

# Does Interbank Market Matter for Business Cycle Fluctuation? An Estimated DSGE Model with Financial Frictions for the Euro Area

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## Abstract

The aim of this paper is to assess the impact of the interbank market on the business cycle. To do that, we built a DSGE model with heterogeneous households and banks.

Net lender banks can allocate their resources between interbank lending and risk free government bonds. This portfolio choice is affected by an exogenous counterpart risk shock on the interbank market. An increase of the counterpart risk diverts funds from the interbank markets toward the government bonds market. This mechanism allows us to capture the freeze of the unsecured interbank market and the flight to quality mechanism underlying the last financial crisis.

**Keywords:** DSGE model, financial frictions, interbank market, Bayesian estimation, Monetary Policy.

**JEL classification codes:** E30, E44, E51, E52.

## 1 Introduction

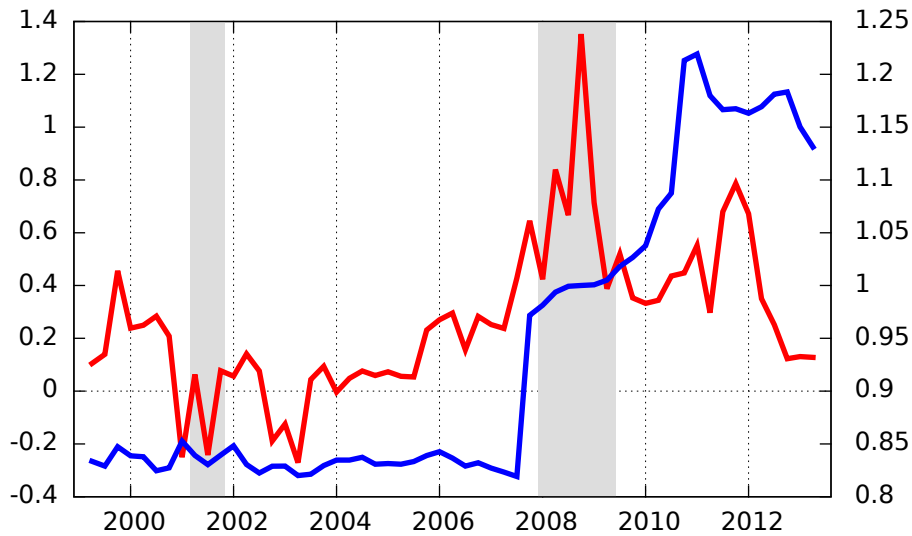
The interbank market is the primary source of fundings for banks that need to gather liquidity in order to create new loans. Shocks that interfere with its normal functioning can have significant repercussions both on the whole financial system and on the real side of the economy.

Figure 1 shows the spread between the three month Euribor and the overnight index swap on the EONIA interest rate. The so called OIS spread is considered one of the most important indicators to evaluate the proper functioning of the liquidity market. The higher the spread, the higher is the risk perceived by the financial intermediaries that operate on the interbank market.

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Figure 1: Eur3M-OIS spread, government bond detained by MFI



Source: The OIS spread (red line, left axis) is taken from Datastream while the statistics of government bonds (blue line, right axis) are from the ECB. OIS is expressed in percentage while government bond are in millions of euro.

Many contributions tried to understand the causes behind this sharp increase of the money market spreads and the first suspect was the increase of liquidity risk on the interbank market (see Beirne (2012)) during August 2007. The smoking gun can be traced back to the decision of BNP Paribas to freeze three investment funds.

Things changed after the collapse of Lehman Brothers in September 2008. Panic spreads in the financial markets and the fear that several financial intermediaries wouldn't be able to refund their loans caused a sudden and extended drainage of liquidity from the unsecured interbank market. As a consequence the OIS spread at the end of 2008 rose by almost 100 basis point with respect to the beginning of the year. Banks looked for a "safe heaven" choosing low but safe returns like government bond (See figure 1). A liquidity problem seemed to turn in a solvency issue (see Socio (2011) and Filipović and Trolle (2013)).

From a theoretical point of view, Heider et al. (2015) identified the key channel behind this flight to liquidity mechanism in the rise of counterpart default risk on the interbank market. Their theoretical framework is able to explained several stylized facts of the last financial crisis like accumulation of reserves by the financial intermediaries, the increased of interest rates and the inability of monetary authority of restoring the normal functioning on the money market through the short term interest rate.

Despite the growing interest of the literature on the role of interbank market, very few papers concentrate their attentions on the macroeconomic and general equilibrium effects of credit and/or liquidity shocks on the business cycle (Radde (2014) is amongst the few exceptions). The primary objective of this paper is try to fill this gap in order to better understand the role of the interbank market in the propagation of the financial crisis using a Dynamic Stochastic General Equilibrium framework.

The novelty of our contribution is to embed an interbank market like in Dib (2010) and deWalque et al. (2010) in a model like the one proposed by Gerali et al. (2010)

including a counterpart risk on the interbank market like Heider et al. (2015). The combination of such models allow us to have a very rich set up in term of banking system features but at the same time flexible enough to take the model to the data applying the standard Bayesian estimation technique, a novelty with respect with the previous calibrated models.

This hybrid model allow us to understand the general equilibrium effects of an increased of riskiness on the interbank market, without disentangling between credit and liquidity risk, and the relative monetary policy implications.

Our results show that *a*) an increase of the counterpart risk on the interbank market can generate a credit crunch and, as a consequence, a recession, mainly driven by a drop of investments and house purchases, *b*) this shock played a non negligible role in the rise of the interest rates in the money and credit market after August 2007, *c*) counterpart risk disrupts the central bank intervention making the conduction of monetary policy through the adjustment of the short term interest rates less effective.

The paper is organized as follow. Section 2 presents the most recent contributions in the field of DSGE model with an explicit interbank sector. Section 3 explains in detail the model and the relative equations. Sections 3 and 4 deal with the solution methods and the estimation techniques. Section 5 and 6 focus their attention on the dynamical properties of the model and the historical variance decomposition of the shocks. Finally, Section 7 summarizes the main findings and the possible extensions.

## 2 Literature review

The paper proposed by Goodhart et al. (2009) is the first attempt to include an active interbank market into a partial equilibrium model. Heterogeneity is imposed assuming a limited participation constraint in the money market. The interbank market is made of a surplus bank, which obtains funds from the households, and of a deficit bank that receives loans from the surplus one to finance corporate lending. The central bank is able to influence the interest rate only through the deficit bank. Many recent contributions are based upon Goodhart et al. (2009) in order to include an interbank market in a general equilibrium framework.

In a general equilibrium framework, deWalque et al. (2010) built up a relatively simple RBC model that captures some stylized facts of the interest rate structure and defaults rate on interbank market. The interbank market is the preferential channel used by the central bank to inject or withdraw liquidity to reduce the differences between interbank funds demand and supply. The authors used the model to investigate the different outcome on stability and growth cased by the Basel I and the Basel II agreements. Secondly but more importantly for our purpose, they also found evidences that the presence of defaults on the interbank market can amplify the effects of a supply side shock.

Dib (2010) added to DeWalque's framework the possibility for the net lender bank to allocate its funds not only on the money market but it can also purchase risk free government bonds. The central bank can alter the composition of the saving bank balance sheet when it intervenes to stem the inflation growth or the output gap. A general result is that the presence of a banking sector attenuates the impact of several shocks.

Both deWalque et al. (2010) and Dib (2010) models focus their attention on the unsecured segment of the interbank market. They both allow the net debtor on the interbank market to not pay bank a fraction of their interbank funds introducing counterpart risk

in their financial market.

Carrera and Vega (2012) built up a DSGE model with an interbank market in order to analyze alternative macroprudential policy rule. The authors developed a hierarchical bank system in which the exchanges between the central bank and the retailers are managed by another subject called the narrow bank. The authors used the model in order to investigate the behavior of the macroprudential policy in presence of an interbank market finding out that a reserve requirement rule can be used jointly with the standard Taylor rule to avoid large swings of the interest rate.

The contributions of Hilberg and Hollmayr (2011) and Gertler and Kiyotaki (2010) concentrate their attention on the unconventional monetary policy and the related role of interbank market in the transmission of such actions by the monetary authority.

