The Development Impact of Financial Regulation: Evidence from Ethiopia and Antebellum USA

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Abstract

Does financial regulation promote financial development by restraining banks profitability? We test this hypothesis in a model with a monopolistic bank investing in branches over a geography and facing classical maturity mismatch. Financial regulation lowers profits by pushing the bank to hold more precautionary holdings and lend less. Because the default probability declines, the bank partly compensates the profit loss and take on more risk by opening new branches. The regulation cause an unambiguous decline in profits, increase in deposits, while two forces affect lending: loans become smaller in old branches (intensive margin); the number of loans increases because of new branches (extensive margin). We show conditions under which the second effect dominates and the regulation makes the bank bigger, safer and less profitable. Two empirical tests are presented: 1) a regulation change by the National Bank of Ethiopia in 2011; 2) the state roll-over of bank taxes in Antebellum USA (1800-1861). Analyzing bank balance sheets, we find that these policies lower profits and increase branches, deposits, loans and overall precautionary holdings.

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Financial development promotes poverty-reduction, investment and ultimately welfare. Plenty of macroeconomic evidence, summarized by Levine (2005), and substantial microeconomic investigations (ie. Burgess and Pande (2005), Karlan and Zinman (2010)...) support this claim. However the study of finance in low-income countries has been mostly confined to two parts: microfinance (MFI)

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and credit constraints. The first has been historically prominent, but recently rediscussed in its effectiveness (Banerjee et al, 2013). Microfinance also plays a negligible role in terms of magnitudes: even in Bangladesh, the country with the most prominent MFIs, only 3.6% of financial assets go to microfinance (IMF, 2010). Characterizing credit constraints is a more recent strand of the literature, which attracted central attention by identifying the returns to more credit in a variety of contexts (ie. del Mel, McKenzie and Woodruff (2008, 2009), Kaboski and Townsend (2011, 2012)...) and showed the high returns of expanding credit and financial development in general.

However neither of these literatures answers the key question of how to promote financial systems. In this paper we bring forward two arguments: 1) financial development is a story of banking; 2) a moderate degree of bank regulation can promote financial development by limiting banks profitability. The first claim is descriptive: banks account for over 95% of financial assets in most low-income countries. Beyond the classical deposit-lending activities, banks have a central role in financial development for at least three other reasons: 1) invest in reaching new customers, providing a public good (“the formal economy”); 2) introduce alternative payment systems, facilitating within-country trade; 3) manage liquidity risk, contributing to shape macroeconomic volatility. The second claim is the core of this work: we show that a moderate degree of financial regulation is conducive to financial development. We aim to alter substantially the “de-regulation” policy framework recommended for the banking industry in low-income countries (IMF, 2013a), which is markedly at odds with the long history of financial development and regulation in western countries before 1980s (Reihardt and Rogoff, 2009).

We think of a specific form of financial regulation, which forces banks to purchase some negative-yield government bonds in proportion to lending. By definition the policy is an additional constraint and detrimental to bank profitability, because pushes toward a privately suboptimal higher level of safety. This clearly highlights how financial regulation can be simultaneously an instrument of monetary and fiscal policy: 1) it is a macro-prudential device, because forces banks to purchase some safe assets (government bonds) for every unit of risky asset (private loan), in the spirit of Hanson, Kashyap and Stein (2011); 2) it is a special tax on banks, as it lowers the return on lending, by taxing a high-yield asset (private loan).

In our paper we model financial development as an investment choice of the bank: households (depositors) and firms (borrowers) can only be reached after an initial cost (branch-installation) as they are distributed over a certain geography (unit line). By introducing this intuition in an essential banking model (Freixas and Rochet, 1994) with classical maturity mismatch (Diamond and Dybvig, 1983), we will be able to characterize the supportive role of financial regulation on branch installation, hence deposits and loans. The mechanism in place is the following: banks face a maturity mismatch risk from the household sector, which may cause a default by withdrawing deposits before borrowers pay in. This forces the bank to hold some precautionary holdings and restrain lending, hence profits. Because the regulation forces the bank to increase its precautionary holdings, it pushes down the expected default cost. As a consequence, the bank can take on more risk and profits by opening new

1The same public ownership of banks may be considered as the extreme of financial regulation, which has been popular until 20th century in USA and until 1980s in Europe. The European Banking Industry in the 1960s and 1970s had some large public banks: Société Générale and Crédit Agricole in France were public until 1987, Banca Commerciale Italiana was also public until 1994, still today 40% of German financial assets are managed by Sparkassen or in USA the Bank of North Dakota is still state-owned.
branches. In this framework, the monopoly power of banks is simultaneously the cause of profitability and low financial development: the stronger is monopoly power, the higher is the lending-deposit rate spread (profitability), the more firms optimally choose lending over precautionary holdings, which results in a lower optimal branch numbers. Unsurprisingly monopoly power leads to lower quantities and, in this case, less financial development. Bearing this in mind, it is natural that financial regulation can promote financial development by limiting bank profitability.

Counterintuitively the overall amount of lending does not necessarily fall in presence of financial regulation, because two opposing forces are in place. On the one hand, lending declines in branches already open because the tax reduces the marginal revenue of loans (intensive margin) - old branches respond to the policy providing smaller loans. On the other hand, given branch expansion, the number of loans increases as new loans are given (extensive margin). Overall, we show there is a region of “moderate” regulation in which the extensive margin always dominates the intensive margin and leads the total loan level to increase. Naturally, if the regulation is too strong, the opposite result occurs and banks start shrinking in size.

Evidence on the negative relation between profitability and branch expansion is supported in the data, for example Figure 1 displays a negative relation between the lending-deposit in a country and the number of bank branches per 100,000 adults. Analogously a negative relation is found by comparing other measures of bank profitability (ie. returns on asset or equity...) with measures of financial development (ie. number of branches, number of accounts...). This is in line with a well-established fact that low-income countries experience low competition in the provision of banking services and this affects a variety of indicators (lending-deposit spread, roa...), as shown by Demirgüç-Kunt and Huizinga (1999), Levine (1999), Beck, Demirguc-Kunt and Maksimovic (2004) and others.

After exploring our theoretical model, we will present an empirical section where we study the causal effect of two alternative policies on bank behavior:

1. a policy change in financial regulation by the National Bank of Ethiopia (NBE) - which in April 2011 forced local private banks to purchase 0.27 Birr of a new NBE bill, with a negative yield, for every Birr of private sector lending;

2. the introduction of taxes on banks (capital or profits) by American states in the Antebellum era (1800-1861) - between 1800 and 1850 several states introduced non-simultaneously taxes on local banks.

The identification of these effects is achieved by comparing big and small banks for Ethiopia, because the theoretical model neatly describes an heterogeneous effect of the treatment; while for the USA we exploit the non-simultaneous introduction of these policies across states in different years and study the roll-over of this tax. In both cases we conclude that regulation restrains banks profits, encourages banks to be safer (hold more cash or liquid assets) and expand deposits, loans and branches.

Taxing banks, rather than financial transactions (the so-called “Tobin Tax”) may be thought as an inadequate tool, only adopted by countries with low state capacity. This is definitely not the

Beyond empirical evidence, there are at least two other theoretical reasons why we expect the banking sector not to be competitive: 1) there exists substantial barriers to entry (ie. minimum capital requirements, banking licenses or charters...); 2) the presence of lender-borrower asymmetries can lead the bank to extract all surplus from the relation.
case. In 2010, the IMF called for a global tax on banks liabilities\(^3\) and in 2011 almost all advanced economies introduced a series of levies on banks (KPMG, 2012): the United Kingdom introduced a tax of 0.1\% on banks global liabilities\(^4\), similarly 0.03\% in Germany (Bankenabgabe), 0.25\% in France (Taxe systémique sur les banques), 0.1\% in Korea (bank levy) and many more; while in the USA the “Financial Crisis Responsibility Fee” of 0.05\% on banks liabilities proposed by President Obama in 2010\(^5\) is set to become effective in the near future.

Figure 1: Profitability and Financial Development

![Graphical evidence of the inverse relation between profitability and financial development.](image)

*Note:* this figure provides a graphical evidence of the inverse relation between profitability and financial development. The panel reports a scatterplot and linear relation between the lending-deposit rate spread (y axis) and the number of branches per 100,000 adults. Each dot is a country-year observation, the correlation is negative -0.23 and statistically different from zero. The source of data is Finstat, collecting financial information for 183 countries, between 1980 and 2011.

Both the literatures on financial regulation and financial development present substantial bodies of macroeconomic and historical studies, with little attention to their respective microeconomics. In particular, insufficient evidence explores the mechanisms through which regulation propagates to the economy and the responses of the most naturally regulated actors: the banking sector. This paper contributes to the microeconomic literature on financial regulation and financial development with an essential model of banking, in presence of households, firms and the government. In particular we contribute to three established literatures. First, we join the literature on the incentive perspective of banking regulation. Besley and Ghatak (2013) argue in favor of special taxation on

\(^3\)Refer to the report by the IMF “A fair and substantial contribution by the financial sector”, June 2010, [http://www.imf.org/external/np/g20/pdf/062710b.pdf](http://www.imf.org/external/np/g20/pdf/062710b.pdf)

\(^4\)Refer to the Financial Times article “Biggest lenders seek to ease bank tax burden”, March 25, 2014, [http://www.ft.com/cms/s/0/4992bec0-b43d-11e3-bac4-00144feabdc0.html](http://www.ft.com/cms/s/0/4992bec0-b43d-11e3-bac4-00144feabdc0.html)

financial bonuses, as a counter-balancing tool to the implicit bailout policy on banks, which distorts the price of capital by encouraging excessive risk-taking and providing insufficient effort incentives. Dewatripont and Tirole (2012) analyze the incentives of bank managers and shareholders, rationalizing capital adequacy requirements as a device to achieve optimal managerial discipline and study the optimality of regulatory policies related to macroeconomic shocks. In a rich model, Fahri and Tirole (2012) relate large-scale maturity mismatch and regulator intervention, showing that optimal regulation would emerge as a liquidity requirement or a short-term debt cap. These conclusions are in line with the work of Kahsyap, Rajan, and Stein (2008), who propose the replacement of capital requirements with a mandatory holding of government bonds. On an analogous line, Calomiris and Gorton (1991), Calomiris (1999) and Calomiris and Mason (2003) encourage the establishment of incentive-compatible safety nets by governments, studying the case of bank panics in pre-1929 American banking, the trade-off between the high-public cost but elimination of panic with federal deposit insurance and the no-public cost but positive probability of panic when bank coalitions are in place. Secondly, we participate to the debate on the tools for public debt reduction and promote a moderate degree of financial regulation as a viable solution. A body of recent studies, Aizenman and Marion (2011), Davig, Leeper and Walker (2011) and Cochrane (2011), supports the view that inflation will emerge as a consequence of fiscal imbalances and be the long-term solution to lowering public debt. On the other hand, Hilscher, Raviv and Reis (2014) conclude that financial regulation/repression coupled with inflation can be more effective to lower the real value of public debt. They find that forcing banks to hold a special lower-yielding bond may be a solution, which is analogous to the policy under study in this paper. Thirdly, we offer an argument to reconcile the radically partitioned literature on the relation between financial regulation and the macroeconomy. Roubini and Sala-i-Martin (1992, 1995), Pagano (1993), King and Levine (1993) support a limited regulation of financial intermediation, because this would lower equilibrium growth through a lower saving rate, less resources for investment, less risk diversification and entrepreneurs screening. On a critical stance, after a cross-country empirical assessment, Dornbusch and Reynoso (1989) argue that “the beneficial effects of removing financial repression remains open to challenge”. While on the entire opposite side of the spectrum, Stiglitz (1993) defends financial regulation as a growth-enhancing force, because by artificially lowering interest rates, it improves borrowers’ incentives, reinforces firms equities and creates capital scarcity. In our work, we find that both views can be right and indeed financial regulation can be either welfare-enhancing or detrimental depending on the magnitude through which it is implemented.

