Bank Monitoring and Liquidity in the Business Cycles

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Abstract

We study a bank monitoring channel of transmission of shocks in a dynamic general equilibrium model with financial frictions. The results reveal that fluctuations in banks’ monitoring can give rise to “banking accelerator” or “banking attenuator” effects. Negative shocks to banks’ access to wholesale liquidity boost banks’ incentive to monitor retail loans, thus attenuating the effect of the shocks. On the other hand, bank monitoring incentives drop following negative shocks to the value of banks’ loan portfolio, amplifying their impact. Relationship lending magnifies the bank monitoring channel of transmission.

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1 Introduction

The access of financial institutions to liquidity is recognized to be of primary importance in the smooth functioning of the financial system and, hence, in macroeconomic stability. During the Great Recession a liquidity dry-up in the wholesale (interbank) funding market acted as a transmission mechanism of the financial crisis. During the Euro area sovereign debt crisis, tightening constraints in the interbank market, driven by a drop in the collateral pledgeability of government bonds, triggered a stop in the intermediation capacity of European banks. These events pushed central banks to implement unconventional (credit) policies to restore liquidity flows in interbank markets. Aside from crisis episodes, the need for a smooth functioning of the market for bank liquidity is widely acknowledge by scholars and policymakers. One of the top concerns after the introduction of the Euro was the creation of an integrated market for interbank liquidity in the Euro area. And, in more recent times, regulators have been intensely debating this issue as part of the creation of the European banking union.1

While the importance of liquidity is well established, less is known about the way banks’ liquidity interacts with a fundamental task performed by banks, the monitoring of loans and borrowers. Banks do not only

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1Several scholars and policy makers have pointed at the widespread lack of information and screening that characterized the extension of loans in the credit boom before the crisis.
intermediate liquidity, but perform a continuous activity of monitoring of their borrowers, certifying the quality and soundness of borrowers to depositors and regulators. According to the banking literature, this is indeed the key role of banks that differentiates them from dispersed investors in capital markets. Several banking studies point at the complex linkages between banks’ access to collateral and liquidity and their monitoring incentives. For example, it has been found that larger collateral and liquidity may make banks more lazy in monitoring borrowers. On the other hand, various studies have uncovered a positive association between banks’ access to liquidity and monitoring.

These considerations elicit fundamental questions: how does liquidity access and bank monitoring interact over the business cycle? Do they reinforce each other in transmitting exogenous shocks or are they instead substitute? How does their interplay shape the effects of credit policies? To address these questions, we first present motivational evidence on the monitoring activity of U.S. banks over the 1995-2015 period. By hand-matching data from the syndicated loan market with comprehensive bank-level data on banks’ access to wholesale interbank markets, we show that easier access to wholesale funding makes banks less inclined to produce effort in monitoring. Further, while banks tend to monitor more intensely during recessions, such countercyclicality of monitoring is reduced when their access to wholesale liquidity is easier.

Motivated by these empirical findings, we build a dynamic stochastic general equilibrium model with bank intermediation and frictional markets for bank liquidity. To capture the aforementioned phenomena, we let banks perform active monitoring of their loan portfolios. In the model, monitoring “certifies” the quality of loans to depositors and regulators, boosting the effective pledgeability of banks’ assets and banks’ capitalization. As our primary focus is on the interaction between bank monitoring and liquidity, we also posit that banks encounter frictions in accessing liquidity. In particular, they can borrow in a wholesale funding, e.g. interbank, market, but they must pledge collateralizable government bonds to interbank lenders. Thus, in our economy an interbank collateral constraint emerges alongside a bank capital constraint. We show that two main mechanisms drive bank monitoring decisions over the business cycle: banks’ appetite for liquidity, triggered by the tightness of wholesale liquidity constraints; and the productivity of bank monitoring, driven by the value of bank loan portfolios. Tighter wholesale liquidity pushes banks to monitor their loans more intensely to gain better access to retail deposit funding; larger values of loan portfolios increase the productivity of monitoring and, hence, bank monitoring incentives.

We perturb the economy with exogenous shocks to investigate how the interaction between liquidity and monitoring affects the transmission of business cycle. The first two shocks we consider aim at mimicking regulatory reforms of wholesale funding markets and changes in the pledgeability of government bonds (as driven, e.g., by sovereign debt turmoils). We find that negative bond return shocks, by reducing the pledgeability of governement bonds in interbank operations, boost banks’ incentive to monitor loans. In turn,

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2 It is observed that the mayors EU banks have accumulated a large amount of sovereign bonds in their portfolios during the recent financial crisis. Government bonds constitute one of the most important forms of collateral pledged by banks in interbank markets. Moreover, it is estimated that around 75 percent of repo transactions in the euro area use government bonds as collateral (Hordahl and King, 2008).

3 The banking sector features two liquidity constraints. It is subject to a standard capital constraint that limits the access to retail deposits and wholesale funds not to exceed a certain fraction of its assets (including loans). The banking sector is also exposed to a borrowing constraint in the wholesale funding market. Precisely, it needs to pledge collateral, under the form of sovereign bonds, to wholesale investors (e.g., in the interbank market).
this acts as an attenuator of the shocks, mitigating the negative response of credit, investment and output. By contrast, the effects of a restrictive regulatory shock to collateral pledgeability in the wholesale funding market are more nuanced. On impact such shocks incentivize bank monitoring, but in later periods banks become lazy monitors, amplifying the output impact of the shocks. Finally, we study the effects of a drop in firms’ capital quality that directly hits banks’ capitalization.

We extend our environment in two dimensions to allow for a richer structure of the banking sector and of the policy setting: first, we allow the government to implement credit policies that directly influence banks’ access to liquidity. We find that, as intended, credit policies directly loosen bank liquidity constraints. On the other hand, in our setting, they also have the unintended consequence of weakening banks’ monitoring incentives. Interestingly, this turns out to be especially true for policies of direct lending to businesses and banks, whereas equity injections into banks better preserve bank monitoring incentives.

In a second variation of our environment, we introduce lending relationships in the retail loan market and in the wholesale funding market. An extensive banking literature finds a strong interplay between credit relationships and bank monitoring. It is thus natural to wonder whether the interaction between bank monitoring and liquidity changes in a more relationship-oriented banking sector. We obtain that lending relationships tend to attenuate the effects of negative shocks per se, but at the same time they magnify the substitutability between bank liquidity and monitoring over the business cycle. Through the latter mechanism, relationship lending can then turn into an amplifier of shocks.

The role of the wholesale liquidity market in the transmission of business cycles has been widely investigated among others by Basu (2009), Gertler and Kiyotaki (2011), Bolton and Jeanne (2011), Bofondi et al. (2013), Bocola (2014), Gennaioli et al. (2014), Bedendo and Colla (2015). In these models, a shock that plummets the price of bonds can amplify a recession, giving rise to a “bank net worth channel”. When the value of sovereign debt drops, bonds are less pledgeable in the interbank market and, then, a tighter interbank constraint limits the ability of banks to borrow in interbank markets. Lakdawala et al. (2018) use the canonical framework developed by Gertler and Kiyotaki (2011), that allows for financial intermediation and liquidity needs, augmented with the assumption that sovereign bonds are pledgeable in the interbank market and used as collateral. It is thus possible to isolate an “interbank collateral channel” of transmission, which works through banks portfolio allocation between loans and government bonds. These papers do not study the role of bank monitoring. A second strand of literature studies the role of bank monitoring in macroeconomic stability. Goodfriend and McCallum (2007) propose a model of the banking sector in which the production of loans (and thus deposits) involves banks’ monitoring effort as an input. Goodfriend and McCallum (2007) do not consider the interaction between bank monitoring and banks’ liquidity access to wholesale and retail funding markets.

