The Cyclical Behavior of the Loan-Deposit Ratio

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Abstract

This paper studies the determinants of the cyclical properties of the loan-deposit ratio. We use an industrial organization approach to develop a banking industry model composed of two business sectors, loans and deposits, which require physical resources for the provision of financial services to households and firms. We introduce the model in an otherwise standard RBC general equilibrium model. The interest rate on deposits is thus endogenously determined, together with the rate on loans and the equilibrium quantities of loans and deposits. We derive endogenously the productivity parameters for both loans and deposits, and our model is capable to reply the cyclical properties of loans, deposits, and the respective interest rates. Our model provides a simple explanation for the observed strongly pro-cyclical behavior of the loan-deposit ratio.

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1 Introduction

The loan-deposit ratio is one of the traditional indicators of the safety and stability of the banking industry, because it provides useful information on the capability of banks to survive substantial unexpected deposit withdrawals. The ratio also affects the sensitivity of banks' profits to market interest rate risk, since demand deposits are normally not remunerated, and deposit rates are far more sticky and sluggish than market rates; the margins of banks relying extensively on market sources of funding are therefore far more sensitive to interest rate variations.

Major deviations deviations from the long-term trends of the loan-deposit ratio are associated with increased financial fragility and the main financial crises in recent decades have been associated with sharp corrections of these imbalances. The average ratio in the US was high by historical standards in the years preceding both the Great Depression of the 1930s and the financial crisis of 2007-8 (Figures 4 and 5), and in both instances the correction has been quite dramatic. A similar pattern can be observed in Asian countries during the crisis of 1997, and across European countries in 2010-2012 (Figures 1 and 2).

These imbalances, however, are very persistent and they build up over rather long periods of time, often covering two ro three decades. Moreover, high loan-deposit ratios are not always associated with big financial crises, as the example of Australia, New Zealand, or Switzerland suggest (Figure 3). It is therefore important to understand the nature of these imbalances to understand if, when, and how far, they represent a significant systemic risk. To complicate matters, the loan-deposit ratio displays a strongly pro-cyclical behaviour at business cycle frequencies. It is

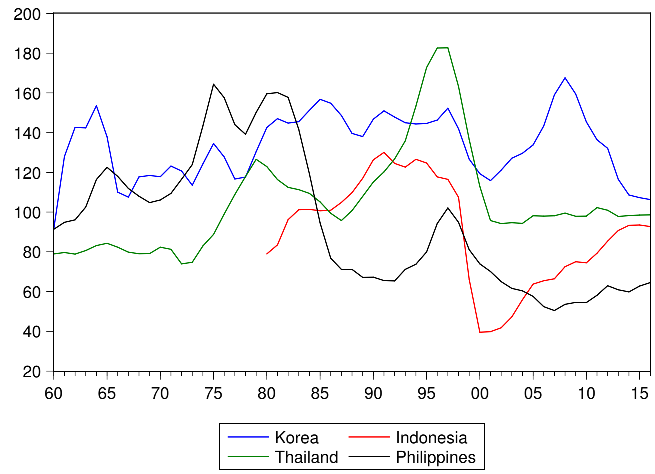

Figure 1: Loan-deposit rate in asian countries. Source: International Financial Statistics, IMF.

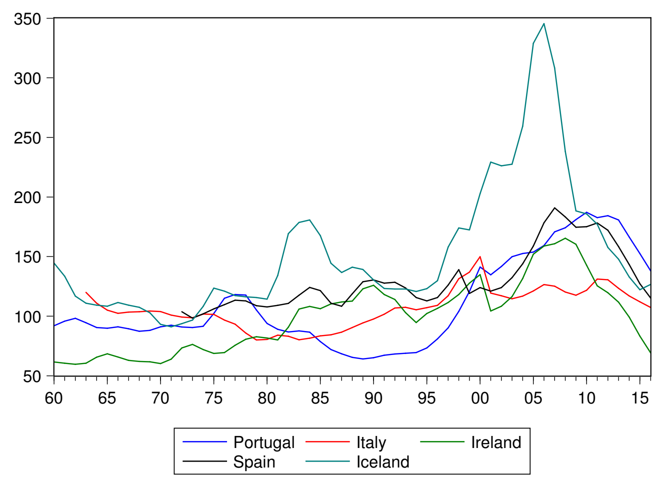

Figure 2: Loan-deposit rate in european countries. Source: International Financial Statistics, IMF.

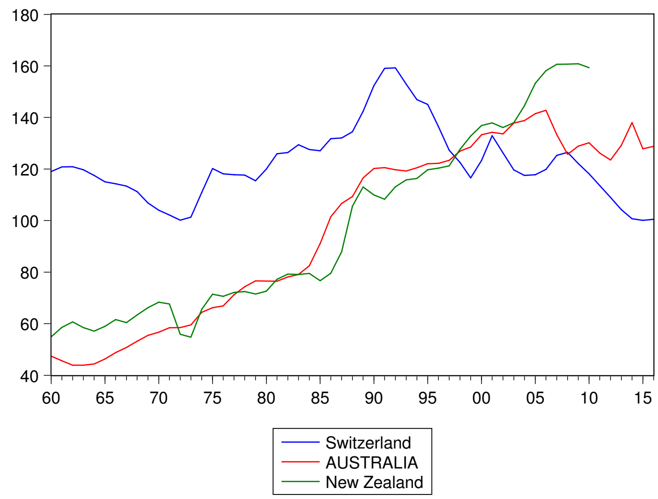

Figure 3: Loan-deposit rate in Australia, New Zealand and Switzerland. Source: International Financial Statistics, IMF.

therefore necessary to disentangle the cyclical behaviour from the longer term trends.

The cyclical behaviour of the loan-deposit ratio has been recognized very early in the literature (from Persons (1924)) but it is quite difficult to replicate by using standard dynamic macro-models. The simplest explanation, in fact, involves some form of credit constraints that are relaxed during boom times. The problem with this explanation is that financial innovation should have reduced credit constraints, making therefore the ratio less cyclical. But this was not the case, as for example in the US the ratio has become more correlated with GDP (Figure 6) in recent decades. Furthermore a similar explanation is hard to reconcile with the observed behaviour of the spreads. Both the spread between the rate on loans and that on bonds and the spread between the rate on bonds and that on deposits are in fact highly cyclical too. This paper instead analyzes the behavior of the ratio adopting an industrial organization framework, which explains the time pattern as a result of productivity innovations in the financial and/or industrial sectors.

Our modelling strategy follows the lead of Chari et al. (1995) and Goodfriend and McCallum (2007) in assuming a firm structure for the banking industry. Banks can in fact be modelled in a very coherent and straightforward fashion in DSGE models, by making use of standard industrial organization models of banking, in line with the standard practice for industrial firms. IO models of banking can replicate in a stylized, but rigorous way many of the features of financial frictions model, they are easy to calibrate and even more importantly, they can be modelled in a comprehensive framework including both industrial and financial firms that interact in different markets. Banks are firms that spend real resources to reduce information cost, and in the current environment they are firms with tens, or hundreds of thousands workers, and a substantial capital expenditure. Dia and Menna (2016) and Dia and VanHoose (2017b) provide evidence that resource costs are by far the most relevant share of banks' costs both along the cycle, and across different countries. Interest costs are larger than resource costs only during periods of very high inflation, while loan-loss provisions are of a comparable size to resource cost only in coincidence of large-scale banking crises. Wages and the rental cost of capital are therefore important channels for the transmissions of shocks, in so far as industrial and financial firms compete in the same markets for resources. Banks employ labor and capital and therefore respond to fluctuations in productivity and costs of resources that affect both sides of banks' balance sheet, as discussed by Dia and VanHoose (2019).

