Bank Due Diligence in the Business Cycle*

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Abstract

Fluctuations in banks' due diligence are increasingly viewed as a force driving the buildup and unfolding of crises. In a dynamic general equilibrium model, we show that banks' access to retail and wholesale liquidity and the values of loan portfolios govern banks' incentives and effectiveness in producing information on loans. A calibration to U.S. data reveals that due diligence deteriorates during expansions and intensifies during contractions. This countercyclicality attenuates funding liquidity shocks but can amplify shocks to loan values. Credit policies may dilute stabilizing effects of due diligence. The predictions are consistent with granular loan-level evidence from U.S. banks.

JEL classification: E32, E44, G21

Keywords: Banks' due diligence; Business cycles; Liquidity; Information.

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Abstract

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1 Introduction

Banks perform fundamental functions in the economy. Among their activities, they intermediate liquidity between savers and borrowers and they perform due diligence and information production on loans, a function that differentiates them from dispersed capital market investors (Allen and Gale, 2000; Degryse et al., 2009). Banks' access to liquidity is of primary importance in their intermediation activity (Acharya and Mora, 2015). During the Great Recession, a liquidity dry-up in the U.S. markets for wholesale funding (e.g., interbank deposits and repos) acted as a transmission mechanism of the financial crisis. During the European sovereign debt crisis, tight constraints in interbank markets, driven by a drop in the values of collateralizable government bonds, triggered a collapse in banks' intermediation capacity. These events pushed central banks to implement unconventional policies to restore the flow of liquidity to the banking sector. Banks' access to liquidity is also a primary driver of their intermediation activity during expansions. Easy access to funding

liquidity promoted a major growth of bank lending in the years preceding the Great Recession (Bernanke, 2009).

While the role of banks' access to liquidity is well established, less is known about the way this interacts with banks' activity of information production and due diligence on loans. And yet this continuous activity of loan assessment is critical for banks' access to funding liquidity. Banks produce a wealth of information (e.g., credit scores and ratings, risk models, financial statements, borrower assessments and reports) that certifies their financial status and regulatory compliance to bank supervisors and financiers, shaping their access to liquidity (BIS, 2015; Barth et al., 2004; Berger and Udell, 2006; Lisowsky et al., 2017).¹ Like banks' access to liquidity, banks' due diligence effort appears to exhibit pronounced variation over the business cycle. In the liquidity frenzy preceding the Great Recession, many observers pointed to the inadequate due diligence performed by banks on their expanding loan portfolios. Several banking studies find that booming liquidity may indeed dilute banks' incentives to undertake information production on loans (Lisowsky et al., 2017; Ruckes, 2004; Dell'Ariccia and Marquez, 2006; Becker et al., 2016), while banks appear to step up their due diligence effort during contractions (Lisowsky et al., 2017; Becker et al., 2016).

These considerations elicit fundamental questions: what forces drive banks' due diligence over the business cycle? How does banks' due diligence interact with banks' access to funding liquidity, and what role does this interaction play in business cycle transmission? To address these questions, we first present motivational evidence on banks' due diligence activities by hand-matching granular loan-level data from the U.S. syndicated market with bank-level data. Using a proxy for banks' due diligence effort often considered in the empirical banking literature, the fraction of loans retained by banks in the syndicated market, we document significant time variation of due diligence efforts in the U.S. banking sector over the 1996-2015 period.² We then find that banks perform more due diligence during contractions, especially if they have poor access to wholesale liquidity.

Motivated by these empirical observations, we build a dynamic stochastic general equilibrium model in which banks intermediate liquidity between households and firms. Following prior studies (e.g., Gertler and Kiyotaki, 2010; Gertler and

¹See, e.g., BIS (2015) for a detailed description of the way banks' due diligence output gets incorporated by bank supervisors in the assessment of banks' regulatory compliance.

²See, e.g., Sufi (2007) and Section 3 for more on this proxy.

Karadi, 2011; Bernanke and Gertler, 1987), banks face constraints when gathering retail and wholesale liquidity. These constraints limit the value of banks' retail deposits and interbank borrowing not to exceed the pledgeable value of their assets (loans and government bond holdings). As in previous studies (e.g., Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011), collateral constraints stem from a moral hazard of banks, which can divert their assets away from their financiers (strategic default). The key departure from previous studies is that, building on micro-oriented banking literature (e.g., Diamond and Rajan, 2001, 2005), we stress the information sensitivity of loans and let banks perform information production (due diligence) on loan portfolios. This costly due diligence affects the loan recovery value expected by bank supervisors and financiers in the event of bank strategic default and, hence, the value of loans pledgeable in liquidity markets. We show that two main mechanisms drive banks' due diligence effort over the business cycle: the tightness of wholesale and retail liquidity constraints ("liquidity channel"); and the marginal product of banks' due diligence effort, governed by the value of assessed loan portfolios ("information productivity channel"). Tighter liquidity pushes banks to perform more intense due diligence to enhance the pledgeability of loans and restore the access to liquidity; larger values of loan portfolios increase the productivity of loan assessment and, hence, due diligence incentives. The liquidity and information productivity channels also govern the impact of banks' due diligence on the aggregate economy.

We calibrate the model to data on the U.S. economy and to the U.S. banking data used in the empirical analysis. We then simulate the response to shocks to investigate how banks' due diligence behaves over the business cycle and affects business cycle transmission. The main results can be summarized as follows. Banks' due diligence effort deteriorates when bank lending and output expand, progressively eroding the recovery and pledgeable values of loan portfolios. By contrast, due diligence strengthens during contractions, sustaining loan recovery and pledgeable values. The model thus matches our empirical findings and the view that in liquidity booms banks become less diligent in producing information on loans, while they step up due diligence during contractions (e.g., Dell'Ariccia and Marquez, 2006; Lisowsky et al., 2017; Ruckes, 2004). As for the aggregate implications of this countercyclical due diligence, the model predicts an ambiguous impact on business cycle transmission: following a contractionary shock, for example, the countercyclical movement of banks' due diligence can attenuate the response of investment and output or

moderately amplify it, depending on the source of the shock.

Specifically, the first two shocks we consider influence banks' access to funding liquidity. The first shock alters the pledgeable value of government bonds. The second shock captures regulatory reforms that modify banks' access to wholesale liquidity markets.³ We find that, by reducing the pledgeability of government bonds, a negative bond value shock significantly boosts banks' "hunger" for liquidity (liquidity channel), while mildly shrinking the value of assessed loans (information productivity channel). The net effect is an increase in banks' incentive to perform loan due diligence. In turn, despite the reduced information productivity due to the diminished value of assessed loans, banks' enhanced due diligence attenuates the contraction of credit, investment and output. The effects of a restrictive regulatory shock to collateral pledgeability in the wholesale liquidity market are similar, though more nuanced. This shock tightens liquidity constraints by less, and more significantly erodes the value of assessed loans. As a result, on impact it incentivizes banks' due diligence, but in later periods banks reduce their loan assessment effort. However, in spite of its less pronounced countercyclical behavior, banks' due diligence retains a role in attenuating the shock.

The interplay between the liquidity channel and the information productivity channel has different aggregate consequences following a shock to loan portfolio values (capital quality shock). This significantly erodes the value of bank loans and, hence, the productivity of banks' information collection. While it is still the case that banks' due diligence intensifies, its lower productivity can make the increasing due diligence an amplifier, rather than an attenuator, of the shock. In particular, costly due diligence activities can end up draining resources from banks more than easing their access to funding liquidity.

The quantitative relevance of the effects is sizeable. Calibrating the magnitude of the contractionary shocks to match the effect of recent aggregate shocks on key banking indicators, the increase in banks' due diligence ranges from 10% to 20% on impact. Following the negative liquidity shocks, the model predicts that a 1% larger increase in banks' due diligence in each quarter is associated with drops of investment and output between 2.7% and 5.6% smaller over a four year horizon. Following the negative capital quality shock, the investment and output drops are

³For instance, following the Dodd-Frank Act, in 2011 the U.S. Federal Deposit Insurance Corporation (FDIC) implemented regulatory changes that altered banks' costs in accessing wholesale liquidity. See Section 3.

instead about 6% and 0.1% larger. Further, the variance decomposition shows that countercyclical due diligence reduces the output variance by 11% following liquidity shocks, while increasing it by 1.3% following a capital quality shock. These effects on macroeconomic volatility are more pronounced than those of a 5% change in the bank capital adequacy ratio.

We extend our environment in two dimensions to allow for a richer structure of the banking sector and of the policy framework. First, we introduce the role of lending experience in banks’ due diligence activities by allowing loan pledgeable values to depend also on banks’ past lending history (“learning by lending”, Ongena and Smith, 2001). Lending experience directly attenuates the impact of negative shocks, but it also dilutes banks’ due diligence incentives. Through the latter mechanism, it may weaken the stabilizing role of due diligence following liquidity contractions. In a second extension, we allow the government to implement credit policies that ease banks’ access to liquidity, including the provision of liquidity in the interbank market (Gertler and Kiyotaki, 2010). Such policies directly loosen banks’ liquidity constraints. On the other hand, they also have the unintended consequence of diluting banks’ due diligence incentives. This dilution appears to be short-lived, however.

The paper unfolds as follows. In Section 2 we relate the analysis to prior literature. In Section 3, we present motivational empirical evidence on banks’ due diligence efforts and access to liquidity using matched bank-loan data from the U.S. banking sector. Section 4 lays out the model and solves for agents’ decisions. In Section 5, we analyze and quantify the effects of shocks. Section 6 further unpacks the role of banks’ due diligence and presents a microfoundation of the link between due diligence and loan pledgeable values. Section 7 studies policies. Section 8 concludes. The Appendices contain details on the data and additional results.

2 Prior literature

The paper relates to a growing literature on the role of banks in business cycles. In this literature, a broad strand of studies investigate the role of banks’ access to liquidity in business cycle transmission (see, e.g., Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011; Gennaioli et al., 2014; Bocola, 2016; Bofondi et al., 2018; Lakdawala et al., 2018). In these papers, shocks that hit banks’ access to liquidity markets impair banks’ intermediation capacity. In some studies (e.g., Gertler and

Kiyotaki, 2010; Gertler and Karadi, 2011) this occurs through a tightening of banks' capital constraints, in others (e.g., Bocola, 2016; Lakdawala et al., 2018) through a drop in the pledgeability of banks' collateralizable assets (e.g., sovereign bonds). These papers do not examine the role of banks' due diligence and information production.

A second strand of studies investigate the role of banks' information production in macroeconomic stability. In Goodfriend and McCallum (2007) loan officers are employed in the production of loans. We share with Goodfriend and McCallum (2007) a reduced-form approach to modeling loan officer activities. In our economy, however, loan officers perform due diligence and information acquisition on loan portfolios, raising the pledgeable value of loans in markets for liquidity. This allows us to study the interaction between banks' information production and their access to wholesale and retail liquidity. The hypothesis that banks' due diligence fluctuates over the business cycle is explored in both theoretical and empirical banking studies. Several works find that during credit and output expansions banks' due diligence deteriorates while during contractions it intensifies (Becker et al., 2016; Lisowsky et al., 2017). In particular, although the mechanisms vary across studies, a tenet of several banking studies is that liquidity booms can be associated with a decline in banks' due diligence effort, while liquidity shortages can incentivize such effort (Ruckes, 2004; Dell'Ariccia and Marquez, 2006). The liquidity channel in our model mirrors this view. The behavior of banks' due diligence over the business cycle is not obvious, however. Some banking studies stress that due diligence incentives are also driven by the value of loans extended and by the returns to loan assessment (Holmstrom and Tirole, 1997; Repullo and Suarez, 1998). Due diligence incentives could then drop during contractions, when loan portfolio values shrink. The information productivity channel in our economy mirrors this view. By investigating the interplay of these contrasting channels in a quantitative general equilibrium setting, we aim at shedding new light on the cyclical behavior of banks' due diligence and its macroeconomic implications.