Our goal is to investigate how the role of liquidity in the amplification/mitigation of business cycles is affected by loan monitoring activities. In particular, we ask whether the presence of loan monitoring services, combined with the frictional interbank markets, give rise to a “banking accelerator” or “banking attenuator” effects. Studying how loan monitoring activities respond to different sources of shock and their macroeconomic effects, in terms of amplification/attenuation of a recession, is important also from a
normative point of view: a central bank that wants to implement credit policies to support the balance sheet of banks facing lack of funds has to take into account how collateral and interbank constraints are affected (i.e., whether they are relaxed or tightened) by changes in loan monitoring. The main message of our analysis is that banks’ access to liquidity can be a double-edged sword. On the one hand, easy access to liquidity facilitates banks’ role in intermediating funds. On the other hand, easy access to liquidity can make banks more lazy in monitoring their borrowers, amplifying the effect of shocks. This latter effect turns out to be stronger banks establishing credit relationships with borrowing firms, although, by themselves, credit relationships enhance banks’ ability to monitor borrowers and overall improve their lending capacity.\(^4\)

The rest of the paper is organized as follows: in Section 2 presents motivational empirical evidence on the relation between liquidity and loans monitoring using rich hand-matched data on the syndicated loan market and banking sector for the United States; Section 3 presents and derive the model; in Section 4 we analyze the effects of shocks; Section 5 introduces credit policies; Section 6 studies the role of relationship lending; finally, Section 7 concludes.

## 2 Empirical background

In what follows, we present motivational evidence on the interaction between banks’ access to liquidity and monitoring over the business cycle exploiting rich data from the United States. We hand-match information from four data sources: the Thomson Reuters LPCs DealScan database, which collects detailed data on syndicated loans extended by banks; the Call Reports compiled by the Federal Reserve Board (FRB, henceforth); the Compustat database; and confidential information about banks’ access to interbank markets obtained from the FRB. The data cover a total of about 25,000 loans extended by # # # banks over the # # - # # period. In the Data Appendix, we provide more details on the data sources and on the construction of the sample.

The syndicated loan market is an ideal empirical laboratory for our purposes. While syndicated lending constitutes only a fraction of banks’ total lending, it is often used to assess bank lending policies and the interactions between lenders and borrowers (see, e.g., Ivashina and Scharfstein, 2010; Bharath, Dahiya, Saunders and Srinivasan, 2009). In a syndicated loan a borrower provides to a bank (lead arranger) the mandate to arrange a deal. The loan agreement with the lead arranger specifies the loan characteristics (collateral, loan amount, covenant, a range for the interest rate, etc.). The lead arranger then invites other banks to participate in the loan. The participants, in turn, delegate the monitoring of the borrower to the lead arranger.\(^5\) The empirical banking literature treats the share of the loan retained by the lead arranger as a proxy for its incentive to monitor the loan: the higher the lead share, the more “skin in the game” the lead arranger retains in the loan, and the stronger its incentive to monitor. The information on syndicated loans is based on the LPC DealScan data set which provides transaction-level data on the loan deal’s characteristics

\(^4\)Several papers find that relationship lending are empirically relevant (see, among others, Ongena and Smith, 2001; Santos and Winton, 2008; Aliaga-Díaz and Olivero, 2010; and Sette and Gobbi, 2015).

\(^5\)Lead arrangers coordinate the documentation process and receive a fee from the borrower for arranging and managing the loan.
and on the banks in the syndicate, their roles, and their shares of the loan. We drop from our database loans that are extended to utilities (public services) and financial companies. We then hand-match DealScan with Call Reports to obtain rich information on the characteristics and balance sheets of lending banks. Because Call Reports are available on a quarterly basis, we collapse the loan data set on a quarter level. Finally, we obtain confidential information on banks’ borrowing in the wholesale market directly from the FRB. This is measured as the sum of four liabilities of the bank:...

We estimate the following baseline empirical model on a quarterly level:

\[
LeadShare_{ijt} = \alpha + \beta LeadLiquid_{jt} + \gamma Recess_t + \delta LeadLiquid_{jt} \times Recess_t + \zeta LEAD_{jt} + \varphi LOAN_{it} + \eta_j + \eta_t + \epsilon_{ijt}
\]

where \(LeadShare_{ijt}\) denotes the share of loan \(i\) retained by bank \(j\) at time \(t\), our proxy for the bank’s monitoring; \(LeadLiquid_{jt}\) is the wholesale funding obtained by bank \(j\) at time \(t\); \(Recess_t\) is a dummy variable that takes the value of one if quarter \(t\) is a recession quarter (according to the NBER classification); \(LEAD_{jt}\) is a vector of time-varying characteristics of the lead arranger; \(LOAN_{it}\) is a vector of loan level attributes; \(\eta_j, \eta_t\) denote lender fixed effects and time fixed effects, respectively; and \(\epsilon_{ijt}\) is the residual.

Our main coefficients of interest are \(\beta, \gamma\), and \(\delta\). The \(\beta\) coefficient captures the impact of a bank’s access to wholesale funding on the (proxy for) bank’s monitoring, the lead share of the bank. The \(\gamma\) coefficient captures the response of monitoring to business cycle conditions; and \(\delta\) reflects the interaction between the two effects. Table 1 reports the baseline estimates.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Share %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(interbank exposure)</td>
<td>-0.019*** -0.020*** -0.01***</td>
</tr>
<tr>
<td>NBER Recession</td>
<td>0.046*** 0.248***</td>
</tr>
<tr>
<td>Ln(interbank exposure) × Recession</td>
<td>-0.011***</td>
</tr>
<tr>
<td>Deposit/Total Assets</td>
<td>0.022 0.022 0.029</td>
</tr>
<tr>
<td>RoA</td>
<td>-0.949* -0.965* -0.902*</td>
</tr>
<tr>
<td>Loan-loss Provisions</td>
<td>1.267*** 1.256*** 1.166**</td>
</tr>
<tr>
<td>Ln(Size)</td>
<td>-0.014 -0.013 -0.014</td>
</tr>
</tbody>
</table>

Columns 1-3 show that banks tend to monitor more intensely (i.e., retain a larger loan share) when they have a lower access to liquidity in the wholesale funding market. Columns 2-3 also show that banks produce more effort in monitoring services during a recession. However, as revealed by column 3, the incentive to
monitor during recession is reduced when banks have easier access to wholesale liquidity (the coefficient on the interaction term is significantly negative). These results are robust to a variety of specifications, as shown in the table. In column 4, we replace the measure of interbank funding with an indicator for the regulatory cost of accessing the wholesale funding market. This is constructed as a dummy that takes the value of one if the bank was subject to a regulatory tax on its wholesale liabilities. The results confirm those of the baseline regressions. In column 5, we experiment by considering ...

3 The model

The model economy includes four sectors: households, non-financial firms (divided, in turn, between final goods producers and capital producers), banks, and a government.

3.1 Households

To keep the model tractable, we follow the standard assumption of a representative household. Households comprise workers, who earn wages, and bankers, who earn profits by managing financial intermediaries. Workers can be employed in goods production activities or in banking (monitoring) activities. There is perfect consumption insurance within the household. We follow the setup in Gertler and Kiyotaki (2011) where bankers exit in each period with a probability \((1 - \sigma)\) and transfer all their earnings to the household when exiting. This ensures that bankers cannot accumulate enough assets and end up in a situation where collateral constraints never bind. To keep the relative number of workers and bankers constant, \((1 - \sigma) f\) workers randomly convert into bankers (where \(f\) denotes the fraction of bankers).

Households earn the wage rate \(W^H_t\) on labor supplied in the goods sector \((H_t)\) and a wage rate \(W^L_t\) on the labor supplied in banking activities \((L_t)\). They also earn a rate of return \(R^D_t\) on deposits as well as profits from owning intermediaries and non-financial firms, \(\Pi_t\). They use their funds for consumption \(C_t\), to pay lump-sum taxes \(T_t\), and hold deposits \(D_t\). Households smooth consumption through bank deposits. They choose consumption, savings and labor supply to maximize lifetime utility according to

\[
\max_{C_t, D_t, H_t, L_t} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, H_t, L_t) \tag{1}
\]

s.t. \(C_t + D_t + T_t = R^D_{t-1} D_{t-1} + W^H_t H_t + W^L_t L_t + \Pi_t\).

We posit CRRA preferences, that is, the utility has the following form

\[
U_t = \left[ \frac{(C_t - h_g C_{t-1})^{1-\sigma_c}}{1-\sigma_c} - k_H \frac{H_t^2}{\varphi} - k_L \frac{L^T_t}{\tau} \right]
\]

where \(\sigma_c\) is the relative risk aversion coefficient, \(h_g\) denotes the habits on consumption, \(\varphi\) is the inverse of Frisch elasticity for workers employed in the production of goods and \(\tau\) is the inverse of Frisch elasticity for workers employed in monitoring services in the banking sector.
Equation (2) is the standard labor supply condition for both labor types stating that the intratemporal marginal rate of substitution between consumption and leisure has to be equal to the wage rate:

\[ \frac{U'_H}{U'_C} = W_t^H, \quad -\frac{U'_L}{U'_C} = W_t^L. \] (2)

Equation (3) is the Euler condition that governs the intertemporal allocation of savings:

\[ 1 = E_t A_{t,t+1} R_t^D, \] (3)

where \( A_{t,t+1} = \beta \frac{U'_C_{t+1}}{U'_C_t} \).