To model this environment, we augment a standard Real Business Cycle model with a banking sector that employs labor and capital to produce both loans and deposits and we develop an extremely parsimonious model that is capable to replicate the cyclical behavior of both the loan-deposit ratio and the banking spreads that we observe in the data. We do so without introducing any financial friction, market power, adjustment cost or price stickiness, and we explain these features of the data as a result of simple productivity shocks, symmetric across business sectors. We highlight that the substantial cyclical variations of both bank quantities and interest rates that we observe can be reproduced by our model even in the absence of the decreasing returns to scale assumed by Cúrdia and Woodford (2010) and Cúrdia and Woodford (2016) or the role of collateral as in in Goodfriend and McCallum (2007), or financial frictions as in Gertler and Karadi (2011). A limitation of this literature, in fact, is that since modelling financial frictions is complicated, most models introduce one of several possible sources of financial frictions only and therefore different models are hard to compare and do not provide a basic common platform that can be used to compare different policy tools in a coherent way.[1] This feature is in sharp contrast with the treatment of industrial firms, since virtually all DSGE models are build on common microeconomic foundations heavily relying on standard microeconomic industrial organization models.

More specifically, we extend the framework from Dia and Menna (2016) where the commercial banks sector provides loans to firms, financing their working capital needs.[2] We introduce deposits in the utility function of households and we model

[1]Dia and VanHoose (2017a) provides an overview of these models.

[2]The interest rate on loans in this setup works therefore as the price of an intermediate factor that is essential for production.

a banking industry composed of two business sectors, loans and deposits, each one requiring a production function. Banks use deposits to finance loans to firms and their net position in bond markets. Introducing deposits in the utility function of households is a shortcut to create a monetary role for deposits and make deposits and bonds imperfect substitutes. The crucial technical feature of the model is the calibration of bank production functions on the basis of data on the physical capital intensity of the industry that allow to obtain either the productivity parameters or the interest rates endogenously.

This model can be extended in several directions. Although we do not consider the role of collateral, loan losses, or financial frictions that can amplify the cyclical profile of bank liquidity and interest rates, our model could easily be extended to integrate those features, as for example in Goodfriend and McCallum (2007) for the case of collateral, Cúrdia and Woodford (2010), for the case of default costs, or in Gertler and Karadi (2011) where financial frictions make equity capital and retained earnings relevant. Similarly, the model can be extended to account for market power in the banking industry, as in Gerali et al. (2010), by introducing adjustment costs in the stock of loans and deposits that generate persistence in bank quantities and interest rates, as in Elyasiani et al. (1995) or Cosimano and Van Huick (1989), or modelling liquidity creation as in Dia (2013). But perhaps more importantly, this framework provides a simple tool to model financial innovation, which would affect the path of the productivity parameters of the banking industry, or medium and long term trends in the banking industry.

The next section of the paper provides some preliminary evidence supporting our modelling strategy. Section 3 illustrates the model, Section 4 describes data and the calibration technique, Section 5 discusses the results of the model, while Section 6 concludes.

2 The cyclical behavior of bank loans and deposits and their respective interest rates

The loan-deposit ratio it is used in the industry as an indicator of the (il)liquidity of the balance sheet. However, a larger ratio does not necessarily imply a less liquid balance sheet: for example, an increase in lending financed by issuing equity does not make the balance sheet less liquid. The amount of equity capital is in fact normally rather stable, because the issuance of shares is very costly. Hence variations in the loan to deposit ratio are normally offset by changes in the opposite direction of the available stock of liquid securities, or by changes in the issuance of debt securities. While liquidity involves the composition of the portfolio of both assets and liabilities and is difficult to measure, the loan-deposit ratio is an easily observable variable that is highly correlated with liquidity itself.[3] And whenever banks are constrained in their capability to raise finance from other market sources, as it the case of small banks, the loan-deposit ratio measures the capability of the banking system to accommodate a positive shock in the demand for loans. The availability of deposits represents in this

[3]The composition of deposits affects significantly the liquidity of the balance sheet, since time or savings deposits cannot be redeemed on demand and household deposits are far more stable than those of corporations, as firms' financial officers manage large sums that are not guaranteed, and need to be more informed and responsive to variation of interest rates and service costs than households. The composition of the loan portfolio is similarly relevant, since mortgages and other secured loans can be sold or securitized, while most unsecured relationship-based loans cannot.

case a binding constraint limiting the size of the portfolio, and banks can increase the amount lending rapidly only when they hold a substantial buffer of low risk securities. Similarly, when banks finance a substantial amount of loans with market sources of finance, they suffer a liquidity risk when corporate bonds markets dry up. In these circumstances the capability of the banking system to smooth shocks is severely constrained. Consequently, the loan-deposit ratio plays a relevant role in the *transmission* of shocks.

A ratio substantially below unity has always been recognized in the industry as an important guideline to assure the liquidity of the balance sheet, since it indicates the availability of a substantial buffer of cash or securities to face any sudden shock in the availability of deposit funds. The size of the buffer is influenced by institutional factors such as the existence and extension of deposit insurance, consequently, the size of the buffer that banks have to hold to be considered "healthy" has changed over time and across countries, under the influence of technological changes and regulatory innovations. For instance, an important development of the years preceding the financial crisis begun in 2007, was a sharp increase in the loan-deposit ratio in most developed countries, a trend that brutally reversed after the crisis. This trend followed the fortunes of securitization techniques, which provide a source of funds that before the crisis was perceived as more stable and reliable than deposits.[4] These developments have played an important role in the build up of the financial crisis of 2007-2009. Jorda et al. (2017) find evidence that both higher levels and faster growth of the loan-deposit ratio, and a greater reliance on wholesale funding, are

[4]Duca (2016) provides evidence on the impact of regulatory innovations on the development of shadow banking.

associated with a higher probability of a banking crisis. Similarly, Berger and Bouwman (2017) find that deviations from trend in bank liquidity creation have a substantial explanatory power in predicting financial crises. Beltratti and Stulz (2012) analyzed the cross-section of stock return of large banks, finding that banks financed with short-term funds performed much worse than those financed with deposits, and identified liquidity as the main factor explaining the different performance. Finally, Cornett et al. (2011) found evidence that during the financial crisis of 2007-2009 bank lending growth fell less at banks that relied more heavily on core deposit and equity capital. Persons (1924) documented the cyclical properties of the ratio in the United States, in the last part of the 19th century and the first two decades of the 20th, finding that the loan-deposit ratio was closely correlated with the interest rate on commercial paper. The ratio declined steadily during all the 1930s, as the Great Depression raged, to stabilize only with the end of the war. The trend moved upwards again the postwar period, and Cox (1966) suggests that the upper trend from the lows of the immediate post-war was strictly linked to the increased share of time and saving deposits, less liquid but more costly, but also documented how the ratio declined during each of the recessions of the postwar. Changes in the ratio were in this view associated with changes in the composition of bank liabilities, most of which occur at a business cycle frequency, but some of which persist for longer periods.

