Determinants of Bank Interest Margins: Impact of Maturity Transformation*

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Abstract

This paper explores the extent to which interest risk exposure is priced in bank margins. Our contribution to the literature is twofold: First, we present an extended model of Ho and Saunders (1981) that explicitly captures interest rate risk and expected returns from maturity transformation. Banks price interest risk according to their individual exposure separately in loan and deposit intermediation fees, but reduce (increase) these charges for loans (deposits) when positive excess holding returns are expected. Second, we disentangle the commonly investigated effects for the net interest margin, by also examining the model-implied hypotheses separately for interest income and expense margins in a sample encompassing the German universal banking sector between 2000 and 2009. Banks price their individual interest rate risk and corresponding expected excess returns via the asset side into the net interest margin. For liabilities, we find interest rate risk exposure only priced by smaller banks.

Keywords: Term transformation; Interest rate risk; Optimal loan and deposit intermediation fees

JEL classification: D21; D22; G21

1 Introduction

The theory of financial intermediation attributes a number of activities, commonly referred to as qualitative asset transformation, as core functions to banks (e.g. Bhattacharya and Thakor, 1993). These activities encompass credit risk, liquidity and maturity transformation.[1] Maturity transformation evolves in most cases as a consequence of liquidity provision when fixed-rate long-term loans are financed using short-term deposits. The resulting maturity gap can be attractive to banks when term premia are present in the yield curve — representing the well known "lure of interest rate risk" (Greenbaum and Thakor, 2004, p. 138) — but it also increases their interest rate risk (IRR) exposure. This exposure can be distinguished with regard to its effects in two forms (Hellwig, 1994): First, *reinvestment opportunity risk*, i.e. the risk of having to roll over maturing contracts at a possibly disadvantageous rate. Second, *valuation risk*, i.e. the risk that changes in the yield curve reduce the net present value of a bank's loan and deposit portfolio.

Recent financial intermediation theory suggests that banks operate with too high maturity mismatch (e.g. Segura and Suarez, 2012; Brunnermeier and Oehmke, 2012). Although these models focus on financial intermediaries' vulnerability to liquidity shocks like the current financial crisis, they simultaneously prove intermediaries' exposure to increasing interest rates in "normal" times.[2] Recently, discussions about the existence of the bank risk-taking channel (Borio and Zhu, 2011), i.e. that low levels of nominal policy rates induce financial intermediaries to take higher risks (and increase leverage), have gained attention. Therefore, discussions of new macroprudential regulatory frameworks include linking monetary policy and banking regulation

[1] We will use the notion of maturity and term transformation interchangeably. Although maturity is not the appropriate risk measure, maturity transformation evolved as a synonym for what can be referred to in more general as term transformation. Bhattacharya and Thakor (1993) have already addressed this issue.

[2] For a brief theoretical comparison of interest rate and liquidity risk management see Brunnermeier and Yogo (2009).

in a form that central banks should consider higher policy rates once the current turmoil is over (e.g. Blanchard et al., 2010). Such a change in central bank policy would directly result in the aforementioned types of IRR.

Seminal models such as Ho and Saunders (1981) and Froot and Stein (1998) imply that banks should charge intermediation fees for risks they keep on-balance. This paper examines the nexus between banks' involvement in maturity transformation, their profitability, and intermediation fees they charge as risk compensation. First, we present a theoretical model that allows analyzing the determinants influencing fees when banks engage in maturity transformation. Second, we test the model-derived hypotheses empirically by analyzing bank margins.

For our analysis, we extend the dealership model initially developed by Ho and Saunders (1981) to determine the factors that influence intermediation fees when a bank's balance shows maturity mismatch. In the original Ho/Saunders model, a bank is viewed as a pure intermediary between lenders and borrowers of funds that sets prices in order to hedge itself against asymmetric in- and outflows of funds. Assuming loans and deposits have an identical maturity, IRR only arises when loan volume does not match deposit volume, but the existing volume gap is closed using short-term money market funds. Rolling over maturing short-term positions creates reinvestment (refinancing) opportunity risk. Maximizing expected utility, the bank charges fees that increase with the volatility of interest rates as a compensation for the potential losses.

We relax the assumption of equal loan and deposit maturity. In our model, loans and deposits can then not perfectly offset IRR, and exposure is not solely determined by interest rate volatility, but additionally by the bank-individual exposure captured in the bank's maturity structure, i.e. its maturity gap. As a consequence, banks price loans and deposits according to their individual exposure to risk, bidding more aggressively for transactions that offset risk when exposures are already high, and vice versa. Banks increase both loan and deposit fees with the size of the maturity mismatch and the uncertainty of future interest rates, but lower (increase) loan (deposit) fees when positive valuation gains, so-called “positive holding period returns” above the money market rate, from long-term exposures are expected. The economic rationale behind this is that banks are already partly compensated for taking the risk by these returns in expectation, which allows them charging lower fees. For deposits, also having a longer maturity than the money market account, the opposite holds as it is a liability position. Adding loan and deposit fees to the net fee income, it increases with interest rate volatility and maturity mismatch and decreases with positive expected holding period return from maturity transformation, given banks have a positive maturity gap.

For the empirical analysis about the impact of maturity transformation on bank fees and their determinants, we utilize a comprehensive dataset of the complete German universal banking sector between 2000 and 2009. The German banking system is well-suited for this analysis. First, as Germany is a bank-based financial system (e.g. Schmidt et al., 1999), the majority of liquidity is provided via maturity transformation by financial intermediaries. The predominance of (long-term) fixed-rate loans intended to be held till maturity instead of being securitized, and the high dependence on (demand and especially savings) deposits are specific characteristics of the German banking sector. Therefore, German banks seem prone to IRR from maturity transformation (Memmel, 2011). Second, IRR management is conducted more frequently on-balance compared to market-based financial systems that rely more heavily on derivatives hedging.[3] Risk management is implemented through buffer stocks of liquid assets and intertemporal smoothing of non-diversifiable risks (Allen and Santomero, 2001), such as liquidity and interest risk, as

[3]Allen and Santomero (2001) explain this difference between market-based systems, such as the U.S., and bank-based systems, such as Germany, drawing on the model of Allen and Gale (1997). The lack of competition from financial markets is considered to be the basis for German financial intermediaries’ ability to manage risk on-balance. Purnanandam (2007) finds that also small U.S. commercial banks manage IRR less frequently via derivatives, but on-balance by adjusting their maturity gap to interest rate changes.

well as interbank lending in bank networks. The latter shield (smaller) banks in major banking groups against monetary contractions, without having to reduce lending as a consequence of large deposit outflows and drastic balance sheet duration adjustments (Ehrmann and Worms, 2004).

In our empirical analysis we not just test the impact of the optimal loan and deposit fee determinants on the commonly investigated net interest margin (NIM), but are the first to test the hypotheses for the the asset and liability side, i.e. interest income and expense margins IIM and IEM, separately. As model-derived optimal intermediation fees represent the difference between bank-set interest rates and fair market rates of the same maturity, we use detailed supervisory data on bank assets' and liabilities' maturities to create maturities-mimicking bond portfolios whose coupon payments control for the impact of market rates on the respective margins in our analysis.

We find the results for the NIM to be consistent with our model-hypotheses, i.e. it increases with the maturity gap and decreases with expected returns from maturity transformation; however the effects of the expected return from maturity transformation are minor. Disentangling the NIM into IIM and IEM, we find strong evidence that banks price maturity transformation-related risk and corresponding expected returns on the asset side; however, we find the model-implied effects for the liability side only with a slight impact for cooperative banks, and for with regard to expected returns even only during the recent financial crisis. Our results, therefore, imply that the effect found for the NIM are mainly driven by the asset side.

The remainder of the paper is organized as follows. Section 2 reviews the related literature on determinants of bank interest margins in Ho/Saunders-type models. In Section 3 we derive the theoretical model with differing loan and deposit maturities. An overview of the data and the institutional characteristics of the German commercial banking sector is provided in

Section 4, where the variables used to proxy for the derived determinants are also introduced. Section 5 presents the econometrics model (Section 5.1) and the empirical results. Institutional differences in the banking sector are taken into account by investigating three different sub-samples, for savings, cooperative and other, mainly private commercial, banks. First, we examine the commonly investigated net interest margin (Section 5.2), and then separately the interest income and expense margin (Section 5.3). Section 5.4 investigates to which extent the previously derived results are robust with respect to the financial crisis and therefore interacts key variables with a dummy capturing the crisis from 2008 onwards. Section 6 presents concluding remarks.

2 Related literature

This paper is most related to the literature dealing with Ho/Saunders-type models. Ho and Saunders (1981) model a monopolistic, risk-averse bank acting solely as an intermediary between lenders and borrowers of funds. Over a single-period planning horizon, the bank's objective is to maximize its utility of terminal wealth by charging demanders of loans and suppliers of deposits fees for providing them with intermediation services. The bank hands out a single type of loan and accepts a single type of deposit, which are assumed to have the same maturity. Thus, financing all loans using deposits perfectly eliminates IRR. Intermediation services encompass provision of immediacy, i.e. to accept every transaction immediately, and not wait until the opposite transaction arrives to offset the risk. The lack of (excess) funds when new loans are demanded (deposits are supplied) forces the bank to adjust its money market positions. The maturity of the money market is assumed to be short term, below that of loans and deposits, and identical to the decision period. At the end of the decision period, money market accounts have to be rolled over. Short (long) positions a consequence of the loan exceeding (falling below) the deposit volume expose the bank to refinancing (reinvesting) risk of rising (falling) rates. The fees charged should, therefore, cover potential losses from rolling over short-term funds.

A series of authors have extended the model: McShane and Sharpe (1985) shift interest uncertainty from loan and deposit returns to money market rates. Switching the source of risk involved a change from price to rate notation which succeeding authors adopted.[4] Allen (1988) considers two different types of loans with interdependent demand functions. Carbó and Rodríguez (2007) regard this second asset as a non-traditional activity and investigate how specialization and cross-selling behavior between assets influence several bank spreads instead of focussing purely on interest margins. Angbazo (1997) attaches credit risk additionally to interest rate risk to the bank's loan, and derives a risk component that does not only depend on the volatility of risk sources, but also on the co-movement thereof. The operating cost necessary to provide intermediation services is taken into account by Maudos and Fernández de Guevara (2004). Finally, Maudos and Solís (2009) combine the independently derived two-asset-type models and all other extensions into a single integrated model.

3 Theoretical model

In this section, we present an augmented dealership model of Ho and Saunders (1981) that explicitly includes maturity transformation due to loan maturity exceeding deposit maturity. To incorporate the resulting valuation risk, loans and deposits are modelled as fixed-rate contracts with different maturities, and thus different sensitivities to changes in the yield curve. We adopt the price notation of Ho and Saunders (1981) and Allen (1988), and focus on the provision of a single loan and a single deposit to keep the bank's risk management decision simple.

The bank sets prices at which it is willing to grant loans (P_L) and take in deposits (P_D) at

[4] The change of the source of risk in McShane and Sharpe (1985) was motivated by the predominance of variable-rate loans and deposits in Australia (p. 116, footnote 2).

the beginning of the decision period before the demand for loans and the supply of deposits can be observed, and does not adjust them afterwards. Fees are set as mark-ups a on deposits, and mark-downs b on loans, in relation to what the bank considers the “fair” price , p_D and p_L, of the given transaction:

$$P_D = p_D + a, \qquad P_L = p_L - b. \tag{1}$$

The fair price can be best thought of as the price of a coupon-paying bond with identical risk characteristics as the underlying transaction. Assuming that only loans bear credit risk, their fair price p_L is that of a (corporate) bond with identical probability of default and recovery rate, whereas the fair price of a deposit p_D corresponds to a default-free (government) bond of identical maturity.

We assume the bank charges (demands) rates equalling par yields, i.e. fair market rates, of the underlying bond which implies the fair price of a new transaction is at par when it is initiated. Consequently, the cost (and profits) of financial intermediation are solely accounted for by the magnitude of the up-front fees a, and b. Mark-ups a on deposits and mark-downs b on loans result in an effective rate of return below that of bond funding for deposits, and above that of bond investing for loans.[5]

The bank's initial wealth portfolio W_0 at the beginning of the period consists of three different portfolios: (i) long positions in loans L, (ii) short positions in deposits D, and (iii) money market funds M, which can take either long or short positions, all denoted in market values:

$$W_0 = L_0 - D_0 + M_0. \tag{2}$$

[5] To illustrate bank pricing decisions, we give an example. Let us assume the bank offers a two year deposit and the par yield of a two year bond equals 3%. The bank will pay this fair interest rate to its depositors. However the bank charges up-front intermediation fees a of, let us say, 1.5%, i.e. any depositor has to hand in \$101.5 for a claim guaranteeing the repayment of \$100. By this, the bank decrease the effective rate of return paid on deposits below the fair market rate of 3%.

The length of the planning horizon T is shorter than the maturities of the loans and deposits. Thus, the terminal value of the loan and deposit portfolios in T are random due to unexpected changes in the yield curve or in default risk. Loans generate an expected rate of return of r_L, and deposits of r_D. Returns are the market returns of the underlying bonds since intermediation fees are not considered as they are charged in advance. The returns of both the loan and the deposit portfolio are subject to IRR, and the loan return additionally to credit risk. The uncertainty of returns will be captured in stochastic terms $\tilde{Z}$. Interest rate risk in loans will be displayed as $\tilde{Z}_I$, credit risk as $\tilde{Z}_C$, and interest rate risk in deposits as $\tilde{Z}_D$. All stochastic terms have an expected mean of zero and are trivariate normally distributed $N_3\left(\mathbf{0}, \sum\right)$, with variance-covariance matrix $\sum$. With loan maturity being assumed to exceed deposit maturity, normally-shaped yield curves lead, in general, to higher (expected) returns on long-term bonds compared with short-term bonds, i.e. $r_L > r_D$. In this case, loan prices are more sensitive to changes in the yield curve, and their return volatility is larger than that of deposits, i.e. $\sigma_I^2 > \sigma_D^2$. The rate of return on the money market account, on the contrary, is certain over the period and denoted r.