### 3.2 Non-Financial Firms

#### 3.2.1 Final Goods Producers

There is a continuum of firms of unit mass located on a continuum of islands. Each firm produces output by operating a constant returns to scale Cobb-Douglas production function with capital and labor as inputs. Capital is not mobile, while labor is perfectly mobile across firms and islands.

Following Gertler and Kiyotaki (2011), in every period \( t \), final goods producers face a random opportunity to invest with probability \( \pi^i \). Thus, a fraction \( \pi^i \) of islands receive the opportunity to invest, whereas in a fraction \( \pi^n = 1 - \pi^i \) of islands there are no investment opportunities. Contingent on obtaining funding from intermediaries, firms on investing islands issue state-contingent securities \( X^i_t \) at a market price \( Q_t^{X^i} \). They use these funds to buy new capital goods. Their technology is given by

\[ Y_t = A_{1,t} K_t^\alpha H_t^{1-\alpha} \] (4)

where \( \alpha \) denotes the capital share, \( K_t \) is the stock of capital and \( A_{1,t} \) represents the total factor productivity (TFP). The TFP follows an \( AR(1) \) process:

\[ A_{1,t} = \rho A_{1,t-1} + \varepsilon^A_t \]

where \( \varepsilon^A_t \) is a white noise.

The factor demand curves are given by

\[ W_t^H = (1 - \alpha) \frac{Y_t}{H_t} \] (5)

\[ Z_t = \alpha \frac{Y_t}{K_t}, \] (6)

where the return to capital is denoted by \( Z_t \).
3.2.2 Capital Producers

The capital producing firms choose their investment to maximize the expected present discounted value of profits given by the value of new capital sold to firms in investing sectors minus the cost of investment inclusive of adjustment costs. Their optimization problem reads

$$\max_{I_t} E_t \sum_{j=0}^{\infty} A_{t,t+j} \left\{ Q_t^{X,j} I_{t+j} - \left[ 1 + F \left( \frac{I_{t+j}}{I_{t+j-1}} \right) \right] I_{t+j} \right\}$$  \hspace{1cm} (7)$$

where $F \left( \frac{I_t}{I_{t-1}} \right) I_t$ represents physical adjustment costs, with $F(1) = F''(1) = 0$, and $F'' \left( \frac{I_t}{I_{t-1}} \right) > 0$. In equilibrium the price of investment goods has to equal the marginal cost of producing capital goods:

$$Q_t^{X,i} = 1 + F \left( \frac{I_t}{I_{t-1}} \right) + \frac{I_t}{I_{t-1}} F' \left( \frac{I_t}{I_{t-1}} \right) - E_t A_{t,t+1} \left( \frac{I_{t+1}}{I_t} \right)^2 F'' \left( \frac{I_{t+1}}{I_t} \right).$$  \hspace{1cm} (8)$$

Let $\delta$ denote the rate of physical depreciation. Then, capital accumulated in sectors with investment opportunities is $I_{t-1} + \pi^t (1 - \delta) K_{t-1}$, while in sectors without them it is $\pi^n (1 - \delta) K_{t-1}$. Aggregating and denoting by $\psi_t$ a shock to the quality of physical capital available for production at time $t$, the law of motion for aggregate capital is

$$K_t = \psi_t [I_{t-1} + (1 - \delta) K_{t-1}] = \psi_t \left[ I_{t-1} + \pi^t (1 - \delta) K_{t-1} + \pi^n (1 - \delta) K_{t-1} \right].$$  \hspace{1cm} (9)$$

The capital quality shock can capture disruptions in the good producing sector that are unrelated to financial factors.\(^6\) This provides a convenient way of capturing exogenous variation in the value of capital. We let $\psi_t$ follow the autoregressive process

$$\psi_t = \rho_{\psi} \psi_{t-1} + \varepsilon_t^\psi$$  \hspace{1cm} (10)$$

where $\rho_{\psi}$ is the autoregressive coefficient and $\varepsilon_t^\psi$ is a white noise shock.

3.3 Banks

In period $t$ the objective of each individual bank in sector $h$ is to choose deposits ($d_t$), sovereign bond holdings ($b_t$), the quantity of labor to employ in loan monitoring activities ($l_h^t$), interbank position ($m_h^t$), and holdings of shares in non-financial firms ($x_h^t$), where the $h \in (i,n)$ superscript represents whether an investing opportunity is available or not in that sector. Since deposits and bond holdings are chosen before uncertainty over types is resolved, banks in sectors without investment opportunities find themselves with a surplus of funds, while banks in sectors with investment opportunities face a shortage.\(^7\) The former will then lend to the latter at an interest rate $R^M_t$. An important assumption of our model is that banks are required to pledge government bonds as collateral to borrow in the interbank market. This collateral requirement can

\(^6\) For example, certain goods become obsolete over time and this shock is a reduced form way of capturing the effect of obsolescence on the capital stock.

\(^7\) Note that, accordingly, $d_t$ and $b_t$ are not indexed by $h$. 

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lead the cost of credit for the production sector to exceed the risk-free rate.

Each bank of type \( h \) maximizes the expected discounted sum of profits it transfers to the household:

\[
V_t \equiv \max_{d_t, b_t, x_t, m_t, l_t} \sum_{j=1}^{\infty} (1 - \sigma) \sigma^{j-1} \Lambda_{t+t+j} n_{t+j}^h
\]

s.t.

\[
Q_t^{X,h} x_t + Q_t^{B} b_t = n_t^h + d_t + m_t^h - W_{t}^{L,h}
\]

\[
R_t^D d_t + \theta_M R_t^M m_t^h \leq \xi_t B_t b_t + (\xi^X x_t)^{\phi} (\xi^L A_t l_t)^{1-\phi}
\]

\[
R_t^M m_t^h \leq \frac{1}{\chi_t} Q_t^B b_t
\]

where \( n_t^h \) represents the bank’s net worth and \( R_t^M \) denotes the interest rate on interbank loans. Banks’ net worth at time \( t \) is defined as the gross payoff from assets funded at \( t - 1 \), net of borrowing costs:

\[
n_t^h = [Z_t + (1 - \delta)Q_t^{X,h}] \psi_t x_{t-1} + \psi_t^B b_{t-1} - R_{t-1}^D d_{t-1} - R_t^M m_{t-1}.
\]

The gross payoff from assets depends on the location specific asset price \( Q_t^{X,h} \); through this mechanism, \( n_t^h \) depends on the realization of the location specific shock at \( t \). The term \( \psi_t^B \) represents an AR(1) shock to the returns to bonds issued by the sovereign; this exogenous shock evolves as

\[
\psi_t^B = \rho B_t \psi_{t-1}^B + \varepsilon_t^B
\]

where \( \varepsilon_t^B \) is a white noise shock.

Equation (11) is the flow of funds constraint. Equation (12) is a (regulatory or market) capital constraint, which requires that the weighted sum of bank liabilities (deposits and interbank borrowing) cannot exceed a fraction of bank assets. We introduce three parameters (namely \( \xi_t^B, \xi_t^X \) and \( \xi_t^L \)), capturing weights on each variable on the right hand side of the capital constraint. The term \( \theta_M \) captures the assumption that the interbank borrowing \( m_t^h \) may require less collateral than deposits. A key component of our model is the assumption that banks can monitor their retail loans by employing workers specialized in this activity (e.g., loan officers). Two features of our specification are worth discussion: bank monitoring allows to raise the pledgeability of loans towards investors and bank supervisors as well. In the spirit of Gertler and Karadi (2011), one can think that the larger is the loan monitoring performed by loan officers, the higher is the liquidation value of bank loans in the event of default of a bank. In the real world, the more intensive the monitoring, the lower the share of non-performing loans and the haircuts that banks face in the evaluation of their loans by investors and supervisors. A second relevant feature of our specification is that monitoring applies only to retail loans and not to other assets, such as government bonds. This aims at reflecting the observation that government bonds represent a plain-vanilla asset which is informationally transparent and, hence, does not require monitoring.