In Hilberg and Hollmayr (2011) model, the retail bank is subject to a borrowing constraint (See Kiyotaki and Moore (1997) and Iacoviello (2005)) in the amount of funds it can obtain from the investment bank. The asset back securities are evaluated at market price instead of the fundamental price. The formation of asset price bubble can increase the value of the collateral, enhancing the ability of the retail bank of receiving funds from the investment bank. This mechanism gives raise to a boom and burst financial cycle. The investment bank is also subject to a borrowing constraint. In this case, the unconventional policy rule is related to the haircut that the central bank can apply to the assets of the investment bank in order to provide liquidity. In normal time the central bank accepts only liquid assets like government bonds while during financial stress it can also buy illiquid asset back securities like loans. The authors find that relaxing the haircut is an effective tool to boost the interbank market lending and consequently economic growth. Differently from deWalque et al. (2010) and Dib (2010), Hilberg and Hollmayr (2011) focus their attention on the collateralized market leaving out the role of defaults.

Gertler and Kiyotaki (2010) built a DSGE model with an interbank market in which all banks borrow from and lend to firms. In their model the interbank market arises because banks are subject to an idiosyncratic liquidity shock which has the effect of creating surplus and deficit intermediaries. Limited pledgeability gives place to an endogenous leverage constraint where bankers need to use their own equity in order to attract external creditors both on the retail (deposits) and at the wholesale level (interbank borrowing/lending). Gertler and Kiyotaki (2010) use their model to investigate how several different (unconventional) credit policies could mitigate the negative effect of a financial crisis.

In term of modeling, the innovation of Gertler and Kiyotaki (2010) consists of an interbank market that arises endogenously and it is not imposed by a limited participation constraint.

The recent contribution by Boissay et al. (2013) pushes this concept even further. They set up a non linear DSGE model not only able to generate an endogenous interbank market exploiting the different degree of bank efficiency, but the model is also capable of generating endogenous financial crisis capturing several stylized facts of historical systemic banking crises (see Schularick and Taylor (2012)).

Our modeling choices closely follow deWalque et al. (2010) and Dib (2010) in the way the interbank market is introduced in our set up. This modeling choice is motivated on the empirical evidence that assigns a predominant role to defaults but it also allow us to build a rich framework that it can be easily taken to the data and used for policy analyses.

### 3 The model

Our model is an extension of the one proposed by Gerali et al. (2010). The whole economy is made of several representative agents each of them maximizing his objective function under a budget constraint. Two kind of households, patient and impatient, live in the model. Patient households have a higher intertemporal discount factor than the impatient ones. Therefore, patient households are net savers and they decide how much to consume, to work and the amount of deposits to allocate at the surplus bank. Impatient households are net borrowers and they choose how much to consume and to work. They finance part of their spending obtaining loans from the retail branch of the deficit bank. Both patient and impatient households sell their work to a union that sells a composite labor factor to the intermediate firm. Moreover, their utility also depends by the amount of the house services they can purchase.

The rest of the real side of the economy is built on Christiano et al. (2005) and Smets and Wouters (2007). Capital producers operate under perfect competition. They buy the undepreciated capital from the intermediate producers and a fraction of final goods from the final goods producers. They combine these two inputs to produce new capital that they sell at the real price to the intermediate firms. Final goods producers operate under perfect competition but sticky prices. They combine the intermediate goods into a final goods. We strictly follow Gerali et al. (2010) to model the labor market. Two agents operate in the labor market, unions and labor packers. Workers provide a differentiated labor factor to unions. Moreover, a continuum  $m$  of labor packers acquire labor from the unions and they sell, through a CES aggregator, an homogeneous labor factor to the intermediate firms. We will not develop the detailed derivations in the paper for the real economy of this model. They can be found in the technical appendix A.

The bank system of the model is an extension of Gerali et al. (2010) and Dib (2010). The deficit bank is modeled like in Gerali et al. (2010) and it is a net debtor on the interbank market. We have a retail branch that is directly connected with firms and households. The retail branches operate under monopolistic competition and they could set the interest rate on loans provided to impatient households and firms. A wholesale branch of the deficit banks has to manage the capital position of the holding choosing the optimal balance sheet of the bank group. Moreover, like in Dib (2010), deficit banks could choose the optimal amount of default over the interbank. This novelty allows us to introduce the counterpart risk in our framework. In order to keep the model as simple as possible, we introduce two simplifications: a) there is no distinction in the model between credit and liquidity risk and we will describe the exogenous shock hitting the interbank market as a generic counterpart shock as described in Heider et al. (2015) and b) we consider only the unsecured interbank market like in deWalque et al. (2010) but differently from Hilberg and Hollmayr (2011) where they considered only the secure segment of the interbank market. This choice is motivated by many empirical evidences. Taylor (2009) underlines that the turmoil on the interbank market was essentially motivated by a counterpart risk crisis and not by a liquidity issue.

The surplus banks collect loans from patient households and invests part of their deposits either in the interbank market or in government bond. Similar to deWalque et al. (2010), surplus banks are subjected to a disutility cost that is proportional to the interbank exposition. Monetary policy is conducted by the central bank following a Taylor rule. We close our model specifying a government sector that obeys to an intertemporal budget constraint and manages the tax rate according to a feedback rule targeting the

stock of real debt like in Leeper (1991).

### 3.1 Savers and Borrowers

The real side of the model closely follow Gerali et al. (2010). In this section we only presents the main features and we leave the complete derivations to the technical appendix.

#### 3.1.1 Patient households

Patient households choose  $c(i)^P$ ,  $h(i)^P$ , and  $d(i)^P$  (respectively, consumption, house services, and the amount of deposits) in order to maximize their utility function under the budget constraint. The utility function depends positively on consumption and houses services and negatively on the hours worked.

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \left[ (1 - a^P) \epsilon_t^z \log(c_t^P(i) - a^P c_{t-1}^P) + \epsilon_t^h \log(h_t^P(i)) - \frac{l_t^P(i)^{(1+\phi)}}{1 + \phi} \right] \quad (1)$$

where  $\beta_p$  is the intertemporal discount factor of patient households while  $a_p$  represents the external habit formation in consumption with respect to the whole Patient households' consumption. The exogenous variables  $\epsilon_t^z$  and  $\epsilon_t^h$  are two stochastic disturbances affecting consumption preferences and the house services demand. The budget constraint for patient households is described by the following equation

$$c_t^P(i) + q_t^h \Delta h_t^P(i) + d_t^P(i) = w_t^P(i) l_t^P(i) + \frac{(1 + r_{t-1}^d)}{\pi_t} d_{t-1}^P(i) + Tr_t - T_t^P \quad (2)$$

The left hand side is the flow of expenses. It is composed by consumption, variation of the market value of housing services, where  $q^h$  is the real house price, and the amount of deposit allocated at the surplus bank. The right hand side of equation 2 represents the resource owned by the patient households.  $w^P$  is the hourly wage,  $r^d$  is the net interest rate on deposits,  $\pi$  is the net inflation and  $T$  is a lump sum tax. All variables are expressed in real terms.  $Tr_t$  are the transfers from the economy to the patient households. We assume that final goods producer firms are completely owned by the patient households and they transfer to them their profits  $J^r$  while the deficit banks redistribute only a fraction  $(1 - \Omega)$  of their profits to the households.  $T_t^P$  is a lump sum tax used to finance government expenditures. Patients households are net savers and they decide to allocate a fraction of their income in bank deposits at the surplus bank.

