assigned, the cross-sectional dimension of the treatment is challenging. We partially circumvent this problem by studying the heterogeneity of this treatment and exploiting our theoretical setting. In fact, the model prescribes a supermodularity between liquidity and banking technology: following a liquidity injection, 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).

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

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

2) 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;

3) a digitization of all annual reports in the five years around the policy change.

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. While the effects on profitability enjoy a lower power because of yearly observations, in general we observe a slow down in profit growth (statistically different from zero at 10%), but not a negative effect.

This paper participates 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) and Diamond and Rajan (2000) highlight the discipline role of deposits and how this can change when financial regulation is introduced. Allen, Carletti and Marquez (2015) discuss how financial regulation can affect deposit behaviour and consequently bank capital structure, while Allen, Carletti and Marquez (2011) look at asset-side monitoring and how that affects capital choice and depositor remuneration. The empirical literature on these topics is relatively limited and our contribution is mostly directed to fill this gap. Barth, Caprio and Levine (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. Our paper also contributes to a literature on depositors response to exogenous wealth changes. For example, Bustos, Garber and Ponticelli (2016) and Gilje, Loutskina and Strahan (2016) study how exogenous shocks, respectively to technology and wealth, affect the level of deposits and how this translates into credit. Another growing literature studies depositors' responses to changes in deposit insurance. Iyer 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 (2015) find the emergence of double-bank runs (both from borrowers and depositors) in the wake of the European interbank market freeze registered in 2007. Finally, Ioannidou and de Dreu (2006) were among the first to study the impact of explicit deposit insurance on market discipline in a natural experiment in Bolivia.

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 present 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:

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

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.[1]

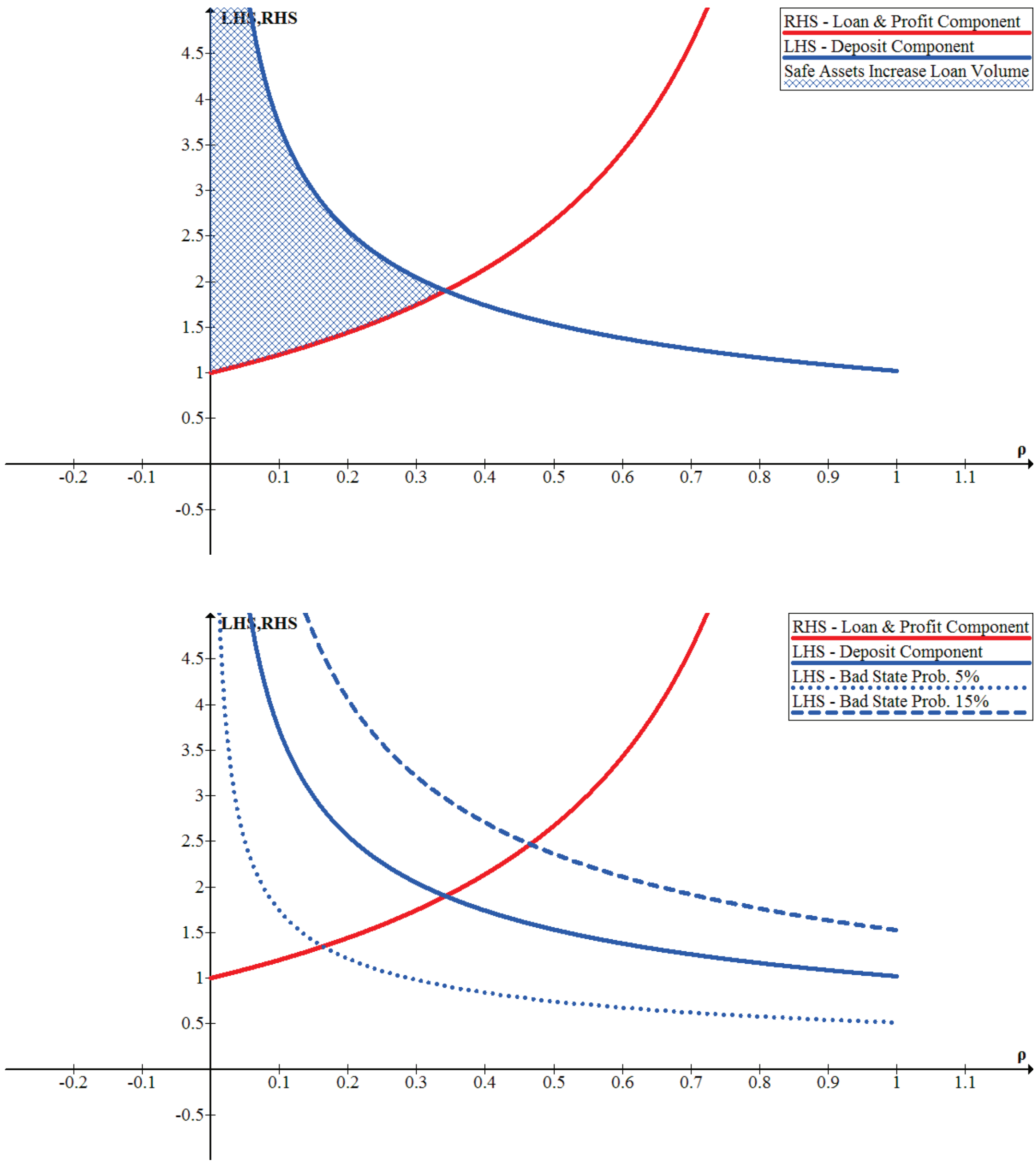
The upper panel of Figure 2 shows the right- and left-hand side expressions, with the shaded area indicating the region in which higher liquidity regulation promotes lending. In the lower panel, we show that such a region increases in the probability of a bad state. In the main scenario, we set $1-p$ 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 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.*

[1] 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.

Figure 1: Loan Volume Increases in Liquid Assets



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

Proposition 2 *The parameter of bank size η, measuring the technological endowment of the bank in terms of branch cost, affects negatively the optimal number of branches and the branch-installation response of the bank to liquidity regulation. If a set of banks is endowed with η_H and another set with η_L, with $\eta_H > \eta_L$, then the banks exhibiting η_L: 1) install more branches than the bank with η_H, $\beta(\eta_L)^* > \beta(\eta_H)^*$); 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 3. 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

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

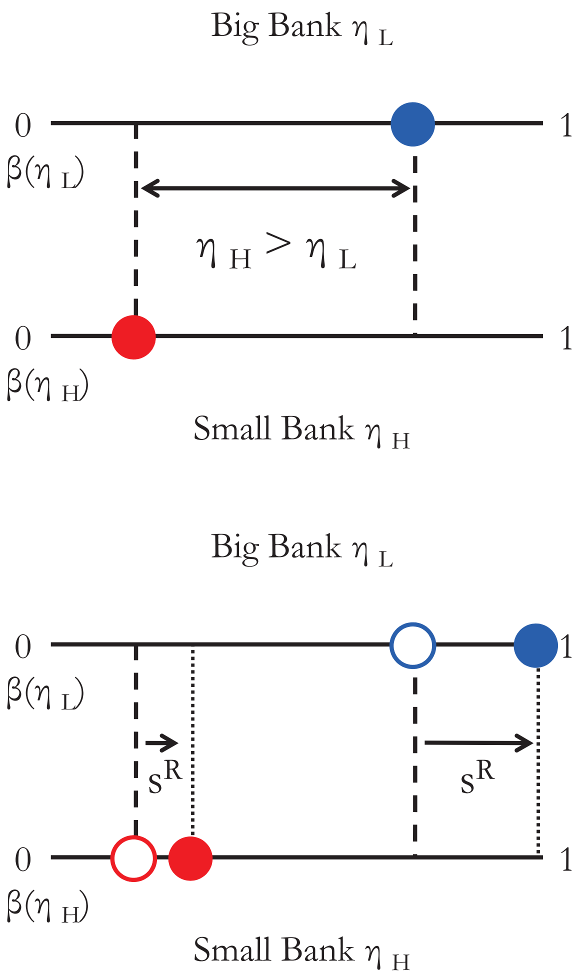
in which the variable of interest v_{it} for bank i at time t (ie., branches, deposits, loans...) is regressed over a bank and time fixed effects, ι_i and ι_t, and an interaction between the technological bank-specific parameter, η_i, and the liquidity regulation parameter, ρ_t. Proposition 2 predicts 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: Heterogeneity and Identification



Note: This figure graphically depicts the identification in this empirical exercise. 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.

2 Empirics

2.1 Evidence from Ethiopia

In this section, we present empirical evidence on Ethiopia and the behavior 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.

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 25% to 30%, as shown in the next subsection, which corresponds to a 25% increase.

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)[2].

In order to test the implications of Propositions 1 and 2, we collect confidential data on the monthly balance sheet of all Ethiopian private banks between 2010 and 2013, on publicly available Annual Reports data on profits between 2008 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 and 2 provide two fundamental elements to test the model: a shock to s^R promotes deposit growth; and cross-sectional variation in η 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. Figure 4 presents the total assets of the 14 Ethiopian banks on March 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

[2]Therefore this policy as well as mandating liquid assets, also lowers the return on private sector lending, as banks are forced to purchase government bonds 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 bills 0.27, 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.

administrative costs over personnel. This result, though not a comprehensive test of a variation due to η, provides some evidence consistent with our identification.

Once both the time-series and cross-sectional variation is clear, we present the following tests of our proposition.

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

1. Balance sheet data. 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 2.2.1).

2. Branch map. 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 2.2.2).

3. Annual reports. Using yearly data, we show that bank profitability does not decline in absolute value and actually increases for larger banks. We also show that the number of employees grows much more after the policy, as banks start to expand further (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.

2.2 Main Results

2.2.1 Balance Sheet Evidence

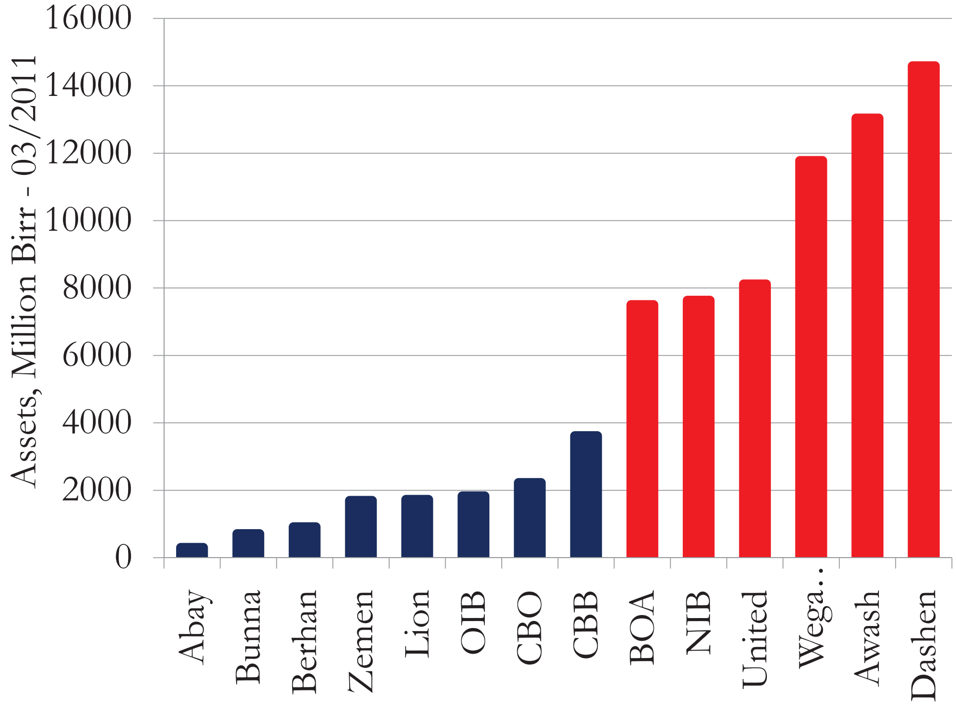
The policy change creates a large exogenous variation in the aggregate s^R, and from the point of view of the theoretical model, this leads to more liquid assets, which stimulate deposits and consequently lending. Because private banks are equally affected by the policy, but respond differentially based on their parameter η, we can produce a variety of tests to study Propositions 1 and 2 empirically. The following two are performed and presented.