In section 1 we present the essential theoretical framework, describing first the economic environment and then investigating the bank decision problem; section 2 discusses empirical evidence from the policy change in Ethiopia and state-level bank-tax rollover in Antebellum USA; in section 3, an inquiry in the optimal financial regulation is developed and discussed; section 4 offers a calculation of the government revenue gains from this policy and section 5 presents some concluding remarks.
1 Theory

In our model, the bank faces a two period problem: in the first, it considers both a liquidity risk decision, how many precautionary holdings to keep against bank-running depositors, and a financial development decision, how many branches to open; in the second, given these aggregates, it maximizes profits by collecting deposits and allocating its assets between private sector loans, government bonds and interbank exchanges. In presence of a first period decision on both precautionary holdings and financial development, there exists a region in which the regulation parameter $\tau$ affects positively lending, deposits and number of branches, while diminishing profits and the probability of default. However if only one of these margins is constrained, hence the bank decides either on financial development or precautionary holdings, then the policy produces the opposite results and decreases not only profits, but also loans, deposits and branches.

1.1 Economic Environment

This economy is constituted by a continuum of locations on the unit line, where each location is populated by a household and a firm, engaged respectively in a saving and investment problem. A risk-neutral monopolistic bank connects households and firms by demanding deposits and supplying loans, as well as other assets. There is no government in this problem, except an automatic rule which forces the bank to buy $\tau$ government bonds remunerated at an exogenous rate $R_G$ for every unit of private lending.

This economy presents the following periods:
1. the bank invests in financial development deciding on the number of branches, $\beta$, and chooses the level of precautionary holdings, $\Psi$;
2. households and firms reached by a branch interact with the bank, which is engaged in deposit collection and asset allocation;
3. there is a morning and a night - in the morning a proportion $\rho$ of “bank-running” depositors withdraw their funds; in the night all assets pay back and the bank reimburses the remaining $1 - \rho$ depositors.

Investing in branches, $\beta \in [0, 1]$, can be thought as the cost of branch-opening and allows the bank to reach a new locus and interact with both households, who can supply deposits as savings, and firms, who can demand loans for investment. If $\beta = 1$ all locations (hence households and firms) are reached, while with zero no branches are opened. Precautionary holdings, $\Psi$, are needed because of the timing: $\rho$ bank-running households withdraw their funds before assets pay in, hence the bank needs liquidity to avoid default, which comes at a cost $C$.

To clarify the intuition of this model I focus on the problem of the bank. In the following paragraphs, I introduce the aggregate formal deposit supply from households as be inelastic to the deposit rate and the loan demand from firms to be downward sloping in the lending rate. In Appendix 1 I present the microfoundation behind these two results. Specifically the aggregate household formal saving function, $S = \beta(1 - \gamma)y$, is a function of: $\beta$ the number of households reached by a branch; $1 - \gamma$ an intertemporal preference parameter and $y$ an exogenous income term; the aggregate firm formal investment function, $I = \left( \frac{\alpha A}{R_L} \right)^{1-\alpha} \beta$, is a function of: $\beta$ the number of firms reached by a
branch; $R_L$ the lending rate; $\alpha$ and $A$ are two parameters from a classical Cobb-Douglas technology where $q = AI^\alpha$.

While the second result is uncontroversial under a variety of standard settings, the first is consistent with a long macroeconomic literature, reviewed by Balassa (1990), that does not find robust evidence on the correlation between real interest rate and savings. Furthermore, recent microeconomic research by Karlan and Zinman (2014) points to an analogous result. They exploit the randomization of deposit rates by a Filipino bank and show that the price elasticity of saving is not statistically different from zero. This is also in line with some of the results reported Dupas et al (2012), Dupas and Robinson (2013) and Prina (2013).

1.2 Bank

In this section I present the two period problem of a monopolistic bank: in the first it decides on liquidity risk, choosing the optimal amount of precautionary holdings $\Psi$, and on financial development, choosing number of branches $\beta$; in the second, given $\Psi$ and $\beta$, it collects deposits and allocates assets.

The crucial intuition of the theoretical model is given by the fact that banks can simultaneously adjust their $\Psi$ and $\beta$, if precautionary holdings were not a choice variable, then financial regulation causes banks to shrink. In these sections I show the general case, where both $\Psi$ and $\beta$ are choice variables. In Appendix 2, I show that in the extreme case of a bank holding a fixed proportion of assets in precautionary holdings (ie. a percentage rule), then financial regulation leads to a smaller equilibrium size.

Second Period

The bank maximizes profits by choosing quantities of assets and liabilities. On the asset side, the bank offers loans $L$ at rate $R_L$, buys government bonds $G$ remunerated $R_G$ and deposits funds in foreign banks or in the central bank $M$ earning $R_M$; deposits $D$ are the only liability and remunerated at rate $R_D$. In equilibrium a no-arbitrage condition guarantees that $R_M = R_D$. In this economy, there is financial repression and the government fixes its bond rate to be lower than deposits, $R_D > R_G$.

The bank solves the following problem

$$\max_{L,G,M,D} \pi = R_L L + R_G G + R_M M - R_D D$$

s.t. $D = L + M + G$

$\Psi = M + G$

$G \geq \tau L$

$L, G, M, D \geq 0$

three constraints are placed on the bank: a balance-sheet constraint, which binds and forces the bank to fund its assets through deposit collection; a precautionary holding constraint, which imposes the level but not the composition of precautionary holdings and a financial regulation constraint, which forces the bank to purchase $\tau > 0$ government bonds for each unit of loan given to the private sector, $G \geq \tau L$. The bank is a monopolist and, therefore, considers the demand for lending of the firms, $I$,
and the supply of deposits from households, $S$,
\[ S = \beta(1 - \gamma)y \quad \text{and} \quad I = \left(\frac{\alpha A}{R_L}\right)^{\frac{1}{1-\alpha}} \beta \]
assuming that households have a storing technology through which they can transmit value inter-temporally without any interest rate, then the bank needs only to satisfy their participation constraint and can offer a fixed $R_D \geq 1$ to have access to all available savings. Therefore setting $R_D$ to 1 is optimal and makes this the numeraire of this economy. While regarding the lending rate, this is pinned down by considering the usual inverse demand $R_L = \frac{\alpha A}{1 - \beta^1 - \alpha}$. Recalling that $R_M = R_D = 1$ and that because of financial repression, $R_G < 1$, a bank would never buy more than the minimum required quantity of bonds, therefore also the financial regulation constraint is binding.

Therefore the problem simplifies to
\[
\max_L [(R_L - 1) - (1 - R_G)\tau] L
\]
where this expression gives a vivid account of the problem faced by the bank: for every unit of lending it earns a positive spread between the lending and deposit rate, $R_L - 1$; however because of the policy every unit of lending pays a negative spread between the deposit and government bond rate, $1 - R_G$, to the extent in which the policy binds, $\tau$. Therefore the “tax” component of this policy can be described by $(1 - R_G)\tau$.

The equilibrium lending is
\[ L = \left(\frac{\alpha^2 A}{1 + \tau(1 - R_G)}\right)^{\frac{1}{1-\alpha}} \beta \]
which determines the amount of purchased government bonds, through the financial regulation constraint; the quantity of interbank holdings, through the precautionary holdings constraint, and deposits, through the balance sheet constrain
\[ G = \tau \left(\frac{\alpha^2 A}{1 + \tau(1 - R_G)}\right)^{\frac{1}{1-\alpha}} \beta \]
\[ M = \Psi - \tau \left(\frac{\alpha^2 A}{1 + \tau(1 - R_G)}\right)^{\frac{1}{1-\alpha}} \beta \]
\[ D = \Psi + \left(\frac{\alpha^2 A}{1 + \tau(1 - R_G)}\right)^{\frac{1}{1-\alpha}} \beta . \]

The equilibrium lending by the monopolist generates an equilibrium lending rate
\[ R_L = \frac{\alpha A}{L^1 - \alpha \beta^1 - \alpha} = \frac{1 + \tau(1 - R_G)}{\alpha} \]
while the equilibrium deposit and interbank are set by the participation constraint $R_M = R_D = 1$. Combining all of these expressions, it is possible to calculate the equilibrium profit level
\[ \pi = \frac{1 - \alpha}{\alpha} \left(\frac{\alpha^2 A}{[1 + \tau(1 - R_G)]^\alpha}\right)^{\frac{1}{1-\alpha}} \beta . \]
Lemma 1: financial regulation is a tax on banks’ profits.

By writing the profit function of a bank faced with a proportional profit tax, or analogously to a lending tax, $\tilde{\tau}$. We can observe that there is a non-linear relation between the tax $\tilde{\tau}$ and the regulation parameter $\tau$, leading to

$$\tilde{\tau} = \frac{(1 - R_G)}{(R_L - 1)} \tau$$

the proof can be found in Appendix 3.

First Period

In the first period the bank decides over precautionary holdings, $\Psi$, and branches, $\beta$, by maximizing expected profits, $E(\pi)$

$$\max_{\Psi, \beta \geq 0} E(\pi) = \pi(\beta) - (1 - \sigma(\Psi, \beta))C - c(\beta) - g(\Psi)$$

where the first term is the level of profits, defined in the previous section, the second term groups the cost of default $C$ times its probability, $c(\beta)$ embodies the costs of installing branches, while $g(\Psi)$ is the banking technology. This is analogous to Freixas and Rochet (1997) and embodies a measure of efficiency in the particular bank: it could indifferently be a function of assets, lending or deposits, however a specification based on precautionary holdings is computationally convenient. The intuition behind this is the following: if a bank is very efficient in the management of its resources, it will keep these costs low and this boosts its expected profits - specifically to precautionary holdings, we may think of this as moving liquid assets to the safest and most remunerative source in every moment.

The probability of bank default is $1 - \sigma(\Psi, \beta)$ and is defined as one minus the ratio between the level of precautionary holdings, $\Psi$, and the proportion of defaulting deposits, $\rho_D$

$$1 - \sigma(\Psi, \beta) = 1 - \frac{\Psi}{\rho D} = 1 - \frac{\Psi}{\rho \left(\Psi + \left(\frac{\alpha^2 A}{1+\tau(1-R_G)}\right)^{\frac{1}{1-\alpha}} \beta\right)}$$

this probability is bounded between zero and one: the bank would never hold more precautionary holdings than bank-running depositors, hence

$$\Psi = \min \left\{ \rho D, \max_{\Psi, \beta} \pi(\beta) - (1 - \sigma(\Psi, \beta))C - c(\beta) - g(\Psi) \right\}. $$

It is important to provide an upper bound on the proportion of bank-running depositors, $\rho < \rho$, with $\rho = \frac{1-\alpha}{\alpha \mu}$, because this guarantees that the bank finds profitable to engage in operations. Its violation implies that there exists too many bank-running depositors, which make the bank disengage from operations, as the equilibrium number of branches in absence of the policy would be zero.

