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Margins: Estimates of a Dynamic Model**

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# The Determinants of Bank Interest Margins: Estimates of a Dynamic Model

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## Abstract

We develop a monopolistic version of a dynamic model of banking, where financial intermediation and payment services play a relevant role. We then empirically test the model using balance-sheet data for large European and US banks, and find strong support for the main predictions of the model. Interest revenues and costs are in fact very persistent, and they are strongly influenced by revenues from fees, and industrial and default costs. Interest margins rise with both short and long-term interest rates; however, when splitting the sample, we find that the results for the impact of interest rates are driven by the European banks. Finally, we find evidence that interest margins are anti-cyclical.

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## Introduction

A substantial part of the empirical literature on the determinants of bank interest margins has focused on the role played by market interest rates and the maturity-mismatch hypothesis. Variations of market interest rates, in fact, have a significant impact on bank profits if banks benefit of market power and/or if they are characterized by a structural maturity mismatch between assets and liabilities. A widely held opinion is that bank lend long and borrow short, so that the duration of assets is longer than that of liabilities: in this case, banks benefit from lower interest rates. To contrast this view, Samuelson (1945) suggested that banks are more similar to life insurers, in having longer term liabilities than assets, so that they benefit of higher interest rates. This thesis is based on the idea that deposits, demand deposits in particular, are not short-term, because they are normally never redeemed.<sup>1</sup> Another possibility is that, given the development of derivative markets, banks may opt to hedge the risks that financial markets price efficiently, as Froot and Stein (1998) suggested is the optimal behavior, and thus hedge any interest rate risk. The empirical evidence based on samples of US banks is so far quite mixed: Flannery (1981) has analyzed the issue by estimating a proxy for the average duration of assets and liabilities, finding that large banks in the US hedge interest rate risks. In a more sophisticated framework Flannery and James (1984) have analyzed the impact on the price of bank shares of interest rate variations, under the assumption that financial markets are efficient, and find that stock returns of banks in the US are sensitive to innovations in interest rates that depend on the maturity mismatch. In particular, they find evidence supporting Samuelson's theoretical suggestion that banks benefit from higher interest rates. Akella and Greenbaum (1992), on the contrary, find that stock returns are sensitive to unexpected changes in interest rates, and that interest rate shock produce a significantly negative impact, that they attribute to a slower repricing of assets than liabilities.

A second important framework for the empirical analysis has been developed by Ho

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<sup>1</sup>Because of the ubiquity of search costs in bank-customer relationship, Flannery (1982) suggested that deposits can be regarded as a sort of quasi-fixed input for the bank.

and Saunders (1981), by assuming that banks balance sheets display a structural maturity mismatch and bankers are risk-averse. In their framework thus, bank interest margins depend on both market power and a risk premium; this last is proportional to the variance of the interest rate, the risk aversion of the banker, and the size of the transactions. Their empirical estimation for a sample of U.S commercial banks suggests that both market power and interest rate variance are significant in explaining bank interest margins. More recent works have used the same analytical framework, but making use of modern panel date estimation methods: Saunders and Schumacher (2000) have studied a panel of European and U.S. banks for the period from 1988 to 1995, supporting the results of Ho and Saunders (1981). Valverde and Fernández (2007) have performed similar analysis for the European Union making use of Arellano-Bond estimators, and suggest that financial innovations, and the degree of diversification, significantly influence interest margins. Maudos and de Guevara (2004) further suggest that in the case of European banks operating costs and credit risk are important predictors of margins.

We study the determinants of bank interest margins by means of a different modelling strategy. We assume, following Froot and Stein (1998), that banks hedge the interest rate risk, so that the impact of market interest rates on bank margins is entirely due to the structure of the industry. We do so by ruling out any maturity mismatch and assuming risk neutrality, and we develop a dynamic model, since there is substantial empirical evidence that bank interest margins are persistent.<sup>2</sup> Moreover, we model the bank as multi-product firm, providing lending and deposit services together with payments and other financial intermediation services. This implies that different services are not priced independently of each other, and thus interest rates on loans and deposits are directly influenced by revenues from fees and industrial costs. As importantly, we model the banking firm as a monopolist, given the strong evidence provided by Cosimano and McDonald (1998) that banks benefit of substantial intra-industry market power, because of rents generated by information costs.<sup>3</sup> This assumption also allows to introduce in the analysis the impact of

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<sup>2</sup>This is an important features of banking rates, as stressed by Akella and Greenbaum (1992).

<sup>3</sup>The same framework could be developed as an oligopolistic market, but the optimal solutions that we

aggregate demand.<sup>4</sup>

We develop a monopolistic version of the model of Elsasani et al. (1995), where financial intermediation and payment services play a relevant role, by introducing revenues from fees, and industrial and default costs in the framework.<sup>5</sup> Dynamic models of banking have seen limited applications in empirical works, notwithstanding their rigorous foundations and intuitive appeal, because the results are often quite complicated.<sup>6</sup> However, notwithstanding the apparently heavy formal structure, we obtain solutions for the interest rates on loans and deposits as a function of market interest rates and marginal fees and costs that are quite straightforward. Both rates are set partially forward looking and partially backward-looking, and display a high degree of persistence. We make use of the solutions for banking interest rates to test the impact of both long and short-term market rates, fees, costs, and aggregate demand on bank interest margins.

Our database consists of balance sheet data of large banks from Europe and the USA, covering the period 1988 to 2007, and the panel is estimated by means of fixed effects and Arellano-Bond estimation procedures. We find that the predictions of the model are coherent with the results of the empirical estimations, as all the variables have the correct sign and are statistically significant. In particular, interest revenues and costs are very persistent, and they are strongly influenced by revenues from fees, and industrial and default costs. This result supports our assumption that banks are multi-product firms, since the prices of different financial products are set jointly. We cannot directly reject the hypothesis of portfolio separation, given that we find no direct evidence that the persistence of interest margins goes beyond the first lag. However, our results do not support the standard hypothesis of portfolio separation. We find that interest margins rise with both short and long-term interest rates, in line with the results of Flannery and James (1984) for

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estimate would remain very similar.

<sup>4</sup>For an analysis of the factors determining the demand for loans see Méliitz and Pardue (1970).