Investigating how banks' due diligence responds to shocks also yields important normative insights. A central bank that implements credit policies in support of banks' liquidity has to take into account how its policies influence loan due diligence. Our analysis reveals that credit policies ease banks' access to funding liquidity but can disincentivize banks from performing due diligence, at least temporarily. A similar implication arises for structural policies that foster the accumulation of

lending experience, e.g., by promoting relationship lending. Although lending experience enhances banks’ ability to produce information on loans, it can weaken loan assessment incentives by reducing banks’ “hunger” for liquidity.

3 Some motivational evidence

In this section, we present motivational evidence on the interaction between banks’ due diligence effort and banks’ access to liquidity over the business cycle. Exploiting matched bank-loan data from the United States, we investigate the response of banks’ due diligence to aggregate shocks and whether this response depends on banks’ access to liquidity.⁴

3.1 Empirical setting

We hand-matched data from three 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, which provide information on banks’ balance sheets and on banks’ access to interbank market liquidity; and data in Rauch (1999) on product information complexity. The data set covers 17,894 loans extended by 199 banks to 5,408 firms over the 1996-2015 period. In the Appendix, we provide more details on data sources and sample design.

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 track banks’ due diligence activities (see, e.g., Sufi, 2007; Focarelli et al., 2008; Ivashina and Scharfstein, 2010; Bharath et al., 2011). In a syndicated loan the borrowing firm signs a loan agreement with the lead arranger and specifies the loan characteristics (collateral, loan amount, covenants and a range for the interest rate).⁵ The lead arranger then invites other banks to participate in the loan. The participants, in turn, delegate due diligence on the loan to the lead arranger. The empirical banking literature treats the share of the loan retained by the lead arranger as a proxy for its incentive to perform due diligence: the higher the lead share, the

⁴Lisowsky et al. (2017) find that, during the lending boom preceding the Great Recession, U.S. banks reduced the collection of audited financial statements. For the same period, Becker et al. (2016) find that Swedish banks were not diligent in assigning credit scores to borrowers.

⁵Lead arrangers receive a fee from the borrower for coordinating the documentation process and for arranging and managing the loan. If two or more lead arrangers are identified, then they are co-leads.

more “skin in the game” the lead arranger retains in the loan, and the stronger its due diligence effort (Sufi, 2007).

3.2 Empirical model and data

Figure 1 plots the evolution over time of the average share retained by lead arrangers in syndicated loans (our proxy for banks’ due diligence effort). The figure highlights key macroeconomic events occurred during the sample period: the NBER recessions (vertical bars) and the aggregate liquidity shock determined by the introduction of a new FDIC regulatory assessment base in 2011 (see Section 3.3 for a description of this shock). We observe, for example, that in the expansionary period preceding the Great Recession (our proxy for) banks’ due diligence remained low; during the Great Recession banks’ due diligence intensified.

To investigate the cyclical behavior of banks’ due diligence and its interaction with banks’ funding liquidity, we estimate the following empirical model:

$$\begin{aligned} Lead\ share_{b,l,t} = & \alpha + \beta_1 shock_t + \beta_2 interbank_{b,t} + \beta_3 (shock_t \times interbank_{b,t}) + \\ & + \beta_4^T X_{b,t} + \beta_5^T X_{l,t} + \eta_b + \eta_{year} + \epsilon_{b,l,t}. \end{aligned} \quad (1)$$

The dependent variable, *Lead share*, is the loan share of bank b in loan l extended at time (quarter) t , which proxies for the bank’s due diligence effort. We expect the lead arranger’s due diligence effort to be increasing in the share of the loan it finances. Indeed, a lender is more willing to undertake due diligence when it has contributed a large amount of money rather than when it only participated to a small extent (Sufi, 2007; Focarelli et al., 2008; Ivashina and Scharfstein, 2010; Bharath et al., 2011). To test how banks’ due diligence responds to aggregate shocks, we insert two indicators for the occurrence of an aggregate *shock*, which respectively capture recessionary shocks and major regulatory shocks to wholesale liquidity access. We define *NBER recessions* as a dummy equal to one if quarter t is recessionary, zero otherwise. We also code a dummy, *exempted*, which aims at capturing the aggregate liquidity shock that was triggered by the 2011 FDIC assessment base regulatory change. This shock effectively raised the cost of wholesale liquidity except for reserve *exempted* institutions. We further describe this shock and the *exempted* variable below. A key independent variable of interest is the *interbank* exposure of the bank, which we use to proxy for the bank’s participation in, and access to, the wholesale liquidity market. Following Furfine (2003), we define the interbank

exposure in quarter t as the natural logarithm of the sum of the following items: cash and balances due from depository institutions, credit exposure of all off-balance sheet derivative contracts, loans to depository institutions and federal funds sold.

In equation (1) we also insert a variety of controls for bank, loan and borrowing firm characteristics (captured by the vectors $X_{b,t}$ and $X_{l,t}$). We insert variables that can proxy for the degree of informational opaqueness of the borrower. In particular, we define *information complexity* as a dummy equal to one if the industry in which the borrowing firm operates produces heterogeneous goods and, hence, it is informationally complex (see Rauch, 1999). Further, we insert *lending experience* as the number of loans that the lead arranger extended to the borrower in the five years prior to the current loan (Bharath et al., 2011). This allows to account for the experience previously accumulated by the bank on the borrowing firm. To control for firms' specialization and riskiness and for the loan type we insert the firm's *sectorial specialization* and its S&P *credit rating* as well as a dummy equal to one if the loan type is *term A*. Concerning time-varying bank-level control variables, we insert the *reserves* balances at the central bank relative to total assets, the ratio of *deposits* to assets, the *return on assets*, the ratio of *TIER1* capital over total assets, the *loan loss provisions* ratio, and the *bank size*. The term η_b denotes bank fixed effects, while η_{year} is a vector of year dummies. Finally, ϵ is a loan-level shock, which captures stochastic disturbances.

The main coefficients of interest are β_1 , β_2 and β_3 . The β_1 coefficient captures the effect of aggregate shocks on the lead lender share (our proxy for bank due diligence). The β_2 coefficient captures the impact of the lead lender's access to wholesale liquidity. The β_3 coefficient reflects how the impact of aggregate shocks depends on the lead lender's access to wholesale liquidity. In Appendix Table 1, we provide definitions for the variables used in the estimations. Appendix Table 2 presents summary statistics.

3.3 Estimates

Our focus is on the effect of aggregate shocks and of the access to interbank liquidity on the loan share retained by the lead arranger. Table 1 reports the main coefficients of interest (see Appendix Table 3 for the full estimates). In column I, we estimate a baseline model without interaction terms (standard errors clustered at the bank-year level). The estimated coefficient of the *NBER recessions* dummy is positive, suggesting that banks undertake more due diligence during recessions than

in normal times. The coefficient of *interbank* exposure is negative and statistically significant. That is, banks tend to retain larger loan shares (higher due diligence incentives) when they have lower access to wholesale liquidity. The estimated coefficient implies that a one standard deviation decrease in the interbank exposure increases the lead lender share by 0.04 (12% of the sample mean). We also find that banks perform somewhat less due diligence when they have more lending experience. Next, in column II we augment the baseline regression with the control for product information complexity. The results carry through and information complexity enters with the expected positive sign, suggesting that banks perform more due diligence when borrowers produce informationally complex products.

In column III, we examine the marginal effect of interbank liquidity access on the lender's loan share during recessions. The coefficient of the interaction term is negative and statistically significant, suggesting that lower access to interbank liquidity further boosts the due diligence effort of the lead arranger during recessions. In column IV, we consider the effect of an aggregate negative liquidity shock of a regulatory origin. The Dodd-Frank financial reform legislation required a change in the FDIC fee for banks to fund the deposit insurance. Specifically, in 2011 the assessment base for banks was changed from one based on domestic deposits to one on assets minus tangible equity, effectively raising the costs for accessing wholesale liquidity. However, foreign branches and agencies and custodial banks were exempted from the new assessment base, retaining easier access to wholesale liquidity. The estimated interaction term between access to interbank liquidity and *exempted* banks in column IV is positive. That is, among the banks hit by the restrictive regulatory shock, those with more difficult access to wholesale liquidity had higher incentive to perform due diligence.

Finally, in column V we augment the regression of column I with the interaction between *NBER recessions* and *lending experience*. The estimates suggest that lending experience dilutes banks' incentive to step up due diligence during recessions.

To summarize, the estimates point to the following empirical patterns: i) banks perform more due diligence following aggregate recessionary shocks; ii) banks perform more due diligence when they have difficult access to wholesale liquidity, especially during recessions; iii) when restrictive regulatory shocks hit the wholesale funding market, banks with difficult access to wholesale liquidity perform more due diligence than banks with easier access; iv) banks perform less due diligence when they have stronger lending experience with firms. As we will see, these patterns are

consistent with the predictions of the theoretical model.

In Appendix Table 4 we perform robustness tests. In column I, we saturate the supply side time-varying unobserved using bank-year fixed effects. These allow to control for unobservable time-varying bank fundamentals to isolate credit supply. Essentially, we compare the same bank lending to a different firm in a given year, while using only the within variation of each bank-firm combination for estimation. The results remain statistically and economically significant. In column II, we add loan purpose fixed effects. The results carry through. In columns III and IV, we control for the firm’s riskiness and the type of loan, respectively. The results remain virtually unaltered. In untabulated tests, we also experimented with replacing the dependent variable with the shares held by participant banks. Consistently across regressions, the coefficients of interest on *interbank* and *shock* tend to lose significance, suggesting that our main findings can be attributed to the lead arranger’s due diligence incentives and not to the tendency of other banks to participate in the loan.⁶

4 The baseline model

Motivated by the empirical findings, we develop a dynamic general equilibrium model where banks intermediate liquidity and perform information production (due diligence) on loans. The economy comprises four sectors: households; firms, divided between final goods producers and capital producers; financial intermediaries (banks); and a government. Households consume and supply labor services to firms and to banks. Banks intermediate liquidity between households and firms. They borrow liquidity from households in a retail deposit market and borrow liquidity one from another in an interbank market. Banks’ access to liquidity is subject to collateral constraints: the value of their retail deposits and interbank borrowing cannot exceed the pledgeable value of their assets. Banks produce information on loans, raising their pledgeable value in markets for liquidity. Due diligence is costly, however, as it entails the hiring of loan officers.⁷ The government finances its expenditures through taxes and issuance of bonds. Banks can pledge government bonds

⁶For example, re-estimating the specification in column I of Table 1 with the participant shares as the dependent variable, the estimated coefficient on *interbank* equals 0.08 (not significant at conventional levels).

⁷Loan officers analyze financial statements, produce reports, conduct financial analysis of borrowers, and interact with bank supervisors and rating agencies (Ruckes, 2004).

as collateral when borrowing liquidity.⁸

4.1 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 banks. Workers can be employed in the production of final goods or as loan officers in banks. There is perfect consumption insurance within the household. We follow the setup in Gertler and Kiyotaki (2010) where bankers exit in each period with an i.i.d. probability $(1 - \sigma)$ and transfer all their retained earnings to the household when exiting.⁹ This ensures that bankers cannot accumulate enough assets such that their 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). Each new banker receives a startup transfer from the household, as a small and exogenous fraction θ of the total assets of exiting bankers.

Households earn the wage rate W_t^H on labor supplied in the goods sector (H_t) and the wage rate W_t^L on labor supplied in the banking sector (L_t). They also earn a gross rate of return R_{t-1}^D on deposits as well as profits from owning banks and firms, Π_t . They use their funds for consumption C_t , to hold deposits D_t , and to pay lump-sum taxes T_t . They choose consumption, deposit holdings and labor supply to maximize their expected lifetime utility according to

$$\begin{aligned} & \max_{\{C_t, D_t, H_t, L_t\}_{t \geq 0}} E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln(C_t - h_C C_{t-1}) - k_H \frac{H_t^{1+\varphi}}{1+\varphi} - k_L \frac{L_t^{1+\tau}}{1+\tau} \right] \quad (2) \\ \text{s.t.} \quad & C_t + D_t + T_t = R_{t-1}^D D_{t-1} + W_t^H H_t + W_t^L L_t + \Pi_t, \end{aligned}$$

where h_C denotes habits on consumption, φ is the inverse of Frisch elasticity for labor supplied to the production of goods and τ is the inverse of Frisch elasticity for labor supplied to banking activities. The parameters k_H and k_L govern the disutility from labor in the two sectors.