1. Within-Year Compliance. 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. Appendix E reports the test and results.

2. Quarter Variation. 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 favor of our model.

Figure 3: Bank Assets



Note: This figure reports a bar chart reporting the total assets of all Ethiopian private banks in March 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 in Sections 2.1.2 and 2.1.4. In Section 2.1.3, because of limited data on the long-run branch installation, we focus within the big banks and compare Awash and Dashen as big banks with BOA, CBB, NIB, and United.

Quarterly Variation

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

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

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.

In Figure 4, we present the trend of NBE bills (upper panel) and overall liquid assets (lower panel) for big and small banks. In Figure 5, we report the differential trend between big and small banks for deposits (upper panel) and lending (lower panel). While Table 1 reports the coefficients and standard errors for the differential coefficients c_{qy} across the available quarters.

By analyzing these elements, it emerges that until the introduction of the policy change, in Quarter 5, the coefficients on deposits, loans, NBE bills, and liquid assets are not statistically different from zero for big banks. Therefore, the parallel trend hypothesis cannot be statistically rejected. However, Quarter 5 establishes the change in three important factors. First, NBE bills start getting purchased by all banks, who pass from holding zero of these assets to roughly 15% of their assets in these bonds, as shown in the upper panel of Figure 5. Secondly, overall liquid assets increase as well, both for big and small firms, by roughly 5%, as the bottom panel of Figure 5 highlights. These two information combined reveal that banks increased their overall liquid asset and switched composition from some type of safe assets toward the new NBE bills. At the same time, as highlighted by columns (3) and (4) of Table 1, such liquidity accumulation did not take place differentially across banks. Third, deposits react almost simultaneously and begin a steady growth, which differentially affects more big banks. The same reaction is also exhibited by private sector lending, however this becomes statistically different from the small bank trend only after 2-3 quarters, as shown by Table 1.

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.

2.2.2 Evidence from a Branch Map of Ethiopia

In this section, we present further evidence on a key feature of Propositions 1 and 2, where we show that the 27% rule is associated with greater 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 2015. The Annual Report by the NBE in 2014 counts 2,208, and therefore our map considers more than 90% of existing branches.

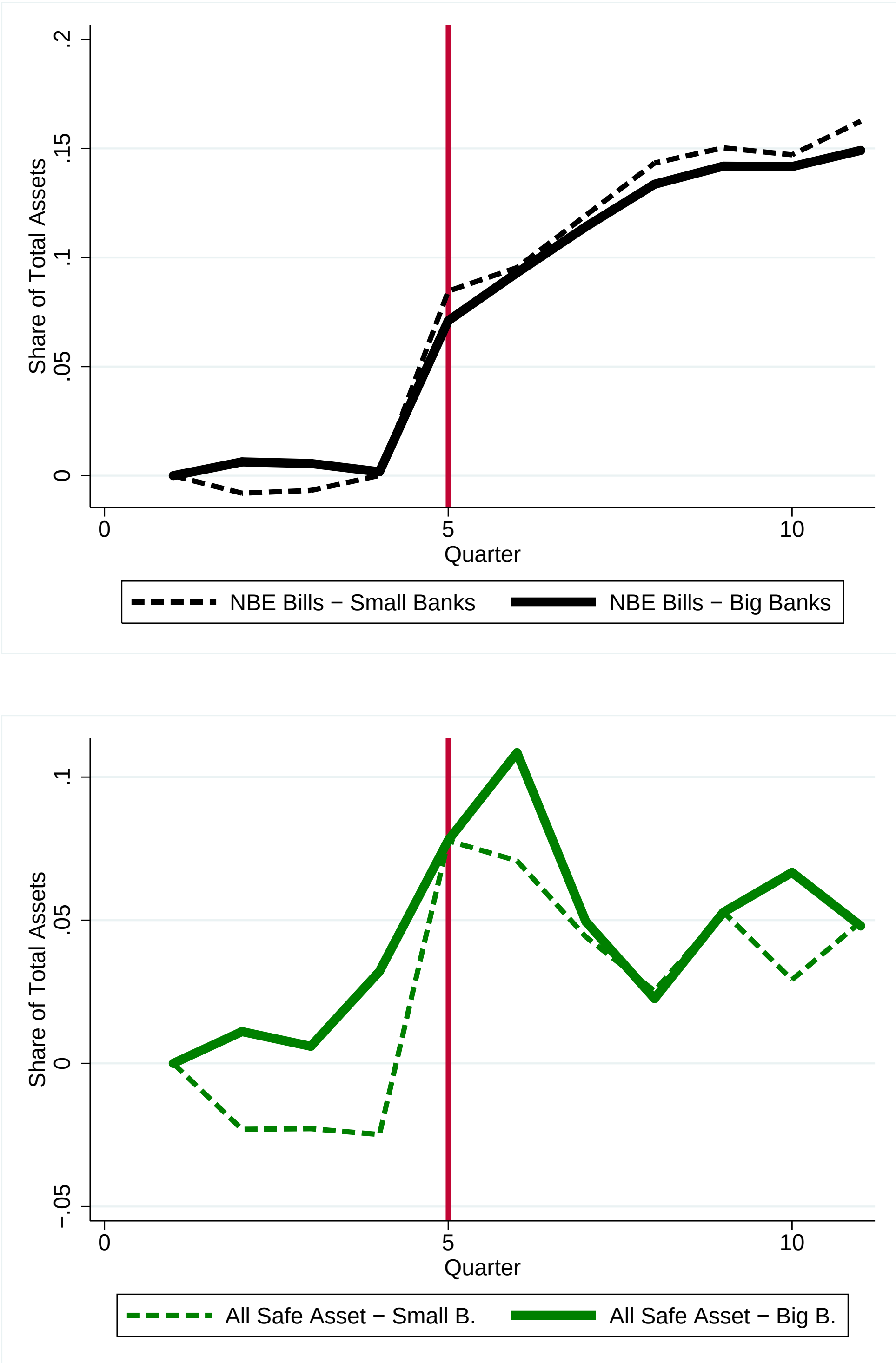
In this analysis, we want to verify two features: 1) the overall number of branches increases as the liquidity effect kicks in, as the model predicts; 2) new branches are more "rural". We define a branch as "rural" if it the first to be opened in a town, which previously had no bank branches - considering this as a proxy of expansion into rural areas. Because our map explores

Table 1: Regulation and Banks: Quarter Variation

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

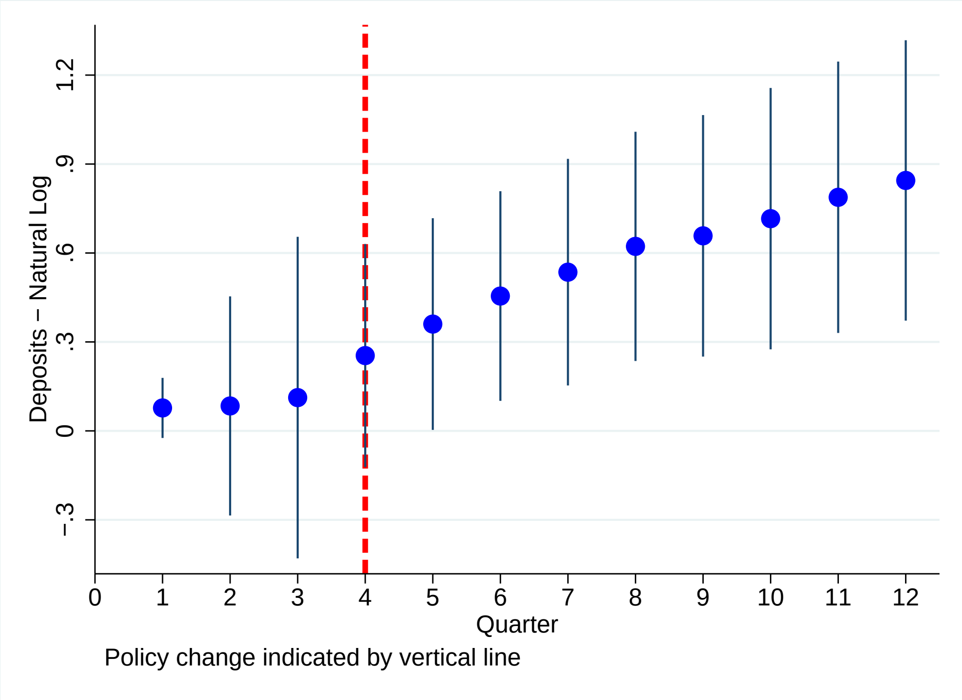
Note: This table reports OLS estimates; the unit of observation is bank level and bank and quarter × year fixed effects are included. Standard errors are clustered at Bank level. Total deposits is a variable aggregating demand, saving, and time deposits at bank level; it is continuous and measured in 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. All liquid assets is the amount of liquid assets held by banks in cash, bank-to-bank deposits, and reserves at the NBE and NBE bills; 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 5 and 6 plot all the coefficients over time. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

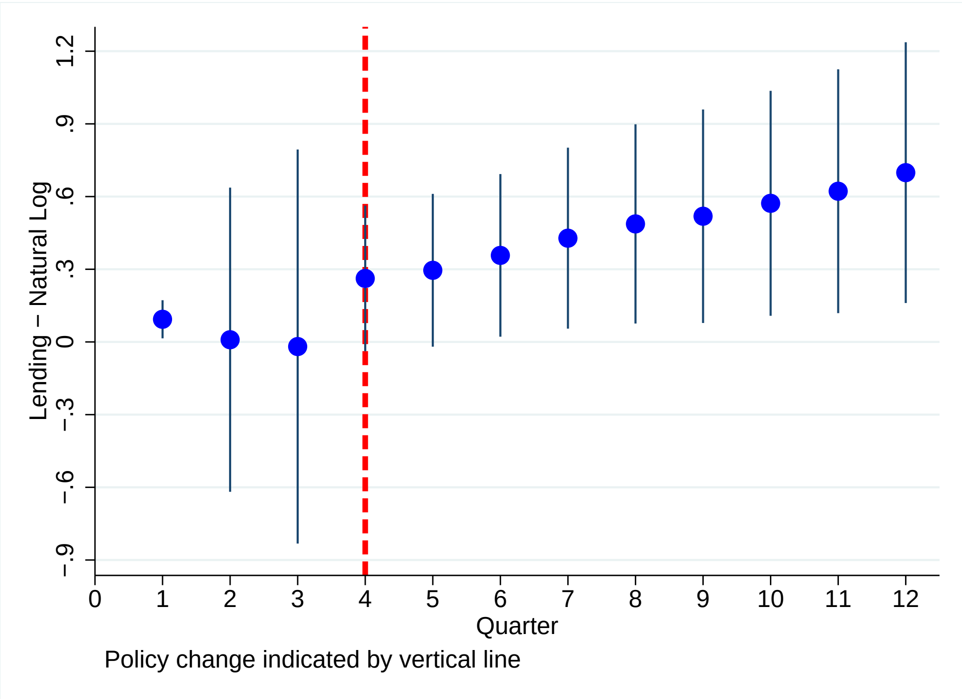
Figure 4: Policy Change and Trends: Deposits and Loans



Note: This figure plots the coefficients of the overall trend exhibited by small and larger banks for 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 (NBE bills in black and safe assets in green). 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) 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 1, the pre-policy trends are not statistically different from zero, while post-policy all of them are. It is notable that all banks, both big and small, become safer in response to the policy. Appendix F reports the same picture with 95% confidence intervals.