<sup>5</sup>There is strong empirical support for the hypothesis that market power is relevant in the market for deposits Hannan and Berger (1991) and Neumark and Sharpe (1992), and the market for loans Cosimano and McDonald (1998).

<sup>6</sup>These model have been developed in Cosimano (1987, 1988), Elsasani et al. (1995), Chami and Cosimano (2001).

the US. The first result suggests that bank margins benefit from tighter monetary policy, while the second that banks benefit from higher expected inflation, supporting the previous findings of Bordes et al. (1991), obtained from aggregate data. This happens because banks can exploit their monopolistic power by raising rates on loans more than those on deposits. However, when splitting the sample, we find that the results for the impact of interest rates are driven by the European banks, while the impact for banks of the USA is not significant. Finally, we find evidence that interest margins are anti-cyclical, and this suggests that banks do not smooth shocks of real origin.

The paper is structured in two main sections: the first section describes the theoretical model and develops the restrictions that we test. The second section introduces the empirical analysis and shows the result of the estimations.

## 1 The model

Banks are multi-product firms providing different kinds of financial services by means of a common platform. The network of branches, and the information system coordinating the activity of the different agents working in the banking firm, allow banks to provide payment systems, industrial and consumer credit, and many kinds of financial intermediation services, such as asset management, brokerage or life insurance. The activity of banks is based on the acquisition of information by establishing personal relationship with their customers. By accumulating information over time, banks obtain rents that insulate them from the competition of other agents whenever specific information is important for the provision of a service, as it is the case of the typical activity of “inside lending”.<sup>7</sup> Information costs make the strategy of a multi-product financial firm extremely efficient, since the multiplication of switching costs ties the customers very strictly to the bank.<sup>8</sup> As a consequence banks benefit of market power.

We model the problem of a profit maximizer bank that provides different services,

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<sup>7</sup>See Fama (1985).

<sup>8</sup>See Klemperer (1995) for a survey on the literature on switching costs.

pricing monopolistically the products where information costs are more relevant. The basic profit maximization problem of the bank is standard:

$$\begin{aligned}
 \text{Max} \quad & \Pi = \underline{P}_Y \bar{Y} - wLa - P_k K \\
 \text{w.r.t.} \quad & \{La, K\}, \quad \quad \quad \text{s.t.} \\
 & Y = f(La, K), \quad \quad \quad (1)
 \end{aligned}$$

where  $Y$  is a column vector of product and financial inputs, and  $\underline{P}_Y$  is a row vector of their prices (interest rates). The resulting cost function is thus of the form  $C(w, P_k)Y$ . We assume that the output of the bank is a set of services that we organize in two classes, credit  $C$  and financial intermediation  $FI$ :  $Y = C + FI$ . The cost function is thus a function of total assets  $C(w, P_k)[C + FI]$ . Clearly the same cost function can be exposed in terms of total liabilities, and the bank can choose to impose the cost on borrowers or lenders, or a combination of both. We assume that the cost is born by borrowers, but we test empirically if this the case. The stream of revenues comes from two sources, net interest revenues and fees. We then assume that banks borrow by means of deposits  $D$ , remunerated at the rate  $r_D$ , or by means of other liabilities  $B$ , remunerated at the market rate  $r_B$ . Analogously, banks extend credit by means of loans  $L$  that earn an interest rate  $r_L$ , or by purchasing bonds  $B$  that earn the market rate  $r_B$ .<sup>9</sup> A fraction  $q$  of deposits is kept as reserve. The bank earns fees from the provision of financial intermediation services, and we assume that fees are proportional to the volume of assets intermediated. Moreover banks earn fees from the provision of payment services services; the amount of these fees depends on the available technologies, on seasonal factors, on the velocity of circulation of money and on aggregate demand; we assume that the fees for payment services are proportional to the amount of deposits. This can be acceptable to the extent that the analysis is based

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<sup>9</sup>The bank thus borrows and lends in financial markets, or the interbank market, at the same rate, in line with Klein (1971) and Monti (1972). However, this assumption can be relaxed.

circulation.<sup>10</sup> Finally, banks earn fees in proportion to the amount of commitment loans extended. Since we do not differentiate commitment from ordinary loans, we assume that loans generate fee income. Formally:  $FEES = lfL + dfD + fifFI$ , where  $lfL$  are fees from commitment loans,  $dfD$  are fees from payment services and  $fifFI$  are fees from financial intermediation. Revenues are thus:

$$\underline{P}_Y \bar{Y} = r^L L + r^B B - r^D D + lfL + dfD + fifFI, \quad (2)$$

profits:

$$\Pi = r^L L + r^B B - r^D D + lfL + dfD + fifFI - C(w, P_k)[L + FI]. \quad (3)$$

In order to work with stable variables, we define all the quantities as ratios with respect to total assets, and we assume that the bank faces convex costs in the amount of loans and deposits produced, and linear costs in the provision of intermediary services.<sup>11</sup> We can thus define the respective cost functions as:

$$\frac{1}{2}gL_{t+j}^2, \quad \frac{1}{2}fD_{t+j}^2, \quad hFI. \quad (4)$$

We finally assume the presence of a quadratic adjustment cost on deposits and loans. This amounts to assuming that banks can increase their activity in a smooth way to the extent that they match the demand of services from existing clients. But it becomes much more expensive for them to grow by getting new clients, since they need to overcome heavy search and switching costs in order to attract them.<sup>12</sup> Thus to quickly increase their size banks must rely on the expensive establishment of new branches or to even

<sup>10</sup>See Osborne (1982) for an analysis of cost and revenues of deposits, and Radecki (1999) for an empirical analysis of the relevance of payment services fees for the banking system of the US.

<sup>11</sup>Non-linear costs on deposits and loans arise because the returns of the investment in information gathering, the basic activity of the bank, are decreasing. This implies that a larger size of the bank, for a given level of capital stock is more risky and thus generates higher default or liquidity costs.