⁸Government bond holdings constitute a relevant share of banks' assets in many countries, including the United States and eurozone countries, and are often used as collateral in wholesale liquidity markets (Gennaioli et al., 2014). For example, around 75 percent of repo transactions in the euro area use government bonds as collateral (Hördahl and King, 2008).

⁹As capital constraints bind for bankers around the steady state, bankers will always retain earnings while in business and pay dividends upon exiting.

Equation (3) is the labor supply condition for the two labor types:

$$-\frac{U'_{H_t}}{U'_{C_t}} = W_t^H; \quad -\frac{U'_{L_t}}{U'_{C_t}} = W_t^L. \quad (3)$$

Letting $\Lambda_{t,t+1} \equiv \beta \frac{U'_{C_{t+1}}}{U'_{C_t}}$, the Euler condition for consumption reads

$$1 = E_t \Lambda_{t,t+1} R_t^D. \quad (4)$$

4.2 Firms

4.2.1 Final goods producers

There is a continuum of final goods producers of unit mass located on a continuum of islands. Final goods producers use capital and labor to produce final goods through a constant returns to scale technology. Capital is not mobile while labor is perfectly mobile across firms and islands, so we can express aggregate output as a function of aggregate capital and labor:

$$Y_t = A_t K_t^\alpha H_t^{1-\alpha}, \quad (5)$$

where Y_t is output, α denotes the capital share, K_t is the capital stock and A_t is the total factor productivity.

Denoting by Z_t the return to capital, the factor demand curves are

$$W_t^H = (1 - \alpha) \frac{Y_t}{H_t}; \quad Z_t = \alpha \frac{Y_t}{K_t}. \quad (6)$$

Following Gertler and Kiyotaki (2010), in every period t a fraction π^i of islands receive the opportunity to invest, whereas in a fraction $\pi^n = 1 - \pi^i$ of islands there are no investment opportunities. Firms on investing (non-investing) islands issue state-contingent securities X_t^i (X_t^n), at a market price $Q_t^{X,i}$ ($Q_t^{X,n}$), to banks. Each firm security constitutes a claim to the future returns of a unit of present capital.

Let δ denote the capital depreciation rate. Then, capital accumulated in islands with investment opportunities is $I_t + \pi^i(1 - \delta)K_t$, while in islands without investment opportunities it is $\pi^n(1 - \delta)K_t$. Aggregating and denoting by ψ_t an AR(1) shock to the quality of physical capital, the law of motion for aggregate capital is

$$K_{t+1} = \psi_t [I_t + (1 - \delta)K_t] = \psi_t [I_t + \pi^i(1 - \delta)K_t + \pi^n(1 - \delta)K_t]. \quad (7)$$

The capital quality shock can capture disruptions in the goods producing sector (Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011). This provides a convenient way of capturing exogenous variation in the value of capital and, hence, in the value of firm shares held by banks.

4.2.2 Capital producers

Capital producers choose their investment, I_t , to maximize the expected present value of profits given by the value of new capital sold to firms in investing islands minus the cost of investment. Their optimization problem reads

$$\max_{\{I_t\}_{t \geq 0}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left\{ Q_t^{X,i} I_t - \left[1 + F \left(\frac{I_t}{I_{t-1}} \right) \right] I_t \right\}, \quad (8)$$

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

$$Q_t^{X,i} = 1 + F \left(\frac{I_t}{I_{t-1}} \right) + \frac{I_t}{I_{t-1}} F' \left(\frac{I_t}{I_{t-1}} \right) - E_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t} \right)^2 F' \left(\frac{I_{t+1}}{I_t} \right). \quad (9)$$

4.3 Banks

The banking sector is the core of our model. Banks intermediate liquidity and perform information production and due diligence on their claims on borrowing firms. Their access to retail and wholesale markets for liquidity is subject to constraints. In particular, banks have to satisfy a collateral (capital) constraint, such that a weighted sum of the values of their liabilities (retail deposits and interbank borrowing) cannot exceed the pledgeable value of their assets (loans and government bonds). They have also to satisfy an interbank collateral constraint, such that their interbank borrowing cannot exceed the value of collateral assets (government bonds) they can pledge in the interbank market.

We model banks' due diligence as follows. When extending financing to firms, banks choose the amount of information they produce about their claims on borrowing firms. Through information production and due diligence, banks can raise the pledgeable value of their claims. Banks routinely produce information on loans and make available a range of information pieces (e.g., credit scores and ratings, risk models, financial statements, borrower assessments and reports) to bank super-

visors and financiers. These, in turn, use this information to assess banks' financial status and regulatory compliance (BIS, 2015). Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) microfound banks' collateral (capital) constraints with the argument that bankers can "run away" (default strategically) without repaying liabilities. Bank financiers, in turn, can force defaulting bankers into liquidation and recover a portion of the liquidation value of banks' assets. Unlike in Gertler and Karadi (2011), we allow the liquidation value of loans (firm shares) in the event of bank default, and hence their pledgeable value, to be increasing in banks' due diligence and information production on loans (see, e.g., Diamond and Rajan, 2001, 2005). In particular, in our broader specification we let banks' due diligence be a function of the endeavor of loan officers (l_t^h) and of the past lending experience (s_{t-1}). In Section 6, we present a formal microfoundation along the lines of Diamond and Rajan (2001, 2005), in which, as a by-product of lending activities, bankers accumulate liquidation skills on loans. These skills allow them to better identify potential buyers of project loans in the liquidation market, thus raising their pledgeable liquidation value. Exploiting the heterogeneity in the banking sector between investing and non-investing islands, in the microfoundation we outline a liquidation market for banks' claims on firms characterized by trading frictions. As in previous studies (see, e.g., Cavalcanti and Wallace, 1999; Araujo and Minetti, 2007), due diligence and information acquisition allow defaulting bankers to mitigate trading frictions in the liquidation market.

In period t , after all aggregate shocks are realized, a bank chooses deposits (d_t) and government bond holdings (b_t). After that, shocks to investment opportunities occur in the islands. Thereafter, a bank in island h chooses its interbank position (m_t^h), holdings of firm shares (x_t^h) and the amount of labor to employ in due diligence activities (l_t^h), where the $h \in (i, n)$ superscript represents whether an investment opportunity is available or not in the island. Since deposits and bond holdings are chosen before uncertainty over types is resolved, banks in islands without investment opportunities find themselves with a surplus of liquidity, while banks in islands with investment opportunities face a shortage. The former will then lend to the latter in the interbank market.

A bank maximizes the expected discounted sum of dividends it transfers to the

household. The bank's optimization problem in recursive form reads

$$\begin{aligned}
V_{t-1}(\cdot) &= E_{t-1} \Lambda_{t-1,t} \left[\sum_h \pi^h (1 - \sigma) n_t^h + \max_{d_t, b_t, m_t^h, x_t^h, l_t^h} \sum_h \pi^h \sigma V_t(d_t, b_t, m_t^h, x_t^h, l_t^h) \right] \\
\text{s.t.} \quad & Q_t^{X,h} x_t^h + Q_t^B b_t = n_t^h + d_t + m_t^h - W_t^L l_t^h, & [\sigma \pi^h \lambda_t^h] \quad (10) \\
& R_t^D d_t + \xi R_t^M m_t^h \leq Q_t^B b_t + \Omega(Q_t^{X,h} x_t^h, l_t^h, s_{t-1}), & [\sigma \pi^h \mu_t^h] \quad (11) \\
& R_t^M m_t^h \leq \chi_t Q_t^B b_t, & [\sigma \pi^h \gamma_t^h] \quad (12)
\end{aligned}$$

where n_t^h is the bank's net worth, Q_t^B is the bond price and R_t^M denotes the gross interest rate on interbank loans. Banks' net worth at time t is the gross payoff from assets funded at $t - 1$, net of borrowing costs:

$$n_t^h = [Z_t + (1 - \delta) Q_t^{X,h}] \psi_t x_{t-1} + \psi_t^{B_g} b_{t-1} - R_{t-1}^D d_{t-1} - R_{t-1}^M m_{t-1}. \quad (13)$$

The gross payoff from assets depends on the location specific asset price $Q_t^{X,h}$. The term $\psi_t^{B_g}$ is an exogenous AR(1) shock to the value of government bonds.

Equation (10) is the resource constraint. Net worth, deposits and interbank net borrowing are used to invest in firms' shares and in government bonds and to pay wages to loan officers. Equation (11) is a collateral (capital) constraint which requires that the weighted sum of the values of bank liabilities (retail deposits and interbank borrowing) cannot exceed the pledgeable value of bank assets. The parameter ξ is a weight governed by capital requirements. The pledgeable value of firm shares is captured by the function $\Omega(Q_t^{X,h} x_t^h, l_t^h, s_{t-1})$. In the baseline analysis we shut down the role of banks' lending experience (s_{t-1}) and specify $\Omega(\cdot)$ as:¹⁰

$$\Omega(\cdot) = \zeta (Q_t^{X,h} x_t^h)^\phi (l_t^h)^{1-\phi}. \quad (14)$$

where ζ is a positive parameter. Our specification reflects the idea that banks' due diligence and information production affect only the pledgeable value of firm shares but not the pledgeable value of other assets, such as government bonds. In fact, government bonds are a plain-vanilla, informationally transparent asset which does not require due diligence.

¹⁰This can reflect the features of banking sectors (e.g., those of the United States and the United Kingdom) that traditionally exhibit limited relevance of lending relationships during which lending experience can be accumulated (Degryse et al., 2009). In Section 6.1 we will reintroduce the role of lending experience in loan due diligence and verify the robustness of the results.

Equation (12) imposes the constraint that interbank borrowing cannot exceed the value of government bonds pledged as collateral in the market for interbank liquidity. The term χ_t represents an exogenous regulatory shock to the loan-to-value (LTV) ratio in the interbank market. When simulating the effects of changes in χ_t , we consider both a persistent AR(1) process and a permanent (deterministic) shock.

The bank's first order conditions are

$$[\partial x_t^h]: \quad -Q_t^{X,h} \lambda_t^h + \underbrace{\zeta \phi \mu_t^h (Q_t^{X,h})^\phi (x_t^h)^{\phi-1} (l_t^h)^{1-\phi}}_{\text{Due Diligence Effect}} + E_t \Lambda_{t,t+1} \sum_{h'} \pi^{h'} [Z_{t+1} + (1-\delta) Q_{t+1}^{X,h'}] \psi_{t+1} (1-\sigma + \sigma \lambda_{t+1}^{h'}) = 0, \quad (15)$$

$$[\partial m_t^h]: \quad \lambda_t^h - \xi R_t^M \mu_t^h - R_t^M \gamma_t^h - R_t^M E_t \Lambda_{t,t+1} \sum_{h'} \pi^{h'} (1-\sigma + \sigma \lambda_{t+1}^{h'}) = 0, \quad (16)$$

$$[\partial d_t]: \quad \sum_h \pi^h \lambda_t^h - R_t^D \sum_h \pi^h \mu_t^h - R_t^D E_t \Lambda_{t,t+1} \sum_{h'} \pi^{h'} (1-\sigma + \sigma \lambda_{t+1}^{h'}) = 0, \quad (17)$$

$$[\partial l_t^h]: \quad l_t^h = \underbrace{\left[\frac{\zeta (1-\phi)}{W_t^L} \right]^{\frac{1}{\phi}}}_{\text{Resource drain}} \underbrace{\left[\frac{\mu_t^h}{\lambda_t^h} \right]^{\frac{1}{\phi}}}_{\text{Liquidity channel}} \underbrace{\left[Q_t^{X,h} x_t^h \right]}_{\text{Information productivity channel}}, \quad (18)$$

$$[\partial b_t]: \quad Q_t^B \left[-\sum_h \pi^h \lambda_t^h + \sum_h \pi^h \mu_t^h + \chi_t \sum_h \pi^h \gamma_t^h \right] + E_t \Lambda_{t,t+1} \psi_{t+1}^{B_g} \sum_{h'} \pi^{h'} (1-\sigma + \sigma \lambda_{t+1}^{h'}) = 0. \quad (19)$$

Consider (15): purchasing more firm shares tightens the current resource constraint (whose shadow value is λ_t^h) but relaxes the next period resource constraint ($\lambda_{t+1}^{h'}$).¹¹ It also tends to relax the capital constraint (μ_t^h), especially when due diligence is intense (l_t^h is high). Looking at (16), an increased interbank market position relaxes the current resource constraint but tightens the capital constraint and the interbank constraint (γ_t^h). From (18), hiring more loan officers in due diligence activities drains resources (through the payment of wages), entailing a tighter resource constraint, but relaxes the capital constraint by raising the pledgeable value of firm shares. The extent of the latter effect hinges on the tightness of the capital constraint (μ_t^h) and

¹¹We 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 they depend on which island type a bank enters in the subsequent period.

on the state-contingent value of firm shares $Q_t^{X,h} x_t^h$. These effects will give rise to the two channels (“liquidity” and “information productivity”) through which banks’ due diligence responds to shocks and, in turn, affects the transmission of shocks to the real sector. From (19) government bonds accumulation loosens both capital and interbank constraints while tightening the resource constraint.