Managing loan and deposit portfolios generates operating cost C each period, which are monotonically increasing functions of the market values of the loan and deposit portfolios. The bank's end-of-period wealth is given by:

$$W_T = \left(1 + r_L + \tilde{Z}_I + \tilde{Z}_C\right) L_0 - \left(1 + r_D + \tilde{Z}_D\right) D_0 + (1 + r)\, M_0 - C\left(L_0\right) - C\left(D_0\right). \tag{3}$$

The bank maximizes expected utility. The utility function $U(W)$ is twice continuously differentiable, with $U' > 0$ and $U'' < 0$ in order to reflect risk aversion. In line with the previous literature, the expected end-of-period utility, $EU\left(W\right)$, is approximated using second-order Taylor series expansion around the expected level of $E(W) = \overline{W}$ and given by:

$$EU(W) = U\left(\overline{W}\right) + \frac{1}{2}U''\left(\overline{W}\right)\left[\left(\sigma_I^2 + 2\sigma_{IC} + \sigma_C^2\right)L_0^2 - 2\left(\sigma_{ID} + \sigma_{CD}\right)L_0 D_0 + \sigma_D^2 D_0^2\right], \quad (4)$$

where σ_{IC} denotes the covariance between the interest rate and credit risk of the loan portfolio and σ_{ID} (σ_{CD}) the covariance between the interest rate risk (credit risk) of the loan and deposit portfolio.

When a new deposit Q_D arrives, the overall volume of deposits increases to $D_0 + Q_D$. As attracting deposits equals selling bonds at a mark-up of a, the money market account increases to $M_0 + Q_D(1 + a)$. Under the common assumption that second-order terms of intermediation fees, expected returns and operating cost are negligible,[6] the increase in utility due to a new deposit inflow is:[7]

$$\begin{aligned} \Delta EU(W|Q_D) =& U'\left(\overline{W}\right)\left[\left[(1+r)(1+a) - (1+r_D)\right]Q_D - C(Q_D)\right] \\ &+ \frac{1}{2}U''\left(\overline{W}\right)\left[\sigma_D^2(2D_0 + Q_D)Q_D - (\sigma_{ID} + \sigma_{CD})Q_D L_0\right]. \end{aligned} \quad (5)$$

Similarly, new loan demand Q_L results in an increase in loans' market values to $L_0 + Q_L$, and a decrease of the money market account to $M_0 - Q_L(1 - b)$. The resulting increase in utility under the same assumptions as before is:

$$\begin{aligned} \Delta EU(W|Q_L) =& U'\left(\overline{W}\right)\left(\left[(1+r_L) - (1-b)(1+r)\right]Q_L - C(Q_L)\right) \\ &+ \frac{1}{2}U''\left[\left(\sigma_I^2 + 2\sigma_{IC} + \sigma_C^2\right)(2L_0 + Q_L)Q_L - 2(\sigma_{ID} + \sigma_{CD})Q_L D_0\right]. \end{aligned} \quad (6)$$

The bank sets loan fees a and deposit fees b to cover unexpected losses from interest rate and credit risk. However, increasing the magnitude of fees demanded will limit the incentives of deposit supply, and loan demand. Transaction volumes Q_D and Q_L are exogenously determined,

[6] i.e. $\left(\left[(1+r)(1+a) - (1+r_D)\right]Q_D - C(Q_D)\right)^2 = 0$.

[7] Ho and Saunders (1981) and all succeeding models calculate the increase in net wealth to be $a\,Q_D$. However, we choose the intermediation fees to be earned in advance and allow them to earn the risk-free rate (see Freixas and Rochet, 2008, p. 232). The same approach is used for newly demanded loans.

but the likelihood of a new transaction occurring will decrease with the magnitude of fees and follows independent Poisson processes with intensity λ:

$$\lambda_D = \alpha_D - \beta_D \times a, \tag{7}$$

$$\lambda_L = \alpha_L - \beta_L \times b. \tag{8}$$

The bank's objective function, conditional to, at most, a single transaction occurring, is to set optimal intermediation fees so as to maximize its end-of-period utility:

$$\max_{a,b} EU\left(\Delta W\right) = \left(\alpha_D - \beta_D \times a\right) \Delta EU\left(W|Q_D\right) + \left(\alpha_L - \beta_L \times b\right) \Delta EU\left(W|Q_L\right). \tag{9}$$

Rearranging first-order conditions, the optimal loan fee is

$$\begin{aligned} b^* =& \frac{1}{2}\frac{\alpha_L}{\beta_L} + \frac{1}{2}\frac{C\left(Q_L\right)}{Q_L\left(1+r\right)} - \frac{1}{2}\frac{r_L - r}{\left(1+r\right)} \\ & - \frac{1}{4}\frac{U''\left(\overline{W}\right)}{U'\left(\overline{W}\right)}\frac{\left[\left(\sigma_I^2 + 2\sigma_{IC} + \sigma_C^2\right)\left(2L_0 + Q_L\right) - 2\left(\sigma_{ID} + \sigma_{CD}\right)D_0\right]}{\left(1+r\right)}, \end{aligned} \tag{10}$$

and the optimal deposit fee

$$\begin{aligned} a^* =& \frac{1}{2}\frac{\alpha_D}{\beta_D} + \frac{1}{2}\frac{C\left(Q_D\right)}{Q_D\left(1+r\right)} + \frac{1}{2}\frac{r_D - r}{2\left(1+r\right)} \\ & - \frac{1}{4}\frac{U''\left(\overline{W}\right)}{U'\left(\overline{W}\right)}\frac{\left[\sigma_D^2\left(2D_0 + Q_D\right) - 2\left(\sigma_{ID} + \sigma_{CD}\right)L_0\right]}{\left(1+r\right)}. \end{aligned} \tag{11}$$

The optimal fees on loans a^*, and deposits b^* both depend on four components: (i) a market power, (ii) an operating cost, (iii) an expected excess holding period return, and (iv) a risk component. Whereas previous models only observed the influence of three components, the influence of the expected excess holding period returns $(r_L - r)$ and $(r_D - r)$, respectively, has been newly derived. This effect as well as the special structure of the risk component originate from the bank's risk transformation, encompassing maturity transformation.

Market power: The competitive structure of the banking industry is determined by the extent to which (the likelihood of) loan demand and deposit supply are inelastic with respect to the intermediation fees charged, represented by the factor β. With an increasing ratio of α/β, elasticity decreases and banks gain market power that translates into higher fees.

Operating cost: The average operating cost incurred per unit of transaction volume, $C(Q)/Q$, are passed on to lenders and borrowers as in a standard monopolistic setting.

Expected excess holding period returns: Additionally to cost, banks also take expected excess holding period returns from risk transformation into account when setting loan and deposit fees which is the major a new result derived from our model. With positive expected excess holding period returns, i.e. $(r_L - r > 0)$ and $(r_D - r > 0)$, respectively, loan fees are reduced and deposit fees increased. This means banks are willing to lower loan fees in those times when granting loans is expected to generate positive risk transformation income above the risk-free rate (in the form of the coupon payments of the underlying bond and possible valuation gains). Other things being equal, higher expected excess returns more compensate the bank for risk taking and allows lowering loan fees demanded from the customer for covering unexpected losses. For deposits at the same time the opposite holds, resulting in increased intermediation fees, as they are a liability position.

Qualitatively, we observe the same effect for expected excess returns as for operating cost when a monopolistic supplier (demander) determines the profit-maximizing price in the Monti-Klein model of financial intermediation: expected excess holding period returns in loans can be regarded as reductions in marginal cost and the expected profits are passed on to customers in the same way as marginal cost are priced (Freixas and Rochet, 2008, pp. 57-59), and vice versa for deposits.

Risk component: The risk component consists of the product of the bank's absolute risk aversion $(-U''/U')$ and the banks' overall risk exposure from the balance sheet side perspective the transaction is related to. Given positive risk exposure, banks facing higher levels of risk aversion charge higher fees.

Fees increase with the total risk exposure of the balance sheet side the initiated transaction belongs to, and decrease with the hedging ability of the opposite balance sheet side. More specifically, loan fees increase with loan's interest (σ_I^2) and credit risk (σ_C^2), as well as their covariance, and the volume of loans affected by such risks after the transaction occurs (L_0+Q_L). However, fees are reduced when deposits hedge loan's risk, i.e. by increasing covariance of the loan's risk and the interest risk inherent in deposits, ($\sigma_{ID}+\sigma_{CD}$), weighted by the volume of deposits D_0. For deposits being priced, the opposite holds.

Ignoring credit risk, i.e. $\sigma_C^2 = \sigma_{IC} = \sigma_{CD} = 0$, the risk exposure in loan fees very much behaves like a bank's modified duration gap. The modified duration gap measures the bank balance sheet's sensitivity to (small) changes in the yield curve by accounting for volume-weighted net effect of interest rate changes on assets' and liabilities' present values. Ceteris paribus, it increases with a higher (shorter) maturity of the loans (deposits). Qualitatively the same holds for the risk components: We have $\sigma_{ID} = \sigma_I^2$ when loans and deposits have the same maturity; thus, interest rate risk of loans and deposits offset each other in this case except for volume-effects. When the loan maturity increases, we can expect higher σ_I^2 and a reduced hedging ability of the deposits as the correlation between respective returns tends to decrease with a higher maturity difference. This implies the risk component increases yielding higher loan margins b^*.

For the risk component in deposit fees analogous considerations hold; however, it is linked to a reverse duration gap as it measures the risk of the deposit portfolio less the hedging ability of the loan portfolio. This implies the deposit fee a^* decreases with an increasing duration gap. The economic rationale is that banks with high IRR from holding long-term loans in their portfolios would be willing to bid more aggressively on deposits by offering more favorable rates.

In sum, loan and deposit fees are determined by the same four components introduced above.

Market power, operating cost and the risk component have a positive impact on fees charged. Positive expected excess holding period returns show a positive effect on loan fees and a negative effect on deposit fees, as a result of the opposed positions — long vs. short — of their underlying portfolios.

As previous literature has focussed on the *pure intermediation spread* s^*, defined as the sum of both intermediation fees, i.e. $s^* = a^* + b^*$, its determinants are illustrated below:

$$\begin{aligned} s^* =& \frac{1}{2}\left(\frac{\alpha_L}{\beta_L} + \frac{\alpha_D}{\beta_D}\right) + \frac{1}{2}\left(\frac{C\left(Q_L\right)}{Q_L\left(1+r\right)} + \frac{C\left(Q_D\right)}{Q_D\left(1+r\right)}\right) - \frac{1}{2}\frac{r_L - r_D}{\left(1+r\right)} \\ & - \frac{1}{4}\frac{U''\left(\overline{W}\right)}{U'\left(\overline{W}\right)} \frac{\left[\left(\sigma_I^2 + 2\sigma_{IC} + \sigma_C^2\right)\left(2L_0 + Q_L\right) - 2\left(\sigma_{ID} + \sigma_{CD}\right)\left(D_0 + L_0\right) + \sigma_D^2\left(2D_0 + Q_D\right)\right]}{\left(1+r\right)}. \end{aligned} \tag{12}$$

It should be noted that the *pure spread* does solely encompass fees related to transaction uncertainty (Ho and Saunders, 1981) but does not fully represent the net interest income (NIM) in our model. Due to the different maturities of loans and deposits the interest payments from the underlying bonds do usually not offset each other but contribute to the NIM as well.

The same four components, found separately in loan and deposit fees, also influence the pure spread. Market power and operating cost are simply the sum of the terms found in loan and deposit fees, and can be interpreted as the bank's overall market power, and operating cost from financial intermediation, respectively. The expected excess returns from loan and deposit fees (partly) net each other and translate into $(r_L - r_D)$, the expected holding period return from overall risk transformation. $(r_L - r_D)$ can be expected to take positive values in times of normally-shaped yield curves due to, in general, a positive maturity transformation. Hence, the bank is willing to lower overall fees when expecting positive returns from maturity transformation. The combined risk component rises in both the loan's and the deposit's risks, always weighted by the new business volume after the transaction takes place, $(L_0 + Q_L)$ and $(D_0 + Q_D)$, and is reduced by the covariance hedges times the volume of the total initial interest-bearing business, i.e. $(D_0 + L_0)$.

4 Data

4.1 The German banking system

To empirically test the predictions derived from the theoretical model, we utilize a dataset covering the complete German commercial banking sector for a range of ten years between 2000 and 2009.[8] The time span contains substantial variation in the yield curve, with steep and considerably flat term structures following each other.

The German banking system is structured into three pillars where affiliation to a certain pillar is determined by ownership (e.g. Brunner et al., 2004). The three pillars are private commercial banks, state-owned banks and banks of the cooperative sector. The majority of these banks belong to the last two pillars. State-owned savings and cooperative banks operate in geographically delimited areas and there is virtually no competition between them across local banking markets. In an international context, they are small to medium sized with only limited direct access to the capital market. The business models of these banks are very homogeneous and mainly consist of pure intermediation services, as assumed in the model. Net interest income corresponds to the largest fraction of their earnings and income from maturity transformation contributes substantially to this (Memmel, 2011), whereas non-interest fee, and especially trading income are of only limited importance.

Savings and cooperative banks access capital markets in general not independently, but mainly through the head institutions of their respective interbank networks. The head institutes provide liquidity supply to their affiliated members and allow them to manage their duration gaps via interbank lending. These interbank networks shield the smaller savings and cooperative

[8] Data for 1999 is used to create instruments from first-differenced covariates.

banks against monetary contractions, without having to reduce lending as a consequence of deposit outflows and drastic balance sheet duration adjustments (Ehrmann and Worms, 2004). The mitigated impact of the monetary transmission channel allows us to investigate interest margins that are only moderately affected by changes in the volume of interest-bearing business.