Inequality (13) imposes the collateral constraint according to which interbank borrowing cannot exceed the value of sovereign bond holdings (priced at \( Q_t^B \)). The term \( 1/\chi_t \) represents an exogenous shock to the
loan-to-value (LTV, hereafter) ratio in the interbank market with \( \chi_t \) evolving as an AR(1) stationary process:

\[
\chi_t = \rho \chi_{t-1} + \varepsilon_t^X
\]

where \( \varepsilon_t^X \) is a white noise shock.

The timing is as follows: first, the bank chooses deposits, bond holdings and how much labor to hire for monitoring tasks, then idiosyncratic shocks (\( \pi^r \)) to investment opportunities occur in the island. Possible shocks to both interbank market or bond prices occur and then, after this, the bank chooses how much to borrow or lend in the interbank market and the amount of loans to extend to firms.

The bank’s first order conditions are

\[
\begin{align*}
[\partial x_t^h] & : -Q_t^{X,h} \lambda_t^h + \phi \mu_t^h (\xi^X Q_t^{X,h})^\phi (x_t^h)^{\phi-1} (\xi^l A_{2,t} h_t^h)^{1-\phi} + E_t \Lambda_{t,t+1} \sum_{h'} \pi_{h'} (1 + \delta) Q_{t+1}^{X,h'} \psi_{t+1}^{1-\sigma + \sigma \lambda_{t+1}^{h'}} = 0, \\
[\partial m_t^h] & : \lambda_t^h - \theta_M R_t^M \mu_t^h - R_t^M \gamma_t^h - R_t^D E_t \Lambda_{t,t+1} \sum_{h'} \pi_{h'} (1 - \sigma + \sigma \lambda_{t+1}^{h'}) = 0, \\
[\partial d_t] & : \sum_{h} \pi_{h} \lambda_t^h - R_t^D E_t \Lambda_{t,t+1} \sum_{h'} \pi_{h'} (1 - \sigma + \sigma \lambda_{t+1}^{h'}) = 0, \\
[\partial b_t] & : -W_t^L \lambda_t^h + \mu_t^h (1 - \phi) (\xi^X Q_t^{X,h} x_t^h)^{\phi} (\xi^l A_{2,t})^{1-\phi} (h_t^h) = 0, \\
[\partial b_{t+1}] & : -Q_t^B \sum_{h} \pi_{h} \lambda_t^h + \xi^B Q_t^B \sum_{h} \pi_{h} \mu_t^h + \frac{1}{\chi_t} Q_t^B \sum_{h} \pi_{h} \gamma_t^h + E_t \Lambda_{t,t+1} \psi_{t+1}^B \sum_{h'} \pi_{h'} (1 - \sigma + \sigma \lambda_{t+1}^{h'}) = 0.
\end{align*}
\]

Consider (14): Increasing loans tightens the current resource constraint (\( \lambda_t^h \)) but relaxes the next period resource constraint (\( \lambda_{t+1}^{h'} \)). Further, a larger volume of loans tends to relax the bank’s collateral constraint (\( \mu_t^h \)). We index the next period price of shares (\( Q_{t+1}^{X,h} \)) and the expected shadow value of the resource constraint (\( \lambda_{t+1}^{h'} \)) by \( h' \) as their value depend on which island type a bank enters in the subsequent period.

Looking at the optimizing condition for interbank holdings (15), an increased interbank market position relaxes the resource constraint (which has shadow value \( \lambda_t^h \)) and tightens the capital and interbank constraints (with shadow values given by \( \mu_t^h \) and \( \gamma_t^h \), respectively). From (17), hiring more workers in banking activities entails a tighter resource constraint (through the payment of wages to loan officers) but relaxes the capital constraint by raising the pledgeability of loans. The extent of the latter effect hinges on the tightness of the capital constraint, as captured by the multiplier \( \mu_t^h \) associated with it, and on the state-contingent value of loans \( Q_{t+1}^{X,h} \). It is also affected by the regulatory parameters \( \xi^X \) and \( \xi^l \). From (18) a higher sovereign bonds accumulation loosens both capital and interbank constraints, whereas the resource constraint is now tighter. Finally, the return on intermediary assets of type \( h \) is given by

\[
R_{t+1}^{K,h'} = \psi_{t+1} \frac{Z_{t+1} + (1 - \delta) Q_{t+1}^{X,h'}}{Q_t^{X,h}}
\]
where the stochastic rate $R_{t+1}^{K,h'}$ depends on the state of the next period $h'$.

### 3.4 Evolution of banks’ net worth

We use capital letters to denote aggregate quantities and $N$ to denote aggregate net worth. The total net worth for type $h$ banks, $N^h_t$, equals the sum of the net worth of existing bankers $N^h_{ot}$ ($o$ for old) and of entering bankers $N^h_{yt}$ ($y$ for young):

$$N^h_t = N^h_{ot} + N^h_{yt}.$$ 

Net worth of existing bankers equals earnings on assets net debt payments made in the previous period, multiplied by the fraction that survive until the current period, $\sigma$:

$$N^h_{ot} = \sigma_n^{h} \left\{ [Z_t + (1 - \delta)Q_t^{X,h}]\psi_t X_{t-1} + \psi_t^{B_g} B_{t-1} - R_{t-1}^{D} D_{t-1} \right\}.$$ 

Because the arrival of the investment opportunity is independent across time, interbank loans are netted out in the aggregate here. We suppose that the family transfers to each new banker is a fraction $\zeta/(1 - \sigma)$ of the total value of the assets of exiting bankers, implying:

$$N^h_{yt} = \zeta n^h \left\{ [Z_t + (1 - \delta)Q_t^{X,h}]\psi_t X_{t-1} + \psi_t^{B_g} B_{t-1} \right\}.$$ 

Then, the aggregate bank net worth evolves as

$$N^h_t = \pi^h \left\{ (\sigma + \zeta)[Z_t + (1 - \delta)Q_t^{X,h}]\psi_t X_{t-1} + (\sigma + \zeta)\psi_t^{B_g} B_{t-1} - \sigma R_{t-1}^{D} D_{t-1} \right\},$$

where $\zeta$ is the share of assets brought in by the new bankers, and $X_t = X^o_t + X^n_t$.

### 3.5 Government and resource constraint

Output is divided among consumption, investment and government consumption, the latter exogenously fixed at the level $G_t$. In particular, the government consumption follows an AR(1) process

$$G_t = \rho_G G_{t-1} + \varepsilon^G_t$$

where $\varepsilon^G_t$ is a white noise shock. The government expenditures, further, are financed by lump sum taxes ($T_t$) and issuance of government bonds

$$G_t = T_t + Q_t^B B_t - \psi_t^{B_g} B_{t-1}.$$ 

The tax rule is

$$T_t = \overline{T} + \eta (B_t - \overline{B}).$$
where $\eta$ measures the elasticity of taxes to public debt. The social resource constraint is then
\begin{equation}
Y_t = C_t + \left[ 1 + F\left( \frac{I_t}{I_{t-1}} \right) \right] I_t + G_t. \tag{23}
\end{equation}

### 3.6 Equilibrium

In the market for bank securities, total securities issued on investing and non-investing sectors equal aggregate capital acquired by each type:
\begin{align*}
X^i_t &= I_t + (1 - \delta)\pi^i K_t \tag{24} \\
X^n_t &= (1 - \delta)\pi^n K_t. \tag{25}
\end{align*}

The labor market clearing condition for bank workers reads
\begin{equation}
L_t = \sum_h \left[ \frac{(1 - \phi)(\xi^h A_{2,t})^{1-\phi} \mu^h_t}{W^h_t \lambda^h_t} \right] \xi^X Q X^h_t. \tag{26}
\end{equation}
where $L_t = L^i_t + L^n_t$.