#### 3.1.2 Impatient Households

Impatient households choose  $c(i)^I$ ,  $h(i)^I$ , and  $b(i)^I$  in order to maximize their utility function under the budget constraint. They behave exactly like patient households, but instead of being net savers they are net borrowers due to their lower intertemporal discount factor. Consequently, they finance a fraction of their spending by obtaining loans  $b(i)^I$  from the retail branch of the deficit bank.

$$E_0 \sum_{t=0}^{\infty} \beta_I^t \left[ (1 - a^I) \epsilon_t^z \log(c_t^I(i) - a^I c_{t-1}^I) + \epsilon_t^h \log(h_t^I(i)) - \frac{l_t^I(i)^{(1+\phi)}}{1 + \phi} \right] \quad (3)$$

Their budget constraint is described by the following expression

$$c_t^I(i) + q_t^h \Delta h_t^I(i) + \frac{(1 + r_{t-1}^{bh})}{\pi_t} b_{t-1}^I(i) = w_t^I(i) l_t^I(i) + b_t^I(i) \quad (4)$$

As in Iacoviello (2005), the amount of funds the impatient households can receive from the deficit bank is limited by the following borrowing constraint:

$$(1 + r_t^{bh}) b_t^I(i) \leq m_t^I E_t[q_{t+1}^h h_t^I \pi_{t+1}] \quad (5)$$

The total exposure toward the deficit banks of the impatient households must be less or equal of the expected value of the collaterals (houses) owned by the households.  $m_t^I$  represents the stochastic loan-to-value-ratio.<sup>1</sup>

### 3.1.3 Entrepreneurs

Entrepreneurs are self employed intermediate goods producers. Entrepreneurs choose  $c(i)^E$ ,  $k(i)^E$ ,  $l(i)^{E,P}$ ,  $l(i)^{E,I}$ ,  $b(i)^E$ ,  $u(i)^E$ , where each variable represents respectively consumption, capital used to produce intermediate goods, labor from patient and impatient households, the amount of loans obtained by the retail branch of the deficit bank and the degree of utilization of capital. Like impatient households, they are net debtors on the credit market. Differently from patient and impatient households, the utility function depends only on entrepreneur's consumption:

$$E_0 \sum_{t=0}^{\infty} \beta_E^t [(1 - a^E) \log(c_t^E(i) - a^E c_{t-1}^E)] \quad (6)$$

The budget constraint of the entrepreneurs is described by the following expression:

$$\begin{aligned} c_t^E(i) + w_t l_t^{E,P}(i) + w_t l_t^{E,I}(i) + \frac{(1 + r_{t-1}^{be})}{\pi_t} b_{t-1}^E(i) + q_t^k k_t^E + f(u_t(i)) k_t^E(i) \\ = \frac{y_t^E}{x_t} + b_t^E(i) + q_t^k (1 - \delta) k_{t-1}^E(i) \end{aligned} \quad (7)$$

We specify the functional form of  $f()$  like in Schmitt-Grohé and Uribe (2006):

$$f(u_t(i)) = \xi_1 (u_t(i) - 1) + \frac{\xi_2}{2} (u_t(i) - 1)^2 \quad (8)$$

The production function is a classical Cobb-Douglas where,  $A_t^E$  represents a stochastic total factor productivity shock.

$$y_t^E(i) = A_t^E [k_{t-1}^E(i) u_t(i)]^\alpha l_t^E(i)^{(1-\alpha)} \quad (9)$$

Entrepreneurs use a combination of labor supplied by patient and impatient households following the expression

$$l_t^E(i) = l_t^{E,P}(i)^\mu l_t^{E,I}(i)^{(1-\mu)} \quad (10)$$

Like the impatient households, entrepreneurs are also subject to a borrowing constraint

$$(1 + r_t^{be}) b_t^E(i) \leq m_t^E E_t[q_{t+1}^k (1 - \delta) k_t^E(i) \pi_{t+1}] \quad (11)$$

While impatient households use their amount of houses as collateral, entrepreneurs use the expected value of their endowment of physical capital.

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<sup>1</sup>Iacoviello (2005) demonstrates that in the neighborhood of the steady state the constraint always binds. We neglect the problem of the occasionally binding constraints. See for further references Guerrieri and Iacoviello (2015) and Brzoza-Brzezina et al. (2013).

## 3.2 Banking system

The banking system is built upon Gerali et al. (2010) and Dib (2010). Both the surplus and the deficit bank are made of a wholesale and a retailer branch. The aim of the wholesale branch is to define the optimal balance sheet of the bank while the retailers have to set the interest rates on loans and deposits. The interbank market operates under perfect competition but the surplus bank has to face a limited enforcement problem: the deficit bank can decide (optimally) to not pay back a certain amount of interbank borrowing in each periods. On the other hand, the surplus bank can allocate its resources among risky interbank loans and government bonds. To keep the model simple, we introduce another simplification: we do not distinguish between secure and unsecured interbank market but we assume that all the interbank transactions are risky. The sequence of events in the interbank market strictly follow deWalque et al. (2010): at time  $t$  the deficit bank receive an amount  $IB_t$  from the surplus bank. At time  $t + 1$  the deficit bank decides the amount of defaults over the interbank market. Since defaults are costly, at time  $t + 2$  the deficit bank have to pay a pecuniary default costs.

### 3.2.1 Deficit Banks

#### 3.2.2 The wholesale branch

The problem the wholesale branch has to face is the maximization of the cash flow of the entire holding subject to the bank's balance sheet constraint:

$$\begin{aligned} \max E_0 \sum_{t=0}^{\infty} \beta_I^t \lambda_t^I & \left[ (1 + R_t^b) B_t(j) - (1 + r_t^{ib}) IB_t(j) \right. \\ & + (1 + r_{t-1}^{ib})(1 - \delta^d) IB_{t-1}(j) \\ & \left. - K_t^b(j) - Adj_t^{kb}(j) - Adj_t^{\delta}(j) \right] \end{aligned} \quad (12)$$

where  $\beta_I^t \lambda_t^I$  represents the stochastic discount factor for the Wholesale branch<sup>2</sup>,  $R_t^b$ , and  $r_t^{ib}$  are respectively the (net) interest rate on loans from the wholesale branch to each retailer and the (net) interest rate on the loans obtained on the interbank market.  $B_t$  is the total amount of assets, which includes both loans to impatient households and entrepreneurs.  $IB_t$  are the resources the deficit banks borrow on the interbank market from the surplus ones while  $K_t^b$  represents the bank capital.  $\delta^d$  represents the share of interbank default that the Deficit bank could decide to not pay back. The term

$$Adj_t^{kb}(j) = \frac{k_{kb}}{2} \left( \frac{K_t^b(j)}{B_t(j)} - v_b \right)^2 K_t^b(j) \quad (13)$$

is the bank capital requirement. The lowest is the ratio between bank capital and the total asset the higher is the penalty cost of providing an additional unit of loans to the retail branch.  $v^b$  is fixed at 8% in order to replicate the Basel II capital requirement constraint. The default option is costly for the banks. Similar to Dib (2010) and deWalque et al. (2010), the term  $Adj_t^{\delta}$  represents a penalty cost that the deficit bank has to pay whenever it decides to default on interbank borrowing.

$$Adj_t^{\delta}(j) = \frac{\chi_{db}}{2} (IB_{t-2}(j) \delta_{t-1}^d(j))^2 \quad (14)$$

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<sup>2</sup>The stochastic discount factor is equal to the marginal utility of consumption of the Impatient households because we are assuming that they are the only owners of the bank



Moreover, deficit bank has to obey in every period to the following balance sheet constraint

$$B_t = IB_t - \delta_t^d IB_{t-1} + K_t^b \quad (15)$$

Bank capital evolves according to the following law of motion

$$K_t^b(j)\pi_t = (1 - \delta_b)\epsilon_t^{kb} K_{t-1}^b(j) + \Omega J_{t-1}^{db}(j) \quad (16)$$

$\delta_b$  and  $\Omega$  are respectively the quarterly depreciation rate of bank capital and the share of profits used to accumulate new bank capital <sup>3</sup> Substituting the balance sheet constraint into the objective function and deriving with respect to  $B_t$  and  $\delta_t^d$  we get the first order conditions for the wholesale branch problem

$$R_t^b = r_t^{ib}(1 - \beta^I \frac{\lambda_{t+1}^I}{\lambda_t^I} \delta_{t+1}^d) - k_{kb} \left( \frac{K_t^b}{B_t} - v^b \right) \left( \frac{K_t^b}{B_t} \right)^2 + \beta^{I^2} \chi^{db} E_t \left\{ (\delta_{t+1}^d)^2 IB_t \frac{\lambda_{t+1}^I}{\lambda_t^I} \right\} \quad (17)$$

Equation 17 links the interest rate on loans to interbank market conditions and to the adjustment costs the bank has to face. In particular, the wholesale interest rate is affected by the capital requirement and by the expected value of defaults. If the bank is under capitalized, it has to pay a cost that is charge by the bank over the wholesale interest rate. Moreover, the share of expected interbank defaults impact positively on the wholesale interest rate: whenever the bank defaults, the subsequent costs are charged over the interest rate.