We investigate the full German universal banking sector, leading to a broad sample of more than 2,000 banks and 16,000 bank years. Such a sample size, though limited to a single country, exceeds most of the international studies on determinants of bank margins conducted so far (e.g. Demirgüç-Kunt and Huizinga (1999); Saunders and Schumacher (2000); Maudos and Fernández de Guevara (2004); Claeys and Vander Vennet (2008) — except for Carbó and Rodríguez (2007), who have a slightly bigger sample size).

Although only limited data is publicly available, using supervisory data we can utilize detailed information on a bank's lender and borrower characteristics and maturities. The data used in this analysis is based on the following supervisory data collected by the Deutsche Bundesbank: balance sheet figures are taken from year-end values of the monthly balance sheet statistics, cost and revenues from bank's earning statements, and additional bank-specific information stems from the auditor's reports. Macroeconomic and term structure data are those provided to the public on the Deutsche Bundesbank's website. Earlier data cannot be used due to a major change in the reporting structure of the monthly balance sheet statistics in 1998.

Another point that has to be taken into account is the treatment of mergers and the thereof effect on the comparability of pre- and post-merger accounting figures. During the sample period, the German banking sector was affected by a major consolidation wave, resulting in several hundred mergers, especially among savings and cooperative banks. In order to account for structural changes in the time series of variables following mergers, a new synthetic bank is created after every merger. Thus, for a single merger between two different banks, three synthetic banks exist: two pre-merger banks and another post-merger one.

To capture differences originating from the institutional characteristics in the banking sector, we initially conduct our analysis at first on the complete sample, but then subsequently divide it into three sub-samples. Although the three pillars would give a good pre-specified segmentation, we place the head institutions of the state-owned (especially Landesbanken), and cooperative pillar together with all private commercial banks into a group from now on referred to as "other banks". The rationale behind this institutional relocation is the differences between head institutions and their affiliated savings and cooperative banks with regard to size, business model, capital market access, but also IRR management (Ehrmann and Worms, 2004).

4.2 Variables

The dependent variables we investigate are (i) the net interest margin (NIM), (ii) the interest income margin (IIM), and (iii) the interest expense margin (IEM), where total assets, interest-earning assets, and interest-paying liabilities have been chosen as denominators. If the denominator of explanatory variables is adjusted in line with the dependent variable investigated this will be displayed as "total (interest-bearing) assets (liabilities)" in the following analysis.

It should be noted that these dependent variables do not equal the (optimal) loan and deposits fees but encompass them. The interest income and expenses from new loan and deposit transactions observed at the end of the period are the par yield coupon payment of a risky long-term corporate bond plus the loan fees, and the par yield coupon payment of a shorter-term default-free government bond less the deposit fee, respectively.

This gives two implications for our empirical design. First, we need to control for coupon payments of fairly-priced capital market bonds as they are included in the dependent variables by construction. We will do this via so-called "revolving portfolios" of bonds, mimicking the maturity structure of the bank. Second, interest expenses and the deposit fees a^* derived from the model are negatively linked. Hence, empirical proxies for deposit fee determinants should have the opposite of the theoretically derived impact. However, for better interpretability we choose some empirical proxies to be negatively associated with theoretical deposit fee determinants. For example, we will employ modified duration gaps, instead of reverse modified duration gaps, but will specifically indicate this in the following section.

The following sub-sections describe the variables proxying for the determinants derived from the model, additional bank-specific and macroeconomic control variables, and the construction of the revolving portfolios. Table 1 provides an overview of the explanatory variables included in the regression analysis, their expected impact on the three bank margins and the use in previous studies investigating bank margins.

[Table 1 about here.]

4.2.1 Model-derived variables

Market power: We include *Lerner indices* to capture banks' ability to exercise market power from facing inelastic demand for loans and supply of deposits. As the model implies a positive influence of market power on loan and deposit margins a^* and b^*, we expect a positive influence of the Lerner indices on IIM and NIM, and a negative influence on IEM.

The Lerner index measures banks' ability to set mark-ups over the marginal cost mc necessary to provide a service in relation to the price p charged, i.e. $(p - mc)/p$. For estimating a bank's overall market power, we estimate a single-output translog cost function dependent on three input factors (see e.g. Maudos and Fernández de Guevara, 2004; Maudos and Solís, 2009). Total assets are specified to proxy for output level. Input prices for personnel, physical and financial costs are included. Taking interest-paying liabilities as an input rather than an output is consistent with the intermediation approach of banking (Sealey and Lindley, 1977). The output price p is exogenously determined and proxied as interest income in relation to interest-earning assets, and therefore identical to the IIM. Equity is included as a netput. Appendix A provides further technical details.

To derive separate market power estimates for loan and deposit markets from aggregated balance sheet and income data, we follow Maudos and Fernández de Guevara's (2007) approach, and specify a two-output translog cost function. This approach is based on the Monti-Klein model of financial intermediation (Freixas and Rochet, 2008, pp. 57-59) and treats deposits as an output rather than an input. Interest-earning assets proxy for loans, and interest-paying liabilities for deposits, with the ratios of interest income / interest-earning assets (IIM), and interest expenses / interest-paying liabilities (IEM) providing the exogenously determined two output prices. With liabilities being treated as outputs, only personnel and physical costs contribute to input prices.

Operating cost: Following Maudos and Fernández de Guevara (2004), and Maudos and Solís (2009), we proxy the operating cost of financial intermediation using *total operating expenses / total (interest-bearing) assets (liabilities)*. However, we should note that banks' operating expenses are likely to also include cost due to inefficiency and those not related to activities of financial intermediation. Operating expenses are expected to have a positive influence on intermediation fees and, thus, a positive (negative) influence on IIM and NIM (IEM).

Expected excess holding period returns: Theoretically derived expected excess holding period returns cover returns from total risk transformation. However, in line with previous research, we neglect expected returns from credit risk and focus on excess holding period returns in "default-free" government bonds. Fama and French (1989) and Ilmanen (1995) provide empirical evidence that the *term spread* proxies expected excess holding period returns.[9] Therefore, Equations (11) and (10) imply that loan fees a^* are reduced, and deposit fees b^* are increased when term spreads increase. This translates into expected negative effects on all three bank margins to be examined.

As different banks have different maturity transformation characteristics and, thus different expected excess holding period returns in their assets and liabilities, we do not use the same term spread for all banks, but calculate *bank-specific term spreads*. For example, given an upward-sloping yield curve, banks with higher average loan maturity should have higher expected excess holding period returns $r_L - r$. To capture this effect, we calculate the duration of the interest-bearing assets and the par yield of government bonds with a maturity equalling this duration. The bank-specific term spread for the assets, proxying $r_L - r$, is then defined as the difference between this duration-implied par yield and the 6-month par yield. The liability term spread is calculated analogously and the asset-liability term spread, proxying $r_L - r_D$, is the difference between the duration-implied asset and liability par yields. The calculation of assets' and liabilities' durations is analogous to the calculation of the modified duration, described in Appendix B.

Risk component: The composite impact of the risk component will be separated into the influence of distinct variables for our empirical analysis: risk aversion, interest and credit risk.

Risk component — Risk aversion: Most previous studies include capital ratios as proxies for risk aversion (McShane and Sharpe, 1985; Maudos and Fernández de Guevara, 2004; Maudos and Solís, 2009), or, without directly referring to risk aversion, as measures of insolvency risk (Angbazo, 1997; Carbó and Rodríguez, 2007). As capital ratios do not account for differing

[9]See Campbell and Ammer (1993) for a theoretical justification. Alternative approaches document the power of current forward rates (Fama and Bliss, 1987), or linear combinations of forward rates (Cochrane and Piazzesi, 2005) to forecast future excess returns.

risk levels, a point already stressed by Gambacorta and Mistrulli (2004), *capital in excess of minimum regulatory requirements / total assets*, or in short *excess capital*, seems in general a more adequate proxy for risk aversion. In our model, excess capital should be related to higher IIM and NIM, and lower IEM. However, empirical studies using capital ratios to investigate the NIM found mixed results, with both significantly positive, as well as negative effects.

Risk component — Interest rate risk: As already discussed in Section 3, the second factor in the risk component very much behaves like a (reverse) modified duration gap. Using the detailed information on volumes and maturities of different lender and borrower types, we calculate the modified durations of the assets and liabilities, D^A_{mod} and D^L_{mod}, respectively; then, the modified *duration gap* D_{gap} is defined as:[10]

$$D_{gap} = D^A_{mod} - D^L_{mod} \frac{\text{total interest-earning liabilities}}{\text{total interest-paying assets}}. \tag{13}$$

Details can be taken from Appendix B. We use the modified duration gap as an independent variable for all three margin for better comparability rather than using a reverse modified duration gap in the case of IEM. Based on our model, this implies we expect a positive influence on all three margins.

Whereas the modified duration gap measures the overall sensitivity of a bank's net portfolio value to changes in the yield curve, it does not capture the interest rate volatility that determines the probability of changes in the yield curve. Due to multicollinearity reasons, we do not include separate volatility measures for loans and deposits, σ_I and σ_D, but just one: the annual *volatility of weekly 6-month LIBOR rates* — measured over a 52-week window — to proxy for the risk

[10]Angbazo (1997) uses the one-year repricing gap, defined as the difference between assets and liabilities with a repricing frequency of less than one year to total assets (first used by Flannery and James, 1984). We prefer in our analysis the usage of more detailed information on the maturities of assets and liabilities as one-year repricing gaps will capture the majority of liquidity and refinancing interest risk, but only partly the valuation risk when long-term securities are affected by interest rate changes.

of unexpected changes in the yield curve. Note previous studies, based on models with the assumption of equal loan and deposit maturity, modeled IRR only as the volatility of specific interest rates (Ho and Saunders, 1981; Saunders and Schumacher, 2000; Maudos and Fernández de Guevara, 2004; Maudos and Solís, 2009). The model implies all there margin increase with higher volatility.

Risk component — Credit risk: The credit risk associated with financial intermediation is integrated into the regression analysis using the level of *risk-weighted to total assets*. Whereas for the other banks risk-weighted assets are likely to be also associated with off-balance sheet activities and market risk, they are mainly determined by the default risk of loan and bond portfolios for many savings and cooperative banks. With deposits assumed to be default-free, the proxy is only used in regressions explaining IIM and NIM, and expected to have a positive impact.

Risk component — Credit-interest covariance: To proxy for the covariance between credit and interest rates we include the *correlation coefficient between the 5-year government par yield and the default spread* of a weighted index of corporate bonds over the 5-year government par yield. The correlation is calculated annually on the basis of weekly rates. Whereas the IIM and the NIM are determined by both the correlation of loan as well as deposit returns with the credit spread, the IEM is only determined by σ^2_{CD}. Therefore, the expected coefficient sign can only be predicted for the IEM and can be expected to increase the expenses paid by the bank.

4.2.2 Control variables

Previous studies investigating bank interest margins include a number of additional control variables not predicted by the model to influence the pure spread of intermediation, but likely to have an impact on observed bank margins. Following these studies, we include three additional bank-specific, as well as two macroeconomic variables. Furthermore, we control for coupon payments of fairly-priced capital market bonds as they are included in the dependent variables.

Non-interest income (NII): Past developments in banking are described as disintermediation with a change from traditional financial intermediation to other banking activities in order to compensate for declining profitability. Carbó and Rodríguez's (2007) model investigates the cross-selling behavior between loans and non-traditional activities, which have been proxied using *non-interest net fee income to total (interest-bearing) assets (liabilities)* (Lepetit et al., 2008).[11] Cross-selling assumes that banks are willing to forego traditional interest generating income for non-interest income (NII). Hence, the higher the *non-interest income to total assets*, the lower the corresponding fees charged, resulting in decreasing IIM and NIM, and increasing IEM.

Implicit interest payments (IIP): We also include a proxy for implicit interest payments (IIP) using *(non-interest expenses less non-interest income) / total (interest-bearing) assets (liabilities)* that aims to reflect the cost of additional services for which customers have not been charged. Initially included to capture competition in the market for deposits (Ho and Saunders, 1981), it is expected to result in lower interest expenses and a negative coefficient on the related margin and a positive one on NIM. However, additional services might also be present for loans, and a positive effect on the IIM might also be observed.

Opportunity cost of holding reserves (OCR): Finally, the opportunity cost of holding reserves (OCR) originates in asset portfolios that pay no, or in the case of central bank deposits in Germany, only below market rates. We include *cash and deposits with central banks to total (interest-bearing) assets (liabilities)* to proxy for OCR. As these reserves implicitly increase the cost of funding by foregone interest income, they are likely to be priced into deposit rates. A

[11] In contrast to Lepetit et al. (2008), we do not additionally include trading activities as many smaller German banks to not generate any such income.

higher ratio of cash and deposits with central banks can therefore be expected to lead to lower interest expenses and ultimately higher net interest incomes; however, the effect on interest income margins remains unclear a priori.

Macroeconomic variables: Two macroeconomic variables are included: the annual real *GDP growth* rate controls for demand (for loans) and supply (of deposits) effects in bank profitability, and the *inflation rate* integrates effects of nominal contracting. For both variables, positive as well as negative coefficients have been observed when investigating bank NIMs (Demirgüç-Kunt and Huizinga, 1999; Claeys and Vander Vennet, 2008; Albertazzi and Gambacorta, 2010) depending on the banking sample and time period observed, so no a priori assumption of the coefficient sign derived will be given.

Revolving portfolios: As already discussed at the beginning of Section 4.2 we have to control for fair coupon-payments from the underlying bonds, captured in the dependent variables, to separate the effects of the fee determinants our model predicts. Since today's interest income and expenses depend on volume and current as well as former fair market rates for different maturities — depending on the points in time current on-balance positions have been conducted — we build revolving portfolios of bonds with different maturities initiated at different points in time. Since credit risk premia are controlled for by the credit risk variable we consider default-free government bonds.