<sup>12</sup>Mr. Kovacevich, Chairman of Wells Fargo, declared in an interview to the FT that for his institution it is ten times more expensive to find a new client rather than selling a new product to an existing one.



more expensive policy of acquiring other competing banks. This amounts to assuming the presence of heavy adjustment costs on the stock of capital and (or) labour. There is in fact substantial empirical evidence that search costs are very relevant in the market for deposits, to the extent that deposits are often treated as a quasi-fixed input.<sup>13</sup> The basic model we develop is thus a dynamic version of the Monti-Klein, where the dynamics is driven by the assumption of the quadratic adjustment cost on deposits and loans.<sup>14</sup> The structure of the model is very simple, the bank maximizes profits subject to a budget constraint, pricing monopolistically both deposits and loans.<sup>15,16</sup> On the contrary, we assume that the market for financial intermediation services is competitive, and the demand for those services is a function of aggregate demand.

The intertemporal portfolio problem is thus:

$$\begin{aligned} \text{Max } V = \sum_{j=0}^{\infty} \beta^j E \left[ r_{t+j}^L(L_{t+j})L_{t+j} + r_{t+j}^B B_t - r_{t+j}^D(D_{t+j})D_{t+j} + \right. \\ \left. - \frac{1}{2}fD_{t+j}^2 - \frac{1}{2}gL_{t+j}^2 - C_{t+j}[L_{t+j} + FI_{t+j}] + \right. \\ \left. - \frac{d}{2}(D_{t+j} - D_{t+j-1})^2 - \frac{e}{2}(L_{t+j} - L_{t+j-1})^2 + lf_{t+j}L_{t+j} + df_{t+j}D_{t+j} + fif_{t+j}FI_{t+j} \right], \end{aligned}$$

$$\text{w.r.t. } \{L_t, D_t\}_0^{\infty}, \quad \text{s.t.}$$

$$\begin{aligned} L_t + B_{t+j} + R_{t+j} + FI_{t+j} = D_{t+j} + FI_{t+j} + NW_{t+j}, \quad R_{t+j} = qD_{t+j}, \\ L_{t+j} = \delta_0 - \delta_1 r_{t+j}^L + \delta_2 r_{t+j}^B + \delta_3 Y_{t+j}, \quad D_{t+j} = \alpha_0 + \alpha_1 r_{t+j}^D - \alpha_2 r_{t+j}^B + \alpha_3 Y_{t+j}. \end{aligned}$$

Here  $D_t$  are deposits,  $L_t$  are loans,  $R_t = \frac{\bar{R}_t}{A_t}$  are reserves, and  $B_t = \frac{\bar{B}_t}{A_t}$  is the net position in the bond market and  $NW_t = \frac{\bar{N}W_t}{A_t}$  is capital. We assume for simplicity that the bank knows

<sup>13</sup>Flannery (1982) provides convincing evidence on the relevance of search cost, while the analysis of Hess (1991, 1995) suggests that bonds are poor substitutes for deposits.

<sup>14</sup>Cosimano (1987, 1988) develops a model where banks face adjustment costs on loans, while Elsasani et al. (1995) presents a model where the bank faces adjustment costs on both loans and deposits. Our model is a monopolistic version of their dynamic problem, for the case of when portfolio separation holds.

<sup>15</sup>There is substantial evidence of market power in both the market for loans and the market for deposits, see Cosimano and McDonald (1998), Berger and Hannan (1989), Hannan and Berger (1991), and Neumark and Sharpe (1992).

<sup>16</sup>Chami and Cosimano (2001) have proposed a dynamic model where banks benefit from market power.

with certainty the demand curve for both deposit and loan services. The only stochastic variable are thus the market interest rate and aggregate demand, and, albeit unrealistically, we assume that both variables follow a random walk.

The first order condition with respect to deposits and loans are:

$$\begin{aligned} \frac{\partial \ell}{\partial D_{t+j}} = & -r_{t+j}^D - \frac{\partial r_{t+j}^D}{D_{t+j}} D_{t+j} + (1-q)r_{t+j}^B - f_1 D_{t+j} + \\ & -d(D_{t+j} - D_{t+j-1}) + \beta d(D_{t+j+1} - D_{t+j}) + df_{t+j} = 0; \end{aligned} \quad (5)$$

$$\begin{aligned} \frac{\partial \ell}{\partial L_{t+j}} = & r_{t+j}^L + \frac{\partial r_{t+j}^L}{L_{t+j}} L_{t+j} - r_{t+j}^B - C_{t+j} - g_1 L_{t+j} + \\ & -e(L_{t+j} - L_{t+j-1}) + \beta e(L_{t+j+1} - L_{t+j}) + lf_{t+j} = 0; \end{aligned} \quad (6)$$

we can rewrite the demand for deposit services (the supply of deposits) and the demand for loans as:

$$\begin{aligned} r_{t+j}^D = & -\gamma_0 + \gamma_1 D_{t+j} + \gamma_2 r_{t+j}^B - \gamma_3 Y_{t+j} = \frac{1}{\alpha_1} \left[ -\alpha_0 + D_{t+j} + \alpha_2 r_{t+j}^B - \alpha_3 Y_{t+j} \right], \\ r_{t+j}^L = & \lambda_0 - \lambda_1 L_{t+j} + \lambda_2 r_{t+j}^B + \lambda_3 Y_{t+j} = \frac{1}{\delta_1} \left[ \delta_0 - L_{t+j} + \delta_2 r_{t+j}^B + \delta_3 Y_{t+j} \right], \end{aligned} \quad (7)$$

and substitute the respective values in Eq. (5) and (6), obtaining:

$$\begin{aligned} \gamma_0 - 2\gamma_1 D_{t+j} + \gamma_3 Y_{t+j} + [(1-q) - \gamma_2] r_{t+j}^B + df_{t+j} - f_1 D_{t+j} + \\ -d(D_{t+j} - D_{t+j-1}) + \beta d(D_{t+j+1} - D_{t+j}) = 0. \end{aligned} \quad (8)$$

and

$$\begin{aligned} \lambda_0 - 2\lambda_1 L_{t+j} + \lambda_3 Y_{t+j} + \lambda_2 r_{t+j}^B - r_{t+j}^B - C_{t+j} - g_1 L_{t+j} + \\ -e(L_{t+j} - L_{t+j-1}) + \beta e(L_{t+j+1} - L_{t+j}) + lf_{t+j} = 0; \end{aligned} \quad (9)$$