The deficit bank can also decide the optimal amount of interbank defaults.

$$\delta_t^d = \left( \frac{\lambda_t^I r_{t-1}^{ib}}{\beta^I \lambda_{t+1}^I \chi^{db} IB_{t-1}} \right) \epsilon_t^{\delta^d} \quad (18)$$

Equation 18 describes the evolution of the interbank default over time. Defaults increase when the interest rate over interbank borrowing is higher and they shrink when the total amount of interbank borrowing increases.  $\epsilon_t^{\delta}$  is a stochastic interbank counterpart risk shock. In the simulation section we will study the effect of an increase of such a shock and how it will affect the business cycle.

### 3.2.3 The retail branch

The retail branch of the deficit bank has the task of providing loans to households and entrepreneurs. The retailers bankers operate under monopolistic competition and they have the power to set the interest rate on their loans. They have to maximize the following profits function

$$\max E_o \sum_{t=0}^{\infty} \beta_t^I \lambda_t^I \left[ r_t^{bh}(j) b_t^I(i) + r_t^{be}(j) b_t^E(i) - R_t^b B_t(j) - Adj_t^{kn} \right] \quad (19)$$

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<sup>3</sup>Consequently,  $(1 - \Omega)$  is the dividend pay-off ratio that is the quantity of bank profit distributed to the Patient households. Assuming  $\Omega = 1$ , the bank is following a zero dividends policy and all profits are used to increase the bank capital.

subject to the loans demand of impatient households and entrepreneurs which are

$$b_t^n(i) = \left( \frac{r_t^{bn}(j)}{r_t^{bn}} \right)^{-\epsilon_t^{bn}} b_t^I \quad (20)$$

The adjustment costs are defined as

$$Adj_t^{kn} = \frac{k_{bn}}{2} \left( \frac{r_t^{bn}(j)}{r_{t-1}^{bn}(j)} - 1 \right)^2 r_t^{bn} b_t^n \quad (21)$$

Every time the bank changes the interest rate it has to pay a cost in terms of profit. This adjustment cost introduces stickiness in the setting of interest rates on loans. We can look at the first order conditions for the retail branch as a New Keynesian Phillips Curve for loan interest rates (see Aslam and Santoro (2008)). Substituting the loans demand into the objective function and deriving with respect to  $r_t^{bh}$  and  $r_t^{be}$  we obtain

$$1 - \frac{\Lambda_t^{bn}}{\Lambda_t^{bn} - 1} + \frac{R_t^b}{r_t^{bn}} \frac{\Lambda_t^{bn}}{\Lambda_t^{bn} - 1} - k_{bn} \left( \frac{r_t^{bn}}{r_{t-1}^{bn}} - 1 \right) \frac{r_t^{bn}}{r_{t-1}^{bn}} + \beta_I E_t \left[ \frac{\lambda_{t+1}^I}{\lambda_t^I} k_{bn} \left( \frac{r_{t+1}^{bn}}{r_t^{bn}} - 1 \right) \left( \frac{r_{t+1}^{bn}}{r_t^{bn}} \right)^2 \frac{b_{t+1}^n}{b_t^n} \right] = 0 \quad (22)$$

where  $n = h, e$ . We express the elasticity of substitution between loans provided by different retail branches as a function of the mark up  $\Lambda$ <sup>4</sup>. Higher values of  $\epsilon$  (or equivalently lower values of  $\Lambda_t$ ) implies a lower market power and a lower margin of intermediation for the bank.

### 3.2.4 Aggregate activity

Profits of the entire holding are defined as the revenues coming from all the business lines of the bank minus the intra group activities and the adjustment costs. We can define the variable  $J_t^{db}$  as the total profits of the deficit group as

$$J_t^{db} = r_t^{bh} b_t^I + r_t^{be} b_t^E + r_t^g G B_t^{db} - r_t^{ib} I B_t (1 - \delta_t^d) - \sum Adj_t^{db} \quad (24)$$

### 3.2.5 Surplus banks

The surplus bank collects deposits from patient households and decides to invest these resources either in the interbank market or purchasing government bonds like in Dib (2010). The balance sheet of the bank is summarized by the following equation.

$$I B_t + G B_t^{sb} - \delta_t^d I B_{t-1} = D_t^P \quad (25)$$

Symmetrically to the deficit bank, the surplus bank is divided into a retail and a wholesale branch.

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<sup>4</sup>The elasticity of substitution could be expressed as a function of the mark up

$$\epsilon_t = \frac{\Lambda_t}{\Lambda_t - 1} \quad (23)$$

### 3.2.6 The retail branch

$$\max E_0 \sum_{t=0}^{\infty} \beta_P^t \lambda_t^P \left[ R_t^d d_t^b - r_t^d d_t^P(j) - \frac{k_d}{2} \left( \frac{r_t^d(j)}{r_{t-1}^d(j)} - 1 \right)^2 r_t^d d_t^P \right] \quad (26)$$

subject to

$$d_t^P(j) = \left( \frac{r_t^d(j)}{r_t^d} \right)^{-\epsilon_t^d} d_t^P \quad (27)$$

that is the deposits demand of the patient households. The resulting first order condition is

$$\begin{aligned} -1 + \frac{\Lambda_t^d}{\Lambda_t^d - 1} - \frac{r_t}{r_t^d} \frac{\Lambda_t^d}{\Lambda_t^d - 1} - k_d \left( \frac{r_t^d}{r_{t-1}^d} - 1 \right) \frac{r_t^d}{r_{t-1}^d} + \\ \beta_P E_t \left[ \frac{\lambda_{t+1}^P}{\lambda_t^P} k_d \left( \frac{r_{t+1}^d}{r_t^d} - 1 \right) \left( \frac{r_{t+1}^d}{r_t^d} \right)^2 \frac{d_{t+1}^P}{d_t^P} \right] = 0 \end{aligned} \quad (28)$$

Equivalent to the expression found in Gerali et al. (2010). Equivalently to the case of the deficit bank the market power in setting the interest rate of deposits allows us to interpret the derivative of the objective function with respect to  $r_t^d$  as a New Keynesian Phillips curve for deposit interest rate.

### 3.2.7 The Wholesale branch

The wholesale branch maximizes the following objective function.

$$\max E_0 \sum_{t=0}^{\infty} \beta_P^t \lambda_t^P \{ (J_t^{sb}(j)) - \Gamma_t(j) \} \quad (29)$$

The term  $J^{sb}$  is the profit of the holding and it could be defined as

$$J_t^{sb}(j) = r_t^{ib} IB_t(j) - r_{t-1}^{ib} \delta_t^d(j) IB_{t-1}(j) + r_t^g GB_t^{sb}(j) - r_t^d d_t^P(j) \quad (30)$$

where  $IB_t$  represents the interbank lending and  $GB_t$  the government bonds detained by the surplus bank. The term

$$\Gamma_t = \frac{\Theta}{2} \left( (\delta_t^d(j) IB_{t-1}(j) - \overline{\delta^d IB}) \right)^2 \quad (31)$$

is a quadratic disutility related to the possibility of suffering a default on the interbank market. The disutility term could be interpreted as the cost the surplus bank has to sustain in case of an unexpected level of suffered defaults such as legal or repossession costs. Moreover, the banking activity is subject to the usual balance sheet constraint expressed by equation 25. Deriving and combining the optimality conditions with respect to  $IB_t$  and  $GB_t$ , we obtain the optimal balance sheet of the surplus bank determined by the following equation

$$IB_t = E_t \left\{ \frac{\overline{\delta^d IB}}{\delta_{t+1}^d} + \frac{r_t^{ib} (1 - \tilde{\beta}_t^p \delta_{t+1}^d) - r_t^g}{\Theta \tilde{\beta}_t^p (\delta_{t+1}^d)^2} \right\} \quad (32)$$

where  $\tilde{\beta}_t^p = \beta^p (\lambda_{t+1}^P / \lambda_t^P)$  is the patient households stochastic discount factor. Two main driving forces are in motion here: on one hand, the increase of defaults push up

the interbank interest rate. Since the surplus bank is risk neutral, higher interest rates represent an incentive to increase the exposition on the interbank market. On the other hand, the increase of defaults negatively affect the amount of interbank lending through the disutility cost. At the same time monetary policy could divert resources from the interbank market steering the short term interest rate  $r_t^g$  controlling the policy rate  $r_t$ .

