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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 returns from maturity transformation. Banks price interest risk according to their individual exposure separately in loan and deposit rates, but reduce these charges when they expect returns from maturity transformation. Second, using a comprehensive dataset covering the German universal banks between 2000 and 2009, we test the model-implied hypotheses not only for the commonly investigated net interest income, but additionally for interest income and expenses separately. Controlling for earnings from bank-individual maturity transformation strategies, we find all banks to charge additional fees for macroeconomic interest volatility exposure. Microeconomic on-balance interest risk exposure from maturity transformation, however, only affects the smaller savings and cooperative banks, but not private commercial banks. Returns are only priced in income margins.

Keywords: Interest rate risk; Interest margins; Maturity transformation

JEL classification: D21; G21

Non-technical summary

Banks are intermediaries between investors and entrepreneurs. They transform long-term, illiquid and risky loans into safe deposits that are due within short notice. By doing so, they take risks, for which they are remunerated. Besides, they can generate income by making use of their market power and by setting their credit and deposit conditions accordingly. In a theoretical model, we show that the bank rates are set in accordance with the costs and earnings caused by the loans and deposits. In addition, banks levy premia for credit and interest rate risk, and for the access to the capital market. We derive the following empirically testable hypotheses: The margins on the asset side should be the higher, the stronger the market power, the more volatile the interest rates and the credit risk and the greater the exposure to interest rate risk. The model also predicts that banks smooth their interest rates (relative to the interest rates observed on the capital market). Accordingly, on the liability side, we expect the same factors to have an impact, expect for the credit risk, which is here not relevant. In an empirical study of all German universal banks for the period 2000 - 2009, we obtain the following results:

1. The statements derived from the theoretical model can be confirmed in our study, in particular we find that the higher the market power the higher the interest income margin and the lower the interest expense margin.

2. The interest rate margins increase for all banks, in the event that the interest rates become more volatile. Additionally, for banks from the savings and credit cooperative sectors, we see the smoothing of bank rates that is predicted by the theoretical model.

Nichttechnische Zusammenfassung

Banken treten als Mittler zwischen Kapitalgebern und Unternehmern auf. Indem sie die langfristigen, wenig liquiden und riskanten Kredite in kurzfristig fällige Einlagen umwandeln, gehen die Banken Risiken ein, für deren Übernahme sie entlohnt werden. Daneben können die Banken Erträge erwirtschaften, indem sie ihre Marktmacht ausnutzen und entsprechend ihre Einlagen- und Kreditkondition gestalten. In einem theoretischen Modell wird gezeigt, dass sich die gezahlten und geforderten Zinssätze an den Kosten und Halteerträgen orientieren und dass die Banken Prämien für Kredit- und Zinsänderungsrisiken sowie für den Marktzugang erheben. Als empirisch testbare Hypothesen können wir Folgendes ableiten: Die Margen auf der Aktivseite sollten umso höher sein, je stärker die Marktmacht einer Bank, je volatiler die Zinssätze und das Kreditrisiko und je stärker die Bank dem Zinsänderungsrisiko ausgesetzt ist. Das Modell sagt auch voraus, dass die Banken die Zinssätze glätten (relativ zu den am Kapitalmarkt beobachtbaren Zinssätzen). Entsprechendes gilt für die Aufwandsmargen auf der Passivseite, wobei hier aber das Kreditrisiko entfällt. In einer empirischen Studie für das gesamte deutsche Universalbankensystem für den Zeitraum 2000 bis 2009 erhalten wir folgende Ergebnisse:

1. Die aus dem theoretischen Modell abgeleiteten Aussagen können in der Studie bestätigt werden, insbesondere schlägt sich eine stärkere Marktmacht in höheren Zinserträgen und geringen Zinsaufwendungen nieder.

2. Bei allen Banken erhöhen sich die Margen, wenn die Volatilität der Zinssätze steigt. Bei den Banken des Sparkassen- und Kreditgenossenschaftssektors zeigt sich zudem noch die theoretisch vorhergesagte Glättung der Zinssätze.

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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.[2] Maturity transformation evolves in most cases as a consequence of liquidity provision when fixed-rate long-term loans are financed using deposits. With term premia present in the yield curve, banks face incentives to increase maturity gaps, and thus 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 interest rates reduce the net present value of a bank's loan and deposit portfolio.