Clearly there emerges a natural trade-off between the amount of precautionary holdings kept and the profit level: increasing $\Psi$ enhances the probability of survival but lowers profits because bonds and interbank lending generate less revenue than loans. Assuming that in the event of a default the
bank makes no profits, \( C = \pi(\beta) \), then the problem simplifies to 
\[
\max_{\Psi, \beta} E(\pi) = \sigma(\Psi, \beta)\pi(\beta) - c(\beta) - g(\Psi)
\]

note that now the expected profit function is supermodular in branches \( \beta \) and precautionary holdings \( \Psi \). By modeling linearly the cost of precautionary holdings, \( \mu \in [0, 1] \), and convexly the cost of branch-opening, \( \eta > 0 \), then this rewrites as
\[
\max_{\Psi, \beta} E(\pi) = \frac{\Psi}{\rho \left( \Psi + \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{\frac{1}{1 - \alpha}} \beta \right)^{\frac{1}{1 - \alpha}}} \frac{1 - \alpha}{\alpha} \left( \frac{\alpha^2 A}{[1 + \tau(1 - R_G)]^{\alpha}} \right)^{\frac{1}{1 - \alpha}} \beta - \eta \frac{\beta^2}{2} - \mu \Psi
\]

taking the first order conditions with respect to \( \Psi \) and \( \beta \), the equilibrium branch-opening and precautionary holding levels are obtained
\[
\beta = \left( \frac{\mu}{\eta} \right) \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{\frac{1}{1 - \alpha}} \left\{ \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{\frac{1}{2}} [1 + \tau(1 - R_G)]^{\frac{1}{2}} - 1 \right\}^2
\]
\[
\Psi = \left( \frac{\mu}{\eta} \right) \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{\frac{2}{2 - \alpha}} \left\{ \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{\frac{1}{2}} [1 + \tau(1 - R_G)]^{\frac{1}{2}} - 1 \right\}^3
\]

which imply the following equilibrium profit expression
\[
E(\pi) = 2 \left( \frac{\mu^2}{\eta} \right) \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{\frac{2}{2 - \alpha}} \left\{ \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{\frac{1}{2}} [1 + \tau(1 - R_G)]^{\frac{1}{2}} - 1 \right\}^4
\]

The previous results rely on the assumption that there proportion of bank-running depositors does not exceed a threshold on \( \rho \leq \bar{\rho} \), which secures a non-negative level of profits and all other aggregates. If such threshold is passed, the bank in equilibrium decides optimally not to operate, because the expected default cost is too high.

**Proposition 1**

The regulatory parameter \( \tau \) affects bank operations through two channels: a profit-decreasing channel, which pushes down the level of profits as regulation creates a negative funding shock; a safety-enhancing channel, which pushes up bank safe asset choice as the risky asset, \( L \), is taxed. There exists a region, \( \tau < \bar{\tau} \), where a higher \( \tau \) makes the bank less profitable but safer and because of this additional safety cushion caused by the policy, the bank can take on more default risk by expanding.

In the region where \( \tau < \bar{\tau} \), the mechanisms embedded in the previous description can be summarized through these two sets of predictions:

**a)** Balance Sheet Predictions, an increase in \( \tau \) leads to

1 - an absolute increase in deposits;
2 - an absolute increase in lending, lower than deposits;
3 - an increase in precautionary holdings ($\Psi = G + M$) as a proportion of assets;
4 - a decrease in lending as a proportion of assets.

b) Annual Report Predictions, an increase in $\tau$ leads to

1 - a decrease in profits and in default probability;
2 - an increase in the number of branches;
3 - an increase in the lending rate.

This proof can be found in Appendix 4, containing also a paragraph on the mechanics of the policy change. A graphical intuition is given by Figure 2: the upper panel shows through a dashed line termed 1 the expected profit function of the bank before the policy, with the number of branches chosen by maximizing this function $\beta_1$; the upper panel also reports that after the policy change the “regulation tax” is introduced, which shifts down the function from 1 to 2, leading to less branches $\beta_2$. However, as the lower panel clarifies, the additional cushion of safety given by the new precautionary holdings, lets the profit function “spread out” from 2 to 3 and the bank chooses in equilibrium $\beta_3$ as the number of branches. From the expected profit function in period 1 it is clear that there is supermodularity between the number of branches, $\beta$, and the level of precautionary holdings, $\Psi$. 
Figure 2: Mechanics of a Policy Change

Note: this figure explains how precautionary holdings and bank branches interact in causing branches to expand in response to financial regulation. In the upper panel, the x-axis reports number of branches $\beta$ and y-axis the level of expected profit $E(\pi)$: the dashed green represents $E(\pi)$ as a function of $\beta$ before the policy, because of concavity the monopolist chooses an optimal quantity $\beta_1$ of branches which maximize profits. The policy $\tau$ produces a shift of the curve from 1 to 2 and consequently of the optimal branch number, from $\beta_1$ to $\beta_2$. In the lower panel however, we can see that as the bank re-optimizes the quantity of precautionary holdings $\Psi$, accounting for the effect of $\tau$, then the function changes shape and shifts from 2 to 3, leading to a growth in branch numbers from $\beta_2$ to $\beta_3$. The shape of the function changes because after the policy, the bank holds more precautionary holdings: this lowers profits in the most remunerative areas and increases it in the less lucrative ones, creating positive profits in regions previously untouched (because the default cost would make them deliver a negative profits). A mathematical counterpart of this picture can be found in the definition of $E(\pi)$ which is supermodular in $\Psi$ and $\beta$. 

$E(\pi)$

$E(\pi_1)$

$E(\pi_2)$

$\tau$

$\beta_1$

$\beta_2$

$E(\pi)$

$E(\pi_2)$

$E(\pi_3)$

$\Psi$

$\beta_2$

$\beta_3$
2 Empirics

In this section we present empirical evidence on regulatory episodes analogous to the ones highlighted in the model section. Mapping theory into empirics, we are looking for shocks to the financial regulation parameter $\tau$. As stated at the beginning of this work financial regulation can be interchangeably interpreted as a macro-prudential device or a special tax on banks.

Our empirical evidence exploits this by using results on two very different contexts:

- **Ethiopia (2010-2013):** in April 2011 the National Bank of Ethiopia (NBE) announced the establishment of a new bond market (NBE Bill), forcing banks to purchase 0.27 Birr of this bond for every Birr of private lending - $\tau$ goes from zero to 0.27, this is closer to the macro-prudential interpretation;

- **Antebellum USA (1800-1861):** following the establishment of the federal government, American states lost significant revenue from seigniorage and counterbalanced this by imposing significant taxes on banks’ capital or profits (Sylla, Legler, and Wallis, 1987). This is a clear taxation intervention, where $\tau$ jumps from zero to a positive quantity (depending on state level criteria).

These two sources of variation in $\tau$ will be very useful in identifying the effect of financial regulation on bank behavior and validate the results of proposition 1. The identification of the effect of shocks to $\tau$ on the main banking variables comes from

- **Heterogeneity across banks in Ethiopia:** the model, as shown below, predicts that more efficient banks are larger in size (level effect) and respond more to the policy (differential effect). Because the Ethiopian private banking sector seems to be traditionally divided between 6 very large banks and 8 small banks, this cross-sectional heterogeneity combined with the time-series treatment permits to identify causally the effect of $\tau$;

- **Heterogeneity in bank tax adoption across US states:** this policy is not simultaneously adopted by all states, the early movers are Massachusetts and Maine in 1812, while others adopt it later like Pennsylvania in 1817, Rhode Island and New Hampshire in 1822, Georgia in 1834, New York in 1839 or Connecticut in 1850.

In both cases we will exploit time-series variation, exploiting within-year monthly data and, for the case of Ethiopia, combine this with the use of a difference-in-difference analysis and the results seems to support the mechanism we proposed in the previous section.

2.1 Evidence from Ethiopia

Ethiopia is the second-most populous country in Sub-Saharan Africa with a population exceeding 90 million and also among the world’s poorest: per capita income lies at $500 (WDI, 2013), substantially lower than the regional average, yet growing steadily at more than 10% per year in the last decade. The Government role in the economy is very active and the financial sector is not an exception. The Ethiopian banking system presents a large public bank, the Commercial Bank of Ethiopia (CBE), accounting for 50% of the market and 13 private commercial banks accounting for the remaining part. This contrasts the trend observed in Sub-Saharan Africa and across the developing world,
where banking systems have much higher shares of private and foreign participation. Despite a relatively low level of financial development, the Ethiopian financial sector is stable and presents a well capitalized banking sector, registering profitability levels well above the regional average (IMF, 2013b).

In this section, we present some empirical evidence on Ethiopian banks’ behavior, exploiting the introduction of a new financial regulation measure introduced in April 2011. In this date, the National Bank of Ethiopia (NBE) issued a directive requiring all commercial banks to hold 27 percent of new loan disbursements in NBE bills. This policy classifies as a case of financial repression: it creates a captive audience, by forcing banks to hold bonds, and postulates a lower-than market price of this bond. In fact the NBE bill pays a fixed 3% per year, well lower than the average deposit rate, 5.4%, or the average lending interest, 12% (NBE, 2012). Differently from many western economies, who used analogous measures to slash public debt, Ethiopia launched this regulation for an expansionary fiscal policy objective: the financing of several long term infrastructure projects and especially the Grand Ethiopian Renaissance Dam on the Nile (IMF, 2013). As reported in the introduction this is analogous to what American states did in 1830s-1840s in financing several local infrastructure or educational projects.

The relevant aspect of studying the so-called “27% rule” is given by the unique nature of this shock:

1. it is unexpected and announced less than a month before implementation;
2. it is large causes an average mobilization of 10% of banks’ assets.

From the lenses of theory, this policy can be mapped as a shock to the \( \tau \) parameter, which jumps from zero to 0.27 and conditions 1. and 2. make this shock ideal for our analysis. Figure 3 shows graphically the effect of this policy on the relative composition of assets, by picturing the average balance sheet composition of a bank before and after the policy change. In the top panel, we show that there is compliance as banks start purchasing this new bill after the introduction of the norm. At the same time, it is evident that private sector loans do not decline as a consequence of the policy: they lie at a stable 40% of assets, exhibiting a mild cyclical decrease. The main change in asset composition is given by the replacement between interbank holdings and NBE bills. This pictures is useful to clarify another relation between our model and the empirical analysis: Ethiopian banks hold a substantial amount of precautionary holdings (in red in Figure 1), which are kept in cash, government bonds and bank-to-bank deposits. This is given by the fact that deposit volatility is very high in this country: the standard deviation of deposits is 918.7, while that of loans only 638.5. During our interviews with local bank executives, we find that this is a core problem of local banks and, indeed, supporting evidence toward our “maturity mismatch” risk assumption going through the theoretical model.