### 3.3 Central Bank

The central bank manages the short term interest rates following a non linear Taylor rule:

$$(1 + r_t) = (1 + \bar{r})^{(1-\phi_R)}(1 + r_{t-1})^{\phi_R} \left\{ \left( \frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi} (\Delta y_t)^{\phi_Y} \right\}^{1-\phi_R} (1 + \epsilon_r^R) \quad (33)$$

where  $\bar{r}$  is the steady state value of the interest rate, while  $\phi_R$ ,  $\phi_\pi$  and  $\phi_Y$  are respectively the weights assigned by the central bank to the past short term interest rate, the inflation target and the GDP growth.

### 3.4 The Government

The government sector has to obey an intertemporal budget constraint

$$G_t + GB_{t-1} \frac{(1 + r_{t-1}^g)}{\pi_t} = GB_t + T_t \quad (34)$$

where  $G_t$  is the exogenous public expenditure and  $T_t$  a lump sum tax. Following Leeper (1991), government fixes taxation according to the following rule

$$T_t = \bar{T} + \rho_{fp} \left( \frac{GB_{t-1}^{sb}}{\pi_t} - \frac{\overline{GB}^{sb}}{\bar{\pi}} \right) \quad (35)$$

In order to close the model, we assume that the interest rate paid by government bonds are equal to the interest rates set by the central bank  $r_t = r_t^g$ .

### 3.5 Market clearing conditions and autoregressive process

We close our model specifying fifteen exogenous shocks that evolve like AR(1) process in the form

$$\log(X_t) = (1 - \rho) \log(\bar{X}) + \rho \log(X_{t-1}) + e_t \quad (36)$$

With respect to the original model we add two additional stochastic disturbances: the public expenditure  $G_t$  and the counterpart shock on the interbank market ( $\epsilon_t^{\delta^d}$ ).

The resource constraint for the economy is described by the following equation

$$y_t = c_t + q_t^k [k_t - (1 - \delta)k_{t-1}] + k_{t-1} \left[ \xi_1(u_t - 1) + \frac{\xi_2}{2}(u_t - 1)^2 \right] + \frac{\delta_b K_{t-1}^b}{\pi_t} + G_t + \sum Adj_t^j \quad (37)$$

where  $c_t$  is defined as

$$c_t = c_t^P + c_t^I + c_t^E \quad (38)$$

and

$$h = h_t^P + h_t^I \quad (39)$$

Without an explicit supply sector for housing, we close the model fixing a positive net supply  $h = 1$  of the real estate sector. Moreover, the term  $\sum Adj_t^j$  includes all the adjustment costs of the models.

## 4 Solution of the model

The model is log-linearized around the non-stochastic steady state. Like in Gerali et al. (2010), certainty equivalence holds and there is no role for uncertainty in determining the behavior of the agents.<sup>5</sup>

### 4.1 Dataset

We employ fourteen observable variables on the Euro area from 1998 : Q1 to 2014 : Q2 in order to carry out the estimation. We use, investment, consumption, house price, inflation, wage inflation, deposits, loans to households and entrepreneurs, deposit interest rate, central bank interest rate, interbank market interest rate, interest rate on households and firm loans. All variables, with the exception of the interest rates, are expressed in real terms. We made all the time series stationary applying the one side HP filter for the trending variables<sup>6</sup> and subtracting the sample mean from the interest rates.

### 4.2 Bayesian estimation

Following Gerali et al. (2010) and DARRACQ PARIÉS et al. (2011), we use Bayesian techniques in order to estimate only a small subset of the parameters, focusing our attention only on those affecting the dynamic of the system. The steady state parameters are calibrated in line with the values of Gerali et al. (2010). The complete list of calibrated parameters can be found in table 1. We departed from the original numerical setting imposing a steady state ratio of the Basel II capital requirement equal to 8% , fixing the depreciation rate of bank capital close to 0.05, a slightly lower value then the one proposed in Gerali et al. (2010). We set the deficit bank default cost  $\chi^{db}$  close to 0.99 in order to obtain a steady state value of the default  $\delta^d$  equal to 0.0025 on quarterly base which implies a yearly rate of 1% of interbank defaults. We modify the original value of the elasticity of substitution to deposits and households and entrepreneurial loans in order to match the pre crisis mean of the interest rates. The complete list of steady state values implied by the model is reported in table 3 in section C of the technical appendix.

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<sup>5</sup>All the procedures is carried out using DYNARE. We used DYNARE 4.4.3 version Adjemian et al. (2011), a MATLAB and OCTAVE toolbox capable of solving and simulate DSGE model.

<sup>6</sup>Since we used quarterly data we assumed that the smoothness parameters of the HP filter is set equal to 1600. Following Stock and Watson (1999), the use of the one side HP filter allows the data to be fully compatible with the backward looking nature of the Kalman filter used to recover the likelihood function of our model. We adapt the MATLAB code provided by Meyer-Gohde (2010) to obtain the filtered series.

Table 1: Calibrated parameters

Parameter	Definition	Value
$\beta^P$	Patient households discount factor	0.99430
$\beta^I$	Impatient households discount factor	0.97500
$\beta^E$	Entrepreneurs discount factor	0.97500
$\alpha$	Capital share	0.25000
$\delta$	Depreciation rate of physical capital	0.02500
$\phi$	Inverse of Frisch elasticity	1.00000
$\mu$	Share of Patient workers	0.80000
$\bar{m}^I$	Steady State value of LTV for impatient households	0.70000
$\bar{m}^E$	Steady State value of LTV for Entrepreneurs	0.35000
$\bar{\pi}$	Net Steady State inflation	1.00000
$\bar{\zeta}^d$	Elasticity of substitution of deposit	-2.2602
$\bar{\zeta}^{bh}$	Elasticity of substitution of households loans	3.39126
$\bar{\zeta}^{be}$	Elasticity of substitution of entrepreneurs loans	3.52017
$\xi_1$	Coefficient associated with the degree of utilization of physical capital	0.04590
$\xi_2$	Coefficient associated with the degree of utilization of physical capital	0.00459
$v_b$	Basel II capital requirement	0.08000
$\delta_b$	Depreciation rate of bank capital	0.05016
$\Omega$	Profits invested in new bank capital	1.00000
$\chi^{db}$	Deficit bank default cost	0.98600

#### 4.2.1 The choice of the Priors

Given the similarity between our model and Gerali et al. (2010) a very natural starting point for the selection of prior distributions is to choose those proposed in their original work. We choose to slightly modify the original setting. We choose an *Inverse Gamma* for the standard deviations of the structural shock. The prior mean and standard deviations are very close to Iacoviello (2014). This choice is motivated by the fact of being conservative about the relevance of the financial shocks. The related autoregressive components are set with a mean of 0.75 and the standard deviations equal to 0.1 using a *Beta* prior distribution. The parameter related to the disutility cost of the surplus bank ( $\Theta$ ) is the novelty of our estimation. Since we have few prior informations about this parameter we decide to be quite agnostic and setting a wide prior. We only assume a positive support choosing a *Gamma* prior with mean equal to 15 and a standard deviation equal to 10. We also include in the estimation the coefficient related to the fiscal policy rule  $\rho^{fp}$ . We set a *Gamma* distribution with mean 0.3, a value provide by Falagiarda and Saia (2013) in their calibration, and a standard deviation of 0.1. The detailed choice of the priors and their distributions can be found in Table 2.

#### 4.2.2 Posterior distributions

We obtained the posterior distribution applying the classical procedure of Monte Carlo Markov Chain simulation (See for a detailed explanation Fernandez-Villaverde (2010)). We launched two Markov chains each of them composed by 1.000.000 draws. We choose the scale factor of the variance and covariance matrix of the random walk Metropolis-Hastings in order to obtain an acceptance rate slightly above 26%. We also check the

convergence of the chains through both the CUSUM statistic <sup>7</sup> and the Brooks and Gelman (1998) statistics.

The results are in line with Gerali et al. (2010). Some parameters deserve further discussion. The degree of persistence of habit formation in consumption is different among the different type of agents in the model. Patient Households present a low value  $a^P$  of their persistence in consumption while the Impatient Households and the entrepreneurs present higher values, 0.75 and 0.76 respectively. This result was previously found in Iacoviello and Neri (2010).