We make use of the Deutsche Bundesbank's monthly balance sheet statistics that reports volumes for different lender and borrower clienteles in time brackets according to the initial time to maturity, as shown in Table 8. The strategy of revolving portfolios basically consists in revolvingly investing into par-yield government bonds whose initial maturity depend on the respective balance sheet position's maturity bracket. We assume initial maturity is equally distributed within each bracket, each bond pays par-yield when initiated, and maturing bonds are replaced by new bonds of the same maturity. The resulting coupon-payments represent weighted moving-averages of par-yields as shown by Memmel (2008). They are calculated for each position and time bracket and are — divided by interest-paying assets, interest-paying liabilities, or total asset, respectively — used as control variables when investigating NIM, IIM, and IEM.[12] Memmel (2008) provides empirical evidence that this approach explains much of the serial and cross-sectional variation of banks' interest income and expense margins. Further details can be taken from Appendix C.

4.3 Summary statistics

We employ a dataset of the complete German commercial banking sector, but exclude synthetic banks if (i) they have missing values for one of the above-stated variables; (ii) showed negative values for any balance sheet position that could not be negative. For estimating non-negative marginal cost in translog cost functions we additionally completely excluded synthetic banks whose (iii) input prices differed by more than 2.25 times the standard deviation in a given year, and (iv) whose assets are below EUR 25 million. This leaves us with a total sample of 2,380 (synthetic) banks, 594 of which are savings, 1,730 cooperative, and 56 so called other, mainly private commercial banks. Table 2 provides summary statistics for the overall sample and the sub-samples.

[Table 2 about here.]

There are some noteworthy features in the data, especially highlighting differences between the sub-samples of savings and cooperative banks, and the remaining banks in the other bank

[12]As the reported maturity brackets for assets and liabilities do not have matching maturities, we cannot create net revolving portfolios for every single bracket — used in explaining income and expenses — when analyzing the net interest margin. Therefore, we create in this case three net product group revolving portfolios by combining revolving portfolios for bank, non-bank, and bond lending and then subtracting those for borrowing. Savings accounts are added to non-bank borrowing and subordinated debt to bonds issued.

sample. Average total assets are EUR 1,018 million, but range from EUR 395 million for cooperative banks to EUR 9,077 million for other banks. The overall sample median, however, is only EUR 329 million, giving evidence that a huge number of small banks operate in the German banking system, whereas averages are driven by a small number of large institutions. Savings and cooperative banks samples are comparatively homogeneous with respect to size, whereas the other bank sample is much more heterogeneous. Duration gaps are higher for savings and cooperative banks, which have interest sensitivities of 0.84 and 0.9, respectively, compared with other banks with only 0.64. Net interest income margins range from 2.03% for savings, 2.48% for cooperative to 2.58% observed for other banks. However, the standard deviation of NIM is more than three times as high for other banks as for cooperatives. The smaller savings and cooperative banks rely to a larger extent on savings deposit funding, which corresponds to 32.6%, and 33.7% of total assets, whereas other banks show a quota of only 14.8%. Revisiting that half of the savings deposit are considered to be long-term core deposits, it is remarkable that savings and cooperative banks still have substantially larger duration gaps. As other banks have the highest net interest income though they are less heavily involved in maturity transformation seems to make them earn interest income through credit risk premia. And indeed, other banks have credit risk higher ratios of RWA to total assets: 63.2% compared to 55.3% and 60.2% for savings and cooperative banks, respectively.

5 Empirical analysis

5.1 Econometric model

Previous studies mainly focussed on an investigation of the net interest margin (NIM) as a widely used measure of commercial banks' core business profitability.[13] Empirical findings have been compared to the theoretical determinants derived for the pure spread. As Ho-Saunders-type models derive determinants for loan and deposit fees independently, we can test the related hypotheses for loans and deposits separately. We are the first to additionally examine the influence of the model-derived factors on the interest income margin (IIM) and the interest expense margin (IEM) separately. The reduced form regression equation of the model is given by:

$$BM_{it} = \alpha_i + \sum_{j=1}^{J} \beta^j TM_{it}^j + \sum_{k=1}^{K} \gamma^k BS_{it}^k + \sum_{l=1}^{L} \delta^l ME_t^l + \sum_{m=1}^{M} \eta^m RP_{it}^m + \varepsilon_{it} \tag{14}$$

for $t = 1, ..., T$, indicating the time period, and $i = 1, ..., N$ as the number of banks in the sample.[14] BM is the bank margin examined and will be one of the three bank margins introduced. TM refers to the vector of variables determined by the theoretical model. BS is a vector of additional bank-specific control variables that are likely to influence empirically observed bank margins, but are not part of our model. ME represents macroeconomic variables with a common influence on bank margins. Finally, RP represents the vector of revolving portfolios.

All regressions are estimated using fixed effects two-stage least squares (2SLS) instrumental

[13] Exemptions are, e.g. Carbó and Rodríguez (2007), who use a wider definition of bank margins and also include New Empirical Industrial Organizations margins, and Lepetit et al. (2008), who investigate several different definitions of bank spreads.

[14] Ho and Saunders (1981) and Saunders and Schumacher (2000) estimate the model in a two-step procedure that aims to derive the pure spread from the first-step regressions. The pure spread is considered to be the intercept from a regression of the NIM on all factors not explicitly derived from the model. Focussing on interest risk, we prefer in our setting the single-step approach as it allows the revolving portfolios and the variables proxying for the interest risk in the intermediation fees to be correlated.

variables (IV) techniques. As output prices for Lerner indices (and in the case of overall market power indices, also the input price of financial cost) were estimated on the basis of those variables they should now explain, we instrument Lerner indices with their own first difference. Furthermore, non-interest income (NII) might be endogenous for reasons of reversed causality, when banks are willing to grant more favorable interest conditions in order to stimulate the cross-selling of fee-generating business (Maudos and Solís, 2009). As Anderson-Rubin F-tests reject the hypothesis of NII being exogenous, we also instrument it with its own first difference. We investigate the relevance of the instruments testing for underidentification (Kleibergen and Paap, 2006) and weak identification based on the Cragg-Donald F-statistic. Tests for underidentification can be rejected for all samples and all margins at convenient levels. The test statistic for weak identification is calculated for clustered standard errors and based on the rank test of Kleibergen and Paap. The critical value of the Stock and Yogo (2005) weak instrument size test with two exactly identified endogenous regressors based on heteroskedastic Cragg-Donald statistic is 7.03. All samples except for the other bank sample, which has by far lower sample size, reject the weak instrument hypothesis. For the NIM and the IIM the test statistics for the complete sample statistics display always the highest value, indicating that the low statistics for the other bank sample are driven by sample size. Results are displayed for all samples both as coefficients from level-on-level regressions as well as elasticities. The coefficients for elasticities have been multiplied by the factor 10 for better visibility.

5.2 Net interest margin

First, we investigate the net interest margin, in line with most of the previous literature and display our results in Table 3. Our interest is focused on the explanatory variables determining the pure intermediation spread (12) in our theoretical model, namely the bank's market power, operating costs, expected excess holding period returns, risk aversion, interest rate risk and credit risk, and the correlation between these two risks.

[Table 3 about here.]

The Lerner indices as a proxy for market power are highly significant and have a strong impact: An increase by 10% leads to an increase in the net interest margin by nearly 11%. This effect is especially pronounced for savings banks (increase in the NIM by 14%) and significant for all subsamples. The higher impact of market power on the NIM underlines the fact that many rural savings and cooperative banks face only competition from a single bank of the other pillar as these banks operate in delimited areas and have only few branches of private commercial banks in their area, allowing them to charge higher fees. The operating costs are highly significant as well. The positive sign of the coefficients is in line with the model predictions and the magnitude of the coefficients is economically relevant: an increase by 100 basis points in operating costs translates into an increase of 139 basis points in the NIM, for savings banks the increase amounts even to 173 basis points.

For the term spread included as an instrument for expected returns from maturity transformation, we find the expected negative coefficients. The coefficient is significant for savings and cooperative banks, though it is even larger for other banks. From an economic point the results confirm that banks pass part of the expected holding period returns on to customers during times when an increasing yield curve, controlled for with revolving portfolios, generates earnings from maturity transformation. However, this effect is economically not so relevant: about a 4 to 6 basis points reduction in fees for 100 basis points change in the term spread.

In a similar vein, also the interest risk proxies have to be interpreted as additional net fee income. In line with our expectations, we find savings and cooperative banks to earn significant extra charges of 28, and 20 basis points for each additional percentage point of interest sensitivity due to a positive maturity gap. Other banks, in contrast, have a coefficient close to zero, so that the insignificant impact can be rejected for more than solely small sample size. Similar results are reported for U.S. banks by Angbazo (1997) who finds the one-year repricing gap to be only related to smaller regional banks' NIMs, but not to larger money centered banks. During a period from 2005 to 2009, Memmel (2011) estimates the income generated from maturity transformation to be around 30 basis point for savings and cooperative banks, and 7 basis points for other banks. Hence, the risk premia charged in fees are of a similar magnitude and come in addition to these earnings.

LIBOR volatility, proxying the macroeconomic risk of unexpected changes in the yield curve, is priced significantly in all banking samples and confirms results of previous studies investigating banks' NIM. Fees charged are about 100 basis point per percentage point of realized volatility, and are the highest for savings banks.

Credit risk is priced with lower magnitude, but not significant for other banks, though inference might suffer from too small sample size here. Given positive risk components, as found by the positive coefficients described above, we find positive effects of excess capital for all samples investigated. The impact of the correlation between interest and credit risk is positive, but only of limited economic magnitude.

Summarizing the results for the net intermediation fee income, we find that our model predictions hold. Fees are (a little) reduced when positive returns form maturity transformation are expected. Macroeconomic and microeconomic interest rate risk, i.e. LIBOR volatility and bank-specific duration gap, are priced. Whereas all this holds for the total sample, savings and cooperative banks, we sometimes find a lack of significance for other banks which may be due to too small sample size in some cases. However, whereas the LIBOR volatility has a clear impact for other banks, the impact of duration gap is insignificant and the coefficient very small. Given that other banks include (large) private commercial banks whose business is less traditional, that have better access to capital markets and are, thus, more likely to manage their smaller duration gap via derivatives rather than on-balance, this result seems plausible.

5.3 Separation of interest income and interest expenses

In this section, we separately run the regressions for the interest income margin (IIM, see Table 4) and the interest expense margin (IEM, see Table 5). Controlling for fair coupon payments from the underlying bonds via revolving portfolios this allows, based on (10) and (11), testing the model-derived hypotheses, for the loan and deposit fee separately. This also reveals which balance sheet side, loans or deposits, drives the results discovered in the NIM in Section 5.2. When we run the separate regressions the share of explained variation (the generalized R^2) increases — compared to the regression for the net interest margin — from around 0.54 to 0.87 in both cases.

[Table 4 about here.]

[Table 5 about here.]

Lerner indices are significant for interest income as well as for interest expenses, indicating that banks can exploit their market power by increasing intermediation fees on both the asset and the liability side as predicted by our model. Comparing the magnitude of the coefficients and elasticities, results imply market power has a much greater impact on the asset than on the liability side. By contrast, operating costs seem to be solely priced on the liability side. Whereas the coefficients are insignificant or at most weakly significant on the asset side, we find highly significant coefficients (except for the subsample of other banks) on the liability side.

The term spread, as an indicator by how far banks price expected excess holding period returns, reveals the expected negative coefficient on the asset side, and here the effect is even bigger than the one observed for the net interest income. Banks are willing to lower loan fees by 9 to 17 basis points for a 100 basis point steepness in the yield curve.

For liabilities, we find against the model predictions positive coefficients, though only significant for the subsample of cooperative banks. Moreover the size of the coefficients (0.01 to 0.02) and elasticities (0.002 to 0.004) are economically negligible.

Similar effects can be observed for the pricing of on-balance interest rate risk measured by the duration gap. For the asset side, we find the expected positive and significant (except for other banks) coefficients (from 0.04 to 0.06). This implies banks charge extra intermediation fees when a long-term loan exposes them to interest rate risk from maturity transformation. This fee also increases with the risk of unexpected changes in the yield curve, measured by LIBOR volatility, with coefficients ranging from 0.93 to 1.67.

For the liability side, the duration gap also has positive coefficients (0.005 to 0.08) but they are only significant for cooperative banks. The LIBOR volatility has a positive and significant (except for other banks) impact on fees as well; however, these volatility coefficients and elasticities are much smaller than those for the asset side.

Concerning a bank's risk aversion, measured by its excess capital, positive and significant (except for other banks) coefficients are found on the asset sind. However, results (sign and significance) are mixed for the liability side.[15]

Credit risk has the expected positive sign and is significant. The correlation between interest and credit risk is significantly negative for both, the asset and liability side. The positive effect on the NIM is, therefore, explained by the higher magnitude of the elasticities on the liability side. However, the negative coefficients contradict the model's predictions.

[15]Focussing on short-term bank rates rather than intermediation fees in Italy, Gambacorta (2008) finds that high endowments of excess capital lead to significantly different loan rate adjustments, however not for deposit rates which is consistent with our results.

In summary, we find in line with our model predictions that loan fees depend negatively on expected holding period returns and positively on macroeconomic interest rate risk (LIBOR Volatility) and microeconomic duration gaps. This means banks pass part of positive expected holding period returns to customers but price higher risk charges when loans add to a large duration gap and when interest rate uncertainty is high.

On the liability side, we do not find an economically relevant impact of expected excess holding period returns. This suggests that banks do not charge higher fees in deposits as a compensation for higher valuation risk compared to funding in the money market. However, we find strong evidence that macroeconomic interest rate risk is priced. Results on the impact of the duration gaps are mixed, suggesting that the effect, if existing, is not strong and only present for the smallest of the banks in our sample, cooperative banks. The different pictures for assets and liabilities imply that the results for the NIM are mainly driven by the asset side.