Figure 5: Policy Change and Trends: Deposits and Loans





Note: This figure plots the coefficients of the differential trend between big and small banks for deposits (upper panel) and loans (lower panel) over all quarters available in the data. The policy is announced in mid-March 2011 and implemented in April 2011 (shown by the vertical red dashed line). As is evident, there occurs an important discontinuity around the policy introduction (Quarter 5) and larger banks respond substantially more than smaller banks by collecting more deposits and giving more loans. As is evident from Table 1, the pre-policy trends are not statistically different from zero, while post-policy the deposit trend differs almost immediately, while the loan trend only from Quarter 9 onwards.

all geographical features, we can see how many branches are opened in previously unbanked areas and therefore we can rely on this as the most reliably measure of bank ruralization.

For this reason, we run two tests, collapsing our branch-level database to a panel at bank level with months and year. The first test is a typical difference in difference regression

$$v_{ity} = a + b \cdot Policy_{ty} \cdot Big\ Bank_i + \iota_i + \iota_{ty} + \epsilon_{iy}, \tag{3}$$

where the number of branches and the number of branches in previously unbranched areas, v_{ity}, are regressed over bank and month-year fixed effects and the interaction between a policy dummy taking unit value after April 2011, the introduction of the 27% rule, and the big bank dummy variable.

With the second test, we run the same variables over a series of yearly dummies, ι_y, which describe the branch accumulation trend for small banks

$$v_{iy} = a + \sum_y b_y \cdot \iota_y + \sum_y c_y \cdot \iota_y \cdot Big\ Bank_i + \iota_i + i_m + \iota_y + \epsilon_{iy}, \tag{4}$$

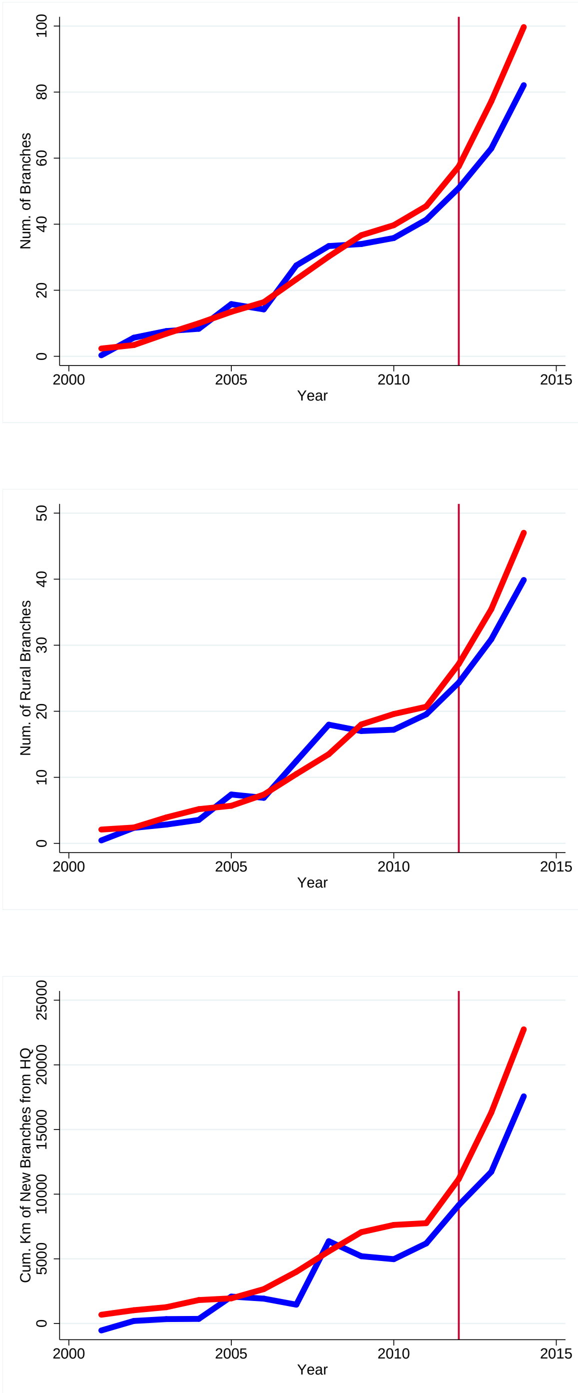
and an interaction of these with the big bank dummy, which describe the differential branch expansion of big banks. Table 2 reports that in line with our expectation, after the policy each big bank opened 10 branches more than the other banks, and they also accelerated rural branching, as big banks opened 2.5 additional branches over small banks in previously unbanked areas. Comparing these values with the mean dependent variable row, these magnitudes are substantial: branches grow for big banks 20% more than smaller banks and rural branches by almost 50%.

Figure 7 further explores this and shows the coefficients for big and small banks by describing their trends. The upper panel reports the evolution of branch installation; it is clear that up until 2012 the trends are indistinguishable, but they start to diverge after the introduction of the policy. Analogously, the lower panel shows a similar story for new branches opened in unbanked locations. Appendix F shows a test of the parallel trend hypothesis, showing that the differences between big and small banks were generally statistically different before the introduction of the policy, while after the introduction of the policy they became in line with the theoretical model.

2.2.3 Evidence from Annual Reports

In this section, we present some supporting evidence concerning the non-negative effect of a shock to s on profits and its positive effect on the number of employees, as a proxy for size. Because these aggregates are collected yearly by banks, we lack the rich within-year variation, which has been exploited in the previous sections. Also, the number of observations becomes a big limitation, because now we only face a panel with five observations at most for each bank. However, we present two tests. The first is a simple difference-in-difference regression, where we verify whether profits and the number of employees grow more for larger banks than for

Figure 6: Policy Change and Trends: Branch Installation



Note: This figure plots the coefficients of the overall trend exhibited by small and larger banks in overall branches and rural branches for big banks (blue) and small banks (red). The policy is implemented in April 2011 (shown by the red vertical line). As is evident, while branch accumulation does not differ before the policy change, afterwards big banks start to install more branches overall (upper panel) and more rural branches (lower panel). Appendix F reports the same picture, showing the difference with 95% confidence intervals.

Table 2: Branches and New Towns: Branch Map of Ethiopia

Variables	(1) Number of Branches	(2) Number of Rural Branches	(3) Cumulative Distance of New Branches from HQ
Policy × Big Banks	12.60***	3.677**	1,533**
	(2.604)	(1.418)	(622.2)
Bank FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Obs.	379	379	379
Adjusted R^2	0.943	0.925	0.886
Mean Dep. Var.	53.87	29.08	10,055
SD Dep. Var.	33.11	15.61	6,882

Note: This table reports OLS estimates. The unit of observation is bank level, and bank and month-year fixed effects are included. Robust standard errors are reported in parentheses. The number of branches is defined as the cumulative number of branches installed by a bank, while the number of rural branches is defined as the cumulative number of branches opened in towns previously unbranched. 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 the Big Bank dummy previously defined. The adjusted R^2 of these regressions is also reported. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

smaller banks:

$$v_{iy} = a + b \cdot Policy_y \cdot Big\,Bank_i + \iota_i + \iota_y + \epsilon_{iy}. \tag{5}$$

Here, as usual, v_{iy} is a variable under observation for bank i in year y (note that the subscript t that refers to months is dropped as we deal with annual observations); this variable is regressed over the interaction, $Policy_y \cdot Big\,Bank_i$, which accounts for the differential effect of the policy dummy in big banks. The variable $Policy_y$ takes unit value for the fiscal years during which the policy has been in place (i.e., 2012 and 2013), while $Big\,Bank_i$ takes unit value for the big banks, as presented in Figure 4. These results are reported in Table 3 and show that big banks' profits grow more rapidly after the policy and the number of employees expands at a similar faster rate.

However, because difference-in-difference regression may present severe limitations in absence of parallel trends, we take a requires a test of the parallel trend hypothesis before the policy. For this reason, we present a second test by running the following regression,

$$v_{iy} = a + \sum_y b_y \cdot \iota_y + \sum_y c_y \cdot \iota_y \cdot Big\,Bank_i + \iota_i + \iota_y + \epsilon_{iy}, \tag{6}$$

where real profits and number of employees are run over a series of yearly dummy variables, ι_y, which describe the evolution of profits and number of employees for small banks through the coefficients b_y and the interaction of yearly dummies with the big bank dummy, describing through the coefficients c_y their differential trend. As highlighted in Figure 8, there seems to occur a discontinuity at the introduction of the policy, both in real profits (upper panel)

Table 3: Profits, Branches and Regulation: Annual Reports

Variables	(1) Real Profits (million birr)	(2) Number of Employees
Policy × Big Bank	24.47*	393.3***
	(14.86)	(114.6)
Bank FE	Yes	Yes
Year FE	Yes	Yes
Observations	52	52
Adjusted R^2	0.938	0.971
Mean Dep. Var.	126.2	1,461
SD Dep. Var.	96.42	976.7