Another difference is related to the adjustment cost of the interest rates. In Gerali et al. (2010) the adjustment costs of the interest rates on loans are higher than the deposits counterpart while it is the exact opposite in our model. One of the possible explanation is related to structure of our banking system: the surplus bank can gather deposits as the only source of external funding while the wholesale branch designed by Gerali et al. (2010) can rely also on its own capital. This introduces more stickiness in the deposits market with respect to the original framework.

The disutility parameter  $\Theta$  is quite high implying a strong negative effect of defaults on the surplus balance sheet. The counterpart shock displays a certain degree of persistence with an autoregressive coefficient  $\rho_{\delta^d}$  close to 0.81. The complete list of estimated parameters can be found in the section C of the technical appendix.

Table 2: RESULTS FROM BAYESIAN ESTIMATION

Parameters	Definition	Prior shape	Post mode	Post mean	Confidence interval 5 %	Post Median	Confidence interval 95 %
$k_p$	p. stickiness	$\Gamma[50, 20]$	53.78	64.90	53.78	62.85	98.93
$k_{bh}$	H. loans adj cost	$\Gamma[6, 2.5]$	4.109	5.028	3.019	4.857	7.618
$k_{be}$	E. loans adj cost	$\Gamma[3, 2.5]$	2.264	2.622	1.657	2.555	3.811
$k_d$	Dep. adj cost	$\Gamma[10, 2.5]$	8.057	8.691	5.932	8.499	12.16
$k_i$	Inv adj cost	$\Gamma[2.5, 1]$	5.766	5.928	4.590	5.860	7.502
$k_w$	w. stickiness	$\Gamma[50, 20]$	82.06	92.45	63.12	90.55	127.6
$k_{kb}$	Cap. req. adj cost	$\Gamma[15, 5]$	20.59	22.57	15.53	22.05	31.48
$\Theta$	Dis cost default	$\Gamma[15, 10]$	34.23	31.88	17.64	31.49	47.28
$a^P$	Habit PH	$\mathcal{B}[0.6, 0.1]$	0.661	0.679	0.549	0.682	0.798
$a^I$	Habit IH	$\mathcal{B}[0.6, 0.1]$	0.758	0.750	0.604	0.759	0.865
$a^E$	Habit E	$\mathcal{B}[0.6, 0.1]$	0.776	0.768	0.692	0.770	0.835
$\iota_w$	w. indexation	$\mathcal{B}[0.5, 0.15]$	0.367	0.377	0.199	0.373	0.570
$\iota_p$	p. indexation	$\mathcal{B}[0.5, 0.15]$	0.080	0.098	0.040	0.092	0.174
$\phi_R$	Policy rate smooth	$\mathcal{B}[0.75, 0.1]$	0.870	0.870	0.840	0.871	0.896
$\phi_\pi$	Inflation target	$\Gamma[2.2, 0.15]$	2.158	2.195	1.813	2.182	2.623
$\phi_y$	Output gap	$\mathcal{N}[0.1, 0.15]$	0.093	0.096	0.035	0.094	0.163
$\rho_{fp}$	Fiscal rule	$\Gamma[0.3, 0.1]$	0.314	0.320	0.216	0.316	0.434

<sup>7</sup>To obtain the COSUM statistics we exploit the DSGEBayesianToolbox provided by Ambrogio Cesa Bianchi. It can be downloaded from <https://sites.google.com/site/ambropo/DSGEBayesianToolbox.zip?attredirects=0>. The graph can be found in section D of the technical appendix.

## 5 Quantitative experiment

In this section we report the impulse response functions of the model for three structural shock: technological, monetary policy and the counterpart risk on the interbank market. We compare two versions of our model like in deWalque et al. (2010): the baseline scenario with an "active" interbank market (endogenous defaults) and the second scenario where defaults are fixed at the steady state value of the "active" scenario.

### 5.1 Technological shock

The impulse responses to a positive one standard deviation (on annual terms) technological shock (See Figure 2) present several of the standard features observed in the literature (see Smets and Wouters (2007) or Christiano et al. (2005)). Total output, driven by an increase of investments, reacts positively to an increase of technological efficiency, while the inflation rate decreases.

The whole structure of the interest rates follows the policy rate and coherently decreases. Credit demand is boosted by the consequent increased of assets price (both  $q^h$  and  $q^k$ ) that relaxes the borrowing constraint enhancing households and firms capability to raise more financing. Similar to Dib (2010), positive technological shock increases bank leverage and decreases the amount of interbank defaults. The implications on the supply side of the credit market are straightforward. In fact, according to equation 32, a reduction of defaults pushes up interbank lending supply and as a consequence loans supply. Total credit increases for almost six quarters confirming the evidence found by Carrera and Vega (2012).

The composition of the surplus bank's balance sheet change. The share of interbank lending over total assets increases<sup>8</sup>. In terms of a negative shock, we can interpret it as a flight to quality scenario. A sudden deterioration of the economic conditions encourages the surplus bank to shrink risky interbank lending in favor of secure risk free government bonds.

Finally, the model with endogenous defaults amplifies the impact of the technological shock on the business cycle in particular with respect to the financial variables consistently with deWalque et al. (2010).

### 5.2 Monetary policy shock

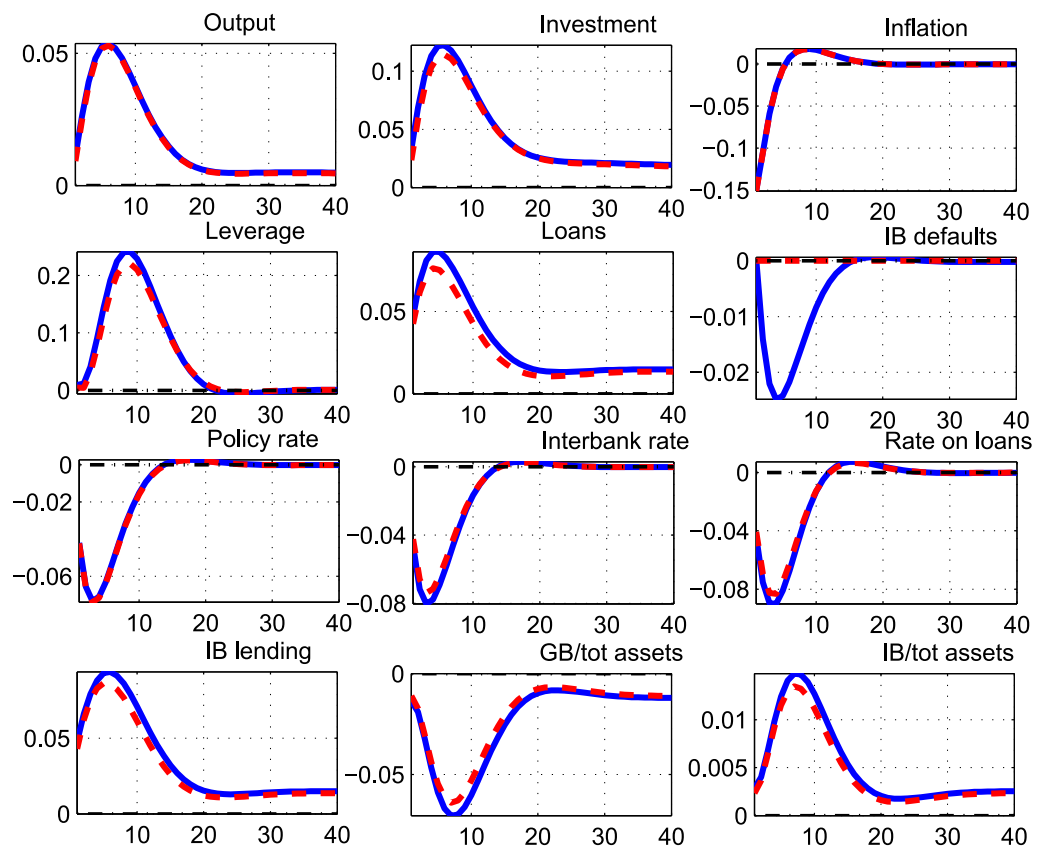
Figure 3 represents the response to an increase of 50 basis points of the central bank policy rate. The total output, even in this case is driven by the drop of investments, and inflation fall. The entire structure of the interest rates rises sharply following the increase of the policy rate. It is worth noticing that credit tightness is not entirely transmitted to the credit market through the interbank market channel due to the presence of stickiness in the setting mechanism of loans interest rates. On impact, credit loans rate spike 20 basis points less than the interbank market interest rate.