Fig. 4 displays the average loan-deposit ratio (L/D) for all commercial banks in the United States of America, during the period 1914-1940, Fig. 5 displays the average loan-deposit ratio for FDIC insured banks, during the period 1934-2015,

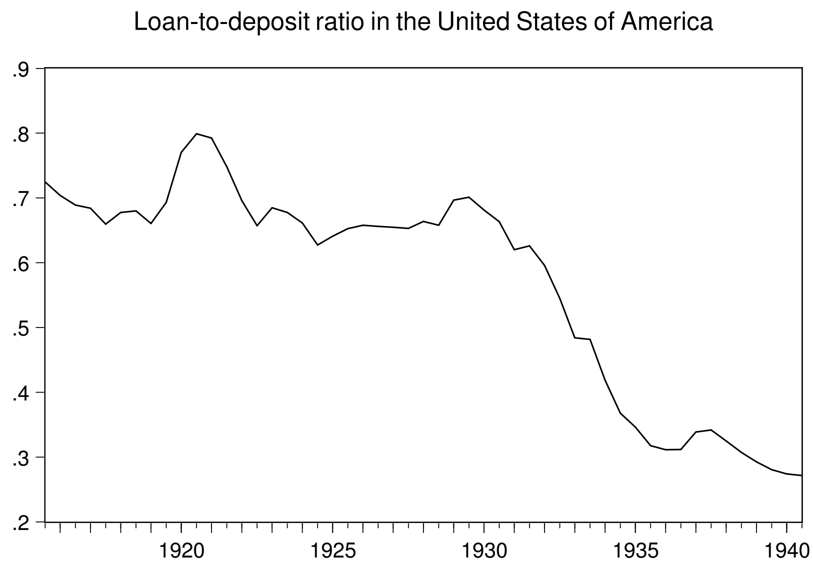

Figure 4: Loan-deposit ratio for all commercial banks, United States of America.

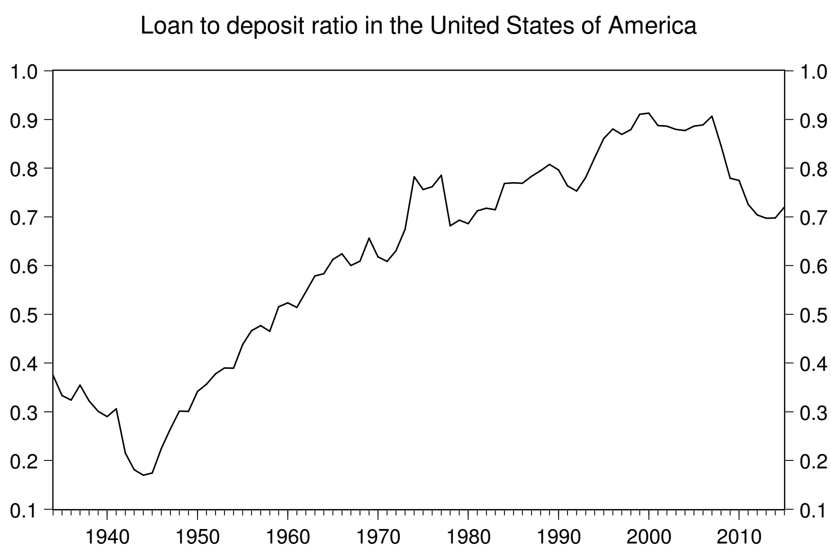

Figure 5: Loan-deposit ratio of FDIC insured banks, United States of America.

while Figure 6 displays the HP filtered series of the loan-deposit ratio and GDP for the same years. The behavior has remained strongly pro-cyclical even in the most recent decades, with the only exception of the years around World War Two and period of high inflation of the 1970s.

In this work we focus on the period beginning in 1987, the year of the abolition of Regulation Q, because we want to analyze an environment where loans, deposits and the respective interest rates are set by market forces.[5] The correlation of the HP-filtered loan-deposit ratio with HP-filtered output for the 1987-2015 period is 0.78. Both CPI-deflated deposits (0.48) and CPI-deflated loans (0.25) are positively correlated with output. Hence both loans and deposits comove with GDP at quarterly frequencies, but loans are more strongly correlated than deposits with output.

A simple explanation of the cyclical behavior of the ratio is that loan growth is muted during recessions, either because loan demand declines, or because banks reduce supply when loan losses bite because they need to keep their equity capital ratio stable, while deposits do not decline as a share of GDP.[6]We have in fact empirical evidence that bank loan supply is highly cyclical, and declines when loan losses rise during downturns, see for example Becker and Ivashina (2014). The cyclical behavior

[5]Established by the Federal Reserve Board in 1933, Regulation Q imposed various restrictions on the payment of interest on deposit accounts, prohibiting the payment of interest on demand deposits, and imposing banks a ceiling on interest rates on time deposit, such as savings accounts and NOW accounts. The ceilings on time deposit rates were phased out during the period 19811986 by the Depository Institutions Deregulation and Monetary Control Act of 1980. The prohibition to pay interest rates on demand deposits has been repealed by the DoddFrank Wall Street Reform and Consumer Protection Act of 2010.

[6]Herman et al. (2017) provides recent evidence that aggregate lending is highly pro-cyclical in the United States.

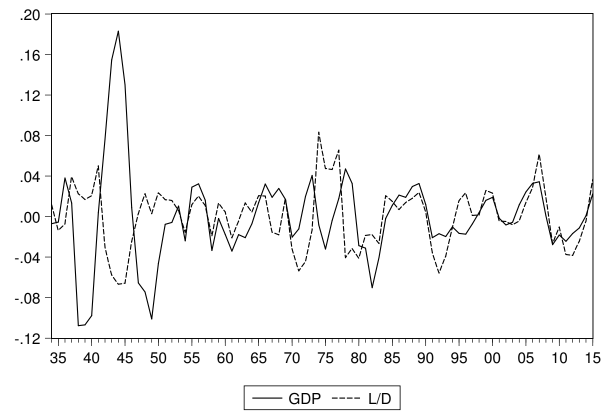

Figure 6: HP-filtered loan-deposit ratio and log GDP, United States of America.

of the loan-deposit ratio, however, cannot be explained just by the cyclical behavior of loans losses. Loan losses display a clear cyclical pattern, but the correlation between the HP filtered series for loan loss provisions as percentage of total loans and GDP for the 1987-2015 period is equal to -0.51, substantially smaller than that between the loan-deposit ratio L/D and GDP. Moreover, the correlation between the HP filtered series for loan loss provisions and that of L/D is not very strong, -0.23.

A substantial share of the literature on liquidity risk suggests that the cyclical behavior of bank liquidity is driven by cyclical variations of the banks' risk profile, with banks taking more risks in boom times to retrench in recession.[7]Adrian and Shin (2010), for instance, have suggested that when balance sheets items are marked to market, asset price variations influence the net worth of financial intermediaries, who, to the extent that capital constraints bite, need to adjust the size of their balance sheets. Leverage, as measured by the ratio between assets and equity capital,

[7]Adrian et al. (2013) provide evidence that lending is pro-cyclical while lending spreads are counter-cyclical.

becomes highly pro-cyclical. While this mechanism is very relevant for investment banks and in general for banks and other intermediaries that have a large portfolio of securities, it does not apply to the loan portfolio, which is not marked to market. The cyclical pattern of loans can to an extent be explained by variations of real estate prices, since a substantial share of bank lending is nowadays supported by real estate collateral. However, before the violent crisis of 2007, the volatility of real estate prices has been rather limited, as for example the average home price in the U.S. has not declined since the 1930s, with downward real price adjustments driven by periods of stable real estate prices matched by rising prices of consumption goods. As a consequence, while the increased role of real estate lending in bank portfolios and the development of securitization techniques may have played an important role in explaining the trend of the loan to deposit ratio over the last decades, real estate price dynamics are not a major candidate to explain the cyclical variations of the ratio.