Market clearing in the market for interbank loans requires:
\begin{equation}
M^i_t + M^n_t = 0. \tag{27}
\end{equation}

The aggregate bank balance sheet for each type $h \in \{i, n\}$ is given by
\begin{equation}
Q^X X^h_t + \pi^h Q^B B_t = N^h_t + \pi^h D_t + M^h_t - W^h_t \left[ \frac{(1 - \phi)(\xi^h A_{2,t})^{1-\phi} \mu^h_t}{\lambda^h_t} \right] \xi^X Q^X X^h_t. \tag{28}
\end{equation}

The aggregate profit transferred to households reads
\begin{equation}
\Pi_t = Q^i I_t - \left[ 1 + f\left( \frac{I_t}{I_{t-1}} \right) \right] I_t + (1 - \sigma) \sum_h \pi^h \left\{ \left[ Z_t + (1 - \delta)Q^X_t \right] \psi_t X_{t-1} + \psi^B_t B_{t-1} - R_{t-1} D_{t-1} \right\} \\
- \zeta \sum_h \pi^h \left\{ \left[ Z_t + (1 - \delta)Q^X_t \right] \psi_t X_{t-1} + \psi^B_t B_{t-1} \right\}. \tag{29}
\end{equation}

### 4 Results

In this section, we study the impulse responses of our model economy to three selected shocks commonly investigated in the literature on financial frictions: a bond returns shock, a regulatory change in the interbank...
market, and a capital quality shock. Our goal is to shed light on the interplay between banks’ access to liquidity and monitoring effort following the shocks. We are especially interested whether this interaction propagates or attenuates business cycle fluctuations.

### 4.1 Calibration

The model is solved numerically by locally approximating around the non-stochastic steady state. We use fairly standard parameters for preferences, technology and shock processes and choose parameters for the banking sector in line with other studies (see, e.g., Gertler and Kiyotaki, 2011; Gertler and Karadi, 2011). In what follows we describe the parameter values used in the calibration. All parameter values are presented in Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>Discount factor</td>
</tr>
<tr>
<td>$h_g$</td>
<td>0.50</td>
<td>Habit parameter</td>
</tr>
<tr>
<td>$\sigma_c$</td>
<td>1.5</td>
<td>Risk aversion</td>
</tr>
<tr>
<td>$\varphi$</td>
<td>8</td>
<td>Inverse of Frisch elasticity (goods sector)</td>
</tr>
<tr>
<td>$\tau$</td>
<td>2</td>
<td>Inverse of Frisch elasticity (banking sector)</td>
</tr>
<tr>
<td>$k_H$</td>
<td>6</td>
<td>Disutility of labor in goods production</td>
</tr>
<tr>
<td>$k_L$</td>
<td>2</td>
<td>Disutility of labor in monitoring</td>
</tr>
<tr>
<td>Firms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.33</td>
<td>Capital share</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.025</td>
<td>Depreciation rate</td>
</tr>
<tr>
<td>$\phi_K$</td>
<td>2.5</td>
<td>Investment adjustment cost</td>
</tr>
<tr>
<td>Banks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\zeta$</td>
<td>0.003</td>
<td>Transfer to new bankers</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>0.97</td>
<td>Banker survival rate</td>
</tr>
<tr>
<td>$\pi^i$</td>
<td>0.25</td>
<td>Probability of new investment opportunities</td>
</tr>
<tr>
<td>$\phi$</td>
<td>0.33</td>
<td>Cobb-Douglas parameter loans production function</td>
</tr>
<tr>
<td>$\theta_M$</td>
<td>0.60</td>
<td>Weight on interbank loans</td>
</tr>
<tr>
<td>$\xi^l$</td>
<td>3.5</td>
<td>Shifter labor</td>
</tr>
<tr>
<td>$\xi^x$</td>
<td>2</td>
<td>Shifter shares</td>
</tr>
<tr>
<td>$\xi^b$</td>
<td>2</td>
<td>Shifter bonds</td>
</tr>
<tr>
<td>Government</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta$</td>
<td>1.05</td>
<td>Elasticity of taxes to public debt</td>
</tr>
<tr>
<td>$G/Y$</td>
<td>0.18</td>
<td>Steady-state public spending over GDP</td>
</tr>
<tr>
<td>$T/Y$</td>
<td>0.20</td>
<td>Steady-state taxes over GDP</td>
</tr>
</tbody>
</table>
The discount factor $\beta$ is calibrated to 0.99 implying a yearly steady state deposit rate ($R^D$) of around 4%. Parameters affecting the utility function are calibrated according to empirical estimates of DSGE models (see, e.g., Smets and Wouters, 2003; Justiniano et al., 2013).

The parameters that govern the frictions in interbank markets are chosen based on Gertler and Kiyotaki (2011). Thus, it is assumed that one fourth of the sectors face investment opportunities ($\pi^i = 0.25$), that the survival rate of bankers is $\sigma = 0.97$ (implying that bankers survive for eight years on average), and that the transfer to entering bankers $\zeta = 0.003$.

In the production sector, the effective share and depreciation rate of capital are set to the standard values of $\alpha = 0.33$ and $\delta = 0.025$, respectively. These values imply a labor share equal to 66% and annual depreciation rate of capital of 10%. The investment adjustment cost is instead calibrated to 2.5. The parameters measuring the disutility of labor for both types and the coefficients $\xi^l, \xi^X, \xi^B$ are calibrated to meet a leverage in the investing islands of about 8, a value consistent with the bank leverage for the United States in the FRED database and observed for a broad range of economies. For example, the World Development Indicators database reveals that, on average, in the 2013-2017 period aggregate bank leverage equaled 8.33 in countries of Europe and Central Asia (excluding high-income countries); in the same region, in 2017 aggregate bank leverage equaled 8.5. For all low and middle income countries, aggregate bank leverage equaled 8.72 in 2017. The government great ratios are calibrated to values commonly used in literature.

4.2 Shocks to banks’ access to liquidity

In this section, we first study the effects of a negative 1% shock to bond quality, $\psi^{B,s}$, that exogenously lowers the value of sovereign bonds. The persistence of the shock, $\rho_{B,s}$, is calibrated to 0.75. For our experiment we compare our model with an alternative scenario in which the loan monitoring channel is switched off. In Figure 1, the green dotted lines are the IRFs generated by our model, whereas the continuous red lines are
the IRFs associated with the comparison model.

A negative shock to bonds quality has impacts on bank monitoring decisions through the two mechanisms discussed above: the tighteness of liquidity constraints and the productivity of monitoring associated with the value of banks' shares.

The shock implies that sovereign bonds are less desirable and, hence, lowers the demand for bonds and their market price. Then, the nominal value of the bond portfolio held by banks drops. In our framework, bonds serve as collateral in the interbank market and the fall in the value of bond holdings tightens banks' collateral constraint, limiting their ability to obtain liquidity in the interbank market. This can be observed by looking at the IRF of the Lagrangian multiplier associated with the interbank collateral constraint ($\gamma_t$), which rises following the shock. The tightening of the interbank market constraint boosts banks' appetite for liquidity in the retail market, as it can be observed from the rising value of the Lagrangian multiplier associated with the capital constraint ($\mu_t$). The tighter capital constraint, in turn, raises banks' incentive to monitor loans in order to gain easier access to the retail funding market. Put differently, as now banks face a stricter capital constraint, they have a stronger incentive to partially relax it by increasing loan monitoring effort. Note that, in quantitative terms, the increase in monitoring activity is such that it counterbalances the drop in the bonds portfolio held by banks. A further remark is that the drop in the value of shares held by banks tends to reduce the marginal productivity of labor in bank monitoring activities (see eq. 15).
12) reducing banks’ incentive to monitor. This mechanism tends to contrast the increase in monitoring incentives described above. Nonetheless, the reduced incentive to monitor, due to its lower productivity, is largely outweighed by the increased incentive to monitor that permits to alleviate the tighter capital constraint. This depends on the fact that the reduction in bond returns induces bank to switch towards firms shares dampening the contraction in their demand and value. Thus, the net effect of the shock is that labor in monitoring services increases. In fact, the percentage fall in the value of shares is smaller than the observed increase in the constraints faced by banks. From an aggregate point of view, credit extension to the production sector is facilitated by the response of banks’ monitoring and investment and output decrease less than in the model where the bank monitoring channel is absent. To summarize, following a negative bonds return shock, bank access to wholesale funding liquidity and loan monitoring behave as substitute. Put differently, endogenous loan monitoring acts an attenuator mechanism that dampens the impact of an adverse bond quality shock on the real economy. By employing more workers in monitoring services, banks can partially relax their funding constraints, ultimately easing liquidity provision to non-financial borrowers.