5.4 Impact of financial crisis

The last two years of our sample period 2000 to 2009 are years of financial turmoil. Although the German banking system was on the whole less affected than other systems, some of our results might be influenced by this time of high uncertainty. To analyze possible effects, we repeat the regressions from Tables 3 to 5, but additionally interact the variables we are most interested in, i.e. term spread, duration gap, and LIBOR volatility with a dummy for the crisis years 2008 and 2009. We also interact excess capital as a proxy for risk aversion that may play an important role in crisis times. Note as the LIBOR volatility is not bank-specific, estimation of the impact of the interacted LIBOR volatility may suffer from the not available cross-sectional variation since it covers only two years in time series dimension.

Tables 6 and 7 report the results for the NIM, and for the IIM and the IEM, respectively, for the sake of brevity only for the model-derived variables. In the following we concentrate our analysis on the four variables we interacted.

[Table 6 about here.]

[Table 7 about here.]

Results for the NIM in Table 6 indicate that the negative impact of the term spread on net intermediation fees — predicted by our model and found over the whole sample period — reversed during the financial crisis. The non-interacted coefficients are again negative, in general slightly higher in magnitude and of the same significance compared Table 3. They range from -0.07 for savings and cooperative banks to -0.055 for other banks. The interacted coefficients capturing the diverging impact during the financial crisis are positive and exceed the previously presented ones by far in magnitude (from 0.381 to 0.126). The respective sums of both coefficients (e.g., -0.07 + 0.381 = 0.311 for savings banks) represent the pricing impact during the financial crisis. They are positive and tests highly significant (p-values are provided on the bottom of the table) for all but the other bank sample. This suggests banks were able to charge extra net fees during the financial crisis rather than passing expected returns form maturity transformation on to customers.

Analogous analyses for the remaining variables show that microeconomic duration gap and the macroeconomic LIBOR volatility keep their sign and significance in the crisis years, except for other banks where LIBOR volatility gets insignificant. Also for savings and cooperative banks, the initial coefficient of LIBOR volatility is reduced by more than 50% during the financial crisis.

Regarding excess capital, we find that savings and cooperative banks price this variable slightly lower, but still significantly positive during the crisis. For the sample of other banks we find non-interacted coefficients insignificant, but adding the interacted coefficient turns the overall effect significantly positive with a p-value of 1.2% in the financial crisis. This suggests more capital market-oriented banks, for which equity was most valuable, were those that changed their related pricing the most rigorous.

Turning to the disentangled results for interest income and expenses in Table 7, we see that the positive effect of the term spread on the NIM during the crisis years is driven by the asset side. Not-interacted coefficients are in line with expectations for all samples significantly negative for the IIM. However, high positive interacted coefficients (except for other banks) outweigh these effects, leading to a significant positive sensitivity during the financial crisis. Only for other banks the interacted coefficients are highly negative and therefore strengthen the negative impact observed for the non-interacted coefficients. For liabilities, in contrast, the sum of coefficients capturing the effect of the term spread during the financial crisis is not significant in any regression. During normal times, again, we observe slightly positive significant coefficients only for cooperative banks as already shown in Table 5.

For the duration gap, we find qualitatively the same results for the asset side as in our previous analyses. It is positively priced in both normal times and the crisis years — expect for other banks due to insignificant effects. On the liability side, we find the expected positive coefficients in normal times only for the sample cooperative banks. However, interacted coefficients are significantly positive for cooperative and other banks and almost four times as high as the non-interacted ones. The overall effect in the financial crisis, i.e. the sum of coefficients, is positive and significant for the sample of cooperative banks. The significance in the other bank sample might again suffer from small sample size. This suggests that many banks having a higher duration gap reduced deposit fees in the crisis years to stabilize their funding when external finance, in general, was more expensive.

A surprising effect can be found for LIBOR volatility, however has to be interpreted with caution — as mentioned in advance. Whereas the not-interacted coefficients for both the asset and liability side are positive and significant like in the previous analysis of Tables 4 and 5, the interacted coefficients are highly negative significant, leading to an insignificant combined effect in most cases. On the asset side the effect only remains significant positive for other banks, however turns significantly negative for cooperatives. Remembering the reduced coefficients found for the NIM, the analysis suggests banks were not able to price the record high volatility in interbank market rates during the financial crisis in the same magnitude as LIBOR volatility in normal times.

For excess capital endowments, we find for cooperative banks on the liability side still a significantly positive impact — against the predictions of the theoretical model. However, the crisis led to a significant reduction in the previously observed effect. For other banks the crisis enforced the pricing of equity in line with the model — excess capital leads to reductions in interest expenses. On the asset side no significantly different pricing pattern can be observed.

6 Concluding remarks

In this paper, we analyze how interest risk exposure from maturity transformation is priced in banks' intermediation fees. We extend the theoretical dealership model of Ho and Saunders (1981) to incorporate loans and deposits with differing maturities, making the bank sensitive to valuation interest risk when positive shifts in the yield curve lead to declining market value of equity. Thereby, we explicitly integrate one of the central functions of financial intermediation, that of maturity transformation, into the model. The model implies that the fees banks charge on loans and deposits depend on both, macroeconomic risk of unexpected changes in interest rates as well as bank-specific microeconomic exposure to this risk, and expected holding period returns from maturity transformation.

We test the model-implied hypotheses for the German commercial banking sector, a bank-based financial system in which maturity transformation evolves as a consequence of liquidity creation by financial intermediaries. Many of these, especially small and medium-sized banks, manage interest risk on-balance, which makes the dataset suitable for our analysis.

In contrast to earlier studies, we investigate — additionally to net interest income — the interest income and expense margin separately. Our results show that all banks price the macroeconomic risk of interest rate volatility in their interest margins. However, during the recent financial crisis they could not adequately price the record high volatility. The microeconomic risk of the specific on-balance duration gap is priced by the smaller savings and cooperative banks in the net interest income margin and these results are driven via loan pricing on the asset side. The larger private commercial banks with access to capital markets, on the other hands, are not sensitive to on-balance interest rate risk.

Appendix A Lerner indices

A single-product Lerner index is defined as output price minus marginal cost divided by price, and equals the inverse of elasticity of demand for the output:

$$\frac{i^*{}_{TA} - mc_{\ TA}}{i^*{}_{TA}} = \frac{1}{N\epsilon_{\ TA}\,(i^*{}_{TA})}, \tag{A.1}$$

where $mc_{\ TA}$ are marginal costs encompassing financial expenses. $\epsilon_{\ TA}$ represents the elasticity of output demand in a market encompassing N banks. The output price i (the interest rate that the bank charges) is assumed to be exogenous and is proxied by interest income / interest-earning assets. Marginal costs for overall market power are estimated from a single-output (total assets, TA), three-input translog cost function. Input prices are: (i) cost of labor w_1, (ii) cost of physical capital w_2, (iii) and cost of funding w_3. The input prices have been proxied as: (i) w_1 personnel cost / number of full-time equivalent employees measured in 1,000; (ii) w_2 operating cost excluding personnel cost / fixed assets; (iii) w_3 interest expenses paid / total interest-paying liabilities. Equity Eq is included as a netput and a time trend Tr, specified as time dummies, captures technical change. The translog cost function has the following form and is estimated using fixed bank effects to control for unobserved heterogeneity. The usual symmetry and linear homogeneity in input price restrictions are imposed.

$$\begin{aligned}
\ln c_{it} =& \gamma_i + \gamma_A \ \ln TA_{it} + \frac{1}{2}\gamma_{AA} \ (\ln TA_{it})^2 + \sum_{h=1}^{3} \gamma_h \ \ln w_{hit} \\
&+ \frac{1}{2}\sum_{h=1}^{3}\sum_{m=1}^{3} \gamma_{hm} \ \ln w_{hit} \ \ln w_{mit} + \sum_{h=1}^{3} \gamma_{hA} \ \ln w_{hit} \ \ln TA_{it} + \gamma_E \ \ln Eq_{it} \\
&+ \frac{1}{2}\gamma_{EE}\,(\ln Eq_{it})^2 + \gamma_{EA} \ \ln Eq_{it} \ \ln TA_{it} + \sum_{h=1}^{3} \gamma_{hE} \ \ln w_{hit} \ \ln Eq_{it} \\
&+ \gamma_T \ Tr + \frac{1}{2}\gamma_{TT} \ (Tr)^2 + \gamma_{TA} \ Tr \ \ln TA_{it} \\
&+ \sum_{h=1}^{3} \gamma_{Th} \ Tr \ \ln w_{hit} + \gamma_{Tq} \ Tr \ \ln q_{it} + \ln u_{it}.
\end{aligned} \tag{A.2}$$

Marginal costs $mc_{\ TA_{it}}$ are derived from

$$mc_{TA_{it}} = [\gamma_A + \gamma_{AA} \ \ln TA_{it} + \sum_{h=1}^{3} \gamma_{hA} \ \ln w_{hit} + \gamma_{EA} \ \ln Eq_{it} + \gamma_{TA} \ Tr]\frac{c_{it}}{TA_{it}}. \tag{A.3}$$

Separate Lerner indices for interest-bearing assets and liabilities are derived from first-order conditions of profit maximization in the Monti-Klein model and expressed as (see Freixas and

Rochet, 2008, p. 58):

$$\frac{i^*{}_L - i - mc_{\ L}}{i^*{}_L} = \frac{1}{N\epsilon_{\ L}\left(i^*{}_L\right)}; \qquad \frac{i - i^*{}_D - mc_{\ D}}{i^*{}_D} = \frac{1}{N\epsilon_{\ D}\left(i^*{}_D\right)} \tag{A.4}$$

where $i_{\ L}$, $i_{\ D}$ and i are the interest rates set on loans, deposits and the interbank market, respectively. For estimating the marginal cost, we follow the two-product output approach of Maudos and Fernández de Guevara (2007). $i_{\ L}$ is proxied to equal interest income / interest-earning assets, and $i_{\ D}$ equals interest expenses / interest-paying liabilities. The yearly average of the six-month LIBOR rate presents the interbank funding rate. Marginal costs are estimated using a two-product output translog cost function, including loans L and deposits D. Loans are proxied by interest-earning assets less bonds held and deposits as total interest-paying liabilities less bonds issued.[16] The interbank rate is clearly exogenous, and interest expenses on liabilities are now considered to be the output price of deposits, so that we only include the two price input factors of labor (w_1), and physical capital (w_2), which are defined in the same way as in the three-input cost function. Again time dummies control for technical change, and fixed bank effects for unobserved heterogeneity. The translog cost function has the following form:

$$\begin{aligned}\ln c_{it} =& \gamma_i + \gamma_L \ \ln L_{it} + \frac{1}{2}\gamma_{LL} \ \left(\ln L_{it}\right)^2 + \gamma_D \ \ln D_{it} + \frac{1}{2}\gamma_{DD} \ \left(\ln D_{it}\right)^2 \\ &+ \gamma_{LD} \ \ln L_{it} \ \ln D_{it} + \sum_{h=1}^{2}\gamma_h \ \ln w_{hit} + \frac{1}{2}\sum_{h=1}^{2}\sum_{m=1}^{2}\gamma_{hm} \ \ln w_{hit} \ \ln w_{mit} \\ &+ \sum_{h=1}^{2}\gamma_{hL} \ \ln w_{hit} \ \ln L_{it} + \sum_{h=1}^{2}\gamma_{hD} \ln w_{hit} \ \ln D_{it} + \gamma_T \ Tr + \frac{1}{2}\gamma_{TT} \ \left(Tr\right)^2 \\ &+ \gamma_{TL} \ Tr \ln L_{it} + \gamma_{TD} \ Tr \ \ln D_{it} + \sum_{h=1}^{2}\gamma_{Th} \ Tr \ \ln w_{hit} + \ln u_{it}.\end{aligned} \tag{A.5}$$

The cost function has been estimated using fixed bank effects. Marginal cost are derived from:

$$\begin{aligned}mc_{\ L_{it}} =& \left[\gamma_L + \gamma_{LL} \ \ln L_{it} + \gamma_{LD} \ \ln D_{it} + \sum_{h=1}^{2}\gamma_{hL} \ \ln w_{hit} + \gamma_{TL} \ Tr\right]\frac{c_{it}}{L_{it}} \\ mc_{\ D_{it}} =& \left[\gamma_D + \gamma_{DD} \ \ln D_{it} + \gamma_{LD} \ \ln L_{it} + \sum_{h=1}^{2}\gamma_{hD} \ \ln w_{hit} + \gamma_{TD} \ Tr\right]\frac{c_{it}}{D_{it}}.\end{aligned} \tag{A.6}$$

[16] It is assumed that bond supply and demand are perfectly elastic, that the bank cannot exercise market power in trading bonds, and that bond portfolios are not associated with operating cost. Statistically, bond portfolios have been excluded to make the loan and the deposit proxies less correlated to each other. For the same reason, the impact of equity is not controlled for as equity and interest-paying liabilities would otherwise almost total interest-earning assets.

Appendix B Modified Duration gaps

Table 8 gives an overview of the different lender and borrower clienteles and the time brackets reported in the Deutsche Bundesbank's monthly balance sheet statistics. Note the brackets are filled according to the initial time to maturity.

[Table 8 about here.]

To keep things simple, we make the following assumptions for calculating the modified duration $\overline{D_{mod}(M_1, M_2)}$ for a specific position and maturity bracket with the boundaries M_1 and M_2: (i) the initial time to maturity is equally distributed between the boundaries; (ii) the bank has invested revolvingly the same amount in bonds with maturity M where $M_1 < M < M_2$; (iii) all bonds are default-free and continuously pay par yield r_f.