Fig. 7 displays the HP filtered series of GDP together with the real interest rate on deposits and the real interest rate on loans net of loan loss provisions. In this case the evidence of a cyclical behavior is clear only for the recent decades, and the correlation for the 1987-2015 period is 0.22 between GDP and real deposit rates and 0.20 between GDP and real net loan rates. The correlation between HP filtered series of GDP and the spread between the real net loan rate and the the deposit rate is positive, 0.22. Bank margins *net* of loan losses thus display a strong pro-cyclical behavior. Here we need to stress that we are considering interest rates net of loan losses, which behave differently from the banking spreads that are normally analyzed in the banking literature, for example by Adrian et al. (2013) or Cúrdia and Woodford (2010). These last are strongly counter-cyclical because loan losses and hence risk premia are strongly counter-cyclical.

This evidence suggests that in boom times banks in the U.S. not only benefit of deposit growth, but they also lend more of their deposits, and they do so while achieving better margins on their loans than in recessionary periods.

This evidence indicates that the cyclical pattern of loans cannot be explained by the increased loan supply in boom times, because larger loan supply is associated with lower rates on loans, while instead loan rates rise in periods of booms. The cyclical pattern of the demand for loans must therefore play the major role, since the impact on interest rates of the increased demand must at least more than offset that of any eventual increased supply. We need in fact to explain how both quantities rise in boom times, but with loans rising more than deposits, and the same time both rate rise, but with the rate on loans rising more than the rate on deposits. The behavior of loan rates is thus difficult to reconcile with any explanation based exclusively on changes in the banks' attitude toward risk over the cycle, since the risk profile affects loan supply, but not the demand.

The standard Real Business Cycle model provides an explanation of the cyclical behavior of the demand for loans, which rises following a productivity shock. But the standard RBC generates a prediction that is hard to reconcile with the behavior of of deposits and deposit rates: A positive productivity shock generates higher returns on capital and arbitrage requires both market rates and deposit rates to rise accordingly. However, in this framework, the higher rates on deposits are driven

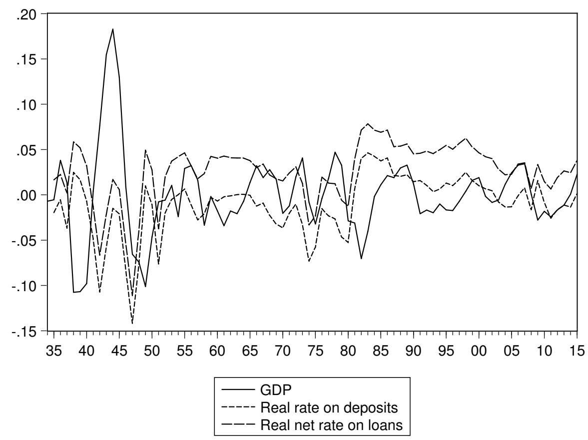

Figure 7: HP-filtered loan-deposit ratio and log GDP, United States of America.

by a contraction of deposit supply, since households reduce their portfolio of liquid assets to invest more in physical capital. Equilibrium quantities therefore should decline, ceteris paribus. But this is not what we observe in the data, since deposits are highly pro-cyclical. Both the equilibrium quantity of loans and that of deposits rise in boom times, but the ratio moves up because loans rise more violently than deposits. To make sense of the positive correlation between deposit rates and GDP we thus need deposit demand to rise far more than supply. And to explain the positive correlation between loan rates and GDP we also need the demand for loans to rise while loan supply does not change, because an increase in loan supply pushes loan rates downward (or demand must rise far more than supply). The basic RBC model must be expanded to generate a response of the banks' demand for deposit funds.

3 The Model

The model is a standard Real Business Cycle model with financial intermediaries. The economy is composed by three set of agents: Households, Firms and Banks. Households derive utility from consumption, leisure and from holding deposits in the banking system, which as mentioned is a shortcut to introduce their monetary role. Firms rent capital and labour from households, and finance their working capital needs by borrowing in the loan market. Banks use capital and labour to supply loans to firms and to collect deposits from households. Any difference between the amount of loans and deposits in the portfolio of banks is matched by a correspondent change in the value of of households' bond position. Households supply deposit funds to get payment services, but they also hold a net bond position against banks. When the net position is positive, households lend to banks for the bond interest rate, when the position is negative they borrow from banks at the same rate. Hence, when deposits exceed the working capital needs of firms, households borrow from banks the difference.[8]

3.1 Households

The representative household maximize a standard utility function in consumption, c_t, and leisure $1 - h_t$. Households also derive utility from holding deposits, d_t. In

[8]In our calibration, as the loan to deposit ratio is below unity, banks are net buyers of bonds. The counterpart are households who therefore borrow on the bond market. While thinking of households as net borrowers on bond markets may seem at odds with reality, one has to take into account that we do not model the government and the central bank. These are in fact the major net issuers of the bonds and reserves that banks hold on their balance sheet. One could think of households in our model as representing the consolidated balance sheet of households and government.

each period, the representative household chooses bank deposits, bonds b_{t-1}, capital k_t, and worked hours, h_t. The representative household's optimization problem is defined as:

$$\max \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\sigma}}{1-\sigma} + \theta \frac{(1-h_t)^{1-\gamma}}{1-\gamma} + \chi \log d_t \right]$$

subject to the budget constraint:

$$c_t + d_t + b_t + k_t = w_t h_t + r_{t-1}^d d_{t-1} + r_{t-1}^b b_{t-1} + (r_t + 1 - \delta) k_{t-1} + \Pi_t^b + \Pi_t^f, \qquad (1)$$

where w is the real wage, r^d is the gross interest rate on deposits, r^b is the interest rate on bonds, r is the rental rate for capital, and Π^f and Π^b are dividends paid by firms and bank. The parameter $\beta < 1$ is the subjective discount factor, $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution, γ governs the Frish elasticity of labour, θ is utility parameter for leisure and χ is the utility parameter of bank deposits.

The first order conditions are as follows:

$$\frac{\partial}{\partial k_t} : c_t^{-\sigma} = \beta E_t \left[c_{t+1}^{-\sigma} (r_{t+1} + 1 - \delta) \right], \qquad (2)$$

$$\frac{\partial}{\partial h_t} : w_t = \theta \frac{(1-h_t)^{-\gamma}}{c_t^{-\sigma}}, \qquad (3)$$

$$\frac{\partial}{\partial b_t} : r_t^b = \frac{c_t^{-\sigma}}{\beta E_t \left[c_{t+1}^{-\sigma} \right]}, \qquad (4)$$

$$\frac{\partial}{\partial d_t} : \chi \left(\frac{1}{d_t} \right) - c_t^{-\sigma} + \beta E_t \left[c_{t+1}^{-\sigma} \right] r_t^d = 0. \qquad (5)$$

Equation (2) is the standard Euler equation describing household's consumption and savings decisions, Equation (3) provides the labour supply schedule, while (4) and (5) regulate the optimal demand for bonds and the optimal supply of deposits. Combining (4) and (5) we obtain the the deposit rate as a mark down on the bond rate:

$$r_t^d = r_t^b - \chi \left(\frac{1}{d_t} \right) \left(\frac{1}{\beta E_t \left[c_{t+1}^{-\sigma} \right]} \right)$$