In Figure 2, we plot the IRFs to an exogenous tightening regulation in the interbank market, consisting of a reduction in the interbank LTV.

![Figure 2 - Negative regulatory shock.](image)

Again, we can read the effects of the shock through the lenses of the two mechanisms aforementioned. The tighter LTV raises the value of the Lagrangian multiplier on the interbank collateral constraint. The
The usefulness of bonds as collateral is now enhanced, pushing up firms’ demand for bonds. This explains the increase in the price and value of bond holdings. Regardless, the interbank market position shrinks (see the response of the multiplier associated with the interbank constraint), suggesting that the direct effect of the tighter LTV dominates over the increase in the value of collateralizable bonds. To understand the response of banks’ monitoring, let us now turn to the capital constraint. The contraction in the access to interbank funds tends to raise the demand for retail liquidity, thus tightening the capital constraint. On the other hand, the increase in the value of bond holdings tends to raise the right hand side of the capital constraint, thus relaxing it. The response of the multiplier depends on the interplay between these two forces. The IRF shows that on impact the multiplier slightly rises. In later periods, however, the relaxing effect gains strength and the multiplier falls below its steady state value. Looking at monitoring productivity effect, we observe that here the value of shares held by banks drop, on impact, more strongly than in the case of a negative bond return shock. Unlike in that shock, there is no incentive to switch to firms’ shares as bond returns do not drop and, actually, there is an increased demand for them as collateral in the interbank operations.

Relative to the bond quality shock, the response of the multiplier on the capital constraint (liquidity effect) and the larger drop in the value of shares (productivity effect) trigger an ambiguous dynamic response of bank monitoring, that initially rises for some periods and then falls below the steady state, mapping one-by-one the dynamics exhibited by the capital constraint. This response is different from that generated by a bond quality shock, which pointed unambiguously to an increase in the bank monitoring. Nonetheless, banks’ monitoring is still a shock attenuator to some extent, although in the long run, it can act as an amplifier. Overall, shareholdings, investment and capital drop, dragging output down. Compared with the case of a bond quality shock, here the attenuating benefits from monitoring are much more pronounced, as revealed by the difference between the IRFs for output and investment in the two scenario analyzed.

### 4.3 Capital quality shocks

We now turn to study the response of the economy to a negative capital quality shock that induces a drop in the value of capital assets and, hence, in the net worth of banks. The impulse response functions are shown in Figure 3.
Following the shock, banks experience a drop in their net worth. This hit to their capitalization significantly tightens their capital constraints, as reflected in the steep rise of the associated Lagrange multiplier. The increase in the capital constraint is about ten times larger compared with the shocks analyzed above. Through this channel their incentive to monitor is significantly enhanced. In the opposite direction, the erosion in the value of their shares pushes down their monitoring incentives. As the figure reveals, monitoring rises sizeably following the shock, suggesting that the former mechanism dominates over the latter. This depends on the fact that the restriction of the liquidity constraints faced by the bank is quantitatively stronger than the fall of the shares value. Overall, bank monitoring would appear to be an important attenuator of the capital shock. However, the increase in monitoring is not sufficient to help the economic recovery and the real variables, i.e., output and investment, go down more than in the model without monitoring.

5 Credit policies

In this section we study how credit policies recently implemented by central banks during liquidity crises interact with the bank monitoring channel. We consider three types of policy interventions: direct lending to nonfinancial borrowers, provision of liquidity facilities to intermediaries in the interbank market, and equity
injections. The central bank finances these policies by issuing bonds to households, say \(D_{G,t}\), that are perfect substitutes of deposits and not usable in interbank operations. This bears a riskless rate \(R^D_{G,t}\).

The first two policies we present consist of direct lending to the private sector. In a first scenario the central bank directly lends to nonfinancial firms by demanding their shares; in the second, it provides noncollateralized liquidity to banks in the interbank market. We start by analyzing direct lending to nonfinancial firms. Under this policy the central bank purchases firms’ shares at a price possibly different from the market price, which is contingent on the island type (this implicitly defines a state contingent lending rate \(R^{K,h'}_{t+1}\)). The central bank has two advantages with respect to private intermediaries: it is not balance sheet constrained and it can lend in whatever market, unlike banks that can only acquire shares of firms located on their same island. Nonetheless, we assume that the central bank is less efficient than private intermediaries in channeling funds and has to sustain a cost equal to \(\%L\) for each unity supplied. This can capture costs for evaluating and screening borrowers or, alternatively, for issuing government debt.

We denote by \(Q^{X,h}x_{P,t}^h\) the total value of intermediated assets of type \(h\). The direct lending provision by the central bank involves that the total value of intermediation is now

\[
Q^{X,h}x_{P,t}^h = Q^{X,h}x_{P,t}^h + Q^{X,h}x_{G,t}^h
\]

(30)

where \(Q^{X,h}x_{P,t}^h\) is the total value of type \(h\) assets privately intermediated, whereas \(Q^{X,h}x_{G,t}^h\) is the value of type \(h\) assets intermediated by the central bank. We assume that the quantity of direct lending is a fraction \(\Phi_t\) of total intermediated assets

\[
x_{G,t}^h = \Phi_tx_t^h
\]

(31)

\(\Phi_t\) can be thought as the instrument used by the central bank to implement this policy. In each period \(t\), the central bank receives a net revenue from this policy given by

\[
(R^{K,h'}_{t+1} - R^D_{t})D_{G,t} > 0
\]

(32)

A second policy involves the central bank’s provision of uncollateralized funds \((m^{G,h}_t)\) to banks operating in the interbank market. Then, banks’ collateral constraint becomes

\[
R^M_t (m^h_t - m^{G,h}_t) \leq \frac{1}{\chi_t}Q^Bb_t.
\]

(33)

Banks’ resource constraint is then modified as

\[
Q^{X,h}x_{P,t}^h + Q^Bb_t = n^h_t + d_t + m^{P,h}_t + m^{G,h}_t - W^{L,h}_t
\]

(34)

where \(m^{P,h}_t\) denotes the funds privately intermediated on the interbank market. In turn, banks’ capital constraint becomes

\[
R^D_t d_t + \theta MR^M_t m^{P,h}_t + \theta_G R^M_t m^{G,h}_t \leq \xi B Q^Bb_t + (\xi X Q^{X,h}x_{P,t}^h)(\xi A^{L,h}_t)^{1-\phi}
\]

(35)
where $\theta_G$ is a parameter capturing the assumption that the funds injected by the government may require less capital than deposits. The net worth for bank of type $h$ must account for the liquidity provided by the government at time $t-1$

$$
n^h_t = [Z_t + (1-\delta)Q^{X,h}_t] \psi_t x_{t-1} + \psi_t^{B_t} b_{t-1} - R_t^D d_{t-1} - R_t^M m_{t-1}
$$

(36)

The last policy we consider are equity injections. This consists of purchases of assets held by banks, again at a price possibly higher than the market. Equity injections are conducted before the realization of the idiosyncratic shock that assigns investment opportunities to the different islands, i.e., before banks learn whether their clients received the opportunity to invest or not. This way we capture the slower efficacy of equity injections. At time $t$ a bank holds an amount of shares given by

$$
x_t = x_{P,t} + x_{G,t}
$$

(37)

where $x_{P,t}$ are shares privately owned whereas $x_{G,t}$ denotes the shares owned by the government. The balance sheet of the bank must now include the term $n^G_t = Q^X_t x_{G,t}$ that denotes the market value of government equity

$$
Q^X_t x_t + Q^B_t b_t = n_t + d_t + m_t - W^L_t l_t + n^G_t
$$

(38)

The price paid by the government to acquire shares, $Q^{X,G}_t$, is above the market price, i.e., $Q^{X,G}_t > Q^X_t$. Thus, the government makes a transfer to banks by paying a premium over the market price. Banks’ capital constraint becomes

$$
R_t^D d_t + \theta_M R_t^M m_t \leq \xi B_t Q^B_t b_t + [\xi Q^X_t (x_t - x_{G,t})]^{\phi}(\xi A_{2,t} l_t)^{1-\phi} + \xi Q^{X,G}_t x_{G,t}
$$

(39)

Note that banks monitor only the amount of shares that they effectively own ($x_t - x_{G,t} = x_{P,t}$). The net worth of the bank must include also the transfer from the government

$$
n_t = [Z_t + (1-\delta)Q^{X,h}_t] \psi_t x_{t-1} + \psi_t^{B_t} b_{t-1} - R_t^D d_{t-1} - R_t^M m_{t-1} + (Q^{X,G}_t - Q^X_t)[x_{G,t} - (1-\delta)\psi_t x_{G,t-1}]
$$

(40)

where $(Q^{X,G}_t - Q^X_t)[x_{G,t} - (1-\delta)\psi_t x_{G,t-1}]$ is the government transfer.