Proposition 1 provides two set of predictions for the effect of \( \tau \), Balance Sheet and Annual Report Predictions. In order to test these, we collect confidential data on the monthly balance sheet of all Ethiopian private banks between 2010 and 2013 and we rely on publicly-available Annual Reports data on profits, number of branches and lending rate from 2008 to 2013.
In section 3.1, we present a variety of tests of balance sheet predictions, as reported in a), and in 3.2 we explore annual reports results, as in b). We are able to show that indeed there is empirical support for our analysis and that the detrimental implications of an increase in \( \tau \) on deposits or lending are not supported by the data.

### Figure 3: Asset Composition and Policy Change

Note: this figure reports the average balance sheet composition on the asset and liability side of an Ethiopian bank for the period between January 2010 (Time 1) and April 2012 (Time 28). The policy change occurs at Time 16. On the asset side it is clear that the introduction of the treatment caused a substantial change in the asset composition of banks, leading on average to a 10% asset re-allocation within 1 month. Interbank holdings were liquidated to purchase NBE bills and loans mildly decreased. On the liabilities side the most important fact to notice is that Ethiopian banks are mostly funded through deposits, roughly 65%, for brevity this is not reported.

#### 2.1.1 Heterogeneity and Identification

The effects described in Proposition 1 have an important dimension of heterogeneity, which permits to identify our effects and will be central in the empirical analysis. As noted in section 1.3 the parameter \( \mu \) embeds the efficiency of the bank in liquidity management and this is central because this affects: the equilibrium size of the bank and the effect of the policy shock.

The first effect is straightforward to observe by recalling the functional form for the number of branches installed by a bank:

\[
\beta = \left( \frac{\mu}{\eta} \right) \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{1-\alpha} \left\{ \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{3/2} - 1 \right\}^2
\]

the less technologically efficient a bank is, the higher is the cost parameter \( \mu \) and the lower number of branches it installs. At the same time the effect of the policy on branch expansion is decreasing in this parameter

\[
\frac{\partial \beta}{\partial \tau} = 2 - \alpha \left[ \frac{1 - \alpha}{\alpha \rho \mu} \right]^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{3/2}
\]
hence the less technologically efficient a bank is, the higher is $\mu$ and the less it responds to the policy by opening up new branches. Therefore we can sum up a testable implication of our model as follows.

**Proposition 2**

Assuming that all banks are monopolist, either geographical or behave such as monopolist through a cartel, and that they are exogenously endowed with two levels of technologies: $\mu_H$ and $\mu_L$, with $\mu_H > \mu_L$, then: banks with a less efficient banking technology, $\mu_H$, are smaller in size (level effect) and respond less to the policy compared to more efficient banks, $\mu_L$ (impact effect):

$$\beta|_{\mu_H} < \beta|_{\mu_L} \text{ and } \frac{\partial \beta}{\partial \tau}|_{\mu_H} < \frac{\partial \beta}{\partial \tau}|_{\mu_L}$$

therefore an increase in $\tau$ creates an heterogeneous effect on banks depending on their efficiency as expressed by the parameter $\mu$. Hence all the predictions of Proposition 1 are differentially stronger for more efficient banks, therefore we can update it as follows:

a) **Balance Sheet Predictions**, an increase in $\tau$ leads to

1 - an absolute increase in deposits, $\frac{\partial D}{\partial \tau}|_{\mu_H} < \frac{\partial D}{\partial \tau}|_{\mu_L}$;
2 - an absolute increase in lending, lower than deposits $\frac{\partial L}{\partial \tau}|_{\mu_H} < \frac{\partial L}{\partial \tau}|_{\mu_L}$;
3 - an increase in precautionary holdings over assets $\frac{\partial \Psi}{\partial \tau}|_{\mu_H} < \frac{\partial \Psi}{\partial \tau}|_{\mu_L}$;
4 - a decrease in lending as a proportion of assets $\frac{\partial L}{\partial D}|_{\mu_H} > \frac{\partial L}{\partial D}|_{\mu_L}$.

b) **Annual Report Predictions**, an increase in $\tau$ leads to

1 - a decrease in profits and in default probability, $\frac{\partial E(\pi)}{\partial \tau}|_{\mu_H} > \frac{\partial E(\pi)}{\partial \tau}|_{\mu_L}$ and $\frac{\partial (1-\sigma)}{\partial \tau}|_{\mu_H} > \frac{\partial (1-\sigma)}{\partial \tau}|_{\mu_L}$;
2 - an increase in the number of branches $\frac{\partial \beta}{\partial \tau}|_{\mu_H} < \frac{\partial \beta}{\partial \tau}|_{\mu_L}$;
3 - an increase in the lending rate, this is unaffected by $\mu$.

These predictions are central in bringing the model to the data because now despite the policy hitting all banks simultaneously, the heterogeneity led by efficiency characterizes also an heterogeneous response by banks. For this reason, by comparing the effect of big versus small banks I can test for the causal effect of the policy on bank behavior. Figure 4 presents the total assets of the 14 Ethiopian banks on March 2011, before the policy implementation, and a natural distinction between big and small banks emerge, as there occurs a pretty large discontinuity between Bank of Abyssinia (BOA), with assets close to 8 billion Birr and Construction and Business Bank of Ethiopia (CBB) with assets below 4 billion. For this reason given that the largest six banks are more than twice as large as the remaining eight, I classify these banks as “more efficient” (hence presenting a lower liquidity cost, $\mu_L$) and define a dummy variable “Big Bank” taking unit value for all of these; while the remaining which are categorized as less efficient (embedding the parameter $\mu_H$).

Figure 1 clearly explains our identification, which emerges by the differential effect of the policy change - shock to $\tau$ - across big and small banks. To keep logical consistency between the theory and empirical model, we are assuming the existence of two monopolists which lie on separate unit
lines. This might seem oversimplifying, however Ethiopia presents the ideal setting for this because of its extremely low level of financial development and large barriers to entry. From official reports we observe that there is only 1 branch for 62,000 people (NBE, 2011) and just 8% population has bank account (IMF, 2013); also monopoly power seems to be substantial: the average bank ROE lies at 55% (other Avg. Africa 30%) and capital requirements to set up a bank are substantial (75 million Birr).

Figure 4: Big and Small Banks in Ethiopia

Note: this histogram reports the total assets of all Ethiopian private banks in March 2011, one month before the introduction of the policy. It is evident the existence of a substantial discontinuity between the 6th largest Ethiopian bank, Bank of Abyssinia BOA, and the 7th, CBB, Construction and Business Bank of Ethiopia. The six largest banks are colored in red and are those which we classify as big banks.
2.1.2 Balance Sheet Evidence

The policy change creates a large exogenous variation in the parameter $\tau$, which jumps from 0 to 0.27 and through the lenses of the theoretical model this leads to more deposits, more lending (but less than deposits), more precautionary holdings as a proportion of assets and less lending relative to assets. Because private banks are equally affected by the policy, but respond differentially based on their parameter $\mu$, we can produce a variety of tests to empirically study Propositions 1 and 2. In the next two subsections the following two tests on the effects of this policy are presented:
1. Within-Year Compliance: we verify that indeed NBE bills were purchased as the policy prescribes and that the policy was not applied differently between big and small banks. This can be found in Appendix 5;

2. Bi-Monthly Variation: we report the bi-monthly evolution of the main aggregates, removing bank-specific effects and quarterly fluctuations, showing the presence of a discontinuity at the policy change introduction, differentially stronger for larger banks.

All of these tests provide empirical support of the balance sheet predictions and offer quantitative evidence in favor of our model.

**Bi-Monthly Variation**

In developing Table 1 we could have also provided a within-year estimation for the other variables of our model (deposits, loans, interbank) and verified whether they supported propositions 1 and 2. However, because this simple difference-in-difference analysis can be misleading (Bertrand et al, 2004), we preferred to provide a stronger test of our theory and explore all available time-series information. For this reason, we verify how the average deposits, lending, NBE bills and interbank move during all the available months and whether a differential trend is registered for big banks. 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 present the following estimation strategy

\[
v_{itpy} = a + \sum_{py=1}^{14} b_{py} \cdot d_{py} + \sum_{py=1}^{14} c_{py} \cdot d_{py} \cdot \text{Big Bank}_i + \tau_i + \tau_{iq} + \epsilon_{itqy} \quad (1)
\]

where the variable \(v_{itpy}\) is regressed over a dummy variable \(d_{py}\) which takes unit value for each two-month period \(py\) of the 18 available, an interaction of this dummy with the Big Bank dummy variable, a bank fixed effect \(\tau_i\) and a bank-quarter fixed effect \(\tau_{iq}\) to account for seasonality. The coefficients \(c_{py}\) are the core of this estimation and report the average differential evolution of the variable \(v_{itpy}\) for big banks.

In Table 2 we present the coefficients \(c_{py}\) across the 18 available periods: it is clear to observe that until the introduction of the policy change, in Period 6, the coefficients on deposits, loans, NBE bills and are not statistically different from zero, indicating a respect of the parallel trend hypothesis. However in period 6 deposits and NBE Bills shoot up, followed by a decrease in interbank holdings in the next quarter and an increase in loans after 2 quarters.

A quick grasp of the intuition of this model is offered by Figure 5: big banks are hit hard by the shock and in quarter six buy substantial NBE bills, the black line, which shots on spot from zero to 700 million Birr. In response to this, deposits are mobilized by the bank, slow initially and then in a measure stronger than the shock - by observing the blue line, it is clear that deposit accumulation discontinuously jumps in quarter 6 and deposits double comparing before (periods 2-5) and after the policy (periods 7-10). Analogously, loans see a discontinuity, yet only observed after 2 periods (4 months). Hence, as evident from Figure 5, all variables co-move as our model predicts: deposits grow, loans grow but less than deposits and NBE Bills purchase increases.
Table 1: Regulation and Banks - Million Birr

<table>
<thead>
<tr>
<th>Period 2 × Big B.</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deposits</td>
<td>Lending</td>
<td>NBE Bills</td>
<td>Interb. Hold.</td>
</tr>
<tr>
<td></td>
<td>44.03</td>
<td>-24.97</td>
<td>-63.05</td>
<td>284.4</td>
</tr>
<tr>
<td></td>
<td>(373.9)</td>
<td>(185.3)</td>
<td>(167.2)</td>
<td>(305.2)</td>
</tr>
<tr>
<td>Period 3 × Big B.</td>
<td>198.9</td>
<td>336.8</td>
<td>-5.568</td>
<td>549.0</td>
</tr>
<tr>
<td></td>
<td>(441.0)</td>
<td>(314.6)</td>
<td>(219.0)</td>
<td>(604.6)</td>
</tr>
<tr>
<td>Period 4 × Big B.</td>
<td>20.43</td>
<td>336.3</td>
<td>-42.81</td>
<td>512.4</td>
</tr>
<tr>
<td></td>
<td>(412.5)</td>
<td>(305.0)</td>
<td>(196.5)</td>
<td>(512.7)</td>
</tr>
<tr>
<td>Period 5 × Big B.</td>
<td>174.3</td>
<td>241.6</td>
<td>-63.72</td>
<td>660.4</td>
</tr>
<tr>
<td></td>
<td>(461.0)</td>
<td>(288.2)</td>
<td>(215.3)</td>
<td>(522.2)</td>
</tr>
</tbody>
</table>