3.2 Firms

We assume a continuum of symmetric firms in the interval $[0, 1]$. The goods market is perfectly competitive and firms are owned by households. The representative firm uses capital $\left(k_t^f\right)$ and labour $\left(h_t^f\right)$ to produce the good (y_t) using a standard Cobb-Douglas technology.

$$y_t = a_t \left(k_t^f\right)^{\alpha} \left(h_t^f\right)^{1-\alpha}, \tag{6}$$

where a is total factor productivity, which we assume to be stochastic. The representative firm demands one period loans to pay a share μ of its labor and capital costs in advance, hence:[9]

$$\left(w_t h_t^f + r_t k_t^f\right) \mu = l_t^d. \tag{7}$$

[9]The cash in advance constraint (7) works as follows: In each period, before production occurs, banks credit firms' deposit accounts a value equal to $\left(w_t h_t^f + r_t k_t^f\right) \mu$ and firms write checks to labor and capital owners for the same amount. Banks transfer the funds on households' accounts. At the end of the period, after all transactions not subject to the cash in advance constraint have been cleared, households recapitalize firms by writing checks for the amount necessary to pay back loans, and once checks are delivered, banks close their credit and debit positions. Interest margins thus contribute to the bank profits of the following period.

Using equations (6) and (9), the problem of the representative firm can be written as

$$\Pi_t^f = l_t^d + y_t - r_{t-1}^l l_{t-1}^d - w_t h_t^f - r_t k_t^f. \tag{8}$$

Equations (7) and (8) imply that dividends can be rewritten as

$$\Pi_t^f = y_t - r_{t-1}^l \left(w_{t-1} h_{t-1}^f + r_{t-1} k_{t-1}^f \right) \mu - \left(w_t h_t^f + r_t k_t^f \right) (1-\mu). \tag{9}$$

Using equations (6) and (9), the problem of the representative firm can also be written as

$$\max \sum_{t=0}^{\infty} \beta^t c_t^{-\sigma} \left[a_t \left(k_t^f \right)^{\alpha} \left(h_t^f \right)^{1-\alpha} - r_{t-1}^l \left(w_{t-1} h_{t-1}^f + r_{t-1} k_{t-1}^f \right) \mu - \left(w_t h_t^f + r_t k_t^f \right) (1-\mu) \right], \tag{10}$$

where the discount factor $\beta^t c_t^{-\sigma}$ takes into account the marginal value to the household of one unit of profits. Cost minimization, together with the zero profit condition, yields the following equilibrium relations:[10]

$$c_t^{-\sigma} \left[(1-\alpha) a_t \left(k_t^f \right)^{\alpha} \left(h_t^f \right)^{-\alpha} - w_t (1-\mu) \right] = \beta c_{t+1}^{-\sigma} r_t^l w_t \mu, \tag{11}$$

$$c_t^{-\sigma} \left[\alpha a_t \left(k_t^f \right)^{\alpha-1} \left(h_t^f \right)^{1-\alpha} - r_t (1-\mu) \right] = \beta c_{t+1}^{-\sigma} r_t^l r_t \mu. \tag{12}$$

Equations (**??**) and (12) collapse to standard labor demand and capital demand functions for μ equal to zero. When μ is bigger than zero, the firm must take into

[10] Also for firms, economic profits are zero. Dividends can differ from zero because firms incur a part μ of their labor and capital costs with a one period delay. In the steady state, discounting implies that dividends are negative.

account the interest rate on loans, r^l in its cost minimization problem.

3.3 Banks

We assume a continuum of symmetric banks in the interval $[0,1]$. The banking sector is perfectly competitive and banks are owned by households. Banks use capital and labour to provide banking services, i.e. deposits and loans. The bank's balance sheet is the following: $l_t = b_t + d_t$, where d_t are one period deposits, l_t are loans, and bonds, b_t, appear on the liability side of the balance sheet. However, when b_t takes a negative value, bonds become an asset for the bank. Hence, we assume that banks can lend to households without sustaining any resource costs. In our calibration, since in U.S. data the average time-series value of the aggregate loan to deposit ratio is smaller than one, b_t takes a negative value in steady state. The production function for loans is:

$$l_t = z_t \left(h_t^l\right)^{1-\kappa} \left(k_t^l\right)^{\kappa}, \tag{13}$$

where h^l are worked hours in loan sector of the bank and k^l is the amount of capital rented by banks and used in the production of loans. κ governs the contribution of capital to the production of loans while z is the bank's total factor productivity in the loan production, which we assume to be stochastic. The production function for deposits is similar:

$$d_t = z_t^d \left(h_t^d\right)^{1-\nu} \left(k_t^d\right)^{\nu}$$

where h^d are hours worked in the deposits sector of the bank and k^d is the amount of capital rented by banks and used in the production of deposits, ν governs the contribution of capital to the production of deposits while z^d is the bank's total factor productivity in the deposit production, which is stochastic as well. The objective of the bank is to maximise discounted dividend payments (Π^b) to households. In each period, funds available for dividend payment are given by:

$$\Pi_t^{Bank} = b_t + d_t + r_{t-1}^l l_{t-1} - r_{t-1}^b b_{t-1} - r_{t-1}^d d_{t-1} - l_t - w_t h_t^l - r_t k_t^l - w_t h_t^d - r_t k_t^d, \quad (14)$$

where r^l is the gross interest rate on loans. The problem for the representative bank can be rewritten as

$$\max \sum_{t=0}^{\infty} \beta^t c_t^{-\sigma} \left[\begin{array}{c} r_{t-1}^l z_{t-1} \left(h_{t-1}^l\right)^{1-\kappa} \left(k_{t-1}^l\right)^{\kappa} - r_{t-1}^b \left[z_{t-1} \left(h_{t-1}^l\right)^{1-\kappa} \left(k_{t-1}^l\right)^{\kappa} - z_t^d \left(h_t^d\right)^{1-\nu} \left(k_t^d\right)^{\nu}\right] - \\ -r_{t-1}^d z_t^d \left(h_t^d\right)^{1-\nu} \left(k_t^d\right)^{\nu} - w_t \left[h_t^l + h_t^d\right] - r_t \left[k_t^l + k_t^d\right] \end{array} \right],$$

where the discount factor $\beta^t c_t^{-\sigma}$ takes into account the marginal value to the household of one unit of profits. Cost minimization, together with the zero profit condition, yields the following equilibrium relations:[11]

$$\frac{\partial}{\partial h_t^b}:\beta^t c_t^{-\sigma}\left[r_{t-1}^l z_{t-1}(1-\kappa)\left(\frac{k_{t-1}^l}{h_{t-1}^l}\right)^{\kappa}-r_{t-1}^b z_{t-1}(1-\kappa)\left(\frac{k_{t-1}^l}{h_{t-1}^l}\right)^{\kappa}-w_t\right]=0$$
$$\frac{\partial}{\partial h_t^d}:\beta^t c_t^{-\sigma}\left[r_{t-1}^b z_t^d(1-\nu)\left(\frac{k_t^d}{h_t^d}\right)^{\nu}-r_{t-1}^d z_t^d(1-\nu)\left(\frac{k_t^d}{h_t^d}\right)^{\nu}-w_t\right]=0$$
$$\frac{\partial}{\partial k_t^b}:\beta^t c_t^{-\sigma}\left[r_{t-1}^l z_{t-1}\kappa\left(\frac{h_{t-1}^l}{k_{t-1}^l}\right)^{1-\kappa}-r_{t-1}^b z_{t-1}\kappa\left(\frac{h_{t-1}^l}{k_{t-1}^l}\right)^{1-\kappa}-r_t\right]=0$$
$$\frac{\partial}{\partial k_t^d}:\beta^t c_t^{-\sigma}\left[r_{t-1}^b z_t^d\nu\left(\frac{h_t^d}{k_t^d}\right)^{1-\nu}-r_{t-1}^d z_t^d\nu\left(\frac{h_t^d}{k_t^d}\right)^{1-\nu}-r_t\right]=0,$$