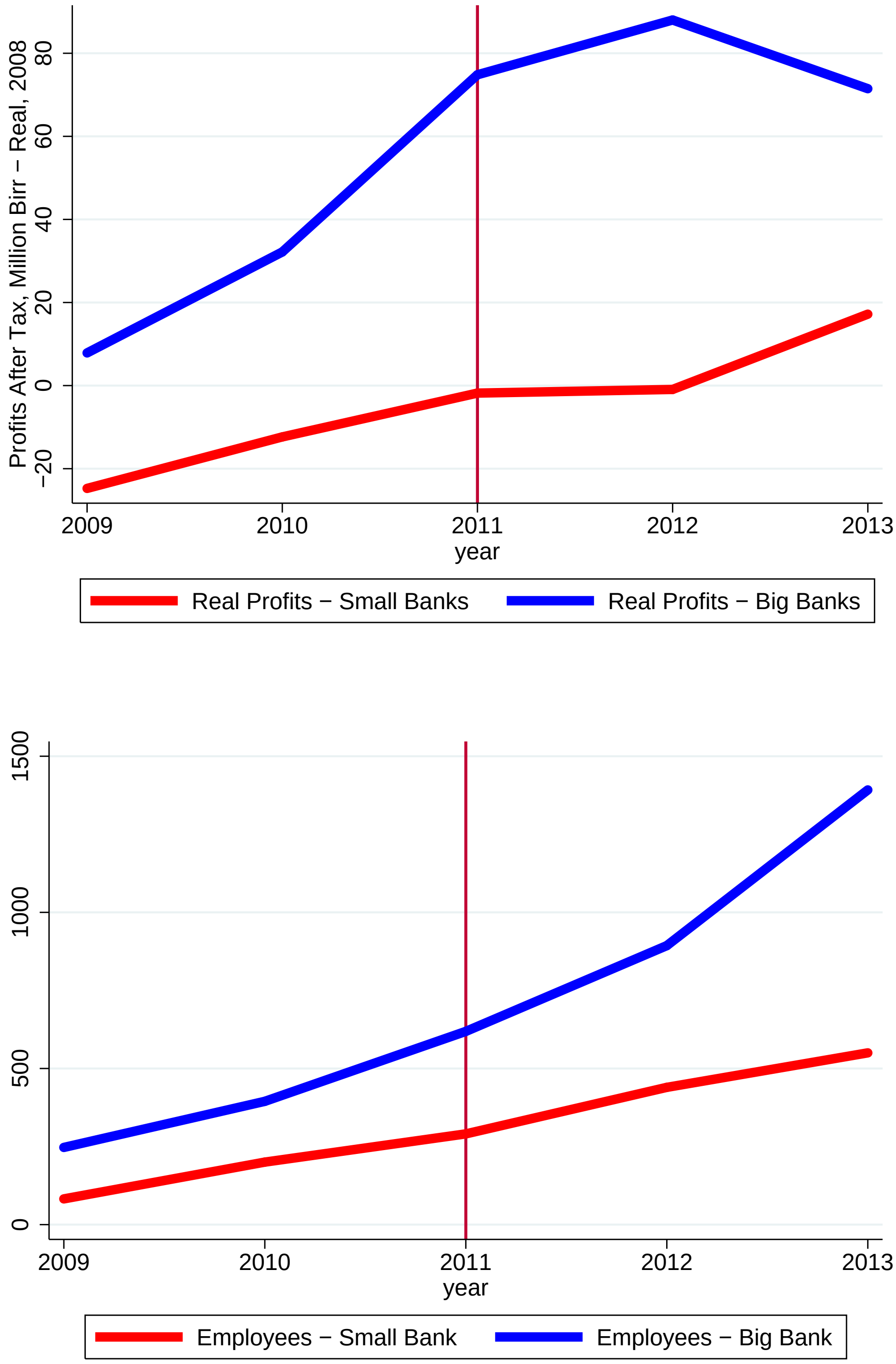
Note: This table reports OLS estimates. The unit of observation is bank level, and bank and month fixed effects are included. Davidson and McKinnon (1993) robust standard errors are reported in parentheses, which for this case are more conservative than bootstrapped bank-level clustered. Real Profits is the difference between the asset-generated income and liability-induced costs after taxes; it is continuous and measured in million birr. The number of branches denotes the total number of branches as shown in banks' annual reports. The variables are made inter-temporally comparable using the core inflation figures from National Bank of Ethiopia (2012, 2013). Their means and standard deviations are reported in the final two rows. These variables are regressed over a Policy dummy, which takes unit value after the introduction of the regulation policy and a dummy for Big Banks, taking unit value for the six banks classified as large in Figure 4. Bank and Year fixed effects are included. The adjusted R^2 of these regressions is reported in the row "Adjusted R^2". ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

and employee numbers, supporting the previously reported hypothesis. In the next section, we clarify how these are in line with the evolution of branch installation.

2.3 Robustness Checks

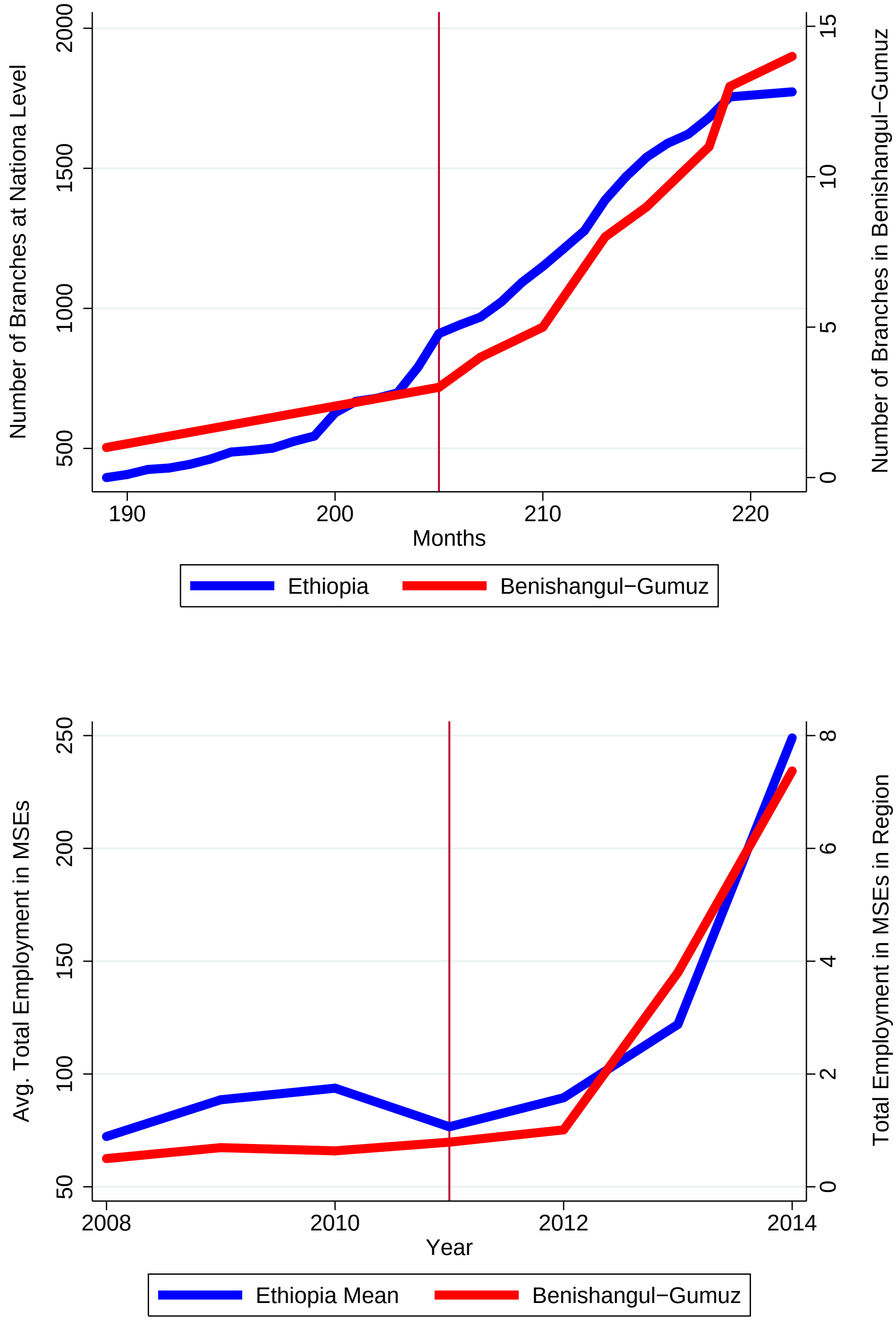
In this section, we explore possible alternative explanations, which might be related to the policy change and invalidate our inference. The most important feature, which has not been previously addressed, is the destination of the funds collected by the NBE, through this new bill. One powerful argument 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). 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

Figure 7: Policy Change and Trends: Real Profits and Number of Employees



Note: This figure plots the coefficients of the overall trend exhibited by small and larger banks in real profits and number of employees for big banks (blue) and small banks (red). The policy is implemented in April 2011 (shown by the red vertical line). As is evident, while both profits and number of employees do not differ before the policy change, afterwards big banks start to earn more (upper panel) and to hire more employees (lower panel). Appendix F reports the same picture, showing the difference with 95% confidence intervals.

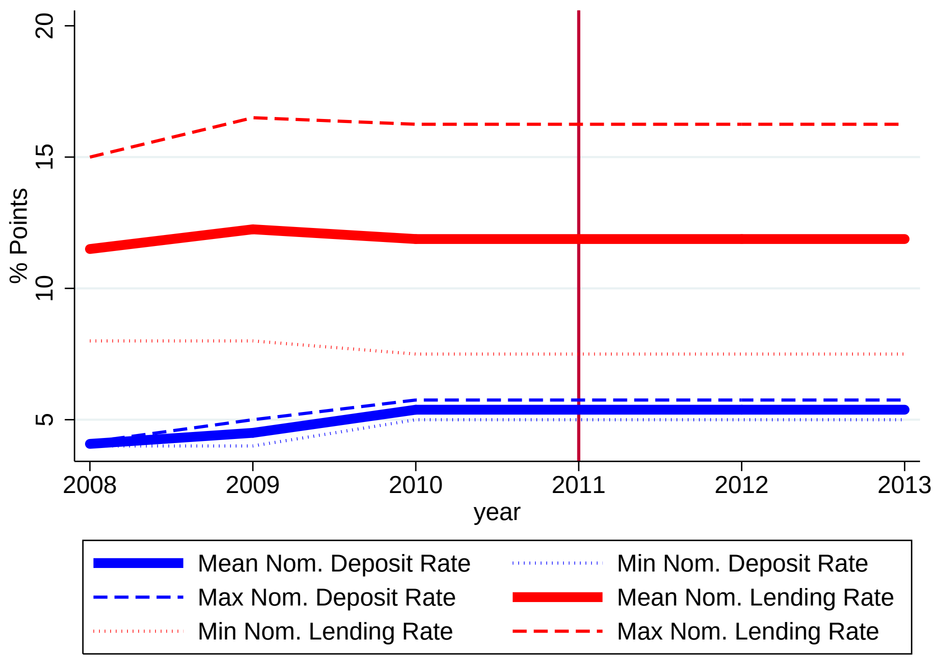
Figure 8: Regional Heterogeneity



Note: 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 center 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.

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.