Post-Policy

| Period 6 × Big B. | 812.8*** | 264.7 | 710.5*** | 292.7 |
|                   | (269.5) | (205.2) | (124.9) | (196.8) |
| Period 7 × Big B. | 974.2*** | 391.9** | 791.6*** | 560.8*** |
|                   | (269.9) | (172.9) | (123.3) | (198.1) |
| Period 8 × Big B. | 1,068*** | 583.7*** | 880.0*** | 430.0 |
|                   | (296.4) | (197.5) | (127.3) | (283.1) |
| Period 9 × Big B. | 1,049** | 1,122*** | 1,082*** | -59.82 |
|                   | (418.3) | (324.8) | (196.9) | (557.3) |
| Period 10 × Big B. | 973.2*** | 1,326*** | 1,183*** | -355.2 |
|                   | (419.8) | (274.7) | (199.1) | (517.6) |
| Period 11 × Big B. | 982.7** | 1,325*** | 1,251*** | -338.1 |
|                   | (406.8) | (227.1) | (203.1) | (507.2) |
| Period 12 × Big B. | 1,350*** | 1,230*** | 1,328*** | -571.0*** |
|                   | (267.9) | (195.8) | (122.2) | (176.8) |
| Period 13 × Big B. | 1,407*** | 1,147*** | 1,355*** | -646.5*** |
|                   | (285.2) | (180.2) | (129.8) | (203.8) |
| Period 14 × Big B. | 1,502*** | 1,226*** | 1,407*** | -723.3** |
|                   | (328.4) | (223.5) | (130.1) | (289.9) |
| Period 15 × Big B. | 1,392*** | 1,554*** | 1,580*** | -740.7 |
|                   | (424.1) | (303.0) | (198.2) | (520.1) |
| Period 16 × Big B. | 1,583*** | 1,771*** | 1,656*** | -849.2* |
|                   | (394.2) | (255.3) | (190.4) | (493.4) |
| Period 17 × Big B. | 1,736*** | 1,752*** | 1,732*** | -773.1 |
|                   | (444.0) | (255.4) | (190.7) | (489.3) |
| Period 18 × Big B. | 2,210*** | 1,719*** | 1,854*** | -1,256*** |
|                   | (265.0) | (209.9) | (127.6) | (194.1) |

Bank FE Yes Yes Yes Yes
Bank × Yes Yes Yes Yes
Quarter FE

Obs. 512 512 512 512
Mean Dep. Var. 4,176 2,413 6,57.1 1,924
S.D. Dep. Var. 3,610 2,080 781.8 1,580

Notes: This table reports OLS estimates, the unit of observation is bank level and bank and bank × quarter fixed effects are included. Standard errors are bootstrapped at bank-level cluster. Total deposits is a variable aggregating demand, saving and time deposits at bank level, is continuous and measured in million Birr. Private lending embodies lending to the private sector (no public sector, regions, cooperatives...) at bank level, is continuous and measured in million Birr. NBE Bills is the amount of bills issued by the National Bank of Ethiopia at bank level, is continuous and measured in million Birr. Interbank holdings is the amount of liquid assets held by banks in cash, bank-to-bank deposits and reserves at the NBE, is continuous and measured in million Birr. The means and standard deviations of these
variables are reported in the row “Mean Dep. Var.” and “S.D. Dep. Var.”. All of these variables are regressed over 18 two-month period dummy variables which span all the months in our data. The policy change occurs in Period 6. These regressions measure the bi-monthly evolution, and an interaction of these dummies with the big bank dummy, to verify whether bigger banks are differentially affected more by the policy, as Proposition 2 states. The reported coefficients are only for the interaction between the big bank dummy and the period dummy: it is possible to notice that before the policy change, the null hypothesis of parallel trends cannot be rejected, while it is rejected afterward. Figures 5 and 6 report also the coefficients for small banks. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

Figure 5: Big Banks and Policy Change

Note: this figure graphs the coefficients of the differential trend between big and small banks reported in Table 2, for all periods, for NBE bills (black), Deposits (blue) and Loans (red). The policy is announced in March 2011, vertical full red line, and implemented in April 2011, vertical dashed line. As evident there occurs an important discontinuity around the policy introduction, quarter 6, 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 spot and from period 8 onward also in private lending. As evident from Table 2, the pre-policy trends are not statistically different from zero, while post-policy all of them are. Appendix 6 reports the same picture with 95% confidence intervals.
Figure 6: Bank Aggregates and Policy Change

Note: this figure graphs the coefficients of the overall trend exhibited by small and larger banks for deposits and loans (upper panel) and NBE bills and interbank market (lower panel) for all periods, Deposits are reported in blue, Loans in red, NBE bills in black and interbank holdings in green. The policy is announced in March 2011, vertical full red line, and implemented in April 2011, vertical dashed line. As evident there occurs an important discontinuity around the policy introduction, period 6, and larger banks respond substantially more than smaller banks by collecting much more deposits and expanding loans; purchasing more NBE bills and dropping substantial interbank holdings. As evident from Table 2, the pre-policy trends are not statistically different from zero, while post-policy all of them are. Appendix 6 reports the same picture with 95% confidence intervals.
2.1.3 Annual Reports Evidence

In this section we present some supporting evidence concerning the negative effect of a shock to \( \tau \) on profits, its positive effect on the number of branches and the lending rate, as predictions b) reported. Because these aggregates are collected yearly by banks, we lack the rich within-year variation which has been exploited in the previous section. Also the number of observations becomes a big limitations, because now we only face a panel with 5 observations at most for each bank. For this reason we focus on simple a test of structural break to verify whether the linear trends in these variables changed with the implementation of the policy. Therefore the following test is presented

\[
v_{iy} = a + b \cdot Year_y + c \cdot Policy_y + d \cdot Year_y \cdot Policy_y + \epsilon_{iy}
\]  

(2)

where as usually \( v_{iy} \) is a variable under observation for bank \( i \) in year \( y \), note that the subscript \( t \) referred to months was dropped as we deal with annual observations; such variable is regressed over the year variable, \( Year_y \), which varies between 1 (2008) and 5 (2013) and picks up the linear trend in the variables; a policy dummy variable, \( Policy_y \), which takes unit value for the fiscal years 2012 and 2013 and embodies the jump in the intercept and finally an interaction, \( Year_y \cdot Policy_y \), which measures changes in the slope of the variable.

Table 3 shows results in line with our theoretical model: column (1) shows that real profits were on average grow by 19 million Birr per year, however though insignificant, there seems to be a significant slow-down in profit growth after the policy: the interaction between Year and Policy has a negative sign and is as large as the Year coefficient. Indeed, a test on whether these two elements sum to zero cannot be rejected. In column (2), I present the same test for branch numbers: the year coefficient shows that an average bank is installing roughly 5 new branches per year and after the policy this doubles to 10. Column (3) report the evolution of the lending rate, which grows 2% per year and after the policy it shots up to 8% (as the Policy term shows), while the year trend collapses to zero (if we sum up the Year and Year \( \times \) Policy coefficients). Finally, in column (4) I show that in line with the theoretical model, the deposit rate stays unchanged before and after the policy. Regarding the number of branches
### Table 3: Profits, Branches and Regulation - Annual Reports

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Profit</td>
<td>Real Profit</td>
<td>Num. of</td>
<td>Num. of</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Mill Birr</td>
<td>Mill Birr</td>
<td>Branches</td>
<td>Branches</td>
</tr>
<tr>
<td>19.10***</td>
<td>27.28***</td>
<td>4.824***</td>
<td>4.806***</td>
<td></td>
</tr>
<tr>
<td>(5.663)</td>
<td>(3.914)</td>
<td>(1.139)</td>
<td>(1.063)</td>
<td></td>
</tr>
<tr>
<td>Policy × Year</td>
<td>-11.60</td>
<td>-42.38*</td>
<td>9.609*</td>
<td>13.53**</td>
</tr>
<tr>
<td></td>
<td>(17.08)</td>
<td>(24.36)</td>
<td>(4.836)</td>
<td>(5.579)</td>
</tr>
<tr>
<td>Policy</td>
<td>-12.95</td>
<td>-3.679</td>
<td>-2.804</td>
<td>-8.529</td>
</tr>
<tr>
<td></td>
<td>(24.45)</td>
<td>(41.57)</td>
<td>(6.525)</td>
<td>(6.261)</td>
</tr>
<tr>
<td>Bank FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Obs.</td>
<td>59</td>
<td>31</td>
<td>61</td>
<td>32</td>
</tr>
<tr>
<td>Banks</td>
<td>All</td>
<td>Big</td>
<td>All</td>
<td>Big</td>
</tr>
<tr>
<td>P-value of Test</td>
<td>0.652</td>
<td>0.365</td>
<td>0.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>R sq.</td>
<td>0.964</td>
<td>0.941</td>
<td>0.939</td>
<td>0.932</td>
</tr>
<tr>
<td>Adj. R sq.</td>
<td>0.951</td>
<td>0.920</td>
<td>0.916</td>
<td>0.908</td>
</tr>
<tr>
<td>Mean Dep. Var.</td>
<td>151.3</td>
<td>247.9</td>
<td>45.16</td>
<td>60.38</td>
</tr>
<tr>
<td>S.D. Dep. Var.</td>
<td>123.9</td>
<td>88.28</td>
<td>25.60</td>
<td>17.89</td>
</tr>
</tbody>
</table>

Notes: This table reports OLS estimates, the unit of observation is bank level and bank and month fixed effects are included. Davidson-McKinnon Robust Standard Errors are reported in brackets, which for this case are more conservative that bootstrapped bank-level clustered. Real Profits is the difference between the asset-generated income and liability-induced costs after taxes, is continuous and measured in million Birr. Number of branches reports the total number of branches as pictured in banks annual reports. Their means and standard deviations are reported in the rows “Mean Dep. Var.” and “S.D. Dep. Var.”. These variables are regressed over an Year variable, taking unit value in 2010, 2 in 2011, 3 in 2012 and 4 in 2013, which accounts for the linear trend in the evolution of these variables; the policy dummy variable takes unit value for the fiscal years 2012 and 2013 (the policy is in place only for 3 months of fiscal year 2011 and all months of 2012 and 2013 fiscal years). The interaction between Policy and Year reports the change in the linear trend after the policy; it is clear that for profits this change is negative, while positive for branches. Columns (1) and (3) reports the regressions for all banks, in columns (2) and (4) I restrict the sample on big banks only and in (3) and (6) on small banks only. It is notable that the interaction effects are stronger, both in negative sense in column (2) and in positive for column (4) for big banks. The R square and Adjusted R square of these regressions are reported respectively in the rows “R sq.” and “Adj. R sq.”. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