which give us the optimal conditions for the loan producing sector

$$\beta E_t c_{t+1}^{-\sigma} z_t(1-\kappa)\left(\frac{k_t^l}{h_t^l}\right)^{\kappa}\left(r_t^l-r_t^b\right)=c_t^{-\sigma}w_t, \tag{15}$$

$$\beta E_t c_{t+1}^{-\sigma} z_t\kappa\left(\frac{k_t^l}{h_t^l}\right)^{\kappa-1}\left(r_t^l-r_t^b\right)=c_t^{-\sigma}r_t, \tag{16}$$

$$\frac{(1-\kappa)}{\kappa}\left(\frac{k_t^l}{h_t^l}\right)=\frac{w_t}{r_t}.$$

Similarly, the optimality conditions for the deposit producing sector are:

$$\beta^t E_t c_{t+1}^{-\sigma} z_t^d(1-\nu)\left(\frac{k_t^d}{h_t^d}\right)^{\nu}\left(r_t^b-r_t^d\right)=c_t^{-\sigma}w_t, \tag{17}$$

$$\beta^t c_{t+1}^{-\sigma} z_t^d\nu\left(\frac{k_t^d}{h_t^d}\right)^{\nu-1}\left(r_t^b-r_t^d\right)=c_t^{-\sigma}r_t, \tag{18}$$

[11] Although economic profits are zero, dividends can differ from zero because banks pay labor and capital one period before earning the return on loans. In the steady state, discounting implies that dividends are positive.

and

$$\frac{(1-\nu)}{\nu}\left(\frac{k_t^d}{h_t^d}\right)=\frac{w_t}{r_t}.$$

3.4 Market Clearing Conditions

Equations (19)-(23) define the market clearing conditions for the capital market, the labor market, the market for deposits, the market for loans and the market for bonds

$$k_{t-1}=k_t^f+k_t^l+k_t^d, \tag{19}$$

$$h_t=h_t^f+h_t^l+h_t^d, \tag{20}$$

$$d_t^d=d_t^s, \tag{21}$$

$$l_t^d=l_t^s. \tag{22}$$

$$b_t^d=b_t^s. \tag{23}$$

The aggregate resource constraint

$$c_t+k_t-(1-\delta)\,k_{t-1}=y_t$$

can be obtained combining equations (1), (14), (8) and(19)-(23).

4 Calibration

4.1 Preliminary evidence

To analyze the realism of the modelling assumption we need to compare the dynamics of the labor market for the banking industry with that of the manufacturing sector or the total private sector in the United States. Unfortunately data for the banking industry are not available for a long enough time span, and we need to use data for the financial sector. Fig. 8 compare the HP filtered hourly wages of the total private sector, of manufacturing and of the financial sector. With the partial exception of the recent years of the financial crisis, the cyclical behavior of three series is very similar. The correlation of between wages in finance and those, respectively of manufacturing and the private sector for the whole 1964-2015 sample is of 0.29 and 0.42. If we consider the sample 1964-2006 excluding the financial crisis period we get 0.63 and 0.70.

4.2 Data

Calibration of model parameters mostly aims at replicating steady state values for the US economy. To analyze firms, we use data from the the Flow of Funds for the nonfinancial corporate business sector. More specifically, to calculate the capital stock we apply the price deflator for investment obtained from NIPA to the figures for gross fixed investment, and we cumulate capital by applying a discount rate of 10 percent.[12] We take the series measuring revenues from sales of goods and services,

[12]The results for the recent decades that we use in the analysis are not sensitive to the initial value chosen.

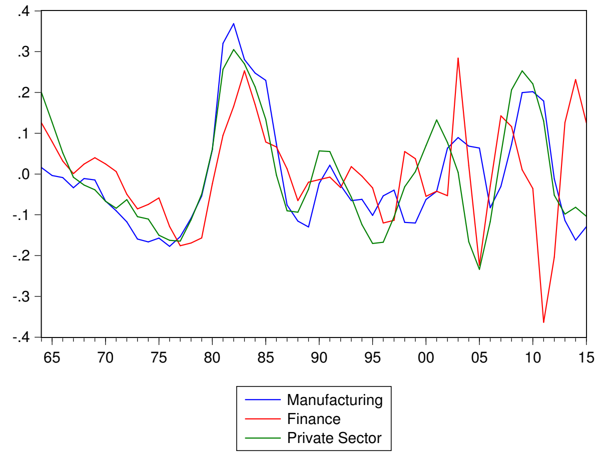

Figure 8: Hourly Earnings of Production and Non supervisory Employees: Total Private, Manufacturing and Financial Activities.

excluding indirect sales taxes (identical to that of gross value added) as our measure of output, and we deflate the series using the deflator for GDP. Using the series for employment and labour share for nonfinancial corporate business sector obtained from the Bureau of Labor Statistics, we calculate the total factor productivity under the assumption of a Cobb-Douglas production function.

To calibrate the parameters in the equations describing the banking industry we use the Historical Statistics on Banking maintained by the Federal Deposit Insurance Corporation. These data cover all commercial banks in the United States since 1934 and provide detailed aggregate information on both balance sheet entries and the income statement. We choose to calibrate the model using data since 1987, the year of the final abolition of Regulation Q, because our model does not discriminate between demand and time deposits, and we need to use the total annual interest cost of deposits for the whole banking system, as a proportion of total deposits, to calibrate the interest rate on deposit of the model. Similarly, we calibrate the rate on loans to match the ratio between loan interest income and total loans and leases. We calculate the capital intensities of banks by dividing the total value of premises and equipment by the number of employees.

4.3 Calibration strategy

We adopt an annual calibration and therefore the discount factor β is set to 0.96 to ensure a steady state interest rate on bonds equal to 4%, as common in the macroeconomic literature. The capital stock is assumed to depreciate at a rate equal to 10% a year, which implies that $\delta = 0.1$. The parameter μ governs the ratio between bank credit to firms and output: consistently with the data described above we set it at a value of 0.17. α is set to 0.4, consistently with the capital share of income. The utility weight on leisure, θ, is set to 1.96 to ensure that worked hours are 30% of available time in steady state. Similarly, the utility weight on deposits, χ is set to 0.003, which implies that the steady state loan-deposit ratio is 0.82 as in the data. The total factor productivities of firms and of the two sectors of banks are assumed to be subject to a perfectly correlated shock, whose standard deviation is 0.6% and whose autocorrelation is set to 0.58, consistently with our estimation for the US.

Calibration of the parameters of the production functions of banks, i.e. z, z_d, ν, and κ is used to account for banking sector interest rates and quantities. In particular, our objective is to fit the average interest rates on loans (RL) and deposits (RD) in the data, and the ratio between the capital intensities of firms and banks

(KIF/KIB). As the latter values are three and the parameters are four, we need to either add another restriction or add another moment to fit. We consider two experiments. In the first, we assume that both bank sectors have the same capital intensity, i.e. $\nu = \kappa$. As we discuss in the next section, this exercise allows us to show that our model is able to generate a positive correlation between the loan-deposit ratio and output with a conservative calibration, in which we are agnostic about the different capital intensities in the two bank sectors.