These are two second order difference equation in the level of deposits and loans:

$$\begin{aligned} \beta d D_{t+j+1} - [f_1 + d(1 + \beta) + 2\gamma_1] D_{t+j} - d D_{t+j-1} = \\ -\gamma_0 - d f_{t+j} - [(1 - q) - \gamma_2] r_{t+j}^B - \gamma_3 Y_{t+j}, \end{aligned} \quad (10)$$

$$\begin{aligned} \beta e L_{t+j+1} + [g_1 + e(1 + \beta) + 2\lambda_1] L_{t+j} - e L_{t+j-1} = \\ -\lambda_0 + C_{t+j} - l f_{t+j} + (1 - \lambda_2) r_{t+j}^B - \lambda_3 Y_{t+j}. \end{aligned} \quad (11)$$

Adding a standard transversality condition, implying that interest rates remain bounded,<sup>17</sup> the solutions become:

$$D_{t+j+1} = \mu_1 D_{t+j} - \frac{\mu_1}{d} \sum_{i=0}^{\infty} \left( \frac{1}{\mu_2} \right)^i \left\{ -\gamma_0 - d f_{t+j+1} - [(1 - q) - \gamma_2] r_{t+j+i}^B - \gamma_3 Y_{t+j+1} \right\}, \quad (12)$$

$$L_{t+j+1} = \mu_3 L_{t+j} - \frac{\mu_3}{e} \sum_{i=0}^{\infty} \left( \frac{1}{\mu_4} \right)^i \left\{ -\lambda_0 + C_{t+j} - l f_{t+j+1} + [1 - \lambda_2] r_{t+j+i}^B - \lambda_3 Y_{t+j+1} \right\}, \quad (13)$$

Where, respectively  $\mu_1$  e  $\mu_2$ ,  $\mu_3$  e  $\mu_4$ , are the two characteristic roots. Sargent (1979) shows that  $\mu_1 < 1$  with  $\mu_2 > 1$ , and  $\mu_3 < 1$  with  $\mu_4 > 1$ .

The equilibrium level of deposits and loans in each period is a function of the own lagged values of the variables and of the expected values of marginal costs and revenues. The marginal cost coefficients  $d$  and  $e$  together with the marginal costs  $f_1$  and  $g_1$  and the own interest rate semi-elasticity of deposits and loans  $\gamma_1$  and  $\lambda_1$ , determine the value of the roots of the solution, and thus the relative wight of the forward and backward looking part of the solutions. The dependence of the roots on the interest rate elasticity is a peculiarity of the model, since it depends on the monopolistic assumption. It can easily be shown that a higher interest rate semi-elasticity increases the value of both roots. This implies that the forward looking part of the solution shrinks and the persistence of

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<sup>17</sup>See Sargent (1979).

the backward looking part rises. This happens because when the demand is more price sensitive, an increase the optimal quantity implies a stronger response of the interest rate. There is thus a reduced incentive to change the equilibrium quantities. We would thus expect a larger persistence of deposits and loans level when the own interest rate semi-elasticity of demand is higher., for example if technological developments increase the competition from non-banking intermediaries.

Moreover the coefficients  $d$  and  $e$  scale the forward looking part of the solutions: the higher these costs, the smaller the values of the equilibrium quantities. The forward looking part becomes the more important the lower the information costs, whenever the bank can change the stock of deposits and loans in a faster way.

The equilibrium level of both deposits and loans grows with aggregate demand, and declines with the level of the marginal costs  $a$  and  $b$ .

To analyze the interest rate coefficients, it is worth remembering that as long as the standard condition that the own price effect is larger than any cross-price effect holds, than both  $\gamma_2$  and  $\lambda_2$  are smaller than one.<sup>18</sup> Positive interest rate shocks should thus produce a decline in the equilibrium level of loans, while whenever the reserve coefficient  $q$  is quite small (as it is normally the case in most developed economies), they generate an increase in the equilibrium amount of deposits. We have so far assumed that the bank is a lender in the interbank market: in this case higher market rate increase the marginal return of deposits and the opportunity cost for loans. When the bank is a borrower in the interbank market, deposits from banks and customers are complements, and thus an increase in interest rates raises the cost of interbank borrowing more than that of deposits and the opportunity cost of deposits declines; the amount of loans declines because marginal costs rise.

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<sup>18</sup>This is certainly the case for the demand for loans, while in the case of the demand for deposits it has been suggested that the coefficient may be equal to one (see Siegel (1981)).

The interest rate solutions are the following:

$$\alpha_0 + \alpha_1 r_{t+j+1}^D - \alpha_2 r_{t+j+1}^B - \alpha_3 Y_{t+j+1} = \lambda_1 \left[ \alpha_0 + \alpha_1 r_{t+j}^D - \alpha_2 r_{t+j}^B - \alpha_3 Y_{t+j} \right] + \frac{\lambda_1}{d} \sum_{i=0}^{\infty} \left( \frac{1}{\lambda_2} \right)^i \left\{ -\gamma_0 - d f_{t+j+1} - [(1-q) - \gamma_2] r_{t+j+i}^B - \alpha_3 Y_{t+j+1} \right\}, \quad (14)$$

$$\delta_0 - \delta_1 r_{t+j+1}^L + \delta_2 r_{t+j+1}^B + \delta_3 Y_{t+j+1} = \mu_3 \left[ \delta_0 - \delta_1 r_{t+j}^L + \delta_2 r_{t+j}^B + \delta_3 Y_{t+j} \right] + \frac{\mu_3}{e} \sum_{i=0}^{\infty} \left( \frac{1}{\mu_4} \right)^i \left\{ -\lambda_0 + C_{t+j} - l f_{t+j+1} + [1 - \lambda_2] r_{t+j+i}^B - \lambda_3 Y_{t+j+1} \right\}. \quad (15)$$

The interest rate on deposits is thus an increasing function of the current value of the market interest rate, although whenever the coefficient  $\gamma_2$  is close to unit (when the demand of deposit services is highly elastic to the market interest rate), the impact is quite small. Higher market interest rates, in fact, increase the equilibrium amount of deposits and thus the equilibrium interest rate.

The interest rate on loans rises with the current value of the market interest rate. Higher market rates reduce the equilibrium amount of loans, and the bank charges a higher interest rate on loans. As it is the case for the quantities, the persistence of the series largely depends on the adjustment cost coefficients, but increases with the own interest rate sensitivity of the demand functions.