The objective of this paper is to investigate the nexus between the magnitude of banks' term transformation and the associated risk and return, their pricing policy, and finally their traditional commercial business profitability, as measured by interest margins. For our analysis, we extend the dealership model initially developed by Ho and Saunders (1981) to determine the factors that influence interest margins of banks engaging in maturity transformation. In the original Ho and 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

[1]This paper represents the authors' personal opinions and does not necessarily reflect the views of the Deutsche Bundesbank. The research for this paper was partly conducted while Benedikt Ruprecht was a visiting researcher at the Deutsche Bundesbank. He would like to thank the Deutsche Bundesbank for its hospitality and Cusanuswerk for financial support. We are grateful to the participants of the finance seminars at the Deutsche Bundesbank, Barcelona GSE, University of Liechtenstein and the PhD workshop at the 3rd Annual Conference "Global Financial Markets", Jena, the 1st Workshop "Banks and Financial Markets", Augsburg, and the 12th Symposium on Finance, Banking, and Insurance, Karlsruhe. We would especially like to thank Benjamin Böninghausen, Frank Heid, Thomas Katzschner, and Moshe Kim for helpful comments on an earlier draft of this paper, and Thomas Kick for providing data. All remaining errors are our own.

[2]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.

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. To account for the potential losses, the bank charges fees that increase with the volatility of interest rates.

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 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. Whereas banks increase interest risk premia in fees with the uncertainty of future interest rates, they are willing to offer more favorable rates when positive excess holding period returns from risk transformation activities are expected.

For the empirical analysis about the magnitude of interest risk premia in bank margins, we utilize a comprehensive dataset of the complete German universal banking sector between 2000 and 2009. Both the period of observation and the banking sample are well-suited for an analysis of the impact of maturity transformation on bank margins. The time span contains substantial variation in the yield curve, with steep and considerably flat term structures following each other. As a bank-based financial system (e.g. Schmidt et al., 1999), with the majority of liquidity provided by financial intermediaries via term transformation, German universal banks seem prone to IRR. The predominance of 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. In bank-based financial systems, on-balance IRR management is conducted more frequently compared to market-based financial systems that rely more heavily on derivatives hedging. 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. Risk management is implemented through buffer stocks of liquid assets and intertemporal smoothing of non-diversifiable risks, such as liquidity and interest risk. Intertemporal smoothing shields households from the aforementioned risks, but is clearly associated with maturity transformation and exposes banks to IRR. The ability to sustain intertemporal smoothing strategies crucially depends on the magnitude of the liquidity buffers, as other assets otherwise have to be sold below face value, as a result of valuation risk. German banking supervisory authorities, therefore, closely monitor IRR exposures (e.g. Deutsche Bundesbank, 2010), which clearly increase with the steepness of the yield curve. Savings and cooperative banks in particular have higher exposures compared with their private commercial counterparts, and income from term transformation contributes substantially to their overall net interest income (Memmel, 2011).

Having detailed supervisory data on bank assets' and liabilities' maturities, we derive more precise duration gap proxies than previous studies. Furthermore, controlling for the earnings from term transformation strategies, we are the first to empirically test the impact of the optimal loan and deposit fee determinants on the interest income and expense margins separately. In contrast, previous studies mainly focussed on investigating net profitability measures, most often the net interest margin. Proxying IRR with bank-specific duration gaps additionally to macroeconomic measures of interest rate volatility, we show that interest risk premia are priced in the interest income, expense, and net interest margins. Savings and cooperative banks' interest margins are sensitive to both risk proxies, whereas private commercial banks' margins are solely influenced by the volatility of interest rates. The influence of IRR proxies is most pronounced for interest income and less strong for expenses.

The remainder of the paper is organized as follows. Section 2 reviews the related literature on determinants of bank interest margins. In Section 3 we derive the theoretical model with differing loan and deposit maturities. An overview of the data and its institutional characteristics is provided in Section 4, where the variables used to proxy for the derived determinants are also introduced. Section 5 presents the empirical results separately first for the commonly investigated net interest margin, and then separately for the interest income and expense margin. Institutional differences in the banking sector are taken into account, investigating three different sub-samples, for savings, cooperative and other, mainly private commercial, banks. Section 6 presents concluding remarks.

2 Related literature

Ho and Saunders (1981) model a monopolistic, risk-averse[3] bank acting solely as an intermediary between lenders and borrowers of funds. Over a single-period planning horizon, the bank's

[3]For a justification of risk aversion, see McShane and Sharpe (1985); Angbazo (1997).

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.[4] 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.[5] 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.

[4]The dealership model of financial intermediation is adapted from pricing and risk management decisions of security dealers managing their inventory (Stoll, 1978; Ho and Stoll, 1981), where long and short positions of one and the same security necessarily have the same risk characteristics.