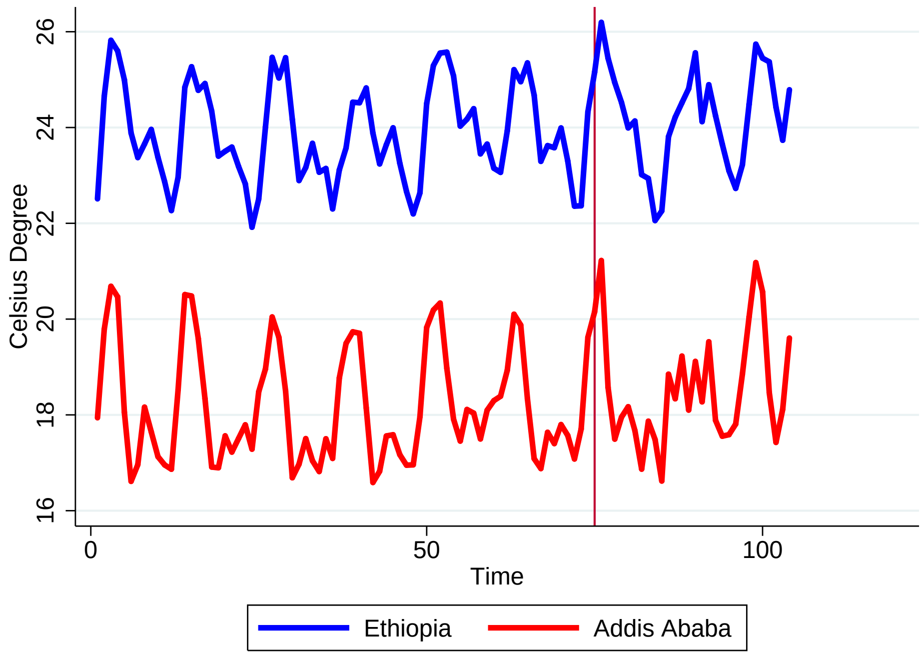
Figure 9: Policy Change and Prices: Lending and Deposit Rates



Note: 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.

Figure 10: Climate and Policy Change



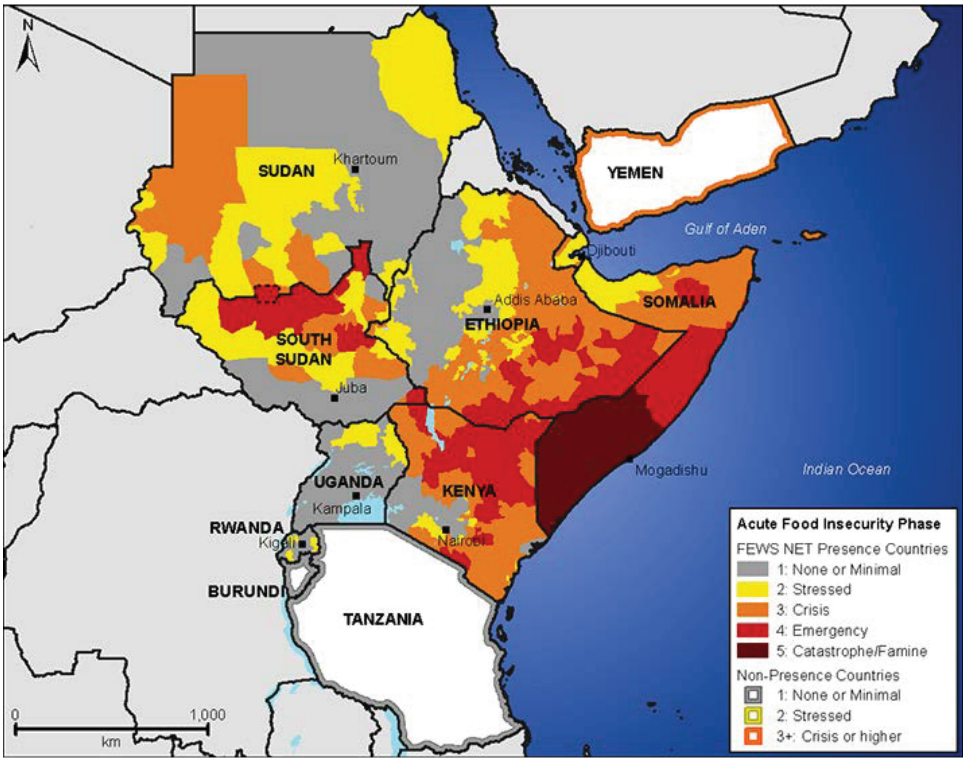
Note: This figure reports the monthly average temperature in Ethiopia (blue) and Addis Ababa (red) between January 2005 and August 2013. The policy change occurs in April 2011, Time 75, and there does not seem to be any response to weather changes. The data come from the Berkeley Earth project (`http://berkeleyearth.org/`). 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.

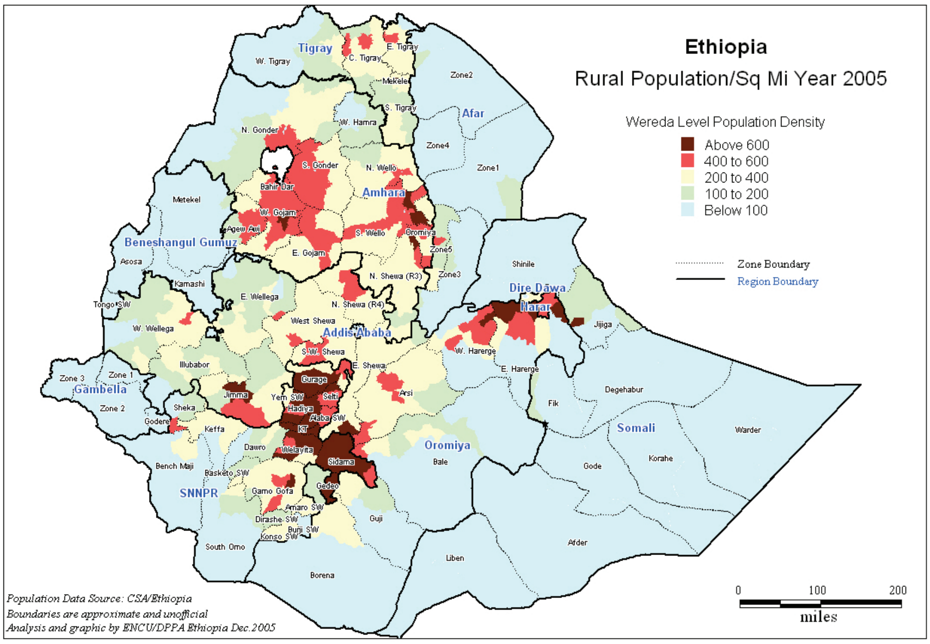
Thirdly, climate might be considered problematic, if the policy change occurred over periods of extensive temperature fluctuations, which might affect the agricultural and/or industrial productivity and hence financial markets. Ethiopia is a country with an heterogeneous climate, close to the equator 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.

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,[3] 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

[3]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`.

Figure 11: Drought and Population Density in Ethiopia in 2011





Note: 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.

Table 4: Largest Disasters in Ethiopia

Type	(1) Date	(2) 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

Note: 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`).

(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,[4] which is a sizable number, but limited relative to the 2011 population of 89.39 million. In Table 4, 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.[5]

Last but not least, alternative policy changes might have contemporaneously affected bank behaviour. In this period, the introduction of interest-free banking (IFB)[6] is the most important 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

[4]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`.

[5]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."

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

products only in 2014 and 2015[7]. 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.

3 Conclusion

In this paper, we show that liquidity regulation can promote bank deposits by imposing safe asset holding, in the absence of deposit insurance and credible safe-asset commitment by banks. This is true if the regulation does not exceed a threshold below which the elasticity of deposit mobilization to liquidity regulation exceeds the elasticity of the profit margin and asset loan share to the regulation. Such policy can promote also bank lending and profits, if the decline in the profit margin is exceeded by the size of the balance sheet growth, caused by additional deposits flowing in as the financial system becomes safer.

Given these theoretical results, we test the predictions of our model exploiting the introduction of a new liquidity regulation in Ethiopia in April 2011. This case study offers a unique feature, which is key to our identification: a large and unexpected policy change, which boosted the liquid holdings by banks by 25% in one quarter. This is combined with four special features that allow our analysis: balance sheets at monthly frequencies, which allow us to tightly track the policy change; distinct cross-sectional variation in asset size across Ethiopian banks, which contributes to a neat identification; a long-term branch map covering installations in the last 15 years; and annual report digitization for five years around the policy. Combining the time-series variation generated by the introduction of the policy, with cross-sectional variation in bank size, we find that banks exposed to this policy do not lose profits, accumulate more safe assets, and increase their deposits and loans.

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.

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[7] 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/ http://addisfortune.net/articles/interest-grows-in-interest-free-banking/

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Internet Appendix

Appendix A: Deposit Decision with Different States and Remunerations

As in Section 1.3, the depositor problem can be described by

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

Plugging the constraint in the maximand, we obtain

$$c_1^{\alpha} + \delta[p R_D^{\alpha}(y - c_1)^{\alpha} + (1-p) R_{DB}(\rho)^{\alpha}(y - c_1)^{\alpha}].$$

The first-order conditions are

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

and

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

which describe the deposit decision

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

This quantity is always positive and increasing in $R_{DB}(\rho)$.

Appendix B: Financial Regulation as Safe Asset Purchase

As reported in Section 1.4, it can be shown that the loan level increases in the policy parameter ρ if

$$\frac{\partial L}{\partial \rho} > 0 \rightarrow \frac{\partial \pi(\rho)}{\partial \rho}\frac{1}{\eta} d(\rho)[1 - s(\rho)] + \frac{\pi(\rho)}{\eta}\frac{\partial d(\rho)}{\partial \rho}[1 - s(\rho)] - \frac{\pi(\rho)}{\eta} d(\rho)\frac{\partial s(\rho)}{\partial \rho} > 0,$$

which implies that the elasticity of deposit mobilization to the regulation parameter exceeds the elasticity of the intermediation margin and loan provision to the regulation

$$\epsilon_{d\rho} > \epsilon_{\pi\rho} + \epsilon_{l\rho}.$$

Alternatively, recalling the definition of the profit margin

$$\pi(\rho) = p[(R_G - R_D) - \rho(R_G - R_S)]$$

and its first derivative with respect to ρ

$$\frac{\partial\pi(\rho)}{\partial\rho} = -p\rho(R_G - R_S),$$

we note that

$$\frac{\partial\pi(\rho)}{\partial\rho} = [\pi(\rho) - p(R_G - R_D)],$$

while the deposit function

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

Recalling that $R_{DB}(\rho) = \rho R_S + (1-\rho)R_B = \rho(R_S - R_B) + R_B$

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

and its derivative in ρ

$$\frac{\partial d(\rho)}{\partial\rho} = \frac{\alpha}{1-\alpha}y\frac{\delta^{\frac{1}{1-\alpha}}\{pR_D^\alpha + (1-p)[\rho(R_S-R_B)+R_B]^\alpha\}^{\frac{1}{1-\alpha}-1}(1-p)[\rho(R_S-R_B)+R_B]^{\alpha-1}(R_S-R_B)}{[1+\delta^{\frac{1}{1-\alpha}}\{pR_D^\alpha + (1-p)[\rho(R_S-R_B)+R_B]^\alpha\}^{\frac{1}{1-\alpha}}]^2},$$

which can be simplified

$$\begin{aligned}\frac{\partial d(\rho)}{\partial\rho} &= \frac{\alpha}{1-\alpha}y \\ &\times \frac{(1-p)(R_S-R_B)[\rho(R_S-R_B)+R_B]^{\alpha-1}}{\{pR_D^\alpha + (1-p)[\rho(R_S-R_B)+R_B]^\alpha\}[1+\delta^{\frac{1}{1-\alpha}}\{pR_D^\alpha + (1-p)[\rho(R_S-R_B)+R_B]^\alpha\}^{\frac{1}{1-\alpha}}]}d(\rho).\end{aligned}$$