4.4 Government

We use capital letters for aggregate quantities. Output is divided among households’ consumption, firms’ investment and government consumption, which is exogenously fixed at the level G . Government consumption is financed by lump sum taxes (T_t) and bonds

$$G = T_t + Q_t^B B_t - \psi_t^{B_g} B_{t-1}. \quad (20)$$

Let η denote the elasticity of taxes to public debt, T be the long-run level of taxation and B be the long-run level of public debt. The tax rule is

$$T_t = T + \eta (B_t - B). \quad (21)$$

4.5 Equilibrium

As the information production function (14) exhibits constant returns to scale, policy functions are linear and we can aggregate. In equilibrium, total claims issued in investing and non-investing islands equal aggregate capital acquired by each type:

$$X_t^i = I_t + (1 - \delta)\pi^i K_t, \quad (22)$$

$$X_t^n = (1 - \delta)\pi^n K_t. \quad (23)$$

The labor market clearing condition for bank workers reads

$$L_t = \sum_h \left[\frac{\zeta(1 - \phi)\mu_t^h}{W_t^L \lambda_t^h} \right]^{\frac{1}{\phi}} Q_t^{X,h} X_t^h, \quad (24)$$

where $L_t = L_t^i + L_t^n$. The market clearing condition for interbank loans requires

$$M_t^i + M_t^n = 0, \quad (25)$$

while the social resource constraint reads

$$Y_t = C_t + \left[1 + F \left(\frac{I_t}{I_{t-1}} \right) \right] I_t + G_t. \quad (26)$$

The economy can be hit by aggregate shocks to bond values ($\psi_t^{B_g}$), interbank market regulation (χ_t) and capital quality (ψ_t).

In the Appendix we also report the law of motion of banks' net worth.

5 Model analysis

In this section, we study the impulse responses of the economy to shocks. The first two shocks ("liquidity shocks") capture disruptions in the flow of liquidity to the banking sector. As noted, we consider a bond value shock that reduces the value of pledgeable government bonds; and a regulatory shock that increases the collateral requirements in the wholesale liquidity market. The former can mimic the effects of sovereign debt problems (a prominent example being the sovereign bond distress of peripheral European countries in 2011). The latter can reflect changes in the stance of regulators, such as the U.S. FDIC regulatory shock studied in the empirical analysis of Section 3. The third shock ("capital quality shock") is a hybrid between a reduction in the returns of firms' productive capital and a drop in the value of banks' claims on firms. All the shocks are intended to produce a downturn.

We ask the model two main questions: what is the response of banks' due diligence following shocks? Does the response of due diligence, and its interaction with banks' access to liquidity, propagate or attenuate business cycle fluctuations?

5.1 Calibration

The model is calibrated to quarterly frequency and solved numerically by locally approximating around the non-stochastic steady state. All parameter values are in Table 2. We use fairly standard parameters for preferences, technologies and the government sector. Parameters affecting the utility function are calibrated according to empirical estimates of medium scale DSGE models (see, e.g., Lubik and Schorfheide, 2006; Smets and Wouters, 2007; Justiniano et al., 2013). Habits in consumption are calibrated to 0.5, whereas the Frisch elasticity of labor supply is set to 4 in both the final goods and the banking sectors, in line with the suggestion by Chetty et al. (2011) for macro models. The labor disutility parameters, k_H and

k_L , are calibrated in order to match a steady state for the hours worked equal to 0.33. The discount factor β is calibrated to 0.99, implying a yearly steady state deposit rate $(R^D - 1)$ of around 4%. In the final goods 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 imply a labor share of 66% and an annual depreciation rate of 10%. The investment adjustment cost is calibrated to 2.5. The steady state proportion of government expenditures (G/Y) is calibrated to 0.2 in line with Gertler and Karadi (2011).

In the banking sector, following Gertler and Kiyotaki (2010) we set the survival rate of bankers $\sigma = 0.97$, implying that bankers survive for eight years on average. We use data from the banking sector, including the database used in the empirical analysis of Section 3, to jointly calibrate six parameters, π^i , ξ , θ , ϕ , ζ , B/Y . We match six targets: i) investing banks' leverage; ii) investing banks' bond-to-asset ratio; iii) investing banks' annual salary to asset ratio; iv) the loan-deposit interest rate spread; v) the bond-deposit interest rate spread; vi) the interbank-deposit interest rate spread. In the U.S. Call Reports data, between 1996 and 2015 (the time frame of the empirical analysis of Section 3) the average bank leverage was 9.5. For the same period, the average holdings of Treasury securities and agency- and Government-sponsored enterprise (GSE)-backed securities amounted to 15% of bank assets. The annual expenses on salaries and employee benefits amounted to 1.46% of bank assets. Banks' leverage ratio and the share of sovereign bonds holdings as a percentage of bank assets are similar for banks in the euro area. From the OECD Survey of the euro area we calculated an average banks' leverage ratio of 9 for the year 2014, while, for the same year, intersecting data from the Supervisory Banking Statistics of the European Central Bank with data in Altavilla et al. (2017) we computed an average holding of government bonds amounting to 13% of bank assets. We set the annual loan-deposit spread, bond-deposit spread, and interbank-deposit spread to 3%, 0%, and 0.5%, respectively.

5.2 Liquidity shocks

We first study the effects of a shock that exogenously lowers the values of government bonds (i.e., a fall in $\psi_t^{B_g}$). The standard error of the shock is set to obtain a drop of bank capital equal to 3% of the GDP. This is in the ballpark of the impact on banks' capitalization of a sovereign debt restructuring such as that occurred during the euro area sovereign debt distress (see Guerrieri et al., 2013). The persistence of the shock,

ρ_{B_g} , is calibrated to 0.85. We compare our model with an alternative model in which the role of banks' due diligence is partially shut down by construction. In particular, we posit that in the comparison economy banks pay an exogenous tax on their labor hiring and get rebated the tax revenues lump sum. The tax is set in order to obtain a hiring of loan officers that is on average 1% lower than in our baseline economy along the simulation period.

In Figure 2, the continuous lines are the impulse response functions (IRFs) generated by our model, whereas the dashed lines are the IRFs of the comparison model.¹² All variables are expressed as quarterly percentage deviations from the steady state except for the external finance premium (EFP_t , the ratio between the return on firm shares and that on deposits), for which we consider the annualized deviation from the steady state.¹³ A negative shock to bond values affects banks' due diligence effort primarily through two channels (see equation 18): the tightness of liquidity constraints (liquidity channel) and the marginal product of due diligence associated with the value of assessed claims (firm shares) held by banks (information productivity channel).

The shock implies that government bonds are less desirable and, hence, lowers the demand for bonds and their market price. Thus, the value of the bond portfolio held by banks drops. Bonds serve as collateral in the interbank market and the fall in the value of bond holdings limits banks' ability to borrow liquidity in the interbank market. This can be observed by looking at the IRF of the Lagrange multiplier on the interbank constraint (γ_t^i), which rises following the shock. The tightening of the interbank constraint boosts banks' hunger for liquidity, as it can also be inferred from the rising value of the Lagrange multiplier on the capital constraint (μ_t^i). This raises banks' incentive to perform due diligence to gain easier access to liquidity in the retail funding market. Put differently, as now banks face a tighter capital constraint, they have a stronger incentive to relax it by increasing their due diligence effort and, hence, the pledgeable value of their claims on firms.

Looking at the information productivity channel, the tightening of the interbank and capital constraints reduces banks' demand for firm shares, lowering their price. The fall in the value of firm shares held by banks tends to depress the marginal

¹²In all figures, the responses refer to investing islands except for output, investment and values of bond holdings which are aggregate.

¹³The return on firm shares of type h is $R_{t+1}^{K,hh'} = \psi_{t+1} \left[Z_{t+1} + (1 - \delta)Q_{t+1}^{X,h'} \right] / Q_t^{X,h}$ where the stochastic rate $R_{t+1}^{K,hh'}$ depends on the state of the next period h' .

productivity of labor in due diligence activities. Nonetheless, the reduced incentive to perform due diligence due to its lower productivity is outweighed by the increased incentive associated with the tightening liquidity. Overall, the net effect of the shock is then to increase labor in due diligence activities. The predominance of the liquidity channel can be gleaned from the left panel of Figure 3 which shows how the channels highlighted in equation (18) (liquidity, information productivity, resource drain) contribute to the response of banks' due diligence. The liquidity channel is quantitatively stronger than the information productivity channel and the resource drain channel (driven by the increase in loan officers' wages). Therefore, the net effect is that banks perform more due diligence. This is in line with the evidence in Section 3, where we found that banks increase due diligence when they have lower access to liquidity, especially during recessions. The countercyclical response of banks' due diligence is also in line with Lisowsky et al. (2017) and Becker et al. (2016), who show that during a lending contraction banks step up loan due diligence. In our model, indeed, there is a strong negative correlation (around -0.9 under the bond value shock) between the value of bank financing to firms and due diligence effort.

From an aggregate point of view, the increase in banks' due diligence effort supports the pledgeability of firm shares, tends to relax banks' capital constraint and facilitates credit extension to firms. At the same time, it also drains resources from the banking sector, due to the larger wage bill paid by banks. In spite of the fall in information productivity, the former effect prevails, so that investment and output decrease less than in the comparison model (where the due diligence effort is on average 1% lower than the baseline by construction). To summarize, following a negative bond value shock, banks' enhanced due diligence attenuates the impact of the shock on the real sector. By employing more resources in loan information production, banks partially relax their liquidity constraints, ultimately easing liquidity provision to firms.

In Appendix Figure 1, we study how the weight ϕ on banks' due diligence in the function (14) influences the responses to the shock. In one scenario ("high ϕ ") $\phi = 0.8$; in the other ("low ϕ ") $\phi = 0.60$. When ϕ is high banks' due diligence responds more on impact (Appendix Figure 1, top panel). This implies that the pledgeable value of firm shares, investment and output drop less. Thus, due diligence is a more powerful shock attenuator in the "high ϕ " scenario.

We next study the effects of a regulatory tightening in the interbank market,

consisting of a reduction in the interbank LTV χ_t (as, e.g., following the FDIC assessment shock examined in Section 3). Figure 4 plots the IRFs to a temporary regulatory shock. The standard deviation of the shock is set to obtain a decrease of the interbank rate of around 2%, like that observed after the 2011 change in the FDIC regulation (see Kreicher et al., 2013). The persistence of the shock, ρ_χ , is calibrated to 0.85. Again, we can read the effects through the lenses of the liquidity channel and of the information productivity channel. The lower LTV tightens the interbank collateral constraint, even if the usefulness of bonds as collateral and, hence, their values are pushed up. The more limited access to interbank liquidity tends to raise the demand for retail liquidity, tightening the capital constraint. On the other hand, the increase in the value of bond holdings relaxes the capital constraint. The multiplier on the capital constraint slightly rises, while after some periods the relaxing effect gains strength and the multiplier converges to its steady state value. The middle panel of Figure 3 indeed shows that for a number of periods the liquidity channel contributes positively to the response of banks' due diligence and, accordingly, as shown in Figure 4, due diligence rises. This is consistent with the estimates in Section 3, which suggested that, following the restrictive FDIC regulatory shock, banks with difficult access to liquidity stepped up their due diligence. In the long run, driven by the attenuation of the liquidity channel, banks' due diligence eventually falls below the steady state. Nonetheless, despite its less countercyclical response, banks' due diligence is still a powerful shock attenuator: holdings of firm shares, investment and output drop less than in the comparison economy, as Figure 4 shows.¹⁴

Regulatory shocks can feature very high persistence. In the Appendix, we then simulate the effect of a permanent regulatory shock to χ_t . The insights are similar to those obtained for the temporary regulatory shock, although banks' due diligence rises more than following a temporary shock.