Assuming for simplicity that market interest rates, fees, costs and aggregate demand follow uncorrelated random walk processes, the solutions become:<sup>19</sup>

$$r_{t+1}^D = \phi_0 + \phi_1 r_{t+j}^D - \phi_2 r_t^B + \phi_3 r_{t1}^B - \phi_4 Y_t + \phi_4 Y_{t+1} + \phi_5 f_{t+1}. \quad (16)$$

$$r_{t+1}^L = \sigma_0 + \sigma_1 r_t^L - \sigma_2 r_t^B + \sigma_3 r_{t+1}^B - \sigma_4 Y_t + \sigma_5 Y_{t+1} + \sigma_6 C_{t+1} - \sigma_7 f_{t+1}. \quad (17)$$

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<sup>19</sup>We drop the index  $j$ , from now on, for ease of exposition.

The spread measuring the difference between the two banking rates is:

$$r_{t+1}^L - r_{t+1}^D = \theta_0 + \theta_1 r_t^L - \theta_2 r_t^D + \theta_3 r_t^B + \theta_4 r_{t+1}^B + \theta_5 Y_t + \theta_6 Y_{t+1} + \theta_7 C_{t+1} - \theta_8 f_{t+1}. \quad (18)$$

## 1.1 No portfolio separation

A more general version of the model can be obtained by introducing in the profit function an additional cost function, a non-linear (quadratic) term in the amount of the net bond position  $\frac{1}{2}\delta B_t^2$ . The presence of this term implies that borrowing cost rise non linearly as the amount demanded rise. The introduction of this non-linearity complicates the model because now in the first order derivative with respect to the quantity of loans we find a term in the quantity of deposits and vice/versa, so that the two equations become a system. Elsasyani et al. (1995) highlight that in the case of a competitive market, after solving the system, the solutions for the quantity of both deposits and loans are second order difference equations. Moreover, in the intercept term of the solution for loans, the current, lagged and forward interest rate on deposits is present on top of that on loans and the market rate. And conversely, the same applies to deposits.<sup>20</sup> The dynamic structure of our model is identical to that of Elsasyani et al. (1995), so that we can use the result of their model, by simply mapping from quantities to prices. Under the assumption of rational expectations and that market interest follow a random walk, the solution becomes the following system of equations:

$$r_{t+1}^D = a_0 + a_1 r_t^D + a_2 r_{t-1}^D + a_3 r_{t+1}^L + a_4 r_t^L + a_5 r_t^B + a_6 r_{t+1}^B + a_7 Y_t + a_8 Y_{t+1} + a_9 f_{t+1}. \quad (19)$$

$$\begin{aligned} r_{t+1}^L = & b_0 + \sigma_1 r_t^L + b_2 r_{t-1}^L + b_3 r_{t+1}^D + b_4 r_t^D + \\ & + b_5 r_t^B + b_6 r_{t+1}^B + b_7 Y_{t+1} + b_8 Y_t + b_9 C_{t+1} - b_{10} f_{t+1}. \end{aligned} \quad (20)$$

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<sup>20</sup>See Elsasyani et al. (1995) p.958.

After substitution, the two reduced form equations become:

$$\begin{aligned}
r_{t+1}^D &= c_0 + c_1 r_t^D + c_2 r_{t-1}^D + c_3 r_t^L + c_4 r_{t-1}^L + \\
&+ c_5 r_t^B + c_6 r_{t+1}^B + c_7 Y_t + c_8 Y_{t+1} + c_9 f_{t+1} + c_{10} C_{t+1}.
\end{aligned} \tag{21}$$

$$\begin{aligned}
r_{t+1}^L &= d_0 + d_1 r_t^L + d_2 r_{t-1}^L + d_3 r_t^D + d_4 r_{t-1}^D + \\
&+ d_5 r_t^B + d_6 r_{t+1}^B + d_7 Y_{t+1} + d_8 Y_t + d_9 C_{t+1} - d_{10} f_{t+1}.
\end{aligned} \tag{22}$$

A test for the portfolio separation hypothesis is thus that  $c_2 = c_3 = c_4 = 0$  and  $d_2 = d_3 = d_4 = 0$ . The interest spread is:

$$\begin{aligned}
r_{t+1}^L - r_{t+1}^D &= \zeta_0 + \zeta_1 r_t^L - \zeta_2 r_t^D + \zeta_3 r_{t-1}^L - \zeta_4 r_{t-1}^D + \\
&+ \zeta_5 r_{t+1}^B + \zeta_6 r_t^B + \zeta_7 Y_{t+1} + \zeta_8 Y_t + \zeta_9 C_{t+1} - \zeta_{10} f_{t+1}.
\end{aligned} \tag{23}$$

Where now,  $\zeta_1 = d_1 - c_3$ ,  $\zeta_2 = d_3 - c_1$ ,  $\zeta_3 = d_2 - c_4$  and  $\zeta_4 = d_4 - c_2$ . The test for the portfolio separation hypothesis is thus that  $\zeta_3 = \zeta_4 = 0$ . However, the last condition is a necessary but not sufficient condition. In fact, a finding that  $\zeta_4 = 0$  could result either from  $d_4 = c_2 = 0$ , as the hypothesis suggests, or from  $d_4 = c_2 \neq 0$ .

## 2 Empirical Analysis

### 2.1 Database

In what follows we test the empirical relevance of the theoretical specifications derived in the previous section using a sample of publicly owned banks from OECD countries over the period 1988-2007. The accounting data are taken from *Bankscope* and regard publicly owned banks from the original 12 members of the euro area plus Switzerland, UK, Norway, Sweden, Denmark, and USA. In particular, we use information on consolidated

financial statements, and unconsolidated ones if the former were not available.<sup>21</sup>

The sample of banks used below is filtered using the following criteria. First, we select institutions with at least 1 billion euros of assets and 500 million euros of loans, among commercial banks, mutual banks, savings banks, and bank holding companies, whose shares are quoted in major stock markets. We have chosen a sample of large banks because these banks represent more than 50 % of loans and deposits in most of the countries of our panel, the only exception being Germany. The inclusion of small banks would have biased the sample, since in most European banking markets the degree of concentration is high. The choice of publicly owned banks reflects the decision to exclude from the analysis institutions whose aim is different from profit maximization. This has led to the exclusion from the sample of any bank entirely owned by state entities. A strict application of the criteria would have brought to the exclusion of savings and mutual banks; however, to the extent that these institutions have issued shares and are on the stock market, they have to behave according to commercial standards not different from those other private-sector banks.