The modified duration of a continuously par-yield-paying, default-free bond of maturity M is:

$$D_{mod}(M) = \frac{1}{r_f}\left(1 - \exp(-r_f M)\right). \tag{B.1}$$

The modified duration of a portfolio revolvingly investing in such bonds of maturity M, i.e. where the residual maturity is equally distributed within the interval [0,M] can be expressed as (see also the Appendix of Memmel, 2011):

$$\begin{aligned}\overline{D_{mod}(M)} &= \int_{t=0}^{M} \frac{1}{M} D_{mod}(N) dN \\ &= \frac{M - 1/r_f\left(1 - \exp(-r_f M)\right)}{M r_f}.\end{aligned} \tag{B.2}$$

Finally, the modified duration of revolvingly investing in a portfolio of the aforementioned type of bonds of a given maturity bracket from M_1 to M_2, with initial maturity being equally distributed between the boundaries, is:

$$\overline{D_{mod}(M_1, M_2)} = \frac{1}{M_2 - M_1} \int_{M_1}^{M_2} \overline{D_{mod}(M)} dM. \tag{B.3}$$

Using first-order Taylor series approximations around $r_f = 0$, equation (B.2) yields:

$$\overline{D_{mod}(M)} \approx \frac{1}{2} M - \frac{1}{6} M^2 r_f, \tag{B.4}$$

and equation (B.3)

$$\overline{D_{mod}(M_1, M_2)} \approx \frac{1}{4}\left(M_2 + M_1\right) - \frac{1}{18}\left(M_2^2 + M_1^2 + M_2 \cdot M_1\right) r_f. \tag{B.5}$$

The asset's (liability's) modified duration D^A_{mod} (D^L_{mod}) is calculated using equations (B.4) and (B.5) employing weighted sums of all brackets of assets (liabilities) reported in Table 8. The weights correspond to the proportion of assets (liabilities) in a given bracket relative to total interest-bearing assets (liabilities). The modified duration gap is derived as

$$D_{gap} = D^A_{mod} - D^L_{mod} \frac{\text{total interest-earning liabilities}}{\text{total interest-paying assets}}. \tag{B.6}$$

When no upper boundary for a maturity bracket is reported, it is assumed to be 8 years. For saving accounts, applying legal maturities of 3 and 6 months would clearly overestimate the duration gap. Therefore, we assume 50% of the volume to be core deposits with long-term maturities of 5 years (see also Purnanandam, 2007), and the other half is assigned its legal maturity.

Appendix C Revolving portfolios

The strategy of revolving portfolios is illustrated using an example. Imagine a bank that grants solely risk-free loans of five years of maturity. Whenever a loan becomes due, a new loan with five years of maturity is granted. Under the assumption of time-invariant business, the residual maturity of the bonds in the bank's portfolio is equally distributed between zero and five years. Memmel (2008) shows that this bank's interest income margin is equal to the five year moving average of five year risk-free par-yield bonds. For balance sheet positions with a predetermined repricing period (like loans) the calculation is relatively straight-forward. For other positions, we chose the following assumptions:

- When no upper boundary for a maturity bracket is reported, it is assumed to be 8 years.
- Daily maturities are modelled using the 3-month government par yields in order to reduce the volatility resulting from estimation errors in fitting the lower end of the Svensson term structure.
- Savings deposits are modelled as 50% core deposits (see also Purnanandam, 2007). Deposits with up to 3 month maturities are modelled as the equally weighted moving average of the 3-month and 9.5-year par yields, deposits with longer maturities as the 6-month and 10-year par yield. Modelling savings deposits as weighted sums of moving averages of long and short-term interest rates is a methodology consistent with internal IRR management approaches of smaller German banks (see also Memmel, 2011).

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Tables

Table 1: Variable description

Variable	Proxy	Pred. coeff.	Use in other studies
Model-derived variables			
Market power	Lerner index: $(p - mc)/p$, where total market power is calculated using total assets as an output with a three factor translog cost function. Loan and deposit market power, however, have been jointly estimated using total interest-bearing assets and liabilities, respectively, as output proxies and a two input factor translog cost function, excluding financial cost (of deposits) as in Maudos and Fernández de Guevara (2007)	(+|-|+)	Maudos and Fernández de Guevara (2004); Maudos and Solís (2009)
Operating cost	Operating expenses / total (interest-bearing) assets (liabilities)	(+|-|+)	Maudos and Fernández de Guevara (2004); Maudos and Solís (2009)
Expected excess holding period returns	Term spread: the difference between the duration implied par yield and the 6-month par yield, or between asset and liability duration-implied par yields for the NIM	(-|-|-)	Not used before
Risk aversion	Excess capital: (Regulatory capital - 0.08 × risk-weighted assets) / total assets	(+|-|+)	Excess capital has not been used so far, but been proposed by Maudos and Solís (2009). Previous studies used capital ratios, i.e. (regulatory) capital / total assets (McShane and Sharpe, 1985; Angbazo, 1997; Maudos and Fernández de Guevara, 2004; Carbó and Rodríguez, 2007; Maudos and Solís, 2009)
Banks-specific IRR exposure	Duration gap: asset duration - liability duration × interest-paying liabilities / interest-earning assets	(+|+|+)	Not used so far; the most similar interest rate risk measure is the net position of balance sheet items with a repricing period of less than one year in relation to total assets (Angbazo, 1997)
Macroeconomic IRR magnitude	LIBOR volatility: annual standard deviation of the weekly observed 6-month LIBOR rate	(+|+|+)	Different interest rate volatilities have been used to proxy for interest rate risk when explaining NIMs (Maudos and Fernández de Guevara, 2004; Lepetit et al., 2008; Maudos and Solís, 2009). However these studies were based on models with a single IRR source and could therefore derive predictions for coefficients.
Credit risk	Risk-weighted assets / total assets	(+|nu|+)	Not used before
Credit-interest covariance	Annual correlation coefficient between the 5-year government par yield and the 5-year credit spread on corporate bonds over the 5-year government par yield	(?|+|?)	Not used before
Bank-specific variables			
Non-interest income (NII)	net fee income / total (interest-bearing) assets (liabilities)	(-|+|-)	Carbó and Rodríguez (2007); Maudos and Solís (2009)
Implicit interest payments (IIP)	(non-interest expenses - non-interest income) / total (interest-bearing) assets (liabilities)	(+|-|+)	Ho and Saunders (1981); Angbazo (1997); Saunders and Schumacher (2000); Maudos and Fernández de Guevara (2004); Maudos and Solís (2009)
Opportunity cost of reserves (OCR)	(cash + deposits with central banks) / total (interest-bearing) assets (liabilities)	(?|+|-)	
Macroeconomic variables			
GDP growth	annual real GDP growth rate	(?|?|?)	Carbó and Rodríguez (2007); Claeys and Vander Vennet (2008); Albertazzi and Gambacorta (2010); Maudos and Solís (2009)
Inflation rate	annual growth rate of consumer price index	(?|?|?)	Demirgüç-Kunt and Huizinga (1999); Claeys and Vander Vennet (2008); Maudos and Solís (2009)
Revolving portfolios	Balance sheet proportion of several lender (borrower) clienteles and maturity brackets × the moving average of par yield government bonds	(+|+|nu)	Memmel (2008) explains interest income and expense margins with revolving tracking bank portflios

Total (interest-bearing) assets (liabilities) indicates that the denominator of an explanatory variable is total interest-bearing assets if the dependent variable is IIM, total interest-bearing liabilities in case of IEM, and total assets for NIM. The following symbols were used for predicted coefficients, where the following order within brackets is given (IIM, IEM, NIM). (+) denotes an expected positive coefficient, (-) a negative coefficient, (?) that the effect cannot be predicted a priori, and (nu) that the given variable has not been included in a regression on the specific margin.

Table 2: Summary statistics

	Full sample			Savings banks		Cooperative banks		Other banks	
	Mean	Std. dev.	Median	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Bank size (denominators)in €million									
Total interest-earning assets	898.189	5685.103	290.764	1767.913	2488.304	350.088	559.547	8125.128	35179.374
Total interest-paying liabilities	906.510	5419.367	295.307	1822.069	2543.179	355.553	593.923	7714.408	33341.790
Total assets (TA)	1017.514	6585.622	328.581	2019.671	2814.181	394.656	653.023	9077.482	40872.249
Bank interest margins									
Interest income margin (IIM)	5.509	0.676	5.495	5.467	0.610	5.519	0.634	5.648	1.752
Interest expense margin (IEM)	2.859	0.557	2.841	3.022	0.542	2.795	0.540	3.034	0.796
Net interest margin (NIM)	2.360	0.530	2.377	2.027	0.394	2.473	0.450	2.582	1.554
Model derived variables									
Market power (loans)	49.345	16.165	48.411	51.487	15.945	48.680	16.057	46.121	19.299
Market power (deposits)	-23.625	36.854	-19.333	-24.484	34.023	-23.152	37.734	-28.654	39.037
Market power (overall)	37.006	8.830	37.733	37.879	7.801	36.766	8.799	34.729	16.424
Operating cost	2.222	0.555	2.182	1.828	0.254	2.354	0.518	2.544	1.368
Term spread (asset)	0.611	0.429	0.602	0.621	0.429	0.607	0.428	0.603	0.477
Term spread (liability)	0.543	0.410	0.516	0.577	0.382	0.529	0.413	0.576	0.561
Term spread (asset-liability)	0.068	0.439	0.083	0.044	0.399	0.078	0.440	0.027	0.709
Risk aversion	3.203	1.833	2.844	2.769	1.475	3.361	1.856	3.155	3.324
Modified asset duration	2.429	0.246	2.466	2.559	0.154	2.405	0.208	1.737	0.559
Modified liability duration	1.540	0.223	1.566	1.651	0.188	1.512	0.201	1.169	0.428
Duration gap	0.877	0.274	0.867	0.841	0.241	0.897	0.268	0.639	0.538
LIBOR volatility	0.343	0.161	0.321						
Credit risk	59.016	11.520	60.039	55.258	11.197	60.233	11.073	63.174	17.507
Credit-interest covariance (correlation)	-11.488	12.202	-4.879						
Non-interest income (NII)	0.667	0.260	0.636	0.556	0.111	0.698	0.239	0.951	0.878
Implicit interest payments (IEP)	1.338	0.447	1.310	1.102	0.237	1.431	0.438	1.101	1.055
Opportunity cost of reserves (OCR)	0.898	0.392	0.858	0.744	0.284	0.969	0.393	0.426	0.528
Macroeconomic variables									
GDP growth	0.954	2.124	1.208						
Inflation rate	1.554	0.695	1.763						
Balance sheet compositions									
Loans to banks	11.670	7.581	10.228	8.333	5.987	12.649	7.338	18.469	14.480
Loans to nonbanks	60.042	11.825	61.555	59.541	12.024	60.253	11.314	59.095	21.144
Bonds held	17.866	9.577	16.497	19.092	10.206	17.519	9.022	14.987	15.600
Loans from banks	15.429	8.081	14.203	21.007	8.994	13.382	6.099	16.640	16.814
Loans from nonbanks	38.213	9.885	37.217	32.438	7.762	39.875	9.163	51.004	17.832
Saving deposits	33.025	9.761	33.139	32.591	8.190	33.704	9.612	16.926	14.848
Subordinated debt	0.531	0.964	0.000	1.317	1.395	0.249	0.520	0.524	0.814
Bonds issued	2.714	3.706	0.846	2.755	3.030	2.719	3.896	2.113	4.413

For explanatory variables calculated as quotas to total (interest-bearing) assets (liabilities), total assets has been chosen for the summary statistics above. Balance sheet compositions are quotas in relation to total interest-bearing assets, or liabilities, respectively, and were used to calculate revolving portfolios by multiplying year-end values with moving averages of government par yields. All variables are displayed in percentage terms, except for the size variables used as denominators, which are denoted in €million. Modified asset and liability durations are not used as explanatory variables independently, but were used to calculate the duration gap, and "duration-implied" term spreads.

Table 3: Determinants of net interest margin (NIM)

	Total sample (i)		Savings banks (ii)		Cooperative banks (iii)		Other banks (iv)	
	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.
Model-determined variables								
Lerner index (overall)	0.070***	10.932	0.075***	14.076	0.076***	11.280	0.056***	7.599
	(0.0041)		(0.0063)		(0.0047)		(0.0141)	
Operating cost	1.391***	13.223	1.727***	15.769	1.618***	15.560	0.758***	7.393
	(0.1073)		(0.1845)		(0.1009)		(0.2648)	
Term spread (asset-liability)	-0.041***	-0.011	-0.046***	-0.010	-0.046***	-0.014	-0.057	-0.002
	(0.0064)		(0.0115)		(0.0070)		(0.0437)	
Excess capital	0.046***	0.663	0.098***	1.410	0.041***	0.594	0.036*	0.438
	(0.0051)		(0.0126)		(0.0047)		(0.0200)	
Duration gap	0.180***	0.699	0.284***	1.215	0.201***	0.766	0.034	0.085
	(0.0214)		(0.0470)		(0.0276)		(0.1449)	
LIBOR vola	1.014***	1.520	1.168***	2.040	1.080***	1.542	0.861***	1.168
	(0.0712)		(0.1238)		(0.0770)		(0.2323)	
Credit risk	0.007***	1.772	0.007***	1.862	0.007***	1.783	0.005	1.315
	(0.0006)		(0.0014)		(0.0007)		(0.0039)	
Credit-interest covariance	0.028***	1.021	0.030***	1.302	0.032***	1.119	0.019***	0.636
	(0.0021)		(0.0030)		(0.0024)		(0.0068)	
Bank-specific variables								
NII	-1.357***	-3.889	-3.347***	-9.392	-1.548***	-4.427	-0.430	-1.557
	(0.1505)		(0.4140)		(0.1252)		(0.3414)	
IIP	-0.458***	-2.603	-0.585***	-3.194	-0.623***	-3.614	-0.027	-0.118
	(0.0639)		(0.1161)		(0.0606)		(0.1491)	
OCR	0.003	0.013	-0.010	-0.038	0.019	0.076	-0.037	-0.058
	(0.0103)		(0.0248)		(0.0129)		(0.1442)	
Macroeconomic variables								
GDP growth	-0.118***	-0.478	-0.091***	-0.421	-0.154***	-0.595	-0.066**	-0.257
	(0.0106)		(0.0109)		(0.0133)		(0.0267)	
Inflation rate	0.620***	4.368	0.654***	5.364	0.723***	4.850	0.456***	2.879
	(0.0478)		(0.0686)		(0.0552)		(0.1496)	
Revolving portfolios								
Net loans to / from banks	0.007	0.008	0.133***	0.393	-0.078**	-0.037	0.110	0.022
	(0.0295)		(0.0348)		(0.0343)		(0.0955)	
Net business to / from non-banks	-0.044**	-0.008	0.047**	0.057	-0.123***	-0.074	0.120*	0.121
	(0.0204)		(0.0204)		(0.0267)		(0.0658)	
Net bond portfolios	-0.127***	-0.380	-0.219***	-0.849	-0.175***	-0.481	-0.025	-0.056
	(0.0377)		(0.0603)		(0.0414)		(0.1201)	
Obs.	16,396		4,479		11,524		393	
Number of synthetic banks	2,380		594		1,730		56	
GR^2	0.536		0.459		0.592		0.382	
Underid. LM stat. [p-val]	71.18	[0]	40.48	[0]	52.91	[0]	7.459	[0.006]
Cragg-Donald F-test	58.23		30.28		43.55		5.405	