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<sup>8</sup>The Share of interbank lending over total assets detained by the surplus bank is defined as  $S_t^{ib} = \frac{IB_t}{GB_t + IB_t}$ .

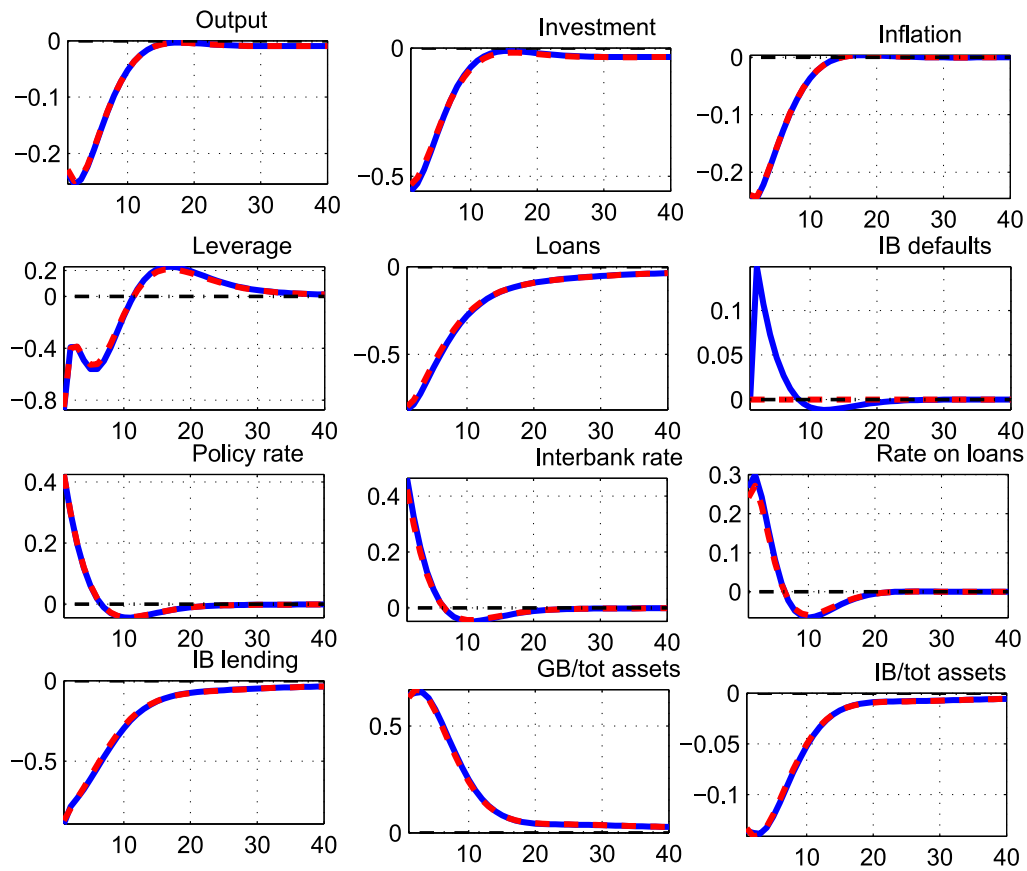


Figure 2: Technological shock



The solid blue line refers to the model with an active interbank market. The dot red line refers to the model with fixed defaults. All the impulse response functions are calculated at the posterior median. The rates are absolute deviation from the steady state. All other variables are computed as percentage deviation from the steady state.

Figure 3: Monetary policy shock



The solid blue line refers to the model with an active interbank market. The dot red line refers to the model with fixed defaults. All the impulse response functions are calculated at the posterior median. The rates are absolute deviation from the steady state. All other variables are computed as percentage deviation from the steady state.

Monetary policy also affects the composition of the banks balance sheet. The increase of the policy rate diverts resources from the interbank market to the bonds market. The reason is that interbank lending is riskier, given a spike of interbank defaults, while at the same time the remuneration of detaining risk free bonds is higher.

The comparison between the two set up is much less clear than in the case of technological shock. The impulse response functions suggest that endogenous defaults amplify the effect of monetary policy shock but the amplitude of such shock is almost negligible. In fact, the increase of the policy rate is entirely transmitted to the money market rate during normal time. With no surprise, higher interest rates on loans discourage credit demand.

### 5.3 Interbank counterpart shock

Figure 4 represents the impulse response functions of the model to a one standard deviation (on annual terms) increase of the counterpart risk shock on the interbank market. We are not trying quantitatively to match the effect of an increase in riskiness on the interbank market but we are trying qualitatively to understand the story behind this mechanism. An increase of counterpart risk on the interbank market modifies the composition of the balance sheet of the surplus bank. The flight to quality mechanism pushes the surplus bank to reallocate resources on the risk free market instead of lending to the deficit bank. As a consequence, the interbank interest rate goes up causing an increase of credit market interest rates. The higher interest rates discourage credit demand, reducing the amount of loans used to purchase new intermediate capital and housing services, resulting in a credit crunch. At this point the recession spreads to the real economy through a contraction of investments and houses purchase. As a consequence, the shrinkage of investments causes an erosion of the physical capital owned by the intermediate firms and of the housing stock detained by the impatient households. The less the capital, the less is the value of the collateral the entrepreneurs could use to obtain credit from the bank, exacerbating the crisis on the credit market.

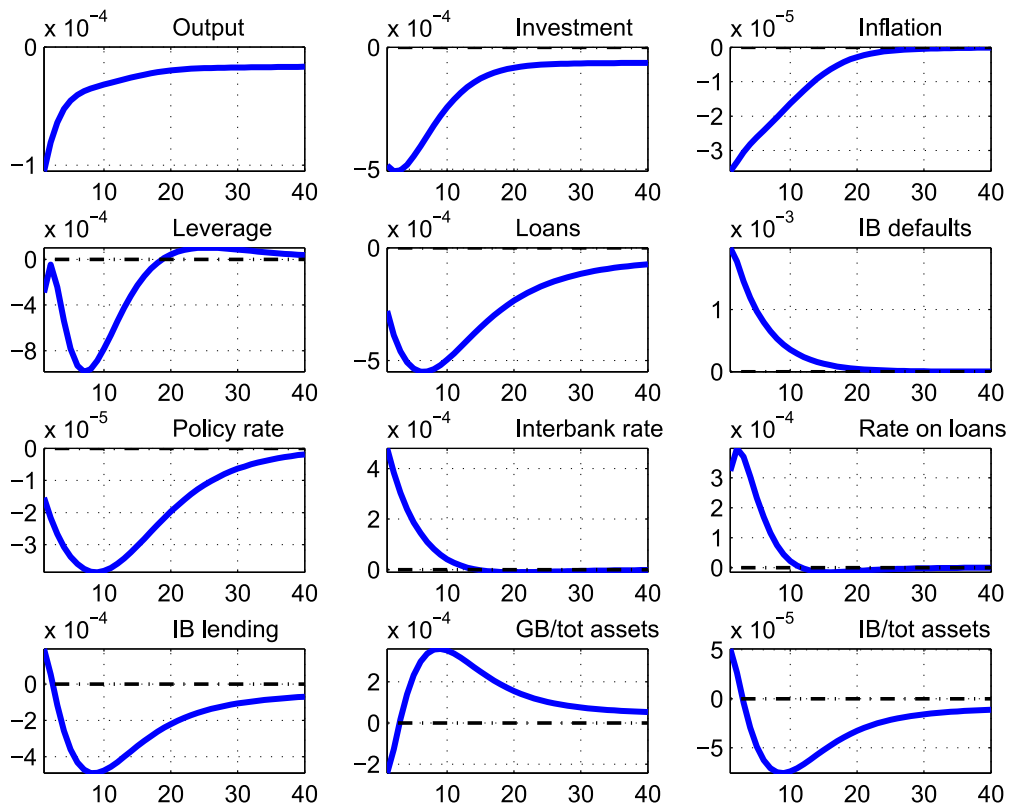
Coherently, facing the fall of the output, the central bank reacts cutting down the policy rate. deWalque and Pierrard (2010) found a similar result analyzing a return shock of a security detained by the deficit bank. As already pointed out by Hilberg and Hollmayr (2011), in this scenario the reduction of the interest rate is highly ineffective and is not sufficient to restore the normal operation on the interbank market. This result underlines a fundamental policy message: shocks that decouple the behavior of the policy rate with respect to the money market interest rates cannot be totally offset only using the traditional monetary policy tools. The next section investigate further this issue especially in relation with the 2007 financial crisis.