In the second experiment, instead, we allow ν and κ to differ, and set them to replicate the exact correlation between the loan-deposit ratio and output in the data. This second exercise allows us to find out which capital intensities in the two bank sectors are needed to perfectly fit the loan-deposit ratio correlation with output. To run both exercises, we use a moment matching exercise, i.e. we minimize

$$L = \big(\bar{\theta} - \theta(X)\big)^T I \big(\bar{\theta} - \theta(X)\big); \tag{24}$$

where $\bar{\theta} - \theta(X)$ is a column vector containing the differences between the quantities we want to replicate in the data, $\bar{\theta}$, and the same quantities in the model, $\theta(X)$. In the first exercise,

$$\bar{\theta} = [RL, RD, KIF/KIB]^T \quad \text{and} \quad \theta(X) = [r^l(X), r^d(X), \frac{k^f(X)/l^f(X)}{k^b(X)/l^b(X)}]^T; \tag{25}$$

while in the second

$$\bar{\theta} = [RL, RD, KIF/KIB, corr(LD, GDP)]^T \quad \text{and} \tag{26}$$

$$\theta(X) = [r^l(X), r^d(X), \frac{k^f(X)/l^f(X)}{k^b(X)/l^b(X)}, corr(l(X)/d(X), y)]. \tag{27}$$

Model quantities are therefore a function of the vector of parameters X: More specifically, $X = [z, z_d, \nu]$ in the first exercise because we assume that $\kappa = \nu$, while it is $X = [z, z_d, \nu, \kappa]$ in the second. In both cases, we are able to set L to zero, i.e. to perfectly replicate the data, therefore the weighting matrix is irrelevant and we can use the identity matrix.

Table 1 displays the values of our calibrated parameters. In both exercises, the total factor productivity in the deposit sector of the bank is higher than in the loan sector, 116 against 37 in the first and 75 against 40 in the second.[13] This result is due to the fact that the mark-down of the deposit interest rate on the 4% rate on bonds is lower than the mark-up of the loan interest rate on the same rate. The larger productivity value obtained suggests that banks use resources more efficiently in the production of deposits. In the first exercise, we also obtain that ν and κ (here, by assumption, the same in the two sectors) are lower than α, namely 0.24 compared to 0.4, in line with the data, which suggest that the capital intensity of banks is lower than the capital intensity of firms. The second exercise, however, provides strong evidence that the lower capital intensity of banks is driven by a lower capital intensity

[13]Numerical differences between the two exercises are of course driven by the fact that as the exponent in the production functions changes, the TFP has to adjust accordingly. Since in the second exercise capital is more heavily used in the production of deposits, this entails a lower TFP to account for the deposit interest rate, and similarly for the TFP of loans.

Parameters	Exercise 1	Exercise 2	Description
β	0.96	0.96	Discount Factor
α	0.4	0.4	Capital Share Firms
δ	0.1	0.1	Depreciation Rate
μ	0.17	0.17	Credit in advance par.
χ	0.003	0.003	Utility Weight on Deposits
θ	1.96	1.96	Utility Weight on Leisure
z	37	40	TFP Loans
z_d	116	75	TFP Deposits
ν	0.24	0.51	Capital Share Deposits
κ	0.24	0.14	Capital Share Loans

Table 1: Calibration

in loan production (κ is 0.14), while the capital intensity of deposit production is even higher than that of firms (ν is 0.51). To understand the latter result it is necessary to discuss the model dynamics and understand why a relatively high capital intensity in deposit production improves the fit of the correlation between the loan-deposit ratio and output.

5 Results

5.1 Steady state

To evaluate the model, we need to check its ability to replicate the cyclical behaviour of the loan-deposit ratio, of the deposit interest rate, of the loan interest rate, and of the spread between the two. Table 2 compares the model correlations under exercise

1 and 2 to the same correlations in the data. Recall that in exercise 1 the capital intensities of the loan and of the deposit sectors of banks are assumed to be the same; while in exercise 2 they are calibrated to replicate the correlation of the loan to deposit ratio with output that is found in the data, i.e. 0.78. In both cases, of course, the overall capital intensity of the bank is such that its ratio to the capital intensity of firms is the same as in the data.

Exercise 1 shows that the model is able to replicate the positive correlation between the loan-deposit ratio and output, even when the latter is not matched by assumption. However, the correlation is overstated (0.96 against 0.78). The fit of the correlation of the loan interest rate, of the deposit interest rate, and of the spread is quite good and it does not depend on the capital intensities of the two bank sectors. In other words, these correlations are the same under exercise 1 and under exercise 2. Hence, different capital intensities in the two bank sectors affect exclusively the dynamics of the loan-deposit ratio, not the steady-state.

Our results suggest that banks are more productive in the provision of deposit services than in the origination of loans, since the total factor productivity is substantially larger in the loan industry under both exercises 1 and 2. We also find

Correlations with output	Data	Exercise 1	Exercise 2
Loan-deposit ratio	0.78	0.97	0.78
Deposit rate	0.22	0.08	0.08
Loan rate	0.20	0.1	0.1
Loan deposit spread	0.22	0.05	0.05

Table 2: Results

that the provision of deposit services is a far more capital intensive activity than loan origination, in line with the empirical results from Dia and VanHoose (2019) and Dia and VanHoose (2017b). Exercise 2 suggests that the share of capital in the deposit sector is larger than in the loan sector. The provision of deposits services is capital intensive, the share of capital (0.51) is in fact much larger than in other industrial sectors (0.4). By contrast, the origination of loans is a labor intensive activity, as the share of capital is just 0.14.

5.2 Impulse response functions

In order to understand how the model is able to generate a positive correlation between the loan-deposit ratio and output and why different capital intensities in the two bank sectors help fine tune such correlation it is necessary to consider the impulse response functions to a symmetric shock, reported in Figures 9, 10, and 11.

More specifically, Figure 9 reports the percentage responses of output, consumption, the real wage, and the rental rate of capital to a one-standard-deviation productivity shock, symmetric across industries. The responses are virtually identical to those of the standard RBC model and do not differ between exercise 1 and 2. The increased productivity generates a positive response of output, and households respond by saving most of the extra output to smooth consumption. Because of the higher productivity, both wages and the rental rate of capital rise, but following different dynamic patterns: Wages rise less on impact than the rental rate of capital, but the impact of the shock on wages is more persistent, and the increase in wages lasts longer than that of the rental rate.

Figure 9: Response to a one standard deviation productivity shock. All variables are in percentage deviation from the steady state.

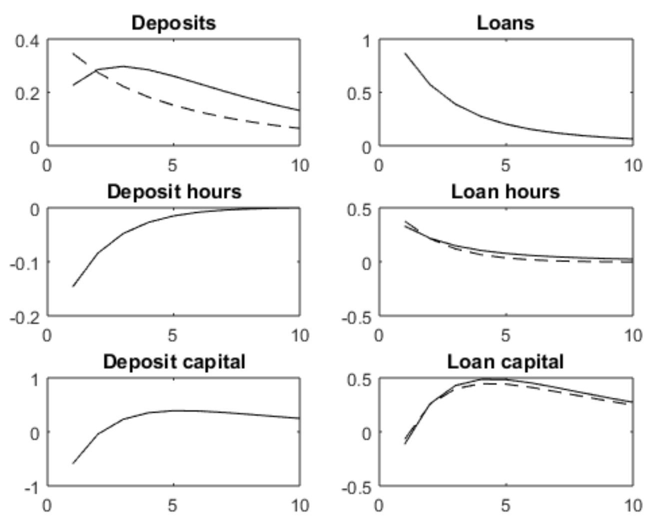

Figure 10: Response to a one standard deviation productivity shock. All variables are in percentage deviation from the steady state. Full line: exercise 2. Dashed line: exercise 1.