5.3 Capital quality shocks

We now turn to study the response of the economy to an exogenous decline in capital quality (ψ_t), that induces a drop in the value of capital assets and, hence, in the value of firm shares held by banks. Following Gertler and Karadi (2011), we set the standard deviation of this shock to 5%. The IRFs are in Figure 5. The

¹⁴Appendix Figure 1 (middle panel) reveals that, similar to what found for the bond value shock, banks' due diligence is more responsive and acts as a better stabilizer for a higher value of ϕ .

main take-away message of this experiment is that, in spite of a large drop in information productivity, the net effect of the liquidity channel and the information productivity channel is still an increase in banks' due diligence effort following the shock (consistent with our empirical findings). The right panel of Figure 3 makes clear that the liquidity channel dominates the other channels (information productivity and resource drain) highlighted in equation (18), implying that banks' due diligence ramps up. However, unlike for the liquidity shocks, the more substantial drop in information productivity makes the increase in due diligence a moderate amplifier, rather than an attenuator, of the capital quality shock. Intuitively, due to the sharper drop in firm shares values and, hence, in information productivity, the drain of resources from the banking sector associated with the rising wage bill for due diligence services is large relative to the benefit of due diligence in preserving the pledgeability of firm shares.¹⁵

Specifically, following the capital quality shock, banks experience a drop in the value of their firm shares. This tightens their capital constraint, as reflected in the rise of the associated Lagrange multiplier. Through this liquidity channel banks' incentive to perform due diligence is thus enhanced. In the opposite direction, the significant erosion in the value of banks' shares pushes down due diligence incentives. As the figure reveals, due diligence effort rises, suggesting that the former mechanism (liquidity tightening) dominates over the latter (drop in information productivity). However, just because of the substantial decrease in shares values and in the productivity of information, the increase in due diligence does not help the recovery of the real sector: output and investment go down more than in the comparison model (where due diligence is on average 1% lower by construction).

Appendix Figure 1 (bottom panel) considers different values of ϕ and confirms that banks' due diligence behaves as a moderate amplifier. The figure shows that more intense due diligence (when ϕ is high) leads to a larger drop of shares values, investment and output.

¹⁵Clearly, the fact that banks' due diligence response can accentuate the contraction of investment and output is not surprising. In choosing their due diligence effort, banks maximize their dividend distribution, not the aggregate investment or output. Further, banks impose externalities one on the other, as they do not internalize the effects of their labor hiring on the wages paid by other banks. Since our analysis is positive rather than normative, a reader should not be tempted to interpret a response of banks' due diligence that magnifies the investment contraction as being suboptimally high.

5.4 Quantitative assessment

We assess the quantitative relevance of the effects. We first quantify the response of banks' due diligence intensity to the shocks. Following a negative bond value shock, due diligence intensity shoots up by 13% on impact (see Figure 2). Cumulatively, after two years (8 periods) it increases by 50%. Following a restrictive regulatory shock, due diligence intensity rises by 11% on impact, but, as noted, after a number of periods, it drops below its baseline value (Figure 4). As a result, after two years the cumulative response is a 12% increase, but after four years the cumulative response is a 2% reduction. Following a negative capital quality shock, due diligence increases by 18% on impact; after two years its cumulative increase is around 130% (Figure 5).

The above magnitudes suggest a sizeable, countercyclical response of banks' due diligence effort. We next turn to evaluate its contribution to the transmission of shocks. A first way to evaluate this contribution is to compare the responses of macroeconomic variables in our model with those in the comparison model featuring a tax on banks' labor hiring. Along the simulation horizon, on average banks' due diligence intensity is 1% higher than in the comparison setup. Following a negative bond value shock, the cumulative percentage drops of investment and output after four years are respectively 2.7% and 3% smaller in our economy than in the comparison. After the restrictive regulatory shock, the cumulative percentage drops of investment and output are respectively 5% and 5.6% smaller in our economy. Following the negative capital quality shock, instead, they are about 6% and 0.1% larger. These figures point to a relevant macroeconomic impact of banks' due diligence, especially when it acts as a stabilizer.

The model predicts that banks' due diligence mitigates the effects on investment and output of liquidity shocks while moderately accentuating those of capital quality shocks. In Table 3, Panel A, we report the percentage difference in the contribution of each shock to the variances of investment and output between the baseline model and the comparison. In the baseline model the combined contribution of the two liquidity shocks is smaller than in the comparison (by 11% for output), while the contribution of the capital quality shock is larger (by 1.3% for output).

An alternative way to quantify the contribution of banks' due diligence to macroeconomic volatility is to look at the size of the variance of output and investment induced by each shock (Table 3, Panel B). For both variables, liquidity shocks entail

a smaller variance in the baseline economy than in the comparison, while the capital quality shock induces a larger variance. To have a better sense of the magnitudes, we also present the variances in an economy where loans are subject to tighter capital regulation. In particular, we alter the parameter ζ in (14) in a way such that the investing banks' leverage is 5% lower than the baseline. The impact of banks' due diligence on macroeconomic volatility appears to be sizeable compared with that induced by this significant alteration of capital requirements.

Finally, Figure 6 assesses the contribution of due diligence to attenuating the drop in the pledgeable value of firm shares in the baseline economy relative to the comparison. We focus on liquidity shocks, for which banks' due diligence acts as an attenuator of the drop of pledgeable values. In the figure, we plot IRFs computed as differences between the baseline economy and the comparison. The bold line is the differenced-IRF of pledgeable values ($\zeta(Q_t^{X,i}X_t^i)^\phi(L_t^i)^{1-\phi}$); the dark area shows the contribution of banks' due diligence (L_t^i) to this difference; the light area is the contribution of the shares value ($Q_t^{X,i}L_t^i$). As Figure 6 shows, following the liquidity shocks the contribution of banks' due diligence to mitigating the fall of pledgeable values is relatively large.

6 Unpacking banks' due diligence activities

This section takes a further step towards investigating the role of banks' due diligence. We first show that the results are robust to allowing for banks' lending experience and study how due diligence interacts with lending experience following shocks (Section 6.1). We then put forward a microfoundation of the effect of due diligence on loan pledgeable values (6.2). Derivation details are in the Appendix.

6.1 Lending experience

The lending experience accumulated by banks during credit relationships can influence banks' ability and incentives to perform loan due diligence (Ongena and Smith, 2001; Sette and Gobbi, 2015). We introduce lending experience in the form of habits in the Cobb-Douglas function (14) for due diligence (see, e.g., Aliaga-Díaz and Olivero, 2010; Ravn et al., 2006). This allows to capture a notion of banks' experience about loan portfolios, which in turn affects the pledgeability of loans.

The function for banks' due diligence and information production now reads:

$$\Omega(\cdot) = \zeta[Q_t^{X,h}(x_t^h + h_x s_{t-1})]^\phi (l_t^h)^{1-\phi}, \quad (27)$$

where

$$s_{t-1} = \rho_s s_{t-2} + (1 - \rho_s) x_{t-1}. \quad (28)$$

In equation (27) the parameter h_x captures the contribution of lending experience to the pledgeability of firm shares. The variable s_{t-1} represents the past stock of lending relationships (experience) between banks and firms. Equation (28) is the law of motion of this stock, where ρ_s denotes the persistence in the stock of habits. In the calibration, h_x is set to 0.7, in line with the estimates in Aliaga-Díaz and Olivero (2010). The persistence parameter ρ_s is calibrated to 0.5.

Figure 7 shows that all the key insights of the baseline model carry through. In the figure, we conduct two exercises to study the influence of lending experience. First, we compare the IRFs in the baseline model in the cases with and without lending experience (Panel A). This comparison captures the direct effect of lending experience in attenuating or amplifying the effect of shocks. Second, we study how due diligence and lending experience interact along the business cycle (Panel B).

The direct effect of lending experience in a model with banks' due diligence (Panel A) is the result of two contrasting forces. On the one hand, following each shock, lending experience works towards attenuating the tightening of the capital constraint. On the other hand, banks have a reduced incentive to step up their due diligence following shocks, due to the looser capital constraint, i.e., a diluted liquidity channel. This is in line with the negative effect of lending relationships on banks' due diligence effort detected in the empirical analysis. We obtain that lending experience overall attenuates the output effects of bond value and capital quality shocks, while it has a more ambiguous influence following regulatory shocks.¹⁶

The second exercise aims at pinning down the interaction between lending experience and due diligence effort (Panel B). To this end, we present IRFs that are obtained as the difference between the response of a model where banks perform due diligence and the comparison economy with reduced due diligence for two polar cases: with and without lending experience. This can help understand the role played by banks' due diligence as an "attenuator" or "amplifier" depending on the intensity of lending experience. In Panel B, a positive (negative) differenced-IRF

¹⁶In the Appendix we also show robustness for different values of ϕ .

signals that due diligence attenuates (magnifies) the negative effects of a shock. A smaller positive difference, say in the lending experience case (dotted lines), reveals that the attenuating role of banks' due diligence is weaker with lending experience. In line with the results in Panel A, following all shocks, due diligence effort rises more sharply in the economy without lending experience (continuous lines). In the case of the liquidity shocks, this leads to a stronger attenuation of the response of output. In the case of the capital quality shock, this leads to a stronger attenuation in the immediate aftermath of the shock, but to a larger amplification in subsequent periods. This is consistent with the results of Section 5.3 that more intense due diligence may amplify, rather than attenuate, capital quality shocks.

6.2 A microfoundation of the due diligence technology

Diamond and Rajan (2001, 2005) relate loan pledgeable values to the liquidation skills acquired by banks through their information accumulation on loans. For example, in their framework due diligence and information production on loans allow banks to more easily identify suitable buyers of project loans in the liquidation market, raising loan pledgeable values. We formalize a mechanism along these lines exploiting the heterogeneity of the banking sector of our economy between investing and non-investing islands. We posit that the specificity of bank claims on firms requires that, if a bank defaults strategically, only banks in the same island type can reuse the liquidated firm shares. Unlike in the primary markets for firm shares and interbank loans, however, in the liquidation market for firm shares trading frictions prevent from identifying buyers from the same island type and defaulting banks are randomly matched with potential buyers (for analyses on trading frictions in liquidation markets see, e.g., Ramey and Shapiro, 2001, Pulvino, 1998, Maksimovich and Phillips, 2001, Eisfeldt and Rampini, 2006, Gavazza, 2011).¹⁷

For instance, in the Appendix we show that the expected liquidation value of the firm shares of a bank in an investing island is

$$\Omega(\cdot) = Q_t^{X,i} x_t^i \mathcal{P}(\mathcal{S}_t^i, \mathcal{M}^i, \mathcal{M}^n) = Q_t^{X,i} x_t^i \frac{\mathcal{S}_t^i \mathcal{M}^i}{\mathcal{M}^i + \mathcal{M}^n}, \quad (29)$$

where $\mathcal{P}(\cdot)$ is the probability of being matched with a bank (buyer) from an investing island, $\mathcal{M}^i$ and $\mathcal{M}^n$ denote the measures of banks in investing and non-investing

¹⁷For a model with a liquidation market for project loans, see also Perri and Quadrini (2018).

islands, respectively, and $\mathcal{S}_t^i$ is the search intensity of the bank. Note also that $\mathcal{M}^i/(\mathcal{M}^i + \mathcal{M}^n) = \pi^i$.