[5]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).

3 Theoretical model

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

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

Assuming the bank charges (demands) rates equalling par yields of the underlying investments, fair prices are at par every time a new transaction is initiated. They react inversely to changes in the yield curve during the decision period with rising yields causing declining prices, and vice versa. Hence, all contracts offered by the bank only pay market rates when initiated, and the cost (and profits) of financial intermediation are solely accounted for by the magnitude of the fees a, and b. As rates are inversely related to prices, mark-ups a on deposits and mark-downs b on loans correspond to a rate of return below that of a market investment for deposits, and vice versa for loans.

To illustrate bank pricing decisions, we give an example assuming an upward-sloping normally shaped yield curve. With deposit maturity being above money market maturity, they offer a higher return (par yield) than money market funds. The bank nevertheless will pay this fair interest rate of, let us say, 2% to its depositors, though it would only have to pay, e.g., 1% for money market funds. However by charging intermediation fees a of, let us say, 1.5%, i.e.

that any depositor has to hand in \$101.5 for a claim guaranteeing the repayment of \$100, the bank can decrease the rate of return paid on deposits after fees to below that of money market funds.

The bank's initial wealth portfolio at the beginning of the period W_0 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:

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

Over the planning horizon, loans generate an expected rate of return of r_L, and deposits of r_D. Returns are the market returns of the underlying bonds, disregarding intermediation fees charged.

At the end of the period, the terminal value of the loan and deposit portfolios are random due to unexpected changes in the yield curve or in default risk. Both realized returns are subject to IRR, and the loan return additionally to credit risk. The uncertainty of realized 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 interest rates, 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 and denoted r.

Managing loan and deposit portfolios generates operating cost C each period, which are monotonically increasing functions of the present 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 $E\left(W\right) = \overline{W}$ and given by:

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

When a new deposit Q_D arrives, the overall volume of deposits increases to $-(D_0 + Q_D)$. As attracting deposits equals selling securities 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, holding period returns and operating cost are negligible,[6] the increase in utility due to a new deposit inflow is:[7]

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

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:

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

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, 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

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

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

[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.

and the optimal deposit fee

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

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 expected excess holding period return has been newly derived, and originates from the bank's risk transformation functions.

- **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, $C\left(Q\right)/Q$, 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. With expected positive excess returns loan fees are reduced and deposit fees increased.

  Qualitatively, we observe the same effect for excess returns as for operating cost when a monopolistic supplier (demander) determines the profit-maximizing price in the Monti-Klein model of financial intermediation: excess holding period returns 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).

  Fama and French (1989) investigate by how far variables that capture business conditions explain expected excess returns of corporate bonds. They find that term spreads are related to shorter-term business cycle fluctuations and forecast positive excess corporate bond returns. Therefore, in the absence of credit risk, given an upward-sloping yield curve, banks are willing to reduce loan fees b as a consequence of $\left(r_L-r\right)>0$. Contrary, they increase deposit fees a as a result of $(r - r_D) < 0$ indicating negative excess returns. The default spread is related to long-term business movements and positively associated with improvements in business climate. Banks can expect decreasing default risk during times of economic upswings, resulting in, ceteris paribus, positive holding period returns.

It should be noted that the excess holding period returns do not correspond to the income generated from risk transformation activities. Such income is generated through the coupon payments of the underlying corporate and government bonds, and equals $y_L - y$, and $y - y_D$, respectively, where y denotes par yields at the beginning of the period. Taking into account the empirical findings of Fama and French, banks are willing to lower loan fees in those times when granting loans financed in the money market generates risk transformation income. For deposits at the same time the opposite holds, resulting in increased intermediation fees.

- **Risk component:** The risk component consists of the product of the bank's risk aversion 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 absolute risk aversion $(-U''/U')$ 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. For a given risk exposure, the change in risk exposure due to the new transactions is more pronounced when the volume gap of financing loans by accepting deposits is large.

  More specifically, loan fees increase with the product of 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 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.

  Focussing solely on IRR, the risk component in loan fees is strongly related to a bank's modified duration gap. The modified duration gap measures the bank-individual volume-weighted net effect of small changes in the yield curve on the bank assets' and liabilities' present values. It is therefore a measure of the interest sensitivity of the balance sheet and it captures the effect by how far the two sides offset each others' interest risk. The volatility and covariance terms proxy for the potential magnitude of shocks in the term structure. The IRR component for deposit fees is, however, linked to a reverse duration gap, as it measures the effect on deposit portfolios less the hedging ability of the loan portfolio.