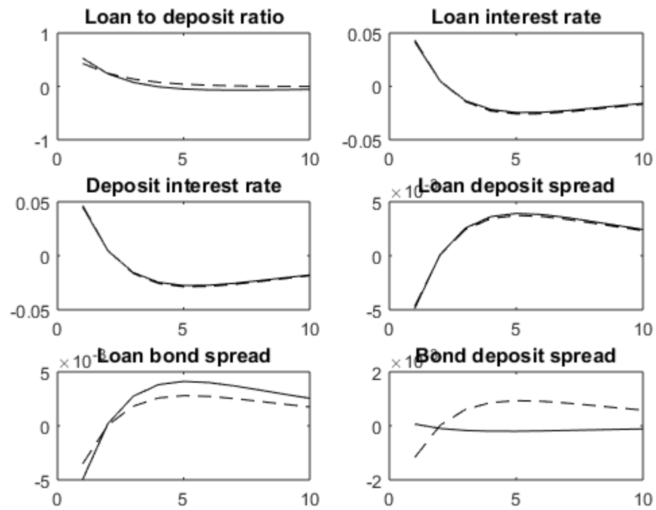

Figure 11: Response to a one standard deviation productivity shock. All variables are in deviations from the steady state multiplied by 100. Full line: exercise 2. Dashed line: exercise 1.

Figure 10 and 11 report respectively the response of bank quantities and the response of bank interest rates to the shock, distinguishing between exercise 1 (dashed line) and exercise 2 (full line). Both loans and deposits move up in each exercise, with loans rising more than deposits: the loan-deposit ratio rises on impact. Hours worked and capital, however, behave differently in the two segments of the banking industry, as they fall in the deposit sector, while they increase in the loan sector. The deposit and the loan interest rates rise, while the spreads between loan interest rate and the deposit interest rate declines at impact, but it rises afterwards for several periods, generating a positive correlation as in the observed data. The spread between the loan interest rate and the bond rate falls in both exercises, while the spread between the interest rate on bonds and that on deposits falls in exercise 1 but is more stable in exercise 2.

To understand these dynamics, it is important to notice that the shock directly affects both the demand and the supply side of the loan and deposit markets. In the deposit market, arbitrage conditions imply that the deposit supply schedule shifts upward, because the returns on capital investment are higher due to the higher rental rate, and households require higher returns on their deposits. *Ceteris paribus* this shift would reduce the equilibrium amount of deposits, without affecting the rate on deposits, because the deposit demand schedule is perfectly elastic due to the constant returns to scale. To produce deposit services, however, banks now face higher marginal resource costs, but their productivity has risen. The latter positive factor dominates, and the demand schedule as a consequence shifts up, more than compensating the negative effect of supply on the equilibrium quantity, which increases. Moreover, to produce this larger quantity of deposit services, banks need a *smaller* amount of resources (labor and capital) then in the initial equilibrium condition: worked hours and capital in the deposit sector fall because banks use part of the increased productivity to save physical resources, and banks are able to pay the required higher rates even if the amount of deposits demanded has risen.

Increased wages and rental rates raise the resource bill of firms, thereby increasing their working capital, and the demand for loans rises. As in the other sector, in the production of lending services banks face two contrasting dynamics: Marginal industrial costs rise because resource costs are larger, and they also need to pay higher rates on their liabilities. However, their productivity has risen, so that they can produce more loans with the same amount of resources. The first effect is stronger, and the loan supply schedule shifts upward. As the demand for loans is quite rigid (firms do not have alternative sources of funding) while the supply of loans is perfectly elastic (as loan production is characterized by constant returns to scale), in equilibrium both loan quantity and interest rate grow strongly. The larger quantity of loans requires employing more capital and labor in the lending sector, notwithstanding the increased productivity.

The increased demand for loans and the reduced supply of deposits (which can only be partly compensated by the higher productivity in the deposit sector) imply that the optimal behaviour of banks is to finance the higher amount of loans partly by borrowing more on the deposit market and partly by reducing their bond portfolio. As a consequence, the loan-deposit ratio increases. The initial reduction of the three spreads is instead the result of the higher productivity of banks. As mentioned, however, the spread between the bond interest rate and the deposit interest rate is much more stable under exercise 2, and the response of the deposit quantity is also more gradual and hump-shaped in the latter exercise. The dynamics of the rates is the result of the differences in the speed of the variation between wages and the rental rate of capital: Wages grow more slowly than the rental rate of capital following the shock, so that most of the increase in resource costs occurs over time and it is passed to customers only slowly. While in exercise 1 wages represent roughly three fourth of the cost bill for both sectors of the banking industry, in exercise 2 the share of capital in the deposit sector rises to more than 50 percent while that of the lending sector declines to 14 percent. As a result, in exercise 2 the deposit sector of banks is far more capital intensive than the loan sector. Hence, in the less capital intensive loan sector, on impact the cost reductions are smaller than in the more capital intensive deposit sector, while the cost advantage is reversed over time. Consequently, the production cost of deposits falls less in exercise 2, which explains why the spread between the interest rate on bonds and that on deposits is more stable and why deposits grow less on impact and more over time. Similarly, the loan-deposit ratio is slightly less autocorrelated in exercise 2, and the correlation with output is 0.78, against a value of 0.97 in exercise 1. The sluggishness in the response of deposit rates, due to the smoothing of the impact of shocks, a well known characteristics of banks deposits that is assumed in models such as Gerali et al. (2010), in this model is simply the result of the substantial capital intensity of the deposit sector.

6 Conclusions

Making use of data on the capital intensity of banks, which reflect resource costs, we have recovered endogenously the productivity parameters of the production function for both loans and deposits and the relative shares of the production factors. Our calibrated results for the banking system of the U.S. suggest that banks are more productive in the provision of deposit services than in the origination of loans. We also find that the provision of deposit services is a far more capital intensive activity than loan origination.

The model is able to replicate the cyclical behaviour of the loan-deposit ratio, of the deposit interest rate, of the loan interest rate, and of the spread between the two. We get our results under the basic assumption that productivity shocks are perfectly correlated among different sectors. We do not need any sector-specific shock to match the data.

The simple dynamics of resource costs induce substantial variations in the liquidity of the bank's portfolio. We find that the loan-deposit ratio, both interest rates and the spread between the two are highly pro-cyclical, in line with the data. Since during the upward phase of the business cycle resource costs are the only relevant cost factor in the banking industry, this analysis is based on very simple but solid evidence. An important caveat is that the analysis is based on the assumption of portfolio separation, very common, but empirically shaky, and some of the results may not survive in the more plausible no-portfolio separation case. However, the development of securitization techniques has made bank lending much less reliant on deposit funds, making our environment far more realistic. Our main conclusion is thus that when banks do not need to rely exclusively on deposits funds, their liquidity becomes anti-cyclical as they need less of a buffer or securities, or eventually they finance loans with market sources of finance.

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