Second, we exclude those banks for which loans represent less than 20% of total assets in order to focus on direct lending activity, since our model is not suited to describe asset managers or investment companies. Third, we exclude banks for which more than 50% of assets and liabilities are outside the country of origin, because market interest rates and aggregate demand are important regressors, and they are country-specific. We have chosen not to exclude institutions involved in mergers and acquisitions, as long as these transformations do not change substantially the ratio between net interest revenues and total assets. However, we deleted those banks that as a result of mergers and acquisitions presented a high degree of volatility in the interest margin. We have thus dropped five banks that presented an extreme degree of volatility in this ratio, and the final sample is an unbalanced panel of 131 banks.

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<sup>21</sup>For most banks, accounting data until 2004 are based on local GAAP while starting from 2005 they are based on IFRS accounting standards.



## 2.2 Results

Consistently with the specification obtained from our theoretical model, we construct the following variables (all as ratios of total assets): net interest revenues (*NIR*), our dependent variable, interest revenues (*IR*), interest expenditures (*IE*), and revenues from fees (*FEES*), while costs are differentiated between operating costs (*COST*) and loan loss provision costs (*LLP*). To control for business cycle we use the natural logarithm of real GDP (*LN**Y*). The market interest rates are measured by either the long term (*IRL*) or the short term interest rates (*IRS*). All macro variables are taken from the OECD Economic Outlook.

Given the dynamic nature of our theoretical specification, and the inclusion of fixed effects to capture time-invariant characteristics of each individual institution, we apply the two-step difference GMM estimator with the corrected standard errors proposed by Windmeijer (2005).<sup>22</sup> We start by estimating the general specification in equation (23) which encompasses the dynamic structure of net interest revenues, obtained under the assumptions of both portfolio and no-portfolio separation. Namely, net interest revenues, *NIR*, are regressed on the first and the second lag of *IR* and *IE*, the contemporaneous and lagged value of *IRL* and *LN**Y*, and the contemporaneous values of *FEES*, *COST* and *LLP*. Column (1) of Table 1 shows the results of this model estimated with standard OLS methods with fixed effects. We report these results not only to test the robustness to different estimation methods, but also because on average we have 12 annual observations for each institution, a time dimension which is relatively large. We find that the parameters of the lagged values of *IR* and *IE* are significant at 1% level and of similar absolute size. This strongly confirms that the choice of a dynamic specification is appropriate. On the other hand, the second lags are statistically insignificant. This is consistent with portfolio separation, however we cannot rule out the possibility that these coefficients are non significant simply because they have a very similar impact on interest revenues and costs. We believe that this second interpretation is the correct one, since we find that even at

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<sup>22</sup>All estimates are implemented with the STATA command *xtabond2*.

the first lag, the coefficients of  $z_1$  and  $z_2$  are of a very similar magnitude, suggesting that interest margins and interest costs display a very similar degree of persistency.

Net interest revenues are affected positively by the contemporaneous long-term rates, but negatively, although to a smaller degree, by their lagged values. Both coefficients are statistically significant at 5% level. This result implies that either banks can reprice loans more frequently than deposits, or that banks can exploit their monopolistic power by raising rates on loans more than those on deposits. This second hypothesis then implies that the interest rate elasticity of deposits is lower than that of loans. Samuelson (1945) thesis is that a large part of deposits, and demand deposits in particular, cannot be considered short-term liabilities because they are seldom redeemed, being held for transaction or precautionary reasons. They thus represent for the bank “core” liabilities whose amount is quasi-fixed. But the argument implies that the bank thus does not need to reprice these deposits them very often. And this can happen only if the elasticity of supply of deposits (the demand for deposit services) is very low. Samuelson thus implicitly assumes monopolistic pricing, and the two arguments are only apparently different. Our results suggest that, in line with the results of Flannery and James (1984) for the US, banks benefit from higher rates. As a consequence they benefit from higher expected inflation, supporting the previous findings of Bordes et al. (1991), obtained from aggregate data. A similar result holds for short-term rates, although the coefficient becomes smaller and less significant, suggesting that banks interest margins benefit from tighter monetary policy, normally driven by higher inflation expectations.

The other variables of our specification are also significant and have the expected sign. Fees generated by other bank activities have a negative impact, whereas operating and loan loss provision costs have both a positive effect.<sup>23</sup> This result supports the validity of the

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<sup>23</sup>In these baseline regressions we do not instrument *FEES*, *COST* and *LLP*, it is in fact likely that the dynamics of these variables are independent of the interest rate decisions of the bank. Fees are heavily dependent on the business cycle, being largely earned on transactions, brokerages and financial intermediation activities. Operating costs are largely due to wages and IT investment, and largely rigid in the short run. Finally, although loan loss provision are likely to be endogenous with respect to the interest rates charged in the case of industrial loans, this may not necessarily be the case for mortgages and other collateralized loans. However, both the size and the statistical significance of these coefficients are very much unaffected where instrumented. Results are available upon request.

model, since it suggest that bank interest rates are set as a function, not only of marginal industrial costs, but also of fees from other banking activities. It is thus correct to view the bank as a multi-product firm, given that different products are not independently priced. This is one of most relevant features of our model, and it is quite at odds with the current empirical literature.

Finally, we find that higher real output leads to a deterioration of net interest revenues so that net inter interest rate variations are counter-cyclical, once taken into account the impact of market interest rates. This result suggests that changes in aggregate demand affect the demand for deposits more than that for loans, so that pricing pressures rise more on the liability side. There are two possible explanations: the first is the monopoly power is lower in the market for deposits than in that for loans, for example because inter-industry competition is stronger in the case of deposits, as many substitutes, such as money market mutual funds, are available. The second is that the demand for loans is countercyclical, as the evidence on the US provided by Gertler and Gilchrist (1993b,a) and Romer and Romer (1990) suggests. In recessions corporations need more finance, because of the growth of their working capital, since they build up undesired inventories of finished products and raw materials. The working capital needs of corporations are to a large extent financed by commercial banks by discounting bills and providing commitment lending, since only highly rated corporations issue commercial paper. Given that commercial and industrial loans make a large share of the loan book of the banks of our sample, we suggest that the build up of inventories is behind the counter-cyclicity of the demand for loans.