Following previous studies that incorporate trading frictions (Cavalcanti and Wallace, 1999; Araujo and Minetti, 2007; Habib and Johnsen, 1999), banks' search intensity in the liquidation market is increasing in the information acquired on firm shares. In particular,

$$\mathcal{S}_t^i = \zeta^i \left(\frac{l_t^i}{Q_t^{X,i} x_t^i} \right)^{1-\phi}, \quad (30)$$

that is, $\mathcal{S}_t^i$ is an increasing and concave function of the loan officers, per unit of firm shares, employed in information production (with the parameter ζ^i capturing the effectiveness of information production). Replacing (30) into (29), and letting $\zeta^i = \zeta/\pi^i$, we obtain the pledgeable value of firm shares in (14).

7 Policy experiments

In what follows, we study how credit policies implemented during recent crises influence the role of banks' due diligence. We consider three interventions: provision of liquidity facilities to banks in the interbank market; bank equity injections; and direct lending to firms. The government finances these policies by issuing bonds to households, $D_{G,t}$, that are a perfect substitute of retail deposits and pay a riskless rate R_t^D . We assume that implementing the policies involves an efficiency cost: the government has to sustain a deadweight loss of ϱ_L for each unit supplied, for example reflecting administrative costs for implementing the policies.

We focus on liquidity provision to banks (details on the other two policies are in the Appendix). The government provides uncollateralized liquidity to banks that borrow in the interbank market. We assume that its liquidity provision $m_{G,t}^i$ is a fraction Φ_t of the total interbank borrowing $m_t^i = m_{P,t}^i + m_{G,t}^i$, where $m_{P,t}^i$ is the borrowing from private banks. As in Gertler and Kiyotaki (2010), the government intervenes when the external finance premium (the ratio between the return on firm shares and that on deposits) exceeds its steady state

$$\Phi_t = v \left[(E_t R_{t+1}^{K,i'} - R_t^D) - (R^{K,i'} - R^D) \right], \quad (31)$$

where $R^{K,i'} - R^D$ is the steady state premium and v is a feedback parameter.

The impulse responses following shocks are in Figure 8; the parameter v is cal-

ibrated to 5 and ϱ_L is equal to 0.001 (see Gertler and Karadi, 2011). On impact, relative to the baseline economy, liquidity provision to banks moderates the tightening of banks' liquidity constraints. This dilutes banks' incentive to perform due diligence to relax the constraints. Thus, on impact, while having a direct beneficial effect on the real sector, the policy dilutes the stabilizing function of due diligence in the wake of tighter liquidity. However, over the medium-long run this diluting effect on banks' due diligence vanishes. In fact, the tightness of the capital constraint progressively converges to that of the baseline economy (liquidity channel). Moreover, the higher shares values induced by the policy promote banks' incentive to perform due diligence (information productivity channel).

To summarize, liquidity provision to banks may have unintended, short-lived consequences in terms of weaker banks' due diligence. Yet, in the long run it retains a stabilizing role. In the Appendix, we show that these insights carry through to the other credit policies. However, direct lending to firms turns out to be more successful in stabilizing the real sector, while equity injections into banks induce the most pronounced dilution in due diligence effort.

8 Conclusion

This paper has studied the behavior of banks' due diligence over the business cycle and its impact on business cycle transmission. An analysis on U.S. data uncovered a tendency of banks to step up loan due diligence during recessions, especially when banks' access to liquidity is limited. Motivated by this evidence, we constructed a model in which banks face constraints in liquidity markets tied to loan pledgeable values and perform due diligence to enhance loan pledgeability. Two major channels govern due diligence: a liquidity channel, whereby changes in access to liquidity alter banks' incentive to produce information on loans; and an information productivity channel, whereby changes in loan values influence the impact of due diligence on loan pledgeability.

The model reveals that banks' due diligence effort rises following contractionary shocks, while becoming slacker during expansions. The countercyclical due diligence, in turn, attenuates the aggregate effects of liquidity shocks, but it may moderately amplify the effects of shocks to loan portfolio values. The analysis also reveals that policies traditionally viewed as stabilizing may have the unintended consequence of diluting banks' due diligence incentives during recessions. For example, credit inter-

ventions aimed at sustaining banks' access to wholesale liquidity may temporarily reduce banks' due diligence, though they retain a stabilizing effect in the long run.

The paper leaves open relevant questions. A natural research question is how conventional monetary policy could influence the cyclical behavior of banks' due diligence. This might also yield insights into the impact of wholesale liquidity market regulations on the effectiveness of the monetary stance. We leave this and other questions to future research.

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Table 1: Banks' due diligence (loan shares), aggregate shocks, and liquidity access

	I	II	III	IV	V
Interbank exposure	-0.040 (0.015)	-0.041 (0.029)	-0.037 (0.015)	-0.013 (0.009)	-0.040 (0.015)
NBER recessions	0.032 (0.013)	0.034 (0.038)	0.288 (0.115)		0.055 (0.016)
Lending experience (# of loans)	-0.010 (0.001)	-0.009 (0.001)	-0.010 (0.001)	0.002 (0.001)	-0.009 (0.001)
Information complexity		0.055 (0.010)			
Interbank exposure*NBER recessions			-0.014 (0.006)		
Interbank exposure*Exempted banks				0.026 (0.010)	
Lending experience*NBER recessions					-0.008 (0.002)
+ bank, loan, and firm controls	Y	Y	Y	Y	Y
Observations	17,756	2,393	17,756	12,387	17,756
R-squared	0.107	0.178	0.108	0.0738	0.108
Year FE	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y
Clustered standard errors	Bank*Year	Bank*Year	Bank*Year	Bank*Year	Bank*Year

The table reports coefficient estimates and standard errors (in parentheses). In all columns the dependent variable is the lead lender share in the syndicated loan. Coefficient estimates for the additional controls are reported in Appendix Table 3. All variables are defined in Appendix Table 1. All specifications are estimated with a linear probability model (HDFE) and include fixed effects (as noted in the lower part of the table) to control for different levels of unobserved heterogeneity. Standard errors are robust and clustered at the bank-year level.

Table 2 - Baseline calibration

Parameter	Value	Description
Households		
β	0.99	Discount factor
h_C	0.50	Habit persistence
φ	0.25	Inverse of Frisch elasticity (goods sector)
τ	0.25	Inverse of Frisch elasticity (banking sector)
k_H	4.45	Disutility of labor in goods production
k_L	0.202	Disutility of labor in due diligence activities
Firms		
α	0.33	Capital share
δ	0.025	Capital depreciation rate
$I(F''/F')$	2.5	Inverse elasticity of investment to the price of capital
Banks		
θ	0.003	Transfer to new bankers
σ	0.97	Banker survival rate
π^i	0.106	Probability of new investment opportunities
ξ	0.934	Weight on interbank loans
ϕ	0.796	Exponent in due diligence Cobb-Douglas function
ζ	1.608	Parameter in due diligence Cobb-Douglas function
Government		
η	1.05	Elasticity of taxes to public debt
B/Y	42%	Annual debt-to-GDP ratio
G/Y	0.20	Steady state proportion of government expenditures

Table 3 - Due diligence and macroeconomic volatility

Panel A - Variance decomposition (% difference)				
		Capital quality	Bond value	Regulatory
Baseline minus Comparison	Y_t	1.29%	-2.8%	-8.1%
Baseline minus Comparison	I_t	29.2%	4.6%	-2.8%
Panel B - Variance driven by each shock (% difference)				
		Capital quality	Bond value	Regulatory
Baseline minus Comparison	Y_t	1%	-2.8%	-8.3%
Baseline minus Lower ζ	Y_t	0.2%	0%	0%
Baseline minus Comparison	I_t	15%	-7.3%	-13.9%
Baseline minus Lower ζ	I_t	5.4%	-0.2%	0.1%

The lower ζ economy features a leverage of investing banks 5% lower than the baseline.

Figure 1 - Evolution of the average loan shares of lead banks in U.S. syndicates.

Figure 2 - Responses to negative bond value shock. All the IRFs refer to investing islands except for output, investment and bond value which are aggregate.

Figure 3 - Forces that contribute to bank due diligence response (see equation 18). All the IRFs refer to investing islands.

Figure 4 - Responses to negative regulatory shock. All the IRFs refer to investing islands except for output, investment and bond value which are aggregate.

Figure 5 - Responses to negative capital quality shock. All the IRFs refer to investing islands except for output, investment and bond value which are aggregate.

Figure 6 - Contribution of shares value and bank due diligence to changes in pledgeable values. The IRF (in difference) refers to investing islands.

Figure 7 - Lending experience: direct effect (Panel A) and interaction with due diligence (Panel B). In Panel B IRFs are in difference between the baseline and the reduced due diligence economy.

Figure 8 - Effects of liquidity provision to banks. The IRF of bank due diligence refers to investing islands whereas investment and output are aggregate.

Online Appendices - For Online Publication

The appendices are organized as follows. Appendix A contains details on the data and supplementary empirical results. Appendix B presents further derivation details on the model, additional quantitative results and the microfoundation for banks' capital constraint. Appendix C further investigates credit policies.

Appendix A – Data and further estimates (complements Section 3)

We obtain data on syndicated loans from DealScan. This database provides transaction-level information on the characteristics of the loan deal (amount, maturity, collateral, borrowing spread, performance pricing), as well as information on the syndicate members, the lead bank, the share of each bank in the syndicate, and the firm receiving the loan. We categorize loans as credit line, term A, B, C, D, and E and exclude term loans B because banks hold none of these loans after the syndication. Term loans B are structured specifically for institutional investors and almost entirely sold off in the secondary market. We apply three selection rules to avoid bias in our sample. This is an essential part of the sample selection process that is absent from most empirical studies using DealScan (for a similar strategy see Lim et al., 2014).

First, we disentangle banks from non-banks. We consider a loan facility to have a non-bank institutional investor if at least one institutional investor that is neither a commercial nor an investment bank is involved in the lending syndicate. Non-bank institutions include hedge funds, private equity funds, mutual funds, pension funds and endowments, insurance companies, and finance companies. To identify commercial bank lenders, we start from lenders whose type in DealScan is *US Bank*, *African Bank*, *Asian-Pacific Bank*, *Foreign Bank*, *Eastern Europe/Russian Bank*, *Middle Eastern Bank*, *Western European Bank*, or *Thrift/SEL*. We manually exclude the observations that are classified as a bank by DealScan but actually are not, such as the General Motors Acceptance Corporation (GMAC) Commercial Finance. Second, we exclude loans granted to utilities or to financial companies. Third, following Roberts (2015), we drop loans that are more likely to be amendments to existing loans, because these are misreported in DealScan as new loans, but they do not necessarily involve new money.

To obtain information for the financial statements of banks, we match these data with the U.S. Call Reports. We hand-match DealScan's lender name with the commercial bank ID (RSSD9001) from the Call Reports because there is no common identifier between these datasets. This process yields a unique identity for each lender. In turn, we link the lenders at their top holding company level (RSSD9348) to avoid losing observations. Because these reports are available on a quarterly basis, we match the origination date of the loan deal with the relevant quarter. For example, we match all syndicated loans that were originated from April 1st to June 30th with the second quarter of that year of the Call Reports.

Finally, to construct a measure for the degree of product information complexity, we exploit data from Rauch (1999) on the categories of product differentiation. To harmonize the trade classification with industry classification, we use OECD information and Muendler (2009). Rauch (1999) sorts products into three categories: products traded on international exchanges, those with reference prices, and differentiated goods for which branding information precludes them from being traded on exchanges or reference priced.