Finally, we have to specify the instrument rule followed by the central bank to implement its credit policy. As during a crisis we observe a rise of credit spreads (see, e.g., Gilchrist et al., 2009), we suppose that the central bank adopts a feedback rule implying that liquidity is injected in the market when credit spreads overcome a certain threshold:

$$
\Phi_t = \Phi + vE[(R^{K,h'}_{t+1} - R^D_t) - (R^{K,h'} - R^D)]
$$

(41)

where $\Phi$ denotes the steady state fraction of assets intermediated by the government, $R^{K,h'} - R^D$ indicates

---

9 Note that given the assumption that equity injection are provided before the realization of the idiosyncratic shock, variables are not indexed to $h$. 

---
the steady state external finance premium, and, finally, $v$ is a positive feedback parameter measuring the extent to which central bank expands credit in response to credit spreads increase. Thus, the central bank pursues a credit policy when credit spreads are higher than their steady state counterpart.

The impulse responses for the direct lending policies are presented in the following figure; the parameter $v$ is calibrated to 5. The dynamic responses associated with the other credit policies presented above are instead reported in the Appendix.

![Figure 4 - Effects of direct lending credit policy.](image)

To understand the effects of direct lending, we have again to look at the dynamics of liquidity constraints and of the shares value. On impact relative to a baseline economy, the implementation of direct lending moderates the tightening of banks’ capital constraint, as shown by the smaller increase (or even decreases) of the lagrange multipliers. This effect attenuates the banks incentive to monitor loans to relax the liquidity constraints. Therefore, at least on impact, while having a direct beneficial effect on the real side of the economy it also dilutes the stabilizing function of monitoring in the wake of tighter liquidity. However, over the medium-long run this side effect of the policy loses relevance and the depressing effect of the policy on monitoring vanishes. Indeed, the IRFs show that in the economy with direct lending, monitoring remains
slightly above its baseline economy level for various periods. This is the result of both the liquidity effect and monitoring productivity effect. Regarding the former, the tightness of the liquidity constraint tends to converge to that of the baseline economy in the medium-long run. Regarding the latter, the higher shares values induced by the direct lending policy, promote the banks incentive to monitor. To summarize, the results reveal that direct lending may have an unintended consequences in terms of weaker banks monitoring. Yet, such effects are relatively short-lead and in the long-run the credit policy retains only its direct output-stabilizing role. In the Appendix, we show that the insights drawn from the direct lending experiment, carry through the other credit policies. Importantly, however, we observe that the diluting effects on monitoring in the short-run can be either more or less pronounced under interbank lending and equity injections conditional to the shock considered. This suggests that a policymaker concerned about side effects of credit policies associated with bank monitoring behavior should privilege, for each shock, the policy for which the side effect is less pronounced.

The figure below plot the dynamic response of labor monitoring under a bond quality shock for the three policy considered in this section. It can be easily observed that labor monitoring is less intensive when the credit policy is implemented as the capital constraint is partially alleviated. In the medium-long run banks produce more effort in monitoring loans as the real effects originated by the credit policy tend to vanish.

Figure 5 - Labor monitoring response for the three credit policies (negative bond return shock).

6 Extensions: Relationship Lending

We extend the main model by introducing relationship lending in the loan retail market. The banking literature finds that credit relationships influence banks’ ability and incentive to monitor loans (see, e.g., Ongena and Smith, 2001; Santos and Winton, 2008; Aliaga-Díaz and Olivero, 2010; and Sette and Gobbi, 2015). It is then natural to examine how this can affect our baseline results.

We introduce firm-bank relationships in the retail loan market in a similar way as Aliaga-Díaz and Olivero (2010). In particular, we model relationship lending in the form of habits in the Cobb-Douglas function for shares holdings and loan monitoring. This allows to capture a notion of experience of the bank about its loan portfolio, which in turn affects the pledgeability and liquidity of loans. We capture the contribution of banks’ experience to loan pledgeability through the habit parameter \( h_x \). The stock of firm-bank relationships \( x_h^t \), which in turn reflects the stock of experience of the bank, evolves according to a standard law of motion.
The bank’s optimization problem becomes:

\[
V_t = \max_{d_t, b_t, t_t^h, x_t^h, m_t^h, s_t^h} \sum_{j=1}^{\infty} (1 - \sigma)^{j-1} A_{t, t+j} n_{t+j}^h
\]

s.t. \[ Q_t^X x_t^h + Q_t^B b_t = n_t^h + d_t + m_t^h - W_t t_t^h \]

\[ R_t^B d_t + \theta_M R_t^M m_t^h \leq \xi^B Q_t^B b_t + [\xi^X Q_t^X(x_t^h + h_t s_{t-1})]^{\phi} (\xi^A A_{2, t+t_t^h})^{1-\phi} \]

\[ R_t^M m_t^h \leq \frac{1}{\lambda_t} Q_t^B b_t \]

\[ s_t^h = \rho_s s_{t-1} + (1 - \rho_s) x_t^h \]

Relative to the baseline specification, equation (43) for the capital constraint now embeds relationship lending (in the form of superficial habits) between banks and their clients. Precisely, the pledgeability of shares issued by non-financial firms now depends on past levels of loans. The variable \( s_{t-1} \) represents the past stock of relationships between borrowing firms and banks. The new constraint (45) is the law of motion of the stock of relationships, where \( \rho_s \) denotes the persistence in the stock of habits. In the calibration, the habit \( h_x \) in firm-bank relationships is set to 0.7, a value consistent with the estimates by Aliaga-Díaz and Olivero (2010). We choose a value of 0.85 for the persistence of the relationship lending effects.

To study the implications of relationship lending, we compare the IRFs generated by the baseline model with those in the extended version with firm-bank relationships (see eqs. 42-45). We conduct two exercises. First, we compare the IRFs in the baseline model in the cases with and without relationship lending. This comparison captures the direct effect of credit relationships in boosting or attenuating the effect of shocks. Second, we study how the bank monitoring channel and relationship lending interact along the business cycle. To this end, we present IRFs that are obtained as the difference between the dynamic response of a model with monitoring services and a model without monitoring for two polar cases: with and without credit relationships. This helps understand the role played by bank monitoring services as an “attenuator” or “amplifier” depending on the intensity of relationship lending in the retail loan market.

Our graphs should be interpreted as follows: a positive (negative) IRFs (expressed in this case as differences) signals that loan monitoring dampens (magnifies) the negative effects of a shock. Then, a larger positive horizontal difference, say under relationship lending, reveals that the attenuating role played by monitoring is stronger under credit relationships. The red continuous lines refer to the dynamic responses of the model with relationship lending, whereas the green dotted lines are the difference IRFs for the baseline model \((h_x = 0)\).

We start by showing the direct effects of relationship lending following a bond quality shock. In Figure 6 we plot the IRFs generated by a model featuring monitoring in banking; the green dotted lines are the dynamic responses of our baseline model, while the red continuous lines depict the variables’ responses under loan relationships. We detect two effects, one direct and the other indirect: relationship lending directly works towards attenuating the tightening of the collateral constraint, moderating the disruption of credit and the fall in real activity. Nonetheless, there is also an indirect effect working in the opposite direction.
This is due to the reduced incentive of banks to step up loan monitoring following the shock, due to a looser capital constraint.

The effects associated with a regulatory shock are illustrated in the figure below. Introducing loan relationships implies that the interbank constraint tightens less relative to the case without credit relationships. Accordingly, the appetite for sovereign bonds is smaller, because there is less need of collateral to pledge in the interbank market. Then, the bonds value goes up less and, ultimately, the capital constraint tightens more. In contrast with what found for the bond quality shock, the direct effect of credit relationships is thus to magnify the impact of the regulatory shock on the real activity.\textsuperscript{10}

The second part of our analysis aims to pin down the joint role of relationship lending and labor monitoring. In the figure below we report the results of our simulations for both the bond quality and regulatory shocks. Looking at the dynamics of real variables, i.e., output and investment, we observe that the green dotted line lies above the red continuous line, implying that the mitigating role played by labor monitoring is stronger when credit relationships are absent. Thus, the indirect effect of credit relationships works to undermine the stabilizing role of bank monitoring.