Then, we can simplify the previous expression

$$\frac{\partial\pi(\rho)}{\partial\rho}\frac{1}{\eta}d(\rho)(1-\rho) + \frac{\pi(\rho)}{\eta}\frac{\partial d(\rho)}{\partial\rho}[1-s(\rho)] - \frac{\pi(\rho)}{\eta}d(\rho) > 0$$

$$-\rho\pi(\rho)d(\rho) - p(R_H - R_D)(1-\rho)d(\rho) + (1-\rho)\pi(\rho)\frac{\partial d(\rho)}{\partial\rho} > 0$$

reaching the following expression

$$\frac{\partial d(\rho)}{\partial\rho}\frac{1}{d(\rho)} > \frac{\rho}{1-\rho} + \frac{1}{1-\rho[(R_H-R_S)/(R_H-R_D)]}$$

whose left-hand side can be described by

$$\begin{aligned}\frac{\partial d(\rho)}{\partial\rho}\frac{1}{d(\rho)} &= \frac{\alpha}{1-\alpha}y \\ &\times \frac{(1-p)(R_S-R_B)[\rho(R_S-R_B)+R_B]^{\alpha-1}}{\{pR_D^\alpha + (1-p)[\rho(R_S-R_B)+R_B]^\alpha\}[1+\delta^{\frac{1}{1-\alpha}}\{pR_D^\alpha + (1-p)[\rho(R_S-R_B)+R_B]^\alpha\}^{\frac{1}{1-\alpha}}]}.\end{aligned}$$

Therefore, we can conclude that

$$\frac{\alpha}{1-\alpha}y\frac{(1-p)(R_S-R_B)[\rho(R_S-R_B)+R_B]^{\alpha-1}}{\{pR_D^\alpha+(1-p)[\rho(R_S-R_B)+R_B]^\alpha\}[1+\delta^{\frac{1}{1-\alpha}}\{pR_D^\alpha+(1-p)[\rho(R_S-R_B)+R_B]^\alpha\}^{\frac{1}{1-\alpha}}]}$$

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

hence defining

$$A(\rho)=\frac{(1-p)(R_S-R_B)[\rho(R_S-R_B)+R_B]^{\alpha-1}}{\{pR_D^\alpha+(1-p)[\rho(R_S-R_B)+R_B]^\alpha\}[1+\delta^{\frac{1}{1-\alpha}}\{pR_D^\alpha+(1-p)[\rho(R_S-R_B)+R_B]^\alpha\}^{\frac{1}{1-\alpha}}]}.$$

Noting that $A(\rho)>0$ and $\partial A(\rho)/\partial\rho<0$ and $\partial A(\rho)/\partial p<0$, we reach the expression stated in Section 1.4

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

This expression can be used to define a threshold $\widetilde{\rho}$, such that

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

By analyzing the previous expression, leaving prices as given, two factors stand out as central: $\widetilde{\rho}=\widetilde{\rho}(p,y)$, the probability of good state p, which has a negative relation on the threshold, and the level of income y, which has a positive effect. The first is intuitive: the higher the probability of a bad state, $1-p$, the stronger the effect of safe assets on mobilized deposits. Analogously for income, other things being equal, an increase in income creates a stronger desire to transfer resources to the uncertain period.

Calibrating the parameters to Ethiopia, setting $\alpha=1/2$, $\delta=0.9$, $y=20$, and market rates in line with the assumptions, this can be simplified to $R_B=0$, $R_D=1$, $R_S=21/20$, and $R_G=25/20$, which implies $\underline{p}=(R_S-R_B)/(R_G-R_B)=0.84$ and $p=0.9>\underline{p}$:

$$\frac{\alpha}{1-\alpha}y\frac{(1-p)(R_S-R_B)[\rho(R_S-R_B)+R_B]^{\alpha-1}}{\{pR_D^\alpha+(1-p)[\rho(R_S-R_B)+R_B]^\alpha\}[1+\delta^{\frac{1}{1-\alpha}}\{pR_D^\alpha+(1-p)[\rho(R_S-R_B)+R_B]^\alpha\}^{\frac{1}{1-\alpha}}]}$$

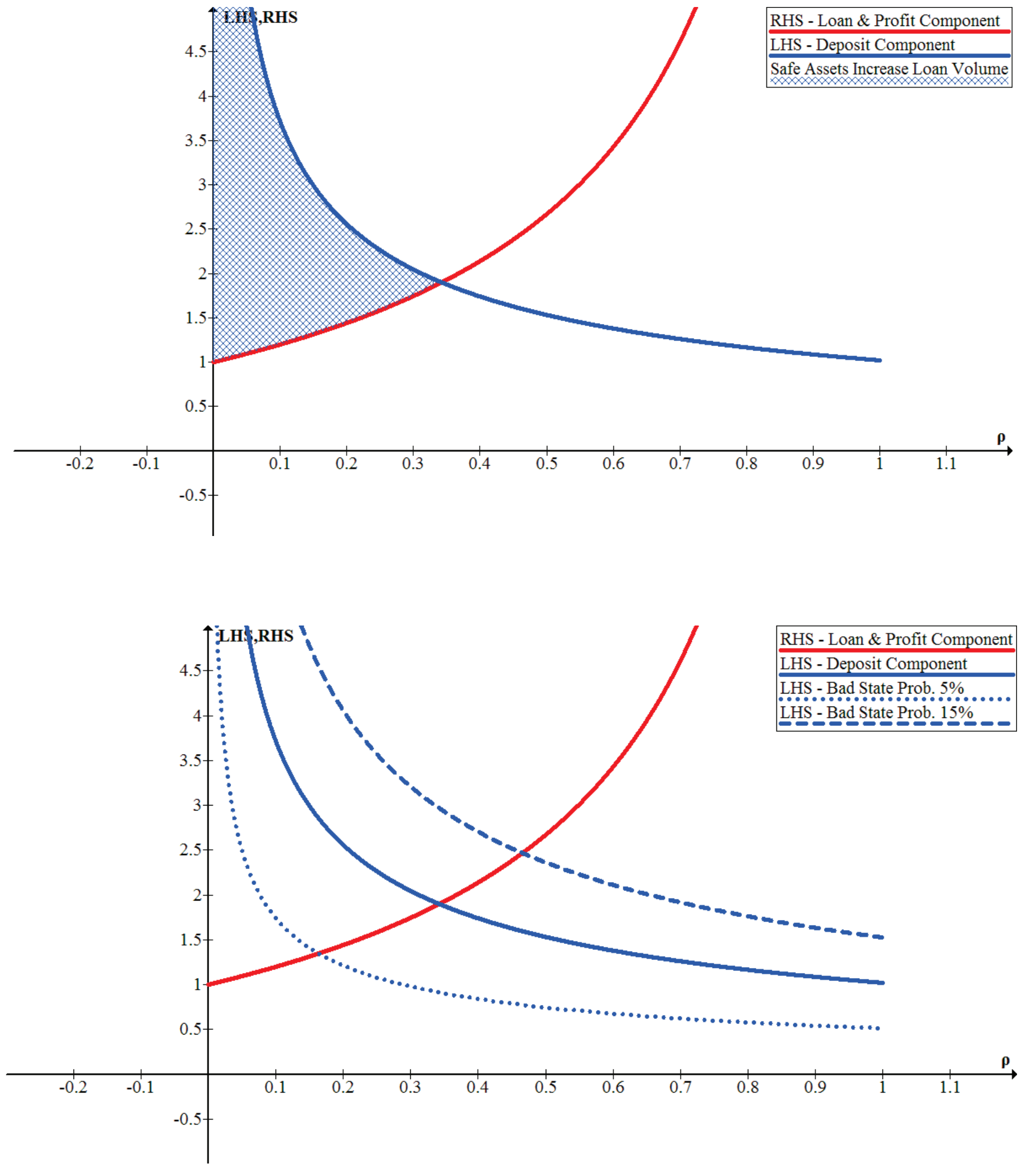
$$>\frac{\rho}{1-\rho}+\frac{1}{1-\rho[(R_G-R_S)/(R_G-R_D)]}$$

$$5\frac{0.1\sqrt{(21/20)}(\rho)^{\alpha-1}}{[0.9+0.1\sqrt{\rho(21/20)}]\left\{1+0.9^2[0.9+0.1\sqrt{\rho(21/20)}]^2\right\}}>\frac{\rho}{1-\rho}+\frac{1}{1-\rho(4/5)}$$

The picture in Section 1.4 is calibrated with these parameters, while in Appendix C, we report the same picture with changes in p and y.

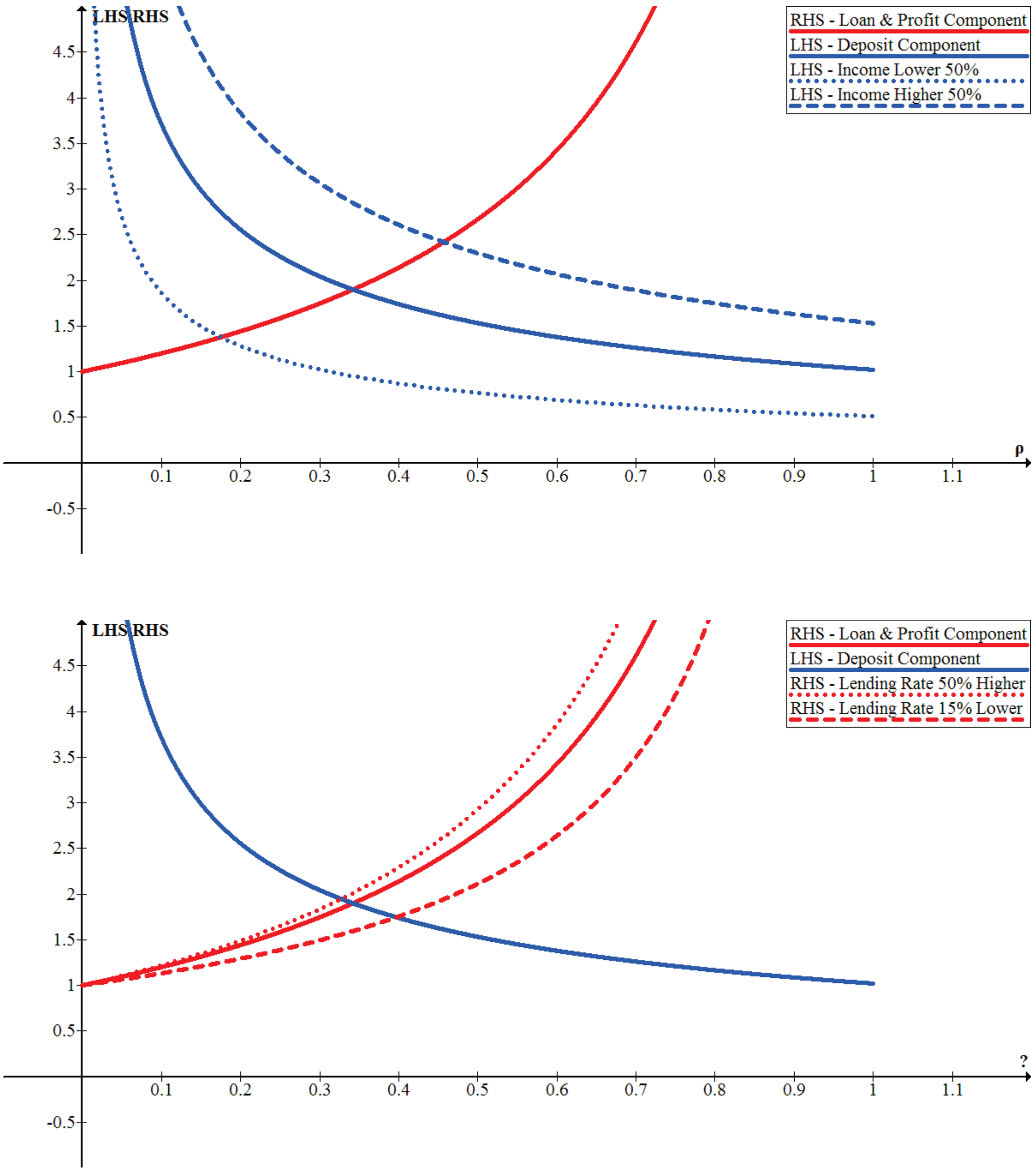
Appendix C: Comparative Statics in p

Figure C1: Comparative Statics of Threshold to p



Note: This figure plots the conditions under which loan volume increases with the regulated share of safe assets. The x-axis reports the values of the safe asset share parameter ρ, and the y-axis reports the values of the right- and left-hand side (RHS and LHS) variables. As is clear from the inequality, the LHS is decreasing with the parameter (reported in blue), while the RHS is increasing (in red). This picture assumes that the bank rates are in line with the model and calibrated with the Ethiopian economy, as from National Bank of Ethiopia (2011), and that 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).