Appendix Table 1: Variables definitions and sources

Name	Description	Source
<i>Dependent variables:</i>		
Lead lender share	The share of the loan held by the lead lender.	DealScan
Participant shares	Percentage of non-lead share held by participant banks.	DealScan
<i>Main explanatory variable:</i>		
Interbank exposure	We use Furfine (2003) to define the interbank exposures as the natural logarithm of the following sum: Cash and balances due from depository institutions (0010), credit exposure of all off-balance sheet derivative contracts (8764), loans to depository institutions and federal funds sold (b987).	Call Reports
Lending experience (# of loans)	The number of loans that the lead lender lent to the same borrower in the past five years prior to a current loan.	Own calculations
Exempted banks	A dummy equal to one if the bank is a reserve-exempted institution. The Dodd-Frank required that the FDIC fee is transitioned from a deposit-based assessment to an assessment based on assets minus tangible equity. However, bankers' banks and banks with a custodial business were given a specific exemption for reserves balances.	Own calculations
NBER recessions	Dummy variable equal to one for NBER recessions and zero otherwise	NBER
Information complexity	A dummy equal to one if an industry produces heterogeneous goods. We use Rauch (1999) data on the categories of product differentiation: those traded on international exchanges, those with reference prices, and differentiated goods for which branding information precludes them from being traded on exchanges or reference priced.	Rauch (1999)
Term	Dummy variable equal to one if the loan type is a term loan such as term loan A.	DealScan
Company rating	Firm S&P credit rating	DealScan
Reserves	Reserves balances at the central bank relative to total assets for each bank-quarter.	Call Reports
Sectoral specialization (SIC2)	$Sector_{b,t}^{Exper} = \frac{Loan_t^{b \rightarrow s}}{Total\ Loan_t^{b \rightarrow S}}$ the amount (\$M) lent by bank b to a firm classified in a two-digit SIC sector s at time t over the total amount of lending (\$M) lent by bank b to the total number of sectors (S). This index ranges from zero to one, with higher values reflecting higher exposure in the sector in which the firm operates.	Own calculations
Deposits	The fraction of total deposits over total assets	Call Reports
Return on assets	Return on assets	Call Reports
TIER 1	The fraction of TIER 1 capital over total assets	Call Reports
Loan loss provisions	Loan loss provisions ratio	Call Reports
Bank size	The natural logarithm of bank's total assets	Call Reports

Appendix Table 2: Sample summary statistics

	Level	N	Mean	Std	Min	Median	Max
Lead lender share	Loan	24,799	0.339	0.340	0.000	0.183	1.000
Participant shares	Loan	39,570	0.563	0.511	0.000	0.400	0.900
Interbank exposure	Bank	24,799	17.230	2.018	8.177	17.456	20.421
Lending experience (# of loans)	Loan	24,799	2.170	3.646	0.000	1.000	71.000
Exempted banks	Bank	2,730	0.927	0.259	0.000	1.000	1.000
NBER recessions	Bank	24,799	0.132	0.339	0.000	0.000	1.000
Information complexity	Bank	3,194	2.479	0.670	1.000	3.000	3.000
Term	Loan	24,799	0.165	0.372	0.000	0.000	1.000
Sectoral specialization (SIC2)	Loan	24,799	0.076	0.114	0.000	0.043	1.000
Company rating	Loan	24,087	16.157	7.029	1.000	15.000	23.000
Reserves	Bank	24,799	0.016	0.049	0.000	0.003	2.070
Deposits	Bank	24,799	0.655	0.105	0.000	0.657	0.932
Return on assets	Bank	24,799	0.010	0.005	-0.138	0.010	0.058
TIER 1	Bank	24,799	0.236	0.271	0.000	0.113	1.000
Loan loss provisions	Bank	24,799	0.019	0.008	0.000	0.017	0.085
Bank size	Bank	24,799	19.087	1.665	11.566	19.283	21.389

The table reports sample summary statistics. See Appendix Table 1 for definitions.

Appendix Table 3: Full coefficient estimates for Table 1

	I	II	III	IV	V
Interbank exposure	-0.040 (0.015)	-0.041 (0.029)	-0.037 (0.015)	-0.013 (0.009)	-0.040 (0.015)
NBER recessions	0.032 (0.013)	0.034 (0.038)	0.288 (0.115)		0.055 (0.016)
Lending experience (# of loans)	-0.010 (0.001)	-0.009 (0.001)	-0.010 (0.001)	0.002 (0.001)	-0.009 (0.001)
Information complexity		0.055 (0.010)			
Interbank exposure*NBER recessions			-0.014 (0.006)		
Interbank exposure*Exempted banks				0.026 (0.010)	
Lending experience*NBER recessions					-0.008 (0.002)
Reserves	0.385 (0.174)	0.633 (0.323)	0.350 (0.174)	0.007 (0.007)	0.367 (0.173)
Sectoral specialization (SIC2)	-0.202 (0.053)	0.260 (0.225)	-0.202 (0.053)	-0.013 (0.020)	-0.201 (0.053)
Deposits	0.109 (0.085)	-0.174 (0.161)	0.124 (0.086)	0.127 (0.051)	0.115 (0.085)
Return on assets	-0.720 (1.055)	-1.443 (1.691)	-0.674 (1.051)	0.066 (0.202)	-0.682 (1.049)
TIER 1	0.031 (0.046)	-0.032 (0.007)	0.041 (0.046)	-0.007 (0.017)	0.037 (0.046)
Loan-loss provisions	1.520 (1.211)	2.795 (2.176)	1.368 (1.202)	-0.524 (0.416)	1.376 (1.207)
Bank size	-0.003 (0.020)	0.017 (0.035)	-0.005 (0.022)	-0.003 (0.268)	-0.003 (0.018)
Observations	17,756	2,393	17,756	12,387	17,756
R-squared	0.107	0.178	0.108	0.0738	0.108
Year FE	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y
Clustered standard errors	Bank*Year	Bank*Year	Bank*Year	Bank*Year	Bank*Year

The table reports coefficient estimates and standard errors (in parentheses). In all columns the dependent variable is the lead lender share in the syndicated loan. All variables are defined in Appendix Table 1. All specifications are estimated with a linear probability model (HDFE) and include fixed effects (as noted in the lower part of the table) to control for different levels of unobserved heterogeneity. Standard errors are robust and clustered at the bank-year level.

Appendix Table 4: Robustness tests

	I	II	III	IV
	Bank*Year FE	Purpose	Company rating	Term
Interbank exposure	-0.045 (0.016)	-0.036 (0.015)	-0.031 (0.014)	-0.039 (0.016)
NBER recessions	0.033 (0.014)	0.030 (0.013)	0.044 (0.015)	0.034 (0.013)
Lending experience (# of loans)	-0.010 (0.001)	-0.009 (0.001)	-0.006 (0.001)	-0.009 (0.001)
Reserves	0.655 (0.186)	0.307 (0.157)	0.262 (0.147)	0.407 (0.175)
Sectoral specialization (SIC2)	-0.191 (0.053)	-0.141 (0.050)	-0.002 (0.040)	-0.195 (0.053)
Deposits		0.089 (0.075)	0.020 (0.075)	0.095 (0.085)
Return on assets		-0.517 (0.940)	-1.360 (0.918)	-0.701 (1.049)
TIER 1		0.013 (0.042)	-0.010 (0.041)	0.025 (0.047)
Loan loss provisions		1.031 (1.129)	1.372 (1.103)	1.534 (1.203)
Bank size		-0.002 (0.016)	-0.004 (0.017)	-0.003 (0.024)
Company rating			0.015 (0.000)	
Term				0.047 (0.007)
Observations	17,724	17,754	17,265	17,756
R-squared	0.147	0.159	0.204	0.110
Year FE	N	Y	Y	Y
Bank FE	N	Y	Y	Y
Purpose FE	N	Y	N	N
Bank*Year FE	Y	N	N	N
Clustered standard errors	Bank*Year	Bank*Year	Bank*Year	Bank*Year

The table reports coefficients and standard errors (in parentheses) for lead lenders. All variables are defined in Appendix Table 1. In column I, we saturate the model with bank*year fixed effects. In column II, we insert loan purpose fixed effects. In columns III and IV, we control for the firm's riskiness and the type of loan, respectively. All specifications are estimated with a linear probability model (HDFE) and include fixed effects (as noted in the lower part of the table) to control for different levels of unobserved heterogeneity. Standard errors are robust and clustered at the bank-year level.

Appendix B – Further model details and results

B1 - Net worth evolution and aggregation (complements Section 4.5)

In this section we provide further details about the derivations for the banking sector. The aggregate bank balance sheet for each type $h \in \{i, n\}$ is given by

$$Q_t^{X,h} X_t^h + \pi^h Q_t^B B_t = N_t^h + \pi^h D_t + M_t^h - W_t^{L \frac{\phi-1}{\phi}} \left[\frac{(1-\phi)\zeta \mu_t^h}{\lambda_t^h} \right]^{\frac{1}{\phi}} Q_t^{X,h} X_t^h. \quad (32)$$

The aggregate profit transferred to households reads

$$\begin{aligned} \Pi_t = & Q_t^i I_t - \left[1 + F \left(\frac{I_t}{I_{t-1}} \right) \right] I_t + (1-\sigma) \sum_h \pi^h \left\{ [Z_t + (1-\delta)Q_t^{X,h}] \psi_t X_{t-1} + \psi_t^{B_g} B_{t-1} - R_{t-1}^D D_{t-1} \right\} \\ & - \theta \sum_h \pi^h \left\{ [Z_t + (1-\delta)Q_t^{X,h}] \psi_t X_{t-1} + \psi_t^{B_g} B_{t-1} \right\}. \end{aligned} \quad (33)$$

where $X_t = X_t^i + X_t^n$.

The total net worth for type h banks, N_t^h , equals the sum of the net worth of existing bankers N_{ot}^h (o for old) and of entering bankers N_{yt}^h (y for young):

$$N_t^h = N_{ot}^h + N_{yt}^h. \quad (34)$$

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

$$N_{ot}^h = \sigma \pi^h \left\{ [Z_t + (1-\delta)Q_t^{X,h}] \psi_t X_{t-1} + \psi_t^{B_g} B_{t-1} - R_{t-1}^D D_{t-1} \right\}. \quad (35)$$

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

$$N_{yt}^h = \theta \pi^h \left\{ [Z_t + (1-\delta)Q_t^{X,h}] \psi_t X_{t-1} + \psi_t^{B_g} B_{t-1} \right\}. \quad (36)$$

Then, the aggregate bank net worth evolves as

$$N_t^h = \pi^h \left\{ (\sigma + \theta) [Z_t + (1-\delta)Q_t^{X,h}] \psi_t X_{t-1} + (\sigma + \theta) \psi_t^{B_g} B_{t-1} - \sigma R_{t-1}^D D_{t-1} \right\}. \quad (37)$$

B2 - Additional IRFs for Sections 5.2 and 5.3

In Appendix Figure 1 we study how the weight ϕ on banks' due diligence in the function (14) influences the responses to the shocks. In one scenario ("high ϕ ") $\phi = 0.8$; in the other ("low ϕ ") $\phi = 0.60$. Due diligence

is always more intense in the “high ϕ ” scenario for all the shocks. See Section 5.2 and 5.3 for comments on the figure.

Appendix Figure 1 - Responses for different values of ϕ . All the IRFs refer to investing islands except for investment which is aggregate.

B3 - Permanent regulatory change (complements Section 5.2)

We here simulate the effect of a permanent (deterministic) regulatory shock to χ_t .

The figure below shows the responses of the model variables for 40 periods (10 years). Similar to the case of a temporary regulatory shock, the permanent rise in banks’ due diligence overall acts as an attenuator of the effects of the shock on investment and output.

Appendix Figure 2 - Responses to a permanent regulatory shock. IRFs for shares value and due diligence refer to investing islands whereas investment and output are aggregate.