### Table 4: Rates and Regulation - Annual Reports

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lending Rate</td>
<td>Lending Rate</td>
<td>Deposit Rate</td>
<td>Deposit Rate</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>0.0206***</td>
<td>0.0132**</td>
<td>0.00118</td>
<td>0.000935</td>
</tr>
<tr>
<td></td>
<td>(0.00698)</td>
<td>(0.00519)</td>
<td>(0.00157)</td>
<td>(0.00155)</td>
</tr>
<tr>
<td>Policy × Year</td>
<td>-0.0184*</td>
<td>-0.0141*</td>
<td>0.000670</td>
<td>0.00524</td>
</tr>
<tr>
<td></td>
<td>(0.00946)</td>
<td>(0.00709)</td>
<td>(0.00479)</td>
<td>(0.00984)</td>
</tr>
<tr>
<td>Policy</td>
<td>0.00933</td>
<td>0.0155*</td>
<td>0.0001</td>
<td>-0.00420</td>
</tr>
<tr>
<td></td>
<td>(0.00828)</td>
<td>(0.00856)</td>
<td>(0.00631)</td>
<td>(0.0125)</td>
</tr>
<tr>
<td>Bank FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Obs.</td>
<td>37</td>
<td>19</td>
<td>37</td>
<td>19</td>
</tr>
<tr>
<td>Banks</td>
<td>All</td>
<td>Big</td>
<td>All</td>
<td>Big</td>
</tr>
<tr>
<td>P-value of Test</td>
<td>0.0224**</td>
<td>0.0284**</td>
<td>0.379</td>
<td>0.606</td>
</tr>
<tr>
<td>R sq.</td>
<td>0.855</td>
<td>0.901</td>
<td>0.733</td>
<td>0.606</td>
</tr>
<tr>
<td>Adj. R sq.</td>
<td>0.752</td>
<td>0.821</td>
<td>0.543</td>
<td>0.290</td>
</tr>
<tr>
<td>Mean Dep. Var.</td>
<td>0.105</td>
<td>0.111</td>
<td>0.0261</td>
<td>0.0247</td>
</tr>
<tr>
<td>S.D. Dep. Var.</td>
<td>0.0191</td>
<td>0.0131</td>
<td>0.00688</td>
<td>0.00653</td>
</tr>
</tbody>
</table>

24
Notes: This table reports OLS estimates, the unit of observation is bank level and bank and month fixed effects are included. Davidson-McKinnon Robust Standard Errors are reported in brackets, which for this case are more conservative than bootstrapped bank-level clustered. Lending rate is the average interest rate obtained by dividing interest income by lending and deposit rate dividing interest expense by deposits. Their means and standard deviations are reported in the row “Mean Dep. Var.” and “S.D. Dep. Var.”. These variables are regressed over an Year variable, taking unit value in 2010, 2 in 2011, 3 in 2012 and 4 in 2013, which accounts for the linear trend in the evolution of these variables; the policy dummy variable takes unit value for the fiscal years 2012 and 2013 (the policy is in place only for 3 months of fiscal year 2011 and all months of 2012 and 2013 fiscal years). The interaction between Policy and Year reports the change in the linear trend after the policy: it is clear that the lending stops growing at an yearly rate after the policy but goes up by 8 points, while the deposit rate is completely unaffected by the policy. Both of these predictions are in line with the model. Columns (1) and (3) reports the regressions for all banks, in columns (2) and (4) I restrict the sample on big banks only and in (3) and (6) on small banks only. It is notable that the interaction effects are not different across big and small banks, as predicted by the model. The R square and Adjusted R square of these regressions are reported respectively in the rows “R sq.” and “Adj. R sq.”. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

2.2 Evidence from Antebellum USA

After the establishment of the federal government of the United States of America, local states lost a significant source of funding from seigniorage and faced the decision of introducing new taxes. As Sylla, Legler, and Wallis (1987) neatly document various solutions were considered, from taxing incomes, properties or introducing infrastructure fees (especially waterways). While almost all states imposed the payment of lump-sum taxes on the provision of a bank charter, a variety of states also introduced substantial taxes on banks, generally on bank capital (but also profits, deposits or dividends): Massachusetts and Maine in 1812, Pennsylvania in 1817, Rhode Island and New Hampshire in 1822, New York in 1839 and Connecticut in 1850 (Sylla, Legler, and Wallis, 1987).

The long-term objective of these taxes was not financial regulation, rather revenue collection (Wallis, Sylla, and Grinath, 2004) and the gains from bank levies were impressive, amounting to 82%, 47% and 35% of state expenses respectively in Massachusetts, Maine and Connecticut (1836-1840). Despite the clear public finance objective, it may be argued that the joint effect of these state initiatives with federal decisions succeeded in a rudimental regulation of a rampant financial industry. As Wallis (2001) documents only two American Banks were allowed to operate nationally in 1810s, the First and Second Banks of the United States, but their influence over money, credit, politics and smaller state banks lead the Congress and President Jackson not to re-charter these banks in 1830s. Analogously state banks were considered supporters of special interests, which states regulated in a variety of ways, by imposing the funding of local infrastructure or special educational programs. For example, Connecticut forced state banks to support Yale University or the Connecticut Retreat for the Insane; New Hampshire a Literary Fund; Vermont a School Construction Fund; Virginia the Fund for Internal Improvement and several other experiences.

From Figure 8, it is possible to see that north-eastern states were the ones predominantly using bank taxes, while historians report that other states adopted a different approach with respect to public revenue collection. As Wallis (2001) concludes “frontier states were heavily dependent on the property tax” and analogously southern states, like Georgia, could generate substantial revenue by selling land rights. As a consequence “from 1835 to 1841, property tax collections on the Atlantic seaboard were only 2 percent of state revenues, in the west they were 34 percent”. Geography and the difference in land endowment, may be one of the reasons behind the different choice by western and eastern states in bank taxation.

The relation between regulation and bank size, especially deposit collection is also consistent with the argument reported by Swayze and Schiltz (2005), whom discussing the introduction of a bank
tax in Delaware in 1864 (outside our sample) conclude that: “An amendment to the Act in 1864 called for taxing state banks (...). Many projected the National Bank Act would cause the demise of state banks. However (...) state banks pioneered demand deposits, and within ten years, state banks had more deposits than national banks – a lead maintained until 1943”.

Figure 8: The Geography of Tax Bank Adoption in Antebellum USA

Note: this figure reports the map of the United States of America in 1848. In pink and red I report the states under control of the federal government, in yellow territories free from USA jurisdiction and in grey states controlled by other countries. Within USA I highlight in red all states that adopted bank taxes and report their names and policy adoption date in brackets.

2.2.1 Pre and Post Policy Analysis

Because the use of a simple difference-in-difference analysis can be misleading, we explore all available time-series and verify how the deposits, lending, precautionary holdings and profits move during all 5 years before and after the policy. This analysis is possible given the non-simultaneous introduction of this tax at state level. As before, the theoretical model predicts a discontinuity around the introduction of the policy, for this reason we present the following estimation strategy

\[ v_{ismy} = a + \sum_{y=-5}^{5} b_y \cdot d_y + \tau_i + \tau_s + \tau_m + \tau_y + \tau_{my} + \epsilon_{ismy} \]  

(3)

where the variable \( v_{ismy} \) is observed for bank \( i \), in state \( s \), in month \( m \) and year \( y \) and is regressed over a 11 dummy variables \( d_y \) which take unit value for every year of the 5 before the policy, in the
policy year and the 5 years after the policy, we are also introducing bank, state, month, year and month × year fixed effects. The coefficients $b_y$ are the core of this estimation and report the average evolution of the variable $v_{isy}^y$.

In Table 5 we present the coefficients $b_y$ across the 10 available years: it is clear to observe that until the introduction of the policy change, in “Year of Policy”, the coefficients on all variables are generally not statistically different from zero. However after the policy change, we can see that precautionary holdings, deposits, loans go up, while profits decline.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Precautionary Holdings</th>
<th>Total Deposits and Disc. and Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year -4</td>
<td>-2,033</td>
<td>-7,575</td>
</tr>
<tr>
<td></td>
<td>(5,307)</td>
<td>(20,765)</td>
</tr>
<tr>
<td>Year -3</td>
<td>2,400</td>
<td>-2,926</td>
</tr>
<tr>
<td></td>
<td>(10,744)</td>
<td>(37,498)</td>
</tr>
<tr>
<td>Year -2</td>
<td>-1,147</td>
<td>-2,969</td>
</tr>
<tr>
<td></td>
<td>(8,573)</td>
<td>(29,447)</td>
</tr>
<tr>
<td>Year -1</td>
<td>-4,168</td>
<td>-6,030</td>
</tr>
<tr>
<td></td>
<td>(5,105)</td>
<td>(25,953)</td>
</tr>
<tr>
<td>Year of Policy</td>
<td>41,042</td>
<td>-26,211</td>
</tr>
<tr>
<td></td>
<td>(57,697)</td>
<td>(57,290)</td>
</tr>
<tr>
<td>Year +1</td>
<td>23,175***</td>
<td>19,321**</td>
</tr>
<tr>
<td></td>
<td>(8,459)</td>
<td>(23,369)</td>
</tr>
<tr>
<td>Year +2</td>
<td>28,722**</td>
<td>24,197***</td>
</tr>
<tr>
<td></td>
<td>(11,995)</td>
<td>(34,000)</td>
</tr>
<tr>
<td>Year +3</td>
<td>25,034**</td>
<td>17,653***</td>
</tr>
<tr>
<td></td>
<td>(10,212)</td>
<td>(28,408)</td>
</tr>
<tr>
<td>Year +4</td>
<td>10,535</td>
<td>9,444</td>
</tr>
<tr>
<td></td>
<td>(19,858)</td>
<td>(31,637)</td>
</tr>
<tr>
<td>Year +5</td>
<td>31,793**</td>
<td>17,819***</td>
</tr>
<tr>
<td></td>
<td>(14,324)</td>
<td>(26,894)</td>
</tr>
</tbody>
</table>

| State FE | Yes | Yes | Yes | Yes |
| Bank FE  | Yes | Yes | Yes | Yes |
| Month FE | Yes | Yes | Yes | Yes |
| Year FE  | Yes | Yes | Yes | Yes |

| Obs. | 3,213 | 3,213 | 3,213 | 3,213 |
| Num. of Banks | 374 | 374 | 374 | 374 |
| R sq. | 0.817 | 0.708 | 0.890 | 0.779 |
| Adj. R sq. | 0.789 | 0.663 | 0.873 | 0.745 |
| Mean Dep. Var. | 255,735 | 133,891 | 495,671 | 29,678 |
| S.D. Dep. Var. | 648,492 | 340,375 | 665,824 | 62,400 |

Notes: This table reports OLS estimates, the unit of observation is bank level and state, bank, month and year fixed effects are included. Standard errors are clustered at bank-level. Precautionary holdings is the amount of liquid assets held by banks in cash, bank-to-bank deposits and government bills, is continuous and measured in US dollars. Total deposits is a variable reporting the overall deposits at bank level, is continuous and measured in US dollars. Loans and Discounts embodies all lending operations at bank level, is continuous.
and measured in US dollars. Profits and Losses is the difference between the asset-generated income and liability-induced costs after taxes, is continuous and measured in US dollars. The means and standard deviations of these variables are reported in the row “Mean Dep. Var.” and “S.D. Dep. Var.”. All of these variables are regressed over 11 yearly dummy variables which account for 5 years before the policy, the year of the policy and 5 years after - the first dummy, hence Year -5 is the omitted category. The policy change occurs in these states at Year of Policy (year zero) and this is different across states: 1812 in MA and ME, 1822 in NH and RI, 1839 in NY and 1850 in CT. These regressions measure the yearly evolution of the main aggregates before and after the policy, exploring the time series variation around the tax introduction. It is possible to notice that before the policy change, there do not seem to be big changes in the main variables, while after the policy changes the predictions follow Proposition 1. The R square and Adjusted R square of these regressions are reported respectively in the rows “R sq.” and “Adj. R sq.”. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

Figure 9: Bank Aggregates and Policy Change
Note: this figure graphs the coefficients of the overall non-linear trend of all treated US banks from 5 years before to 5 years after the policy change for Profits (black), Liabilities (blue) and Loans (red) in the upper panel; for Precautionary Holdings (green) and Profits (black) in the lower panel. As evident there occurs an important discontinuity at the policy introduction, Year 0, and banks respond expanding simultaneously their liabilities, loans and precautionary holdings while profits collapse substantially. As evident from Table 5, the pre-policy trends are not statistically different from zero, while post-policy all of them are. Appendix 7 reports the same picture with 95% confidence intervals.