## 6 Historical variance decomposition

In this section we focus our attention on the historical decomposition of the observable variables in order to understand the contribution of each shock to the business cycle especially the role of the counterpart shock. Figure 5 reports the historical decompositions of six main variables.

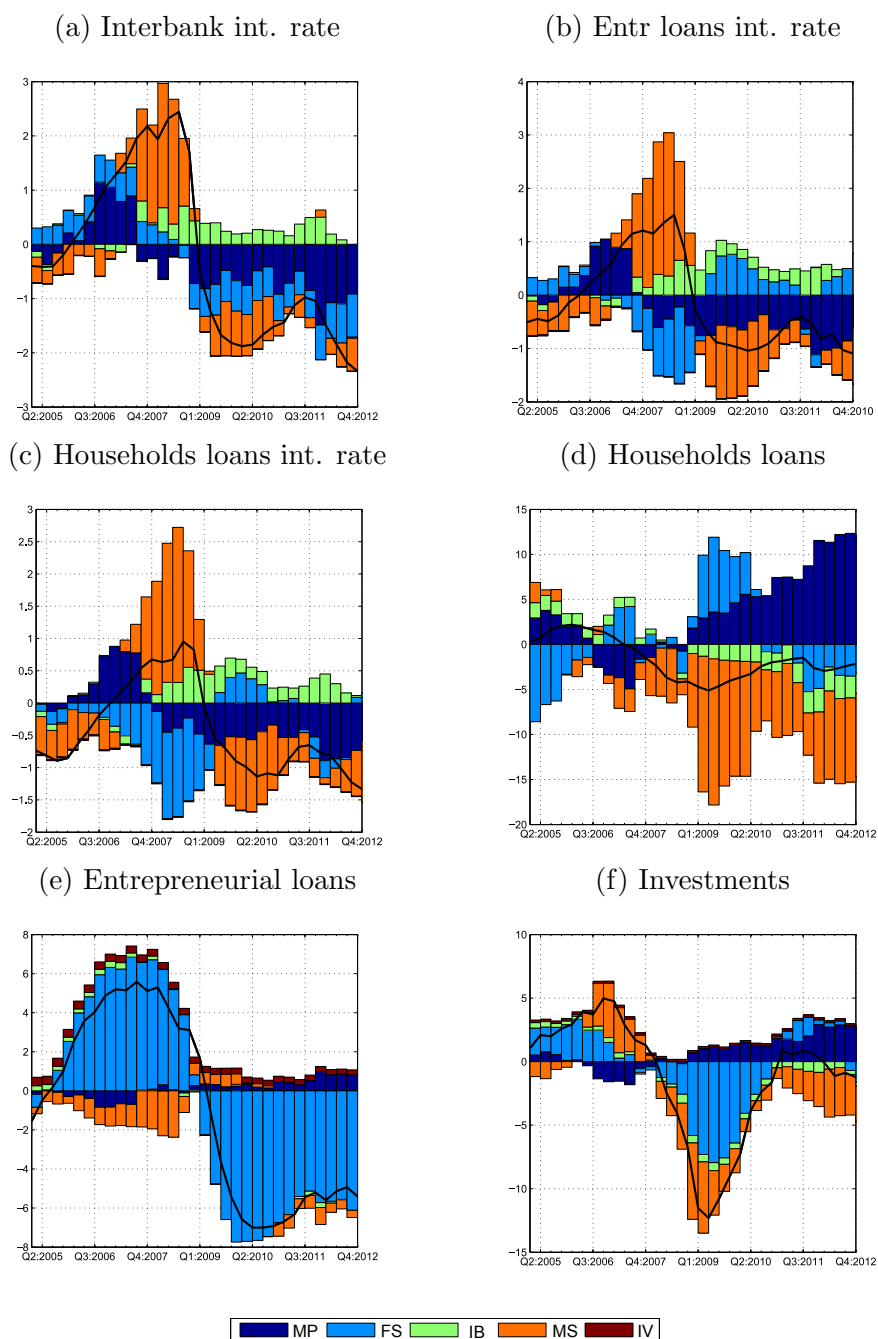
As we expected, the interbank market shock seems to explain part of the rise of the interest rate on the credit market during and after the 2007 financial crisis confirming

Figure 4: Counterpart risk shock on the interbank market



All the impulse response functions are calculated at the posterior median. The rates are absolute deviation from the steady state. All other variables are computed as percentage deviation from the steady state.

Figure 5: Historical variance decomposition



The dark blue bar represents the monetary policy shock, the light blue bar represents all the financial shocks, the green bar represents the counterpart shock, the orange bar group together all the real shocks. The historical decomposition are computed at the posterior median. The interest rates are absolute deviation from the steady state.

that the model is able to explain one of the transmission mechanisms we described in the introduction. Even after 2008, tensions on the interbank market could be explained through the interbank riskiness shock at least until the end of 2012. After 2008, what really changed was the behavior of the ECB towards the prolonged recession. The ECB steered down the interest rates on the credit market drastically cutting the policy rate of over 300 basis points after 2008 pumping a considerable amount of liquidity in the money market in part offsetting the detrimental effect of the counterpart shock. According to figure 5, tensions on the money market gradually decreased until a resurgence during the 2010 sovereign debt crisis.

The interest rates are not the only variables affected by the turmoil on the interbank market. The role of the interbank shock affects in a different way the credit supply to households compared to the firms. The decrease of loans provided to households is explained for a significant portion by the adverse macroeconomic conditions and by a smaller, but not negligible, fraction by the interbank market shock. Instead, the drop of entrepreneurial loans seems to be completely explained by several financial factors such as a shrinkage of the loan to value ratio and the interbank market seems to play no role on the amount of credit available for the firms. The counterpart shock seems to work through two different channels. The interbank market shock raises interest rate and decreases the quantity of loans available to households but on the other hand it seems to have no role in fixing the credit supply for firms. The only active channel for the firms passes through the increase of interest rates that discourage investment and the acquisition of new capital, also amplified by the drop of the value of the collateral.

In general, like pointed out by Iacoviello (2014), after the 2007, a significant portion of the variations of the variables are driven by financial factors instead of real shocks .

## 7 Concluding remarks

In this paper we highlighted the role of the interbank market as an important driver of the business cycle. We extended the model proposed by Gerali et al. (2010) including an interbank market like in Dib (2010) and deWalque et al. (2010). We took it to the data of the Euro area using Bayesian estimation. The results suggest that our model could be able to replicate some features of the 2007 financial crisis, especially some interbank market stylized facts. A counterpart shock could divert resources from the risky interbank lending to a safer government bond holding, ending up with higher interest rates on entrepreneurial loans, less credit provided by the bank to the real economy, causing a recession driven by a fall of the investment. The historical decomposition we presented shows how part of the rise of interest rates during the financial crisis could be explained by the introduction of an interbank counterpart shock. We also investigate the role of monetary policy and we find out that in normal times the interbank market does not interfere with the transmission of the monetary policy. The rise of the interbank market interest rate counteracts the decrease of the policy rate reducing the effectiveness of the traditional tools of the monetary policy. In terms of storytelling, our model provide a framework where this kind of monetary policy can be analyzed and better understood.

Some critical questions remain unresolved. Our log-linearized framework is not the ideal framework to capture the sudden collapse of the interbank market in 2008. As suggested by Benes et al. (2014), financial shocks affecting the balance sheet of the banks are linked in a non linear way to the real economy. Capturing this non linear effect implies

a switching from a linear set up to a non linear one making the estimations a daunting task but such effort can be fundamental to better quantitatively assess the impact of a dysfunctional interbank market.

Nevertheless our model tells us a plausible and coherent tale about the interbank market turbulences during the 2007 financial crisis.

## 8 Acknowledgment

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