Figure C2: Comparative Statics of Threshold to y and R_G



Note: This figure plots the conditions under which loan volume increases with the regulated share of safe assets. The x-axis reports the values of the safe asset share parameter ρ, and the y-axis reports the values of the right- and left-hand side variables (RHS and LHS). As is clear from the inequality, the LHS is decreasing with the parameter (reported in blue), while the RHS is increasing (in red). This picture assumes that the bank rates are in line with the model and calibrated with the Ethiopian economy, as from National Bank of Ethiopia (2011), and that 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).

Appendix D: Testing the Relation between Bank Size and Unit Costs

Table D1: Bank Size and Efficiency: Annual Reports

Variables	(1)	(2)
	Administrative Costs	
	on Asset	on Employee
Big Bank	−0.00446***	−0.0227***
	(0.00127)	(0.00563)
Year FE	Yes	Yes
Obs.	40	49
R^2	0.335	0.506
Adjusted R^2	0.258	0.435
Mean Dep. Var.	0.0113	0.0504
SD Dep. Var.	0.00449	0.0228

Note: This table reports OLS estimates. The unit of observation is bank level, and year fixed effects are included. Davidson and McKinnon (1993) robust standard errors are reported in parentheses, which for this case are more conservative than bootstrapped bank-level clustered. Administrative costs are defined from banks' annual reports as expenses related to the organization of the whole bank as opposed to an individual branch. These are normalized by bank assets in column (1) and by number of employees in coumn (2). Their means and standard deviations are reported in the final two rows. Big Bank is a dummy that takes unit value for the six largest Ethiopian Banks, and zero otherwise. The R^2 and adjusted R^2 of these regressions are also reported. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Appendix E: Testing Compliance of the NBE Bill Policy

This section verifies that 0.27 NBE bills were purchased for each birr of private lending and that this was no different between big and small banks. We present a simple fixed effect regression, introducing a dummy variable for the months in which the policy is in place. The following empirical model is tested:

$$v_{ity} = a + b \cdot Policy_{ty} \times Lending_{ity} + c \cdot Policy_{ty} \times Lending_{ity} \times Big\,Bank_i + \iota_i + \iota_{ty} + \epsilon_{ity}. \quad \text{(E1)}$$

Here, v_{ity} is the amount of NBE bills purchased by bank i in month t of year y, and is run over a dummy variable taking unit value after April 2011, $Policy_{ty}$, interacted with the volume of lending, $Lending_{ity}$, and then another term where we also explore whether there were systematic differences across big and small banks, $Policy_{ty} \times Lending_{ity} \times Big\ Bank_i$. The null hypothesis of these tests is $b = 0.27$ and $c = 0$. Table E.1 does not reject both of these. Indeed, column (1) shows that the point estimate of b is indeed very close to 0.27 (0.265) and even the standard errors are very small, despite using a clustered bootstrapped method (alternative procedures, such as robust, hc3 or unclustered bootstrap, provide less conservative standard errors). In column (2), we introduce an interaction and verify whether there is any differential implementation of the policy across big and small banks. Although the point estimate of b drops to 0.20 (with standard errors doubling), we can also verify that c is not statistically different

Table E1: Compliance in Regulation: Within-Year Variation

Variables	(1)	(2)
	NBE Bills (million birr)	
Private Lending × Policy	0.265***	
	(0.0395)	
Private Lending × Policy		0.206***
		(0.0848)
Private Lending × Policy × Big Bank		0.0621
		(0.0959)
Bank FE	Yes	Yes
Month FE	Yes	Yes
Obs.	168	168
Number of Banks	14	14
R^2	0.875	0.878
Adjusted R^2	0.864	0.866
Mean Dep. Var.	625.3	625.3
SD Dep. Var.	781.8	781.8

Note: This table reports OLS estimates. The unit of observation is bank level, and bank and month fixed effects are included. Standard errors are bootstrapped at bank-level cluster. NBE bills is the amount of bills issued by the NBE in million birr, and is a continuous variable. Its mean and standard deviation are reported in the final two rows. In column (1), NBE bills is regressed on the interaction between Private Lending, in million birr and a continuous variable, and the Policy dummy, taking unit value from April 2011 onward. In column (2), we also add an interaction of this variable with the Big Bank dummy, presented in Figure 4, to verify whether big banks comply differently. The null hypothesis is that in column (1) the coefficient is 0.27, as prescribed by the NBE directive, and we cannot reject this. In column (2), the null hypothesis is whether the big bank interaction is statistically different from zero, and we cannot reject this either. The R^2 and adjusted R^2 of these regressions are also reported. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

from zero. This supports the hypothesis that all banks were equally affected by the policy and complied.

Appendix F: Estimation and Confidence Intervals

Quarterly Variation Confidence Intervals

Figure F1: Bank Aggregates and Policy Change: 95% Confidence Intervals

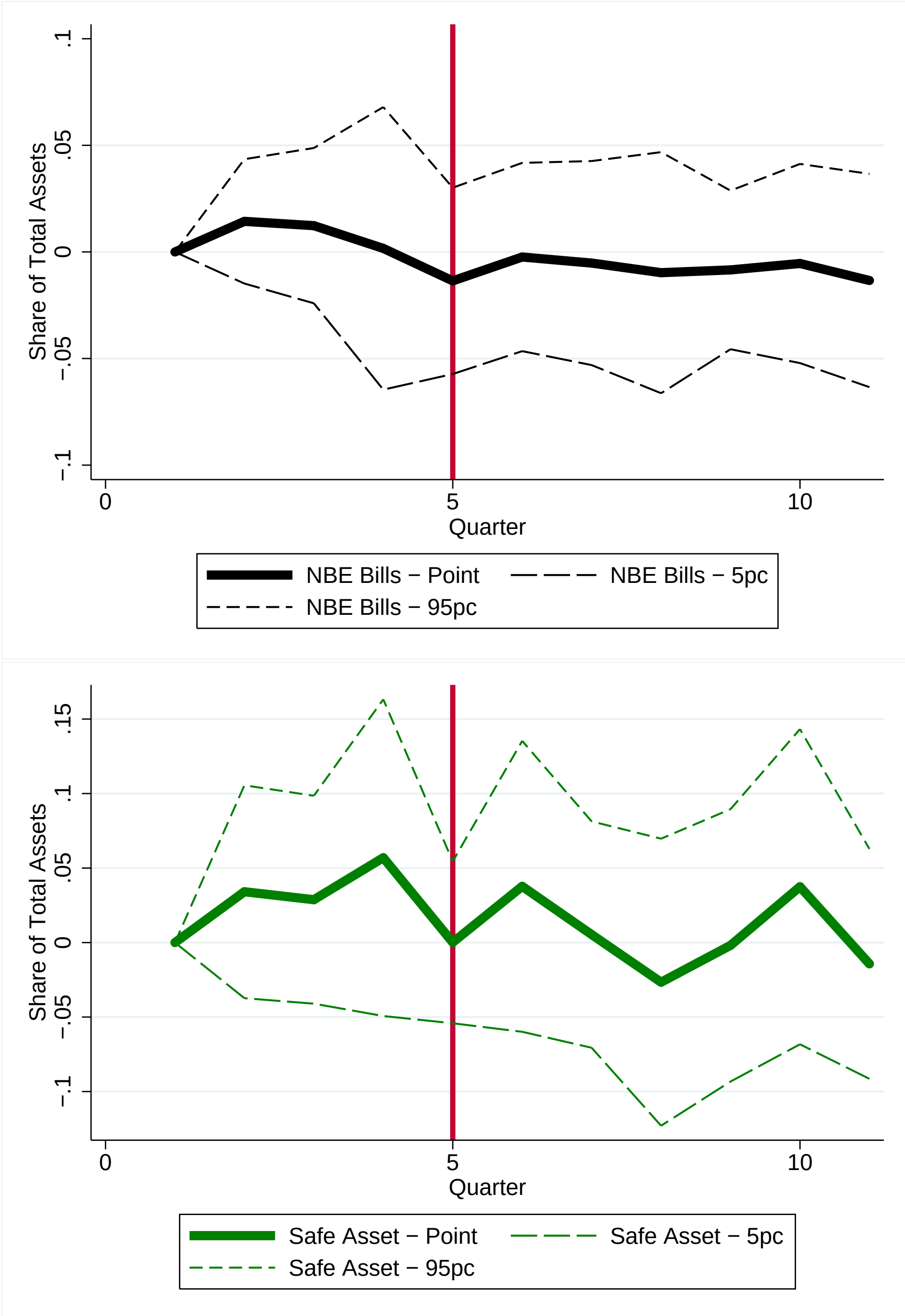
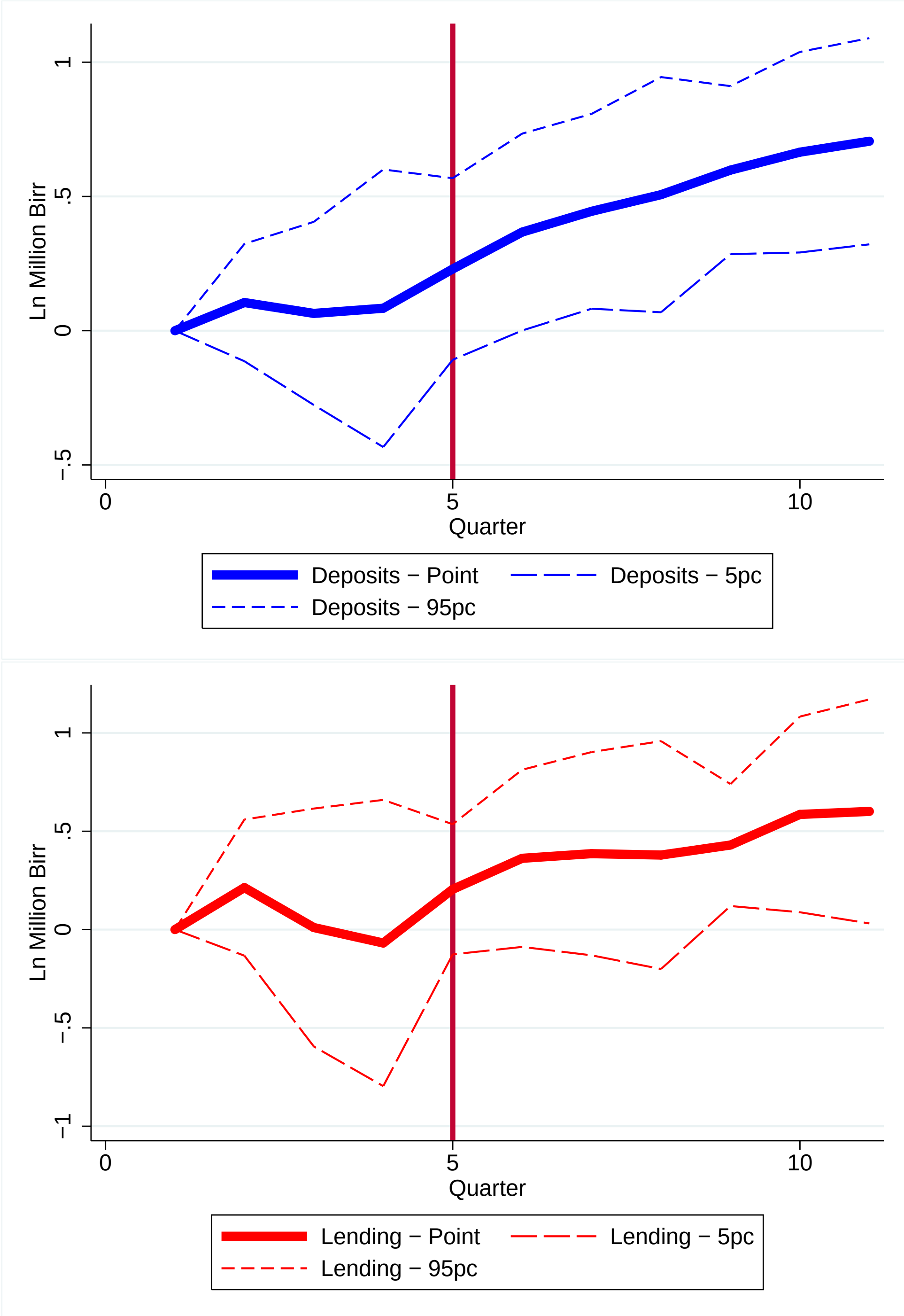