Figure 11: Deposits, Other Liabilities and Policy Change
3 Conclusion

In this paper we show that a moderate degree of financial regulation can promote financial development by reducing profitability. This can be equivalently enacted through a macro-prudential regulation measure, which forces banks to accumulate a fixed proportion of safe assets for every unit of risky assets, or a special tax on bank lending, or risky assets in general. The bank mechanically responds to this policy by expanding the holding of liquid assets, which we call precautionary holdings, becoming less exposed to bank-run defaults but also less profitable: this additional, and privately suboptimal, safety margin can be used by the bank to take on more risk in order to partly counterbalance the profit loss. For this reason expanding branches is one of these margins, which has a socially optimal consequence of expanding financial access and development. While this has an unambiguously negative effect on bank profits and positive on deposit collection, we verify that financial regulation can have an ambiguous effect on lending because this causes a decline in loan size in old branches (intensive margin), but an increase in the number of loans because of the new branches (extensive margin). We show the conditions of this policy under which the extensive margin always dominates the intensive one and this results in bank which are larger, safer and less profitable.

We test the predictions of our theoretical model for two case studies: the introduction of a new financial regulation in Ethiopia in April 2011 and the state roll-over of bank taxes in Antebellum USA (1800-1861). We exploit two different identification strategies for these tests. In Ethiopia, a big challenge was given by the fact that all banks are simultaneously treated by the policy, however the theoretical model predicts that more efficient banks are larger in equilibrium than less efficient ones (level effect) and they react more strongly to the policy (impact effect). Because there is a big discontinuity in asset distribution across Ethiopian banks, with the 6th largest bank being twice as big as the seventh, we can use an essential difference-in-difference strategy and study the differential trend evolution of these banks. In Antebellum USA, we can exploit the fact that states introduce bank taxes in different years and therefore we can simply exploit this fact to do a lead-and-lag identification. In both cases, we find causal evidence of our theoretical predictions: banks exposed to this policy lose profits, accumulate more precautionary holdings, increase their deposits and loans.

We believe our results send two important messages. The first to the economic literature on financial development and highlight that banks, mostly neglected from the literature, should be considered a primal actor in the provision of financial services. Governments have important responsibilities to play in providing an optimal level of regulation and striking a balance between securing profitability and the provision of extensive access. This is a field which needs further research and our paper provides some substantial reference for this. We also aim at challenging the ideological statement that de-regulating the banking sector in low-income countries is an unambiguously optimal policy. A long history of financial regulation in western economies shows the opposite and our paper provides strong quantitative evidence that a moderate degree of regulation should actually be encouraged by international regulators.

References


Appendix

Appendix 1

A microfoundation of depositor supply and loan demand

Household

A representative household faces two periods, \( t = 1, 2 \), and decides its consumption path being endowed with exogenous income \( y \). If the locus is reached by a bank, savings can be deposited through the bank and remunerated at a rate \( R_D = 1 + r_D \). If the locus is not reached, savings are stored through an informal technology, which does not pay any interest but presents a probability \( \varepsilon \) of non-reimbursement (ie. savings may be stolen or not returned by local informal markets).

Households reached by a bank solve the following problem

\[
\max_{c_1, c_2} \gamma \ln(c_1) + (1 - \gamma) \ln(c_2)
\]

s.t. \( c_1 + \frac{c_2}{R_D} = y \)
where $c_t$ is the consumption choice of a certain basket of goods in period $t$ and $\gamma \in (\frac{1}{2}, 1)$ is an intertemporal preference parameter. The solution is simply

$$c_1 = \gamma y \text{ and } c_2 = (1 - \gamma)R_Dy.$$ 

in case access to finance is unavailable, second period consumption is lower and $R_D$ is replaced by $1 - \varepsilon$. The following formal saving function emerges

$$s = y - c_1 = (1 - \gamma)y$$

which, as expected, is increasing in $y$ and decreasing $\gamma$. The aggregate savings in banked loci are

$$S = \beta(1 - \gamma)y$$

the result of a saving function independent of the interest rate is useful to simplify the model and clarify the propagation of shocks from banks to households. Therefore access and availability, embodied by $\beta$ in $S$, seem to be the most important features, rather than the interest rate, $R_D$.

**Firm**

A representative firm produces a homogeneous good $q$. If its locus is reached by a bank it only uses rented capital at the beginning of period $t$, at lending rate $R_L = 1 + r_L$, and pays back at the end of the period. In case its locus is not reached, it accesses an informal technology. For simplicity I assume that the production technology is concave, $q = Ak^\alpha$ with $\alpha < 1$ and $A > 0$, and the problem follows

$$\max_k Ak^\alpha - R_Lk$$

therefore the firm’s investment function is given by

$$k = \left(\frac{\alpha A}{R_L}\right)^{\frac{1}{1-\alpha}}$$

with the aggregate level of formal investment in the loci accessed by the bank being

$$I = \left(\frac{\alpha A}{R_L}\right)^{\frac{1}{1-\alpha}} \beta.$$
Appendix 2

A Banking Model with Fixed Precautionary Holdings

In this case the bank does not adjust its precautionary holdings, $\Psi$, relative to the amount of deposits but keeps a constant amount $K$. For this reason the probability of avoiding a bankruptcy will not vary with $\beta$, but will be simply $p$

$$\max_{\Psi, \beta} E(\pi) = K \left(1 - \frac{\alpha}{\alpha}(\frac{\alpha^2 A}{1 + \tau(1 - R_G)}\right)^{\frac{1}{2}} - \frac{\beta^2}{2}$$

then it is simple to observe that

$$\frac{(1 - \alpha)K}{\alpha \eta} \left(\frac{\alpha^2 A}{1 + \tau(1 - R_G)}^{\frac{1}{2}} = \beta \right.$$

if $\tau$ increases, the level of profits declines and this pushes down the number of branches $\beta$.

Appendix 3

Proof of Lemma 1

Proof: the proof is extremely simple, write the problem of a bank maximizing profits in presence of a proportional profit tax $\tilde{\tau}$

$$\max_L [(R_L - 1)(1 - \tilde{\tau})] L$$

the by comparing the problem of a bank with a profit tax and a bank subject to financial regulation

$$\max_L [(R_L - 1) - (R_G)\tau] L$$

it is immediate to note the equivalence of the two profit functions and that the profit tax $\tilde{\tau}$ presents a one-to-one mapping with the regulation parameter $\tau$

$$\tilde{\tau} = \frac{(1 - R_G)}{(R_L - 1)} \tau.$$

Appendix 4

Proof of Proposition 1

In order to proof all claims in a) and b), it is enough to focus on a3), b2) and b1), the rest follows by simple algebra:

b1) Expected profits decline in $\tau$

$$\frac{\partial E(\pi)}{\partial \tau} = 4 \left(\frac{\mu^2}{\eta}\right) \left(\frac{\alpha^2 A}{1 + \tau(1 - R_G)}\right)^{\frac{2}{\alpha}} \left\{\left(\frac{1 - \alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}} \left[1 + \tau(1 - R_G)\right]^{\frac{1}{2}} - 1\right\}^3 \left(\frac{1 - \alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}} \left[1 + \tau(1 - R_G)\right]^{\frac{1}{2}}$$
\[-\frac{4}{1-\alpha}\left(\frac{\mu^2}{\eta}\right)\left(\frac{\alpha^2A}{1+\tau(1-R_G)}\right)^{\frac{1}{2-\alpha}}[1+\tau(1-R_G)^{-1}(1-R_G)\left\{\left(\frac{1-\alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}}[1+\tau(1-R_G)]^{\frac{1}{2}} - 1\right\}^4\]

\[\frac{\partial E(\pi)}{\partial \tau} = 1 - \alpha \left(\frac{1-\alpha}{\alpha \rho \mu}\right) \left[1 + \tau(1-R_G)\right]^{\frac{1}{2}} < 0\]

this is true if

\[\rho < \left(\frac{\alpha(1-\alpha)}{\mu}\right)[1 + \tau(1-R_G)]\]

but it is always the case under the assumption that \(\rho \leq \bar{\rho}\). Analogously, the probability of bank default declines in \(\tau\)

\[1 - \sigma(\Psi, \beta) = 1 - \frac{\Psi}{\rho D} = 1 - \frac{\mu}{\eta} \left(\frac{\alpha^2A}{1+\tau(1-R_G)}\right)^{\frac{1}{2-\alpha}}\left\{\left(\frac{1-\alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}}[1 + \tau(1-R_G)]^{\frac{1}{2}} - 1\right\}^3\]

\[\rho \left(\Psi + \left(\frac{\alpha^2A}{1+\tau(1-R_G)}\right)^{\frac{1}{1-\sigma}}\beta\right)\]

\[\frac{\partial (1-\sigma(\Psi, \beta))}{\partial \tau} = -\frac{1}{2} \frac{(1-R_G)[1 + \tau(1-R_G)]^{\frac{1}{2}}}{\left(\frac{1-\alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}}} < 0\]

intuitively beyond the tax effect, which diminishes profits, the financial regulation policy reduces the probability of default.

b2) Branch-opening increases in \(\tau\)

\[\beta = \left(\frac{\mu}{\eta}\right) \left(\frac{\alpha^2A}{1+\tau(1-R_G)}\right)^{\frac{1}{2-\alpha}}\left\{\left(\frac{1-\alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}}[1 + \tau(1-R_G)]^{\frac{1}{2}} - 1\right\}^2\]

\[\frac{\partial \beta}{\partial \tau} = -\frac{1}{1 - \alpha} \left(\frac{\alpha^2A}{1+\tau(1-R_G)}\right)^{\frac{1}{2-\alpha}}[1 + \tau(1-R_G)]^{-1}\left\{\left(\frac{1-\alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}}[1 + \tau(1-R_G)]^{\frac{1}{2}} - 1\right\}^2 +\]

\[+2 \left(\frac{\alpha^2A}{1+\tau(1-R_G)}\right)^{\frac{1}{2-\alpha}}\left\{\left(\frac{1-\alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}}[1 + \tau(1-R_G)]^{\frac{1}{2}} - 1\right\} \frac{1}{2}[1 + \tau(1-R_G)]^{-\frac{1}{2}}\]

\[\frac{\partial \beta}{\partial \tau} = 2 - \left[\alpha + \left(\frac{1-\alpha}{\alpha \rho \mu}\right)\right] [1 + \tau(1-R_G)]^{\frac{1}{2}}\]

this leads to

\[\frac{\partial \beta}{\partial \tau} \begin{cases} \geq 0 & \text{if } \tau \leq \bar{\tau} \\ < 0 & \text{if } \tau > \bar{\tau} \end{cases}\]

with

\[\bar{\tau} = \frac{1}{1 - R_G} \left\{4 \left[\alpha + \left(\frac{1-\alpha}{\alpha \rho \mu}\right)^{\frac{1}{2}}\right]^{-2} - 1\right\}\]

as discussed earlier there exists a region in which \(\tau\) affects positively branch opening, hence deposits and loans; however as \(\tau\) exceeds \(\bar{\tau}\), excessive funding costs push the bank to shrink. It is immediate.
to note that the threshold depends positively on $R_G$ and this intuitive: the closer is $R_G$ to the deposit rate $R_D = 1$, the less “constraining” this tax is and therefore the highest imposable extent of bond purchasing consequently increases.