In column (2) we estimate the same specification with the two-stage difference GMM estimator. Results are very similar, with the only exception of the lagged interest rate and the loan loss provision costs which have the same sign, but are statistically insignificant. Given the comparable order of magnitude of the absolute values of the lagged terms  $IR$  and  $IE$ , in column (3) we impose the restriction that they are equal, and estimate a dynamic specification including both the first and second lag of  $NIR$ . The results of this restricted model are very much similar to the ones reported in column (2). In column (4)

we substitute the long term rate with the short term one. The latter has still a positive effect on net interest revenues, although only the lagged value is statistically significant. Other worth mentioning features of this model are the persistence terms which are now more divergent (respectively 0.43 and -0.54), and the cyclical conditions which turn statistically insignificant. Finally, column (5) shows the results of the general baseline model with long term rates over the sample period 1999-2007.<sup>24</sup> Estimates are qualitatively very similar to the one reported in column (2) which is a good indication of the robustness of our specification. The only noticeable difference is that market rates have now an even stronger effect. Namely, a 1% increase in interest rates leads to a 0.09% increase in the ratio of net interest revenues over total assets.

We now check whether the above results are driven by a particular sub-sample of countries. Given the limited number of institutions available for each country, a robustness check based on estimating the baseline regression separately for each country is not warranted. An intermediate and natural option, however, is to split our sample into two groups: EMU and non-EMU countries. The former includes 11 Euro members: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, the Netherlands and Portugal. The non-EMU group is formed by the U.S., the U.K., Sweden, Denmark, Norway and Switzerland. Table 2 displays the results of this country split with both long and short term interest rates. We find that most of the results on the effect of market rates on net interest revenues are driven by the EMU sample. In fact in the latter, market rates have always a positive and statistically significant effect (columns (1) and (2) of Table 2). We have estimated these regressions for the EMU group also for the period 1999-2007, obtaining qualitatively and quantitatively very similar results. Additionally we have checked if the results in columns (1) and (2) are driven by any country in particular. There is some evidence that only Italy plays a role in the size, but not in the statistical significance of the market rates. This may be due to the loss of valuable information (Italy

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<sup>24</sup>Our sample is highly unbalanced due to missing values of accounting data from *BankScope* in the late 1980s and 1990s. As a result we focus on the post-1999 period. This date not only roughly corresponds to the mid-point of our sample, but also to the start of the EMU. This allows us to test if the new monetary regime has changed the structure of the relationship between net interest revenues and its determinants.

contributes with 13 out of the 52 banks), but it is also consistent with the fact that in the Italian banking system demand deposits, which pay a negligible interest rate, are a larger share of total liabilities than in most other countries. On the other hand, we find that the institutions operating in the remaining countries are hardly effected by long term rates. Only short term rates have a contemporaneous negative and lagged positive effects. Both coefficients, however, are only significant at 10% level.<sup>25</sup> These results can be explained by the different market structure of European and US banking systems. In the US securitizations and loan sales have played a bigger role than in Europe, and this development has been matched by the increased relevance of Money Market Mutual Funds in liquidity management. US banks have thus suffered more inter-industry competition, in the market for deposits in particular. European banks, on the contrary, have kept a larger share of the market for liquidity services, and still have sizeable amounts of demand deposits that are seldom repriced. Interestingly, we find that operating costs have a greater impact on net interest revenues in the EMU sample, whereas loan loss provision costs are only significant in the non-EMU group, however, we find no obvious explanation for this result. Overall, these results suggest that the increase of inter-industry competition makes banks less sensitive to market interest rate variations.

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<sup>25</sup>Estimating these models for the U.S. only (56 out of 77 banks) leaves these general conclusions unaltered.

Table 1: Regression Results of Net Interest Revenues Equation

	(1)	(2)	(3)	(4)	(5)
<i>IR(-1)</i>	0.455*** (0.063)	0.431*** (0.098)		0.430*** (0.089)	0.451*** (0.132)
<i>IR(-2)</i>	0.026 (0.045)	-0.012 (0.053)		-0.048 (0.052)	-0.036 (0.060)
<i>IE(-1)</i>	-0.498*** (0.059)	-0.455*** (0.091)		-0.543*** (0.096)	-0.470*** (0.124)
<i>IE(-2)</i>	-0.016 (0.047)	0.018 (0.059)		0.072 (0.062)	0.024 (0.067)
<i>NIR(-1)</i>			0.433*** (0.091)		
<i>NIR(-2)</i>			0.002 (0.052)		
<i>IRL</i>	0.051*** (0.017)	0.051*** (0.016)	0.055*** (0.016)		0.089*** (0.029)
<i>IRL(-1)</i>	-0.030** (0.014)	-0.029 (0.019)	-0.043 (0.016)		-0.016 (0.028)
<i>IRS</i>				0.007 (0.009)	
<i>IRS(-1)</i>				0.049*** (0.017)	
<i>FEES</i>	-0.253*** (0.043)	-0.280*** (0.050)	-0.251*** (0.047)	-0.272*** (0.056)	-0.241*** (0.059)
<i>COST</i>	0.467*** (0.068)	0.564*** (0.088)	0.505*** (0.077)	0.560*** (0.085)	0.459*** (0.088)
<i>LLP</i>	0.158** (0.068)	0.103 (0.088)	0.111 (0.078)	0.107 (0.088)	0.173 (0.135)
<i>LN<sub>Y</sub></i>	-1.729** (0.877)	-2.045** (0.942)	-1.986* (1.089)	-0.837 (0.860)	-2.275* (1.307)
<i>LN<sub>Y</sub>(-1)</i>	1.194 (0.799)	1.650 (0.907)	1.356 (1.066)	0.307 (0.831)	1.638 (1.134)
Estimation Method	OLS	GMM	GMM	GMM	GMM
Country Sample	Full	Full	Full	Full	Full
Sample period	1988-2007	1988-2007	1988-2007	1988-2007	1999-2007
AR(1)	-	0.001	0.000	0.000	0.008
AR(2)	-	0.432	0.458	0.384	0.318
Hansen	-	0.115	0.991	0.111	0.249
Obs	1560	1428	1463	1428	1031
N	131	129	131	129	129

Notes: The dependent variable is NIR. OLS is the Within Group estimator with robust standard errors. GMM is the two-step difference GMM estimator with Windmeijer corrected standard errors. Standard errors are in parenthesis. \* = significant at 10%, \*\* = at 5% and \*\*\* = at 1%. The value reported for the Hansen test is the *p*-value for the null hypothesis of instrument validity. The value reported for AR(1) and AR(2) are the *p*-values for first and second order auto-correlated disturbances. Obs = total number of observations and N = number of banks.