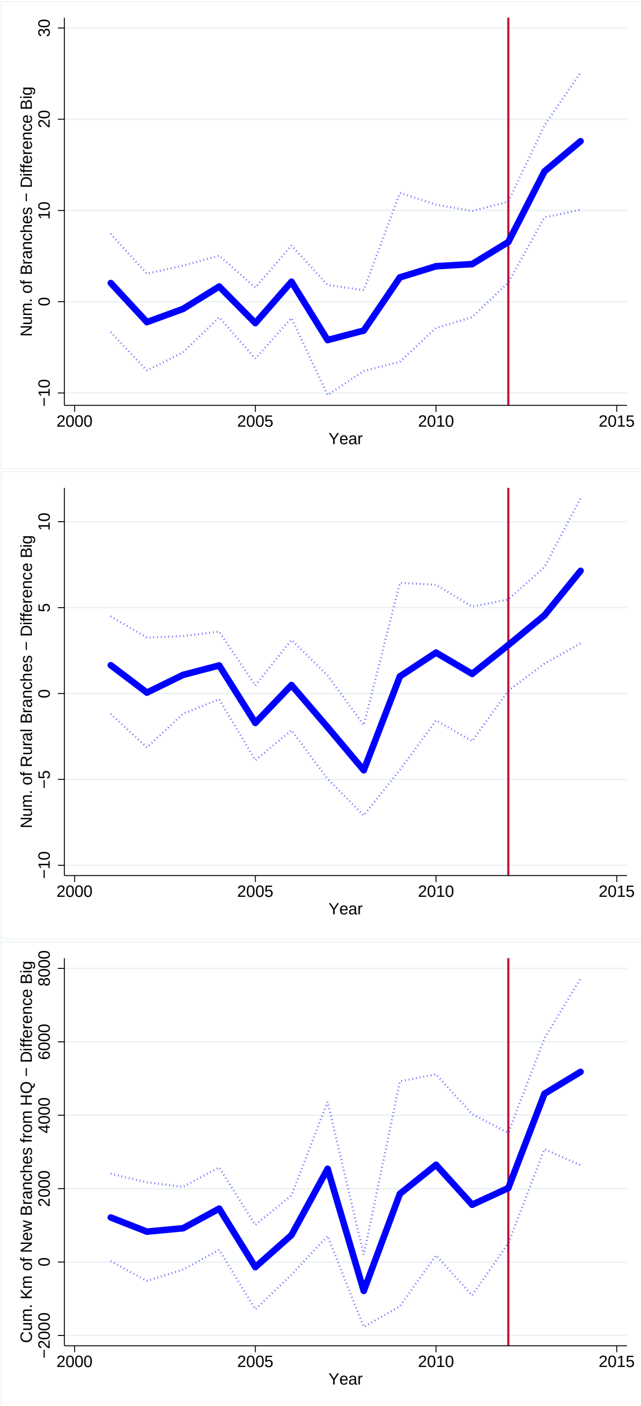
Figure F2: (continued)



Note: This figure plots the coefficients of the differential trend between big and small banks reported in Table 1, for all periods, for NBE bills (black; panel 1), safe assets (green; panel 2), deposits (blue; panel 3), and loans (red; panel 4). The policy is announced in March 2011 and implemented in April 2011 (shown by the vertical solid line). As is evident, there occurs an important discontinuity around the policy introduction for all variables except safe assets, and larger banks respond substantially more than smaller banks. Beyond purchasing more NBE bills in volume, which is true by design of the policy, they expand significantly more in deposits on the spot and from period 8 onwards also in private lending. As is evident from Table 1, the pre-policy trends are not statistically different from zero, while post-policy all of them are. This picture reports graphically the point estimate and 95% confidence interval of the coefficients on the interaction between the quarterly dummies and the big bank dummies from Table 1, but employing quarter dummies rather than two-month period dummies. The dotted lines report the 95th percentile of the effect, while the dashed lines show the 5th percentile.

Branch Installation Confidence Intervals

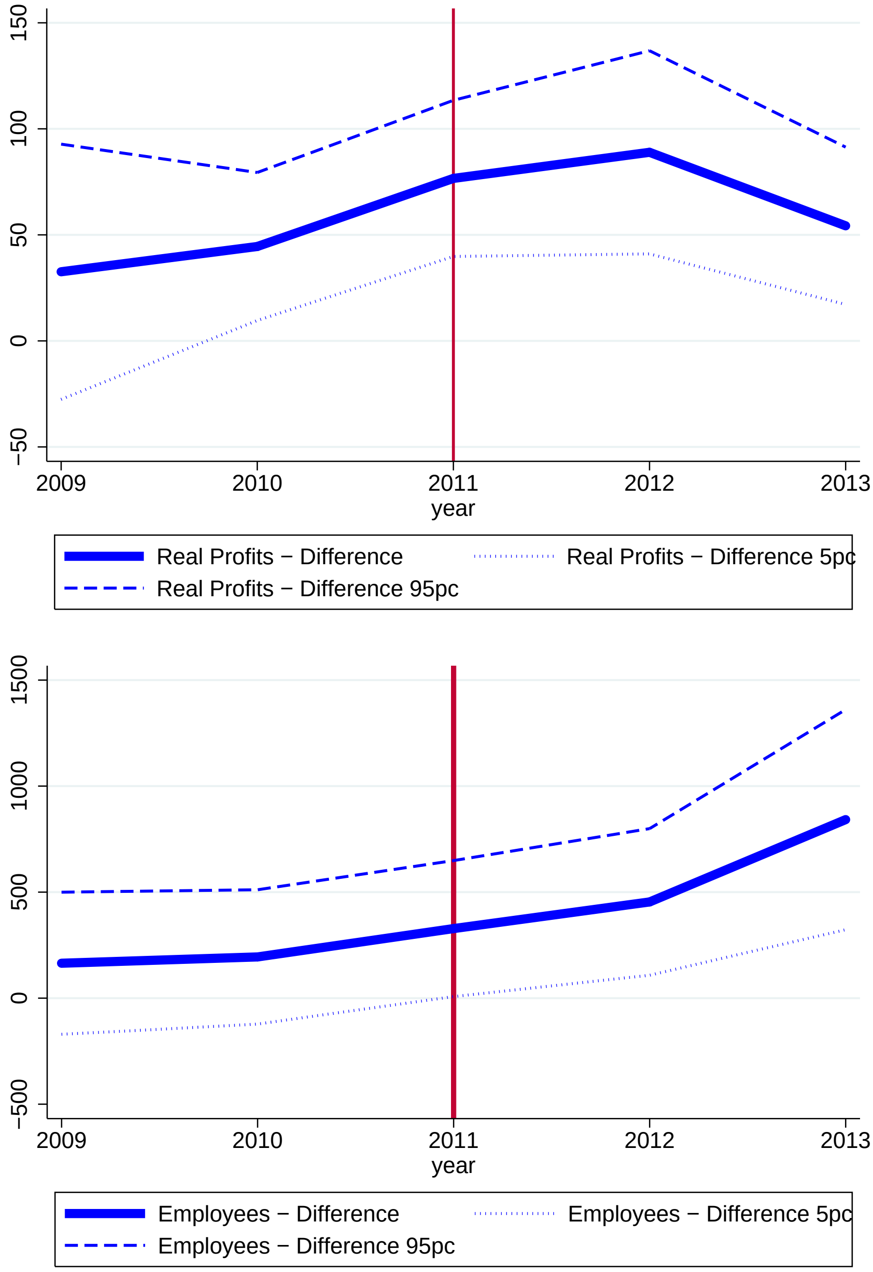
Figure F3: Branch Installation



Note: This figure plots the differential trends and 95% confidence intervals between big and small banks in overall branches (upper panel) and rural branches (lower panel). The policy is implemented in April 2011 (shown by the red vertical line). As is evident, while branch accumulation does not differ before the policy change, afterwards big banks start to install more branches overall (upper panel) and more rural branches (lower panel). The trends for big and small banks can be found in Figure 7.

Annual Reports Confidence Intervals

Figure F4: Real Profits and Number of Employees



Note: This figure plots the differential trends and 95% confidence intervals between big and small banks in real profits (upper panel) and number of employees (lower panel). The policy is implemented in April 2011 (shown by the red vertical line). As is evident, while both profits and number of employees do not differ before the policy change, afterwards there is some evidence that big banks start to earn more (upper panel) and to hire more employees (lower panel). Because of the yearly nature of the data, the power of this test is low. The trends for big and small banks can be found in Figure 8.