B4 - Derivation details for lending experience (complements Section 6.1)

In the setting augmented with banks' lending experience, the representative bank solves the optimization problem:

$$V_{t-1}(\cdot) = E_{t-1} \Lambda_{t-1,t} \left[\sum_h \pi^h (1 - \sigma) n_t^h + \max_{d_t, b_t, m_t^h, x_t^h, l_t^h, s_t^h} \sum_h \pi^h \sigma V_t(d_t, b_t, m_t^h, x_t^h, l_t^h, s_t^h) \right]$$

$$\text{s.t.} \quad Q_t^{X,h} x_t^h + Q_t^B b_t = n_t^h + d_t + m_t^h - W_t^L l_t^h, \quad [\sigma \pi^h \lambda_t^h] \quad (38)$$

$$R_t^D d_t + \xi R_t^M m_t^h \leq Q_t^B b_t + \zeta [Q_t^{X,h} (x_t^h + h_x s_{t-1})]^\phi (l_t^h)^{1-\phi} \quad [\sigma \pi^h \mu_t^h] \quad (39)$$

$$R_t^M m_t^h \leq \chi_t Q_t^B b_t \quad [\sigma \pi^h \gamma_t^h] \quad (40)$$

$$s_t^h = \rho_s s_{t-1} + (1 - \rho_s) x_t^h \quad [\sigma \pi^h \nu_t^h] \quad (41)$$

The first order conditions for m_t^h , d_t and b_t remain unchanged, whereas the FOCs for x_t^h , l_t^h and s_t^h are

$$[\partial x_t^h]: \quad -Q_t^{X,h} \lambda_t^h + \zeta \phi \mu_t^h (Q_t^{X,h})^\phi (x_t^h + h_x s_{t-1})^{\phi-1} (l_t^h)^{1-\phi} + \\ + (1 - \rho_s) \nu_t^h + E_t \Lambda_{t,t+1} \sum_{h'} \pi^{h'} [Z_{t+1} + (1 - \delta) Q_{t+1}^{X,h'}] \psi_{t+1} (1 - \sigma + \sigma \lambda_{t+1}^{h'}) = 0, \quad (42)$$

$$[\partial l_t^h]: \quad l_t^h = \left[\frac{\zeta (1 - \phi)}{W_t^L} \right]^{\frac{1}{\phi}} \left[\frac{\mu_t^h}{\lambda_t^h} \right]^{\frac{1}{\phi}} \left[Q_t^{X,h} (x_t^h + h_x s_{t-1}) \right], \quad (43)$$

$$[\partial s_t^h]: \quad \nu_t^h = E_t \Lambda_{t,t+1} \sum_{h'} \pi^{h'} \sigma \left\{ \rho_s \nu_{t+1}^{h'} + h_x \phi \zeta \mu_{t+1}^{h'} (Q_{t+1}^{X,h'})^\phi (x_{t+1}^{h'} + h_x s_{t+1}^{h'})^{\phi-1} (l_{t+1}^{h'})^{1-\phi} \right\} = 0. \quad (44)$$

B5 - Robustness for lending experience (complements Section 6.1)

We aim at verifying the robustness of the results of Section 6.1 to different weights ϕ in the function (14) for banks' due diligence. We consider two calibrations for ϕ : "high ϕ " ($\phi = 0.8$), and "low ϕ " ($\phi = 0.6$). The degree of lending experience as measured by h_x is set to 0.7. For a high value of ϕ we observe that banks' due diligence is higher than in the case of a low ϕ . This implies that shares values fall less, as a higher information production makes firm shares more pledgeable. Then, the fall of investment and output is mitigated and banks' due diligence behaves as a shock attenuator (see Appendix Figure 3).

Appendix Figure 3 - Responses for different values of ϕ under lending experience. All the IRFs refer to investing islands except investment for which are aggregate.

B6 - A microfoundation of the due diligence technology (complements Section 6.2)

In what follows, we outline a microfoundation of the bank capital constraint in equation (11). As in Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), we posit that bankers can “run away” and abscond assets from their financiers (banks’ strategic default). Bank financiers (retail and interbank depositors) can force a defaulting banker into liquidation and recover a portion of the liquidation value of the bank’s assets. Following Diamond and Rajan (2001, 2005), the liquidation value of firm shares is tied to the liquidation skills accumulated by the bank through due diligence. Diamond and Rajan (2001, 2005) show that, because of the features of deposit contracts, a banker can commit to exerting its liquidation skills at the moment of asset liquidation. In particular, the first-come, first-served nature of deposit contracts induces a collective action problem that forces a transfer of the ownership of project loans if the bank tries to renegotiate the repayment below the recovery value $\Omega(Q_t^{X,h} x_t^h, l_t^h, s_{t-1})$ that the bank can obtain in the liquidation market. Unlike in Diamond and Rajan (2001, 2005), we let bankers choose *ex-ante* their effort in acquiring liquidation skills (i.e., their due diligence intensity).

Diamond and Rajan (2001, 2005) argue that bankers’ liquidation skills materialize in their ability to identify the best buyers of project loans in the liquidation market. Exploiting the characteristics of our economy we can formalize a mechanism along these lines through which bankers can raise the liquidation values of firm shares. Suppose that in our economy the liquidation market for firm shares is an economy-wide market in which all bankers, from both investing and non-investing islands, participate. Further, shares purchased in investing islands can be only resold to, and reused by, bankers operating in investing islands; similarly, shares purchased in non-investing islands can be only resold to, and reused by, bankers operating in non-investing islands. This captures the specificity of bank claims, such that only banks in the same type of island can effectively reuse liquidated shares. Finally, unlike in primary markets (the market for firm shares and the interbank market), in the liquidation market for firm shares a banker cannot identify the island of origin of other bankers. This specification captures the idea that the liquidation process of assets naturally entails trading frictions. A broad literature stresses, and finds evidence, that the asset secondary market is plagued by severe trading frictions (Ramey and Shapiro, 2001; Pulvino, 1998; Maksimovich and Phillips, 2001; Eisfeldt and Rampini, 2006; Gavazza, 2011). Given this specification, the liquidation value of firm shares expected by a bank in an investing island is

$$\Omega(\cdot) = Q_t^{X,i} x_t^i \mathcal{P}(S_t^i, \mathcal{M}^i, \mathcal{M}^n) = Q_t^{X,i} x_t^i \frac{S_t^i \mathcal{M}^i}{\mathcal{M}^i + \mathcal{M}^n}, \quad (45)$$

where $\mathcal{P}(\cdot)$ is the probability of being matched with a bank from an investing island, $\mathcal{M}^i$ and $\mathcal{M}^n$ denote the measures of banks in investing and non-investing islands, respectively, and S_t^i is the search intensity of the bank. Following previous studies that incorporate trading frictions (Cavalcanti and Wallace, 1999; Araujo and Minetti, 2007; Habib and Johnsen, 1999), and in line with Diamond and Rajan (2001, 2005), we posit that the acquisition of information and due diligence of the bank allows it to more easily identify suitable buyers from its same type of island and, hence, to increase the probability of a suitable match. In particular,

the search intensity of the bank satisfies

$$\mathcal{S}_t^i = \zeta^i \left(\frac{l_t^i}{Q_t^{X,i} x_t^i} \right)^{1-\phi}, \quad (46)$$

that is, $\mathcal{S}_t^i$ is a standard increasing and concave function of the loan officers, per unit of firm shares, employed in information production activities. The parameter ζ^i captures the effectiveness with which information translates into search intensity. From (46), denoting $\zeta^i \equiv \zeta(\mathcal{M}^i + \mathcal{M}^n)/\mathcal{M}^i$,

$$\Omega(\cdot) = \zeta(Q_t^{X,i} x_t^i)^\phi (l_t^i)^{1-\phi}. \quad (47)$$

This specification thus allows to reproduce the liquidation value of firm shares in the model.

Appendix C – Policy experiments (complements Section 7)

C1 - Equity injections and direct lending

Here we detail the implementation of equity injections into banks and direct lending to firms and discuss their effects. Equity injections into banks consist of purchases of assets held by banks, at a price possibly higher than the market one. Equity injections are conducted before the realization of the 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 the quantity of shares $x_{G,t}$ owned by the government is a fraction Φ_t of total intermediated shares $x_t = x_{P,t} + x_{G,t}$, where $x_{P,t}$ is the quantity of privately owned shares.¹⁸ The bank balance sheet now includes the market value of government equity $n_{G,t} = Q_t^X x_{G,t}$ and evolves as

$$Q_t^X x_t + Q_t^B b_t = n_t + d_t + m_t - W_t^L l_t + n_{G,t}. \quad (48)$$

The price paid by the government to acquire shares, $Q_{G,t}^X$, exceeds the market price Q_t^X . Thus, the government makes a transfer to banks by paying a premium over Q_t^X . Banks' capital constraint becomes

$$R_t^D d_t + \xi R_t^M m_t \leq Q_t^B b_t + \zeta [Q_t^X (x_t - x_{G,t})]^\phi l_t^{1-\phi} + \zeta Q_{G,t}^X x_{G,t}. \quad (49)$$

The last policy we consider is direct lending to firms. This policy is conducted after the investment opportunity shock is realized and consists of lending to firms on the investing islands. We assume that the quantity of direct lending $x_{G,t}^i$ is a fraction Φ_t of total intermediated shares $x_t^i = x_{P,t}^i + x_{G,t}^i$, where $x_{P,t}^i$ is the quantity of shares privately intermediated.

For both credit policies, Φ_t evolves as in (31). Finally, note that for all credit policies the government budget constraint is amended to account for the deadweight loss ϱ_L (see, e.g., Gertler and Kiyotaki, 2010).

¹⁸Variables are not indexed to h as equity injections are made before the realization of the investment opportunity shock.

We next consider how due diligence effort and funding liquidity interact when the government implements a credit policy based on equity injections into firms. Appendix Figure 4, plots the IRFs of investment, output and bank due diligence to shocks considered. This policy implies that output falls less than in the baseline case. As the government directly provides equity to the banking sector, the capital constraint is now relaxed. This, in turn, tends to reduce the incentive to perform due diligence (liquidity channel). Moreover, as the shares value drops, the lower information productivity provides further incentive to curtail due diligence. Thus, following liquidity shocks, banks reduce due diligence and the stabilizing effects of due diligence fades. As a consequence, output and investment attenuation is smaller under equity injections than under liquidity provisions to banks.

Finally, in the Appendix Figure 5 we show the impulse responses for a direct lending to firms. Results are similar to those in Section 7. In fact, direct lending implies that the interbank and capital constraints are looser than in the baseline economy and this dilutes the incentive to perform due diligence, at least in the short run. In the medium-long run the liquidity effect vanishes and the higher value of firms' shares raises due diligence incentives via the information productivity channel. The effect on the real sector is that the fall of investment and output is attenuated.

Appendix Figure 4 - Effects of equity injections into banks. The IRF of bank due diligence refers to investing islands investment and output are aggregate.

Appendix Figure 5 - Effects of direct lending to firms. The IRF of bank due diligence refers to investing islands whereas investment and output are aggregate.

C2 - Quantitative assessment of credit policies

We now turn to study how different types of credit policies quantitatively affect the responses to shocks. Results are collected in the Appendix Table 5. In our baseline economy, following a negative bond value shock, the cumulated increase in due diligence observed after four years is around 74%, a value higher than that observed when the government pursues a credit policy. In fact, under a liquidity provision to banks the cumulative due diligence increase after four years is 72%; under direct lending to firms the increase is 69%. By contrast, equity injections into banks reduce the cumulative response of the due diligence effort by 41%. Similar results are found for the other shocks. Thus, equity injections into banks is the credit policy that most dilutes due diligence relative to the baseline case.

To quantify how the diluting effects of credit policies on bank due diligence influence the real sector, we compare the output drop under each credit policy with that observed in our baseline case. The mix of lower due diligence and government credit policy always entails an attenuation of the negative effects associated with a bond value shock. In our baseline economy the cumulated output loss after four years is around 5%: the credit policy that achieves the smallest fall of output is direct lending (output goes down by 2.2%, whereas under liquidity provision and equity injections the output reduction is 3.8% and 4.6%, respectively). This result carries through to other shocks. For the regulatory shock the cumulated output loss after four years is 6.5% in our baseline economy and shrinks to 2.7% under the direct lending policy. Liquidity provision and equity injections retain their attenuating effect, but to a lower extent compared with direct lending: in

fact, output declines by 5% under a liquidity provision and by 6.2% under an equity injection. Finally, for the capital quality shock we compute a 15% cumulated output decrease after four years in our baseline. This drops to 12% under direct lending, to 14.3% under liquidity provision and to 14.8% under equity injections. Overall, as the table shows, direct lending to firms turns out to be the most successful policy in stabilizing the real economy.

Appendix Table 5 - Cumulative (4yrs) percentage change of due diligence and output for each credit policy.

	Baseline		Direct Lending		Liquidity Provision		Equity Injections	
	ΔL_t^i	ΔY_t	ΔL_t^i	ΔY_t	ΔL_t^i	ΔY_t	ΔL_t^i	ΔY_t
Bond value	74.7%	-4.9%	69.8%	-2.2%	72.3%	-3.8%	-41.7%	-4.6%
Regulatory	-1.0%	-6.5%	-7.4%	-2.7%	-4.3%	-5.0%	-176%	-6.2%
Capital quality	237%	-15.0%	226%	-12.0%	233%	-14.3%	194%	-14.8%

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