Dependent variable: net interest margin (NIM). Operating cost, non-interest income (NII), opportunity cost of reserves (OCR) and implicit interest payments (IIP) are in relation to total assets. All models have been estimated using fixed effects 2SLS IV regressions, where Lerner index (overall) and NII have been instrumented with their own first differences. Underid. gives the LM statistic and the p-value for the Kleibergen and Paap (2006) rank test of underidentification. Cragg-Donald F-test gives the Cragg-Donald statistic based on Kleibergen and Paap's rank of the matrix. Elasticities of variables are displayed on the right next to coefficients and are calculated at sample mean and multiplied by the factor 10. Elasticities have been estimated using chain rules, and have been multiplied by -10 if evaluated at a negative sample mean. Standard errors are given in parentheses and are clustered at bank level. Significance at the 10%/5%/1%-level is marked by */**/***. GR^2 is the generalized R^2 criterion of Pesaran and Smith (1994) for 2SLS IV estimation.

Table 4: Determinants of interest income margin (IIM)

	Total sample (i)		Savings banks (ii)		Cooperative banks (iii)		Other banks (iv)	
	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.
Model-determined variables								
Lerner index (assets)	0.051***	4.680	0.044***	4.204	0.056***	5.042	0.065***	5.338
	(0.0031)		(0.0045)		(0.0048)		(0.0115)	
Operating cost	-0.083*	-0.381	0.100	0.391	-0.032	-0.154	-0.161	-0.787
	(0.0478)		(0.1269)		(0.0268)		(0.2421)	
Term spread (asset)	-0.155***	-0.153	-0.090***	-0.092	-0.155***	-0.152	-0.168*	-0.164
	(0.0175)		(0.0217)		(0.0251)		(0.0860)	
Excess capital	0.046***	0.287	0.039***	0.208	0.060***	0.394	-0.006	-0.034
	(0.0056)		(0.0076)		(0.0075)		(0.0219)	
Duration gap	0.337***	0.564	0.370***	0.588	0.567***	0.976	-0.046	-0.054
	(0.0505)		(0.0673)		(0.0715)		(0.1335)	
LIBOR vola	1.501***	0.967	0.993***	0.644	1.445***	0.930	1.671***	1.045
	(0.1049)		(0.1227)		(0.1346)		(0.2797)	
Credit risk	0.020***	2.178	0.020***	2.070	0.017***	1.927	0.019**	2.193
	(0.0017)		(0.0021)		(0.0015)		(0.0095)	
Credit-interest covariance	-0.010***	-0.150	-0.009***	-0.144	-0.009***	-0.138	-0.014***	-0.217
	(0.0004)		(0.0006)		(0.0004)		(0.0031)	
Bank-specific variables								
NII	0.570***	0.793	1.250***	1.509	0.427***	0.618	0.618*	1.132
	(0.0879)		(0.3546)		(0.0812)		(0.3514)	
IIP	0.239***	0.656	0.152*	0.355	0.184***	0.536	0.404**	0.877
	(0.0332)		(0.0778)		(0.0189)		(0.2005)	
OCR	0.101***	0.186	0.118***	0.188	0.099***	0.196	-0.145	-0.114
	(0.0124)		(0.0317)		(0.0156)		(0.1259)	
Macroeconomic variables								
GDP growth	0.081***	0.140	0.055***	0.095	0.098***	0.171	0.126***	0.227
	(0.0063)		(0.0097)		(0.0092)		(0.0323)	
Inflation rate	0.283***	0.856	0.250***	0.760	0.265***	0.801	0.235***	0.683
	(0.0233)		(0.0315)		(0.0326)		(0.0721)	
Revolving portfolios								
Loans to banks								
daily	2.208***	0.589	2.207***	0.320	2.465***	0.762	2.120***	0.793
	(0.1171)		(0.1460)		(0.1744)		(0.3395)	
$\leq$ 1 y.	1.976***	0.454	2.042***	0.530	2.112***	0.434	1.828***	1.126
	(0.0997)		(0.1340)		(0.1425)		(0.2509)	
$>$ 1 y. $\leq$ 5 y.	1.626***	0.278	1.680***	0.124	1.717***	0.362	1.784***	0.124
	(0.0706)		(0.1082)		(0.0996)		(0.4567)	
$>$ 5 y.	1.217***	0.199	1.310***	0.194	1.229***	0.212	1.028***	0.078
	(0.0518)		(0.0805)		(0.0642)		(0.3521)	
Loans to non-banks								
$\leq$ 1 y.	2.162***	1.052	3.012***	1.338	2.750***	1.312	1.505***	1.836
	(0.1653)		(0.2245)		(0.1546)		(0.2596)	
$>$ 1 y. $\leq$ 5 y.	1.551***	0.615	1.590***	0.399	1.636***	0.711	1.243***	1.131
	(0.0647)		(0.1441)		(0.0699)		(0.2858)	
$>$ 5 y.	1.120***	4.942	1.015***	4.866	1.089***	4.721	1.185***	2.806
	(0.0252)		(0.0303)		(0.0263)		(0.2162)	
Bonds held								
$\leq$ 1 y.	0.778***	0.011	1.002***	0.016	0.782***	0.011	-1.651	-0.016
	(0.0894)		(0.1451)		(0.1002)		(1.1166)	
$>$ 1 y. $\leq$ 2 y.	0.974***	0.043	1.155***	0.062	1.077***	0.044	0.669	0.039
	(0.0629)		(0.0762)		(0.0771)		(0.5095)	
$>$ 2 y.	0.607***	0.883	0.765***	1.222	0.570***	0.805	0.316**	0.351
	(0.0221)		(0.0486)		(0.0239)		(0.1360)	
Obs.	16,396		4,479		11,524		393	
Number of synthetic banks	2,380		594		1,730		56	
GR^2	0.866		0.896		0.890		0.648	
Underid. LM stat. [p-val.]	92.89	[0]	52.59	[0]	48.90	[0]	7.764	[0.005]
Cragg-Donald F-test	118.4		70.15		48.20		5.191	

Dependent variable: interest income margin (IIM). Operating cost, non-interest income (NII), opportunity cost of reserves (OCR) and implicit interest payments (IIP) are in relation to interest-earning assets. All models have been estimated using fixed effects 2SLS IV regressions, where Lerner index (assets) and NII have been instrumented with their own first differences. Underid. gives the LM statistic and the p-value for the Kleibergen and Paap (2006) rank test of underidentification. Cragg-Donald F-test gives the Cragg-Donald statistic based on Kleibergen and Paap's rank of the matrix. Elasticities of variables are displayed on the right next to coefficients and are calculated at sample mean and multiplied by the factor 10. Elasticities have been estimated using chain rules, and have been multiplied by -10 if evaluated at a negative sample mean. Standard errors are given in parentheses and are clustered at bank level. Significance at the 10%/5%/1%-level is marked by */**/***. GR^2 is the generalized R^2 criterion of Pesaran and Smith (1994) for 2SLS IV estimation.

Table 5: Determinants of the interest expense margin (IEM)

	Total sample (i)		Savings banks (ii)		Cooperative banks (iii)		Other banks (iv)	
	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.
Model-determined variables								
Lerner index (deposits)	-0.010***	-0.822	-0.014***	-1.122	-0.008***	-0.704	-0.019***	-1.792
	(0.0005)		(0.0008)		(0.0004)		(0.0035)	
Operating cost	-0.190***	-1.679	-0.388***	-2.649	-0.209***	-2.018	-0.042	-0.418
	(0.0358)		(0.0536)		(0.0152)		(0.2087)	
Term spread (liabilities)	0.010**	0.017	0.009	0.016	0.022***	0.037	0.017	0.030
	(0.0049)		(0.0085)		(0.0050)		(0.0467)	
Excess capital	-0.001	-0.016	0.014***	0.135	-0.002	-0.026	-0.035***	-0.366
	(0.0029)		(0.0053)		(0.0026)		(0.0114)	
Duration gap	0.042**	0.135	0.012	0.035	0.082***	0.280	0.005	0.011
	(0.0177)		(0.0293)		(0.0188)		(0.1204)	
LIBOR vola	0.125***	0.156	0.097***	0.114	0.111***	0.142	0.091	0.107
	(0.0147)		(0.0220)		(0.0143)		(0.1442)	
Credit-interest covariance	-0.006***	-0.186	-0.006***	-0.181	-0.006***	-0.192	-0.012***	-0.333
	(0.0003)		(0.0003)		(0.0002)		(0.0028)	
Bank-specific variables								
NII	0.365***	0.976	1.252***	2.627	0.397***	1.140	-0.039	-0.143
	(0.0858)		(0.1368)		(0.0348)		(0.3519)	
IIP	0.050**	0.265	0.135***	0.552	0.048***	0.279	-0.028	-0.122
	(0.0198)		(0.0430)		(0.0108)		(0.1570)	
OCR	-0.034***	-0.120	-0.010	-0.028	-0.038***	-0.149	-0.065	-0.103
	(0.0076)		(0.0144)		(0.0071)		(0.0734)	
Macroeconomic variables								
GDP growth	0.007**	0.024	0.006	0.020	0.003	0.011	0.092***	0.309
	(0.0034)		(0.0052)		(0.0030)		(0.0322)	
Inflation rate	-0.022***	-0.128	0.020***	0.109	-0.043***	-0.262	0.007	0.036
	(0.0062)		(0.0075)		(0.0051)		(0.0483)	
Revolving portfolios								
Loans from banks								
daily	0.889***	0.049	1.076***	0.107	0.813***	0.025	0.836***	0.172
	(0.0504)		(0.0659)		(0.0687)		(0.1828)	
$\leq$ 1 y.	0.798***	0.126	0.906***	0.248	0.657***	0.058	1.201***	0.877
	(0.0693)		(0.0408)		(0.0429)		(0.1346)	
$>$ 1 y. $\leq$ 2 y.	0.671***	0.022	0.733***	0.028	0.563***	0.016	1.174***	0.121
	(0.0576)		(0.0946)		(0.0762)		(0.2031)	
$>$ 2 y.	0.869***	1.938	0.975***	2.639	0.919***	1.902	1.014***	1.287
	(0.0246)		(0.0271)		(0.0215)		(0.1108)	
Loans from non-banks								
daily	0.848***	2.013	1.177***	2.475	0.761***	1.887	1.061***	2.698
	(0.0327)		(0.0538)		(0.0299)		(0.1609)	
$\leq$ 1 y.	0.971***	1.363	1.040***	0.880	0.926***	1.479	1.217***	2.961
	(0.0209)		(0.0434)		(0.0192)		(0.1401)	
$>$ 1 y. $\leq$ 2 y.	1.045***	0.226	1.113***	0.131	0.973***	0.250	1.198***	0.259
	(0.0474)		(0.0961)		(0.0434)		(0.3650)	
$>$ 2 y.	0.848***	0.823	0.914***	0.792	0.839***	0.840	0.867***	1.132
	(0.0396)		(0.0464)		(0.0306)		(0.1307)	
Subordinated debt	0.908***	0.079	0.498***	0.099	1.938***	0.078	1.375	0.113
	(0.1238)		(0.1336)		(0.2632)		(1.2662)	
Saving accounts								
$\leq$ 3 m.	0.809***	3.550	0.927***	3.561	0.782***	3.674	0.891***	1.893
	(0.0164)		(0.0290)		(0.0152)		(0.1052)	
$>$ 3 m.	0.777***	0.760	0.905***	1.039	0.752***	0.693	0.956***	0.582
	(0.0182)		(0.0318)		(0.0199)		(0.1703)	
Bonds issued								
$\leq$ 1 y.	0.143	0.001	-0.140	-0.001	0.300	0.001	0.591	0.008
	(0.1977)		(0.2632)		(0.3571)		(1.0066)	
$>$ 1 y. $\leq$ 2 y.	0.213**	0.007	0.058	0.002	0.265***	0.009	1.231	0.023
	(0.0918)		(0.1608)		(0.0999)		(1.5459)	
$>$ 2 y.	0.437***	0.175	0.400***	0.147	0.521***	0.219	0.903*	0.229
	(0.0424)		(0.0707)		(0.0439)		(0.4808)	
Obs.	16,396		4,479		11,524		393	
Number of synthetic banks	2,380		594		1,730		56	
GR^2	0.869		0.882		0.883		0.787	
Underid. LM stat. [p-val.]	98.66	[0]	207.5	[0]	606.3	[0]	7.966	[0.005]
Cragg-Donald F-test	88.79		218.3		2516		5.619	

Dependent variable: interest expense margin (IEM). Operating cost, non-interest income (NII), opportunity cost of reserves (OCR) and implicit interest payments (IIP) are in relation to interest-paying liabilities. All models have been estimated using fixed effects 2SLS IV regressions, where Lerner index (deposits) and NII have been instrumented with their own first differences. Underid. gives the LM statistic and the p-value for the Kleibergen and Paap (2006) rank test of underidentification. Cragg-Donald F-test gives the Cragg-Donald statistic based on Kleibergen and Paap's rank of the matrix. Elasticities of variables are displayed on the right next to coefficients and are calculated at sample mean and multiplied by the factor 10. Elasticities have been estimated using chain rules, and have been multiplied by -10 if evaluated at a negative sample mean. Standard errors are given in parentheses and are clustered at bank level. Significance at the 10%/5%/1%-level is marked by */**/***. GR^2 is the generalized R^2 criterion of Pesaran and Smith (1994) for 2SLS IV estimation.