\textsuperscript{10} In the Appendix we present the results for the capital quality shock.
6.1 Relationship lending in the interbank market

We experimented with an alternative notion of relationship lending, that is credit relationships in the interbank market. A growing number of studies underscore that banks establish long-term relationships one with another in the interbank market, just like they do with firms in the retail loan market (see, e.g., Bräuning and Fecht, 2017; Cocco et al., 2009; Temizsoy et al., 2015). This literature finds that interbank market relationships act as a substitute for collateral reducing the need for banks to post collateral vis-a-vis interbank lenders. To capture such a kind of relationships and investigate their effects on the bank monitoring channel, we modify the interbank market borrowing constraint in the following way:

\[
R^M_t (m_t^h - h_m s_{t-1}^m) \leq \frac{1}{\lambda_t} Q_t^R b_t [\sigma \pi^h \gamma^h_t] \\
s_t^{m,h} = \rho_s s_{t-1}^m + (1 - \rho_s) m_t^h [\sigma \pi^h \nu_t^h]
\]

Both the direct effect of relationship lending and the interaction between relationship lending and labor monitoring are similar to those explained in the previous subsections; results are reported in the Appendix.
7 Conclusion

In this paper we have studied the interaction between bank liquidity and loan monitoring over the business cycle. The analysis is motivated by various phenomena that in the long run are deepening the markets for bank liquidity. On the regulatory front, also in the wake of the Great Recession, effort has been made to facilitate banks’ access to wholesale funding markets. On the banking side, banks’ increasing tendency to accumulate large holdings of sovereign bonds has allegedly expanded their collateral and debt capacity in interbank markets, while leaving banks exposed to swings in the price of sovereign bonds.

Our empirical analysis conducted with bank-level U.S. data showed pervasive substitution effects between banks’ access to liquidity and bank monitoring, especially during recessionary periods. To rationalize these findings, we constructed a DSGE model with a banking sector that features active loan monitoring and limited access to liquidity, due to borrowing constraints in both the retail and the wholesale funding markets. The model economy also includes a government that issues bonds, used as collateral by banks in the wholesale market.

The model reveals that bank monitoring and liquidity tend to comove negatively following recessionary shocks. However, it also shows that such a substitutability is more pronounced when the shocks take the form of contractions in the value of interbank collateral. Indeed, following tighter regulation, the loss of access to wholesale liquidity can even lead banks to monitor less intensely (i.e., monitoring and liquidity become complement). We have explained these findings with the interaction between two key channels: a liquidity channel, whereby changes in access to liquidity alter directly banks’ incentive to monitor to retain this access; and a monitoring productivity channel, whereby changes in the value of loans influence the marginal contribution of monitoring in enhancing loan pledgeability.

The analysis also reveals that policy and structural factors, traditionally viewed as stabilizing forces in the wake of recessionary shocks, may however have unintended consequences in terms in dilution of bank monitoring incentives during the recessions. Regarding the credit market structure, credit relationships mitigate the effects of shocks but also diminish the substitutability between bank liquidity and monitoring. On the policy front, credit interventions aimed at sustaining banks’ access to liquidity also dilute bank monitoring, at least in the short run.

The analysis leaves important questions open to future research. In this paper, we have deliberately abstracted from monetary policy. However, a natural question is how monetary policy could influence the interaction between bank monitoring and liquidity. This might also help shed light on the impact that wholesale market regulations can have on the effectiveness of monetary policy. We leave this and other issues to future research.

References


Appendix A – Government budget constraint and central bank policy

Introducing credit policies involves that the social resource constraint must be augmented for the expenditure in government intermediation, i.e., $\varphi t Q_t^{X,h} X^h_t$. Then, the social resource constraint (23) now reads as follows

$$Y_t = C_t + \left[ 1 + F \left( \frac{I_t}{I_{t-1}} \right) \right] I_t + G_t + \varphi t Q_t^{X,h} X^h_t$$  \hspace{1cm} (48)

Implementing a credit policy provides net earnings to the government and these must be accounted in the government budget constraint. Therefore, government expenditures are financed by lump-sum taxes, government bonds issuance, and net earnings from credit market interventions

$$G_t + \varphi t Q_t^{X,h} X^h_t = T_t + Q_t^B B_t + \psi_t^R B_{t-1} + (R_t^{K,h} - R_t^D) D_{G,t-1}$$ \hspace{1cm} (49)

Now, the right hand side of (49) include also the government intermediation $\varphi t Q_t^{X,h} X^h_t$ net of efficiency cost, whereas the left hand side of (49) accounts for the net earnings obtained by the government and represented by the differential between the rate on intermediate assets of type $h$, $R_t^{K,h}$, and the riskless rate, $R_t^D$.

We now consider how bank monitoring and liquidity interact when the central bank implements a credit policy based on liquidity provision in the interbank market. The figure below plots the IRFs of the capital
constraint, shares value and output for the three shocks considered in our analysis.

Figure 9 - Dynamic effects of a liquidity provision.

Results are similar to those described in Section 5. In fact, pursuing a liquidity provision policy involves that the banks’ capital constraint is less strict compared with the baseline economy and this induces an attenuation of the incentive to monitor. Differently from the direct lending, the positive effects on real variables, i.e., on output, transmits after some quarters.
Finally, in the figure below, we show the dynamics response of our model to an equity injection.

![Figure 10 - Dynamic effects of an equity injection.](image)

Even in this case, the credit policy involves that output falls less compared with the baseline case. The capital constraint is either less tight or relaxed and this entails that bank monitors to a lower extent. The value of the shares falls less and, thus, the productivity effect is less pronounced involving that the disincentive to monitor is reduced compared with the baseline case. However, the liquidity effect dominates the liquidity effect and banks are then more lazy to monitor loans.

**Appendix B – Relationships lending**

Here, we show the dynamics generated by a capital quality shock under relationship lending. A direct shock to the capital value tightens the collateral constraint. However, the presence of loan relationships leads the capital constraint to tighten less and, accordingly, the fall of investment and output is mitigated. The incentive to monitor loans depends on the need to make them more liquid and closely follows the path of the capital constraint: as the constraint is less strict under credit relationships, banks initially hire fewer loans.
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In the figure below, we study how relationships lending affect the model dynamics when a negative capital quality shock hits the economy. In this case the loan monitoring exacerbates the crisis as the IRFs in difference are negative. Moreover, as the red line, which refers to the model including loan monitoring, lies always above the green line, relationships lending work as an attenuator of the negative effects associated with loan monitoring.

In what follows we show the direct and indirect effects of relationship lending in the interbank markets. We start our analysis from the bond quality shock. Credit relationships on the interbank market tighents less the collateral constraint. The capital constraint on impact tightens less and, after some periods, becomes stricter than in the case where loans relationships are absent. Thus, banks initially monitors less than in the baseline case and then, following the dynamics of the capital constraint, produce relative more effort in banking activities. The direct effect of this form of credit relationship is that it initially mitigates the effects of a recession, but in the short run the fall of the real variables is stronger.
We now turn to show the dynamics response of our model with credit relationships on the interbank market to a regulatory shock. IRFs are plot in the figure below.

As shown in Figure 14, the effects associated with a negative regulatory shocks are more or less similar with those arising under a bond quality shock. In fact, credit relationships on the interbank funding market initially attenuates the effect of the shock and, then, magnifies it.

We finally discuss the capital quality shock. As the figure below shows, the presence of loan relationship on interbank operations does not change the IRFs of labor monitoring and real variable that are similar to
those plotted in Figure 11.

![Figure 15 - Direct effect of relationship lending in the interbank market (capital quality shock).](image)

Figure 15 - Direct effect of relationship lending in the interbank market (capital quality shock).

As explained in Section 6.1, the joint role of credit relationships and labor monitoring can be evaluated by investigating the IRFs taken in difference (see Figure 16). Comparing the dynamics depicted in the figure below with those arising in Figure 10 and 12 we can observe that the indirect effect of relationship lending in interbank market is overall similar to that of having credit relationships on the retail market.
Figure 16 - Indirect role of relationship lending (interbank market).