In sum, loan and deposit fees are determined by the same four components introduced above. Market power and operating cost both have a positive impact on fees charged. Holding period returns and the risk component show the opposite effect on loan and 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*, defined as the sum of both intermediation fees, i.e. $s^* = a^* + b^*$,[8] its determinants are illustrated below.

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

The *pure spread* does solely encompass fees related to transaction uncertainty (Ho and Saunders, 1981) but not the premia earned from risk transformation and does not correspond to empirically observable bank margins. The risk component, thus, only captures the second moments of unexpected price changes in loans and deposits.

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 net each other and translate into $r_L - r_D$, a measure of the expected holding period returns from overall risk transformation. In the absence of changes in credit quality, this measure can be expected to take positive values in times of normally-shaped yield curves due to, in general, a positive duration gap. Hence, the bank is willing to lower overall fees when expecting holding 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. $(D_0 + L_0)$.

[8] Note that the assumption of par yield-paying underlying bonds is crucial as it eliminates bond prices from $P_D - P_L = a + b$.

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.[9] Apart from the importance of maturity transformation in bank-based financial systems, such as Germany, additional factors favor the sample.

First, 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. However, 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.[10] 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 (Memmel, 2011), whereas fee, and especially trading income are of only limited importance. Savings and cooperative banks access capital markets in general not independently, but mainly through their head institutions. With regard to on-balance sheet IRR management, Ehrmann and Worms (2004) find that interbank lending networks allow the affiliated institutions to pass part of their exposure on to the head institutions via interbank lending. Additionally, the head institutions provide liquidity to their associated banks and shield them from monetary contraction so that we do not observe drastic duration adjustments during times of monetary tightening.

Second, 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. Furthermore, 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

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

[10] Investigating U.S. commercial banks, Purnanandam (2007) finds that small banks manage IRR less frequently via derivatives, but on-balance by adjusting their maturity gap to interest rate changes. Kashyap and Stein (1995) find that bank size is an important determinant how far a bank can shield itself from monetary shocks.

and Fernández de Guevara (2004); Claeys and Vander Vennet (2008) - except for Carbó and Rodríguez (2007), who have a slightly bigger sample size).

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 interest income margin (IIM), (ii) the interest expense margin (IEM), and (iii) the net interest margin (NIM), where interest-earning assets, interest-paying liabilities, and total assets have been chosen as denominators. Explanatory variables are, if not otherwise mentioned, quotas in relation to the same denominator as the dependent variable investigated, where differing denominators are displayed as "total (interest-bearing) assets (liabilities)".

It should be noted that these dependent variables do not correspond to proxies for the optimal fees. 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, i.e. $y_L + b^*$, and the par-yield coupon payment of a shorter-term default-free government bond less the deposit fee, i.e. $y_D - a^*$, respectively. This gives two implications for our empirical research. First, we need to control for coupon payments of fairly-priced market transactions, as they contain the expected premia the bank charges for its risk transformation functions. Second, we see that interest expenses and the deposit fees a^* derived from the model are negatively linked. Hence, empirical proxies for deposit fee determinants 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. 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.]

The following sub-sections describe the variables proxying for the determinants derived from the model, additional bank-specific and macroeconomic control variables, and revolving portfolios controlling for a bank's asset and liability maturity structure.

4.2.1 Model-derived variables

Market power: *Lerner indices* are included to capture banks' ability to exercise market power from facing inelastic demand for loans and supply of deposits. 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).[11] 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

[11]See Appendix A for more details on the estimation of Lerner indices.

and proxied as interest income in relation to interest-earning assets, and therefore identical to the IIM. Equity is included as a netput.

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). Operating expenses are expected to have a positive influence on intermediation fees. However, banks' operating expenses are likely to also include cost due to inefficiency and those not related to activities of financial intermediation.

Expected excess holding period returns: Theoretically derived *expected excess holding period returns* cover returns from total risk transformation. In line with previous research, we will, however, ignore credit risk and focus on excess holding period returns in "default-free" government bonds. Campbell and Ammer (1993) show that the continuously compounded yield on n-period pure discount bonds consists of three components: n-period averages of (one-period) real rates, inflation rates, and maturity premia in the yield curve. Ilmanen (1995), therefore, proposes to use *term spreads* as instruments to forecast future excess returns.[12]

In order to capture bank-individual term transformation characteristics, we employ proxies for duration-implied expected excess returns. The maturity