Table 3: Regression Results of Net Interest Revenues Equation – Country Split

	(1)	(2)	(3)	(4)
<i>IR(-1)</i>	0.253** (0.112)	0.230** (0.095)	0.333** (0.132)	0.313*** (0.121)
<i>IR(-2)</i>	0.030 (0.055)	0.004 (0.048)	-0.091 (0.073)	-0.133* (0.073)
<i>IE(-1)</i>	-0.303*** (0.114)	-0.339*** (0.097)	-0.315*** (0.123)	-0.388*** (0.146)
<i>IE(-2)</i>	-0.015 (0.068)	0.012 (0.060)	0.079 (0.086)	0.136 (0.091)
<i>IRL</i>	0.062*** (0.017)		0.014 (0.026)	
<i>IRL(-1)</i>	-0.003 (0.020)		-0.046 (0.031)	
<i>IRS</i>		0.031*** (0.012)		-0.021* (0.013)
<i>IRS(-1)</i>		0.050*** (0.017)		0.048* (0.026)
<i>FEES</i>	-0.246*** (0.089)	-0.305*** (0.073)	-0.193*** (0.063)	-0.178*** (0.066)
<i>COST</i>	0.802*** (0.124)	0.809*** (0.100)	0.411*** (0.102)	0.393*** (0.099)
<i>LLP</i>	0.041 (0.039)	-0.024 (0.058)	0.243*** (0.080)	0.253*** (0.077)
<i>LNY</i>	-2.138 (1.509)	-0.323 (1.121)	-1.448 (1.193)	0.254 (1.335)
<i>LNY(-1)</i>	2.747** (1.184)	0.729 (1.057)	-0.264 (1.336)	-2.025 (1.508)
Estimation Method	GMM	GMM	GMM	GMM
Country Sample	EMU	EMU	Non-EMU	Non-EMU
Sample period	1988-2007	1988-2007	1988-2007	1988-2007
AR(1)	0.010	0.005	0.013	0.000
AR(2)	0.629	0.572	0.912	0.384
Hansen	0.895	0.970	0.948	0.111
Obs	629	629	799	799
N	52	52	77	77

*Notes:* The dependent variable is NIR. GMM is the two-step difference GMM estimator with Windmeijer corrected standard errors. Standard errors are in parenthesis. \* = significant at 10%, \*\* = at 5% and \*\*\* = at 1%. The value reported for the Hansen test is the *p*-value for the null hypothesis of instrument validity. The value reported for AR(1) and AR(2) are the *p*-values for first and second order auto-correlated disturbances. Obs = total number of observations and N = number of banks.

### 3 Conclusion

This paper has developed a dynamic model of banking intermediation where banks are described as multi-product firms providing simultaneously different sets of services to the same customers, and benefit of market power. The model predicts that interest rates on loans and deposits are set as a function, not only of market interest rates, but also of revenues from fees, industrial and default costs, and aggregate demand. Moreover,

the model suggests that bank interest revenues and costs display a substantial degree of persistence, which does not result from the persistence of market interest rates.

We find that the predictions of the model are coherent with the results of the empirical estimations, as all the variables have the correct sign and are statistically significant. In particular, fees generated by other bank activities have a negative impact on interest margins, whereas operating and loan loss provision costs have both a positive effect. This result supports the validity of the model and it is thus correct to view the bank as a multi-product firm, given that different products are not independently priced.

The parameters of the lagged values of interest costs and revenues are strongly significant, and of similar absolute size, strongly confirming that the choice of a dynamic specification is appropriate. Consistently with the hypothesis of portfolio separation, the second lags are statistically insignificant. However, we find that interest margins and interest costs display a very similar degree of persistency. This result implies that second lags of the variables are not significant even when portfolio separation does not hold.

Interest margins rise with contemporaneous long-term rates. This result implies that either banks can reprice loans more frequently than deposits, or that banks can exploit their monopolistic power by raising rates on loans more than those on deposits. We suggest that the two arguments are only apparently different, since they are both dependent on the existence of market power. Our results imply that banks benefit from higher rates, and thus bank profits rise with expected inflation, and support the previous findings of Bordes et al. (1991), obtained from aggregate data. Similar results hold for short-term rates, although the coefficient becomes smaller and less significant, suggesting that banks interest margins benefit from tighter monetary policy, normally driven by higher inflation expectations. However, we find that the significance of market interest rate is largely due to the European banks. This is not surprising though, since European banks suffer less the competition from Money Market Mutual Funds, so that inter-industry competition in the market for deposits is weaker. As a result European banks have a larger share of demand deposits, that are seldom repriced, than their counterparts in the US.



Finally, we find that higher real output leads to a deterioration of net interest revenues so that net interest rate variations are counter-cyclical, once taken into account the impact of market interest rates. This result suggests that changes in aggregate demand affect the demand for deposits more than that for loans, so that pricing pressures rise more on the liability side. We suggest, in line with the evidence of Gertler and Gilchrist (1993b,a) and Romer and Romer (1990) for the US, that the demand for loans is at least partially counter-cyclical. In particular, the demand for commercial and industrial loans rises during recessions following the build-up of inventories. Given that commercial and industrial loans make a large share of the loan book of the banks of our sample, we suggest that the build up of inventories is behind the counter-cyclicality of the demand for loans. Industrial and commercial loans, in fact, to a large extent finance the working capital needs of firms, rather than their long-term investments.

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