**a3)** Precautionary holdings increase in $\tau$

$$
\Psi = \left( \frac{\mu}{\eta} \right) \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{2/\alpha} \left\{ \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{1/2} - 1 \right\}^3
$$

$$
\frac{\partial \Psi}{\partial \tau} = 4 - (1 - 3\alpha) \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{1/2}
$$

restricting our attention on $\tau \leq \bar{\tau}$, it is possible to note that in this region

$$
\frac{\partial \Psi}{\partial \tau} > 0 \quad \text{if} \quad \tau \leq \bar{\tau}
$$

indeed defining

$$
\bar{\tau} = \frac{1}{1 - R_G} \left[ 16(1 - 3\alpha)^{-2} \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{-1} - 1 \right]
$$

algebra shows that

$$
\bar{\tau} > \bar{\tau}
$$

as it is always true that

$$
2\alpha > -(1 + 3\alpha) \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2}.
$$

**Mechanics**

In order to understand the mechanics of bank behavior, I describe the equilibrium lending, precautionary holdings and assets (which equal liabilities, $D = L + \Psi$)

$$
L = \left( \frac{\mu}{\eta} \right) \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{2/\alpha} \left\{ \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{1/2} - 1 \right\}^2
$$

$$
D = \left( \frac{\mu}{\eta} \right) \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{2/\alpha} \left\{ \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{1/2} - 1 \right\}^2 \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{1/2}
$$

$$
\Psi = \left( \frac{\mu}{\eta} \right) \left( \frac{\alpha^2 A}{1 + \tau(1 - R_G)} \right)^{2/\alpha} \left\{ \left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{1/2} - 1 \right\}^3
$$

hence defining the lending and precautionary holdings relative to assets, it is possible to see that these are

$$
\frac{L}{D} = \frac{1}{\left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{1/2}}
$$

$$
\frac{\Psi}{D} = 1 - \frac{1}{\left( \frac{1 - \alpha}{\alpha \rho \mu} \right)^{1/2} \left[ 1 + \tau(1 - R_G) \right]^{1/2}}
$$

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it is clear that the policy parameter $\tau$ pushes banks to become safer and hold less assets in lending, operating as a typical regulatory constraint

$$\frac{\partial L}{\partial \tau} = -\frac{1}{2} \left( \frac{1-\alpha}{\alpha \mu} \right)^{\frac{1}{2}} \frac{1-R_G}{[1+\tau(1-R_G)]^{\frac{3}{2}}} < 0.$$ 

We can also verify that indeed the bank does not perfectly insure itself against the cost of default

$$\frac{\Psi}{D} < \rho \rightarrow 1 - \frac{1}{\left( \frac{1-\alpha}{\alpha \mu} \right)^{\frac{1}{2}} \left[ 1+\tau(1-R_G) \right]^{\frac{3}{2}}} < \rho$$

as the left-hand side is lower than one, while the right hand side is always higher than one. Hence banks decrease their default probability after the policy change, but do not perfectly insure.

Therefore a neat interpretation of bank behavior follows: the policy increases the marginal cost of lending for the bank, pushing up the equilibrium lending rate $R_L = \frac{1+\tau(1-R_G)}{\alpha}$. Because the spread between the lending and deposit rate increases in $\tau$, the bank finds convenient to install new branches, increasing financial development, but only to the extent in which this higher rate is preserved. As a consequence, both deposit collection and loans expand, but the former grows at a higher rate. As a result precautionary holdings grow in level and also change in their composition after the policy. Because the bank exploits both margins, $\beta$ and $\Psi$, then part of the policy-induced losses are offset by more customers facing a higher lending rate.

Finally, exploring the proportion of assets allocated to lending and this depends on the structural parameters of the economy summarized:

1. a higher elasticity of production to the lending rate\(^6\), $\frac{\alpha}{1-\alpha}$, leads to less lending as a share of total assets - intuitively the more elastic is production to the lending rate, the lower the equilibrium lending rate and, given the possible default cost, the bank prefers to keep more precautionary holdings;

2. a less efficient banking technology, expressed through a higher liquidity cost parameter $\mu$, which pushes down the proportion of assets invested in precautionary holdings and hence exposes the bank to relatively more lending;

3. an increase in the proportion of bank-running depositors, $\rho$, makes the bank riskier and leads to lower precautionary holdings - this result may seem paradoxical, but is generated by two forces. First when $\rho$ increases $\beta$ decreases because it is less convenient to extend branches and therefore the level of loans and deposits decline; secondly, because deposits respond more strongly than lending to this parameter, though both decline, the ratio between lending and deposits increases.

\(^6\)To see this recall that production is defined as $q = Ak^\alpha$ and that the demand for lending is given by $k = \left( \frac{\alpha A}{R_L} \right)^{\frac{1}{1-\alpha}}$, plugging this last expression in the first $q = A^{\frac{1}{1-\alpha}} \alpha^{\frac{1}{1-\alpha}} \left( \frac{1}{R_L} \right)^{\frac{1}{1-\alpha}}$, hence $\xi_0R_L = \frac{\partial q}{\partial R_L} \frac{R_L}{q} = \frac{\alpha}{1-\alpha}$. 

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Appendix 5

Tesing Compliance of the NBE Bill Policy

In this section we simply verify that 0.27 NBE bills were purchased for each unit of private lending and that this was not different between big and small banks. Therefore 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

\[ v_{ity} = a + b \cdot Policy_{ty} \times Lending_{ity} + c \cdot Policy_{ty} \times Lending_{ity} \times Big Bank_i + \epsilon_{ity} \]  

(4)

where \( v_{ity} \) 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 are: \( b = 0.27 \) and \( c = 0 \). Table 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, for example robust, hc3 or unclustered bootstrap provide less conservative standard errors). In column (2) I introduce an interaction and verify whether there is any differential implementation of the policy across big and small banks, though the point estimate of \( b \) drops to 0.20 (with st. errors doubling), we can also verify that \( c \) is not statistically different from zero. Supporting the hypothesis that all banks were equally affected by the policy and complied.

<table>
<thead>
<tr>
<th>Table 1: Compliance in Regulation - Within-Year Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Private Lending × Policy</td>
</tr>
<tr>
<td>Private Lending × Policy</td>
</tr>
<tr>
<td>Big Bank</td>
</tr>
<tr>
<td>Bank FE</td>
</tr>
<tr>
<td>Month FE</td>
</tr>
<tr>
<td>Obs.</td>
</tr>
<tr>
<td>Number of Banks</td>
</tr>
<tr>
<td>R sq.</td>
</tr>
<tr>
<td>Adj. R sq.</td>
</tr>
<tr>
<td>Mean Dep. Var.</td>
</tr>
<tr>
<td>S.D. Dep. Var.</td>
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</table>
Notes: 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 National Bank of Ethiopia in million Birr and is a continuous variable. Its mean and standard deviation are reported in the row “Mean Dep. Var.” and “S.D. Dep. Var.”. In column (1) this 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 neither. The R square and Adjusted R square of these regressions are reported respectively in the rows “R sq.” and “Adj. R sq.”. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

Table x: Regulation and Banks - Within-Year Variation

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<td>Total</td>
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<td>76.79***</td>
<td>42.94</td>
<td>259.4***</td>
<td>572.3***</td>
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<td>Yes</td>
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<td>R sq.</td>
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<td>14</td>
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<tr>
<td>Adj. R sq.</td>
<td>0.211</td>
<td>0.135</td>
<td>-0.0859</td>
<td>0.0385</td>
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<tr>
<td>Mean Dep. Var.</td>
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<td>717.6</td>
<td>1251</td>
<td>2380</td>
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<td>S.D. Dep. Var.</td>
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<td>781.8</td>
<td>1038</td>
<td>1580</td>
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</tbody>
</table>

Notes: This table reports OLS estimates with ... bootstrapped standard errors

Appendix 6

Figure 7: Deposits, Loans and Policy Change
Note: this figure graphs the coefficients of the overall trend exhibited by small banks (upper panel) and small and large banks (lower panel) for quarters 2 to 10 for Deposits (blue) and Loans (red). As evident there occurs an important discontinuity around the policy introduction, quarter 6, and larger banks respond substantially more than smaller banks by collecting much more deposits after the policy and, after 2 quarters, providing much more loans. As evident from Table 2, the pre-policy trends are not statistically different from zero, while post-policy all of them are. Appendix D reports the same picture with 95% confidence intervals.

Figure 7: Bank Aggregates and Policy Change - 95% Confidence Intervals
Note: this figure graphs the coefficients of the overall trend exhibited by small banks (upper panel) and small and large banks (lower panel) for quarters 2 to 10 for Deposits (blue) and Loans (red). As evident there occurs an important discontinuity around the policy introduction, quarter 6, and larger banks respond substantially more than smaller banks by collecting much more deposits after the policy and, after 2 quarters, providing much more loans. As evident from Table 2, the pre-policy trends are not statistically different from zero, while post-policy all of them are. Appendix D reports the same picture with 95% confidence intervals.

Appendix 7

Figure 10: Precautionary Holdings and Policy Change
Note: this figure graphs the coefficients of the overall trend exhibited by small banks (upper panel) and small and large banks (lower panel) for quarters 2 to 10 for Deposits (blue) and Loans (red). As evident there occurs an important discontinuity around the policy introduction, quarter 6, and larger banks respond substantially more than smaller banks by collecting much more deposits after the policy and, after 2 quarters, providing much more loans. As evident from Table 2, the pre-policy trends are not statistically different from zero, while post-policy all of them are. Appendix D reports the same picture with 95% confidence intervals.