Table 6: Determinants of net interest margin (NIM) with crisis interactions

	Total sample (i)		Savings banks (ii)		Cooperative banks (iii)		Other banks (iv)	
	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.
Lerner index (overall)	0.073***	11.496	0.073***	13.688	0.077***	11.405	0.059***	7.957
	(0.0037)		(0.0045)		(0.0041)		(0.0144)	
Operating cost	1.345***	12.785	1.417***	12.935	1.507***	14.493	0.824***	8.031
	(0.0898)		(0.1362)		(0.0860)		(0.2701)	
Term spread (asset-liability)	-0.065***	-0.018	-0.070***	-0.016	-0.070***	-0.021	-0.055	-0.002
	(0.0068)		(0.0110)		(0.0071)		(0.0479)	
Term spread × Crisis	0.317***	0.080	0.381***	0.118	0.334***	0.081	0.126	0.015
	(0.0315)		(0.0491)		(0.0315)		(0.1553)	
Excess capital	0.061***	0.885	0.112***	1.613	0.055***	0.796	0.026	0.322
	(0.0048)		(0.0112)		(0.0048)		(0.0174)	
Excess capital × Crisis	-0.005**	-0.019	-0.017***	-0.065	-0.004*	-0.015	0.047*	0.095
	(0.0024)		(0.0065)		(0.0026)		(0.0254)	
Duration gap	0.248***	0.963	0.285***	1.222	0.237***	0.903	0.129	0.327
	(0.0229)		(0.0444)		(0.0304)		(0.1649)	
Duration gap × Crisis	-0.068***	-0.058	-0.090**	-0.085	-0.055	-0.046	-0.051	-0.026
	(0.0255)		(0.0418)		(0.0350)		(0.0912)	
LIBOR vola	1.604***	2.405	1.616***	2.824	1.676***	2.392	1.107***	1.502
	(0.0773)		(0.1105)		(0.0896)		(0.2895)	
LIBOR vola × Crisis	-0.927***	-0.363	-0.829***	-0.388	-1.041***	-0.387	-0.705***	-0.220
	(0.0613)		(0.1055)		(0.0710)		(0.1659)	
Credit risk	0.000	0.121	0.002	0.500	0.000	0.046	0.001	0.277
	(0.0007)		(0.0013)		(0.0008)		(0.0046)	
Credit-interest covariance	0.021***	0.757	0.020***	0.856	0.023***	0.784	0.017***	0.571
	(0.0016)		(0.0019)		(0.0018)		(0.0063)	
Significance in crisis								
Term spread [p-val.]	80.22	[0]	49.38	[0]	87.07	[0]	0.203	[0.652]
Excess capital [p-val.]	155.2	[0]	114.2	[0]	125.1	[0]	6.302	[0.012]
Duration gap [p-val.]	56.71	[0]	16.52	[0]	43.61	[0]	0.280	[0.596]
LIBOR vola [p-val.]	76.19	[0]	40.20	[0]	33.45	[0]	2.227	[0.136]
Obs.	16,396		4,479		11,524		393	
Number of synthetic banks	2,380		594		1,730		56	
GR^2	0.552		0.483		0.607		0.391	
Underid. LM stat. [p-val.]	90.63	[0]	59.02	[0]	63.96	[0]	7.709	[0.006]
F-Test weak	77.88		47.76		57.08		5.671	

Variables previously denoted *Bank-specific variables*, *Macroeconomic variables*, and *Revolving portfolios* have been included in the regressions, but are, for the purpose of brevity, not displayed. Term spread (asset-liability), Excess capital, Duration gap, and LIBOR vola have additionally been interacted with a crisis dummy, indicating the years 2008 and 2009. Significance in crisis reports values and p-values of the Wald test of the sum of the parameters of the non-interacted variable and the variable interacted with the crisis dummy (variable × crisis). All models have been estimated using fixed effects 2SLS IV regressions, where the specific Lerner index and NII (not displayed) have been instrumented with their own first differences. Underid. gives the LM statistic and the *p*-value for the Kleibergen and Paap (2006) rank test of underidentification. Cragg-Donald F-test gives the Cragg-Donald statistic based on Kleibergen and Paap's rank of the matrix. Elasticities of variables are displayed on the right next to coefficients and are calculated at sample mean and multiplied by the factor 10. Elasticities have been estimated using chain rules, and have been multiplied by -10 if evaluated at a negative sample mean. Standard errors are given in parentheses and are clustered at bank level. Significance at the 10%/5%/1%-level is marked by */**/***. GR^2 is the generalized R^2 criterion of Pesaran and Smith (1994) for 2SLS IV estimation.

Table 7: Determinants of interest margin (IIM & IEM) with crisis interactions

Panel A: Interest income margin (IIM)

	Total sample (i)		Savings banks (ii)		Cooperative banks (iii)		Other banks (iv)	
	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.
Lerner index (assets)	0.060***	5.455	0.049***	4.695	0.066***	5.954	0.067***	5.565
	(0.0041)		(0.0060)		(0.0066)		(0.0120)	
Operating cost	-0.395***	-1.817	-0.370***	-1.452	-0.530***	-2.563	-0.159	-0.778
	(0.0624)		(0.1284)		(0.0599)		(0.2509)	
Term spread (asset)	-0.199***	-0.198	-0.139***	-0.143	-0.161***	-0.158	-0.171*	-0.166
	(0.0237)		(0.0271)		(0.0288)		(0.0930)	
Term spread × Crisis	0.386***	0.108	0.300***	0.089	0.618***	0.171	-0.615*	-0.114
	(0.0714)		(0.0795)		(0.0771)		(0.3487)	
Excess capital	0.041***	0.254	0.040***	0.212	0.056***	0.366	-0.014	-0.079
	(0.0070)		(0.0089)		(0.0075)		(0.0199)	
Excess capital × Crisis	-0.006	-0.009	0.003	0.004	-0.016***	-0.024	0.028	0.026
	(0.0040)		(0.0069)		(0.0040)		(0.0401)	
Duration gap	0.375***	0.627	0.449***	0.714	0.520***	0.895	0.083	0.097
	(0.0464)		(0.0884)		(0.0742)		(0.1051)	
Duration gap × Crisis	-0.047	-0.017	-0.110**	-0.039	-0.041	-0.015	0.153	0.036
	(0.0323)		(0.0499)		(0.0310)		(0.1318)	
LIBOR vola	3.389***	2.185	2.355***	1.527	3.641***	2.345	3.154***	1.973
	(0.2598)		(0.2704)		(0.3861)		(0.6412)	
LIBOR vola × Crisis	-3.261***	-0.550	-2.530***	-0.439	-3.852***	-0.646	-1.687**	-0.243
	(0.2968)		(0.3122)		(0.4097)		(0.7597)	
Credit risk	0.008***	0.850	0.010***	1.069	0.005***	0.508	0.015*	1.666
	(0.0017)		(0.0018)		(0.0010)		(0.0084)	
Credit-interest covariance	-0.036***	-0.574	-0.030***	-0.476	-0.043***	-0.677	-0.027***	-0.407
	(0.0024)		(0.0024)		(0.0037)		(0.0063)	
Significance in crisis								
Term spread [p-val.]	6.532	[0.011]	5.583	[0.018]	60.32	[0]	4.594	[0.032]
Excess capital [p-val.]	22.80	[0]	19.35	[0]	35.82	[0]	0.0883	[0.766]
Duration gap [p-val.]	37.93	[0]	18.09	[0]	50.95	[0]	2.737	[0.098]
LIBOR vola [p-val.]	0.567	[0.451]	1.650	[0.199]	6.255	[0.012]	14.97	[0]
GR^2	0.868		0.896		0.891		0.661	
Underid. LM stat. [p-val.]	72.75	[0]	36.73	[0]	37.00	[0]	7.797	[0.005]
F-Test weak	97.96		62.26		37.08		5.171	

Panel B: Interest expense margin (IEM)

	Total sample (i)		Savings banks (ii)		Cooperative banks (iii)		Other banks (iv)	
	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.	Coeff.	Elast.
Lerner index (deposits)	-0.010***	-0.894	-0.017***	-1.381	-0.009***	-0.775	-0.021***	-1.957
	(0.0005)		(0.0011)		(0.0005)		(0.0039)	
Operating cost	-0.235***	-2.080	-0.582***	-3.971	-0.264***	-2.546	-0.055	-0.543
	(0.0459)		(0.0686)		(0.0211)		(0.2125)	
Term spread (liabilities)	0.009*	0.015	-0.010	-0.017	0.027***	0.045	0.010	0.018
	(0.0048)		(0.0093)		(0.0049)		(0.0528)	
Term spread × Crisis	-0.034	-0.011	-0.043	-0.014	-0.048**	-0.016	0.008	0.002
	(0.0211)		(0.0390)		(0.0231)		(0.2283)	
Excess capital	0.004	0.051	0.034***	0.326	0.002	0.020	-0.028**	-0.291
	(0.0032)		(0.0060)		(0.0028)		(0.0131)	
Excess capital × Crisis	-0.008***	-0.023	-0.022***	-0.055	-0.002	-0.005	-0.038	-0.067
	(0.0028)		(0.0051)		(0.0029)		(0.0272)	
Duration gap	0.018	0.059	-0.024	-0.069	0.036*	0.125	-0.055	-0.121
	(0.0189)		(0.0335)		(0.0192)		(0.1103)	
Duration gap × Crisis	0.050**	0.036	-0.007	-0.005	0.125***	0.093	0.205**	0.090
	(0.0214)		(0.0313)		(0.0235)		(0.0849)	
LIBOR vola	0.321***	0.401	0.674***	0.791	0.317***	0.407	0.319	0.375
	(0.0496)		(0.0610)		(0.0354)		(0.2413)	
LIBOR vola × Crisis	-0.275***	-0.090	-0.657***	-0.206	-0.486***	-0.162	-0.408	-0.110
	(0.0819)		(0.1150)		(0.0784)		(0.4426)	
Credit-interest covariance	-0.009***	-0.268	-0.014***	-0.399	-0.009***	-0.293	-0.015***	-0.440
	(0.0009)		(0.0010)		(0.0006)		(0.0051)	
Significance in crisis								
Term spread [p-value]	1.430	[0.232]	1.868	[0.172]	0.878	[0.349]	0.006	[0.939]
Excess capital [p-value]	1.203	[0.273]	3.732	[0.053]	0.004	[0.952]	5.379	[0.020]
Duration gap [p-value]	8.350	[0.004]	0.612	[0.434]	34.61	[0]	0.938	[0.333]
LIBOR vola [p-val.]	0.723	[0.395]	0.0421	[0.837]	6.887	[0.009]	0.071	[0.790]
GR^2	0.869		0.883		0.884		0.792	
Underid. LM stat. [p-val.]	91.07	[0]	173.6	[0]	561.3	[0]	8.188	[0.004]
F-Test weak	72.30		195.4		1314		6.048	
Obs.	16,396		4,479		11,524		393	
Number of synthetic banks	2,380		594		1,730		56	

Variables previously denoted *Bank-specific variables*, *Macroeconomic variables*, and *Revolving portfolios* have been included in the regressions, but are, for the purpose of brevity, not displayed. Term spread, Excess capital, Duration gap, and LIBOR vola have additionally been interacted with a crisis dummy, indicating the y ears 2008 and 2009. Significance in crisis reports values and p-values of the Wald test of the sum of the parameters of the non-interacted variable and the variable interacted with the crisis dummy (variable × crisis). All models have been estimated using fixed effects 2SLS IV regressions, where Lerner index and NII (not displayed) have been instrumented with their own first differences. Underid. gives the LM statistic and the p-value for the Kleibergen and Paap (2006) rank test of underidentification. Cragg-Donald F-test gives the Cragg-Donald statistic based on Kleibergen and Paap's rank of the matrix. Elasticities of variables are displayed on the right next to coefficients and are calculated at sample mean and multiplied by the factor 10. Elasticities have been estimated using chain rules, and have been multiplied by -1 if evaluated at a negative sample mean. Standard errors are given in parentheses and are clustered at bank level. Significance at the 10%/5%/1%-level is marked by */**/***. GR^2 is the generalized R^2 criterion of Pesaran and Smith (1994) for 2SLS IV estimation.

Table 8: Initial maturities of lender and borrower clienteles

Position	1st bracket	2nd bracket	3rd bracket	4th bracket
Assets				
Loans to banks	daily	≤ 1 y.	> 1 y. ≤ 5 y.	> 5 y.
Loans to non-banks	≤ 1 y.	> 1 y. ≤ 5 y.	> 5 y.	
Bonds held	≤ 1 y.	> 1 y. ≤ 2 y.	> 2 y.	
Liabilities				
Loans from banks	daily	≤ 1 y.	> 1 y. ≤ 2 y.	> 2 y.
Loans from non-banks	daily	≤ 1 y.	> 1 y. ≤ 2 y.	> 2 y.
Subordinated debt		no maturity breakdown		
Saving accounts	≤ 3 m.	> 3 m.		
Bonds issued	≤ 1 y.	> 1 y. ≤ 2 y.	> 2 y.	

Maturity brackets reported in the Deutsche Bundesbank's monthly balance sheet statistics for different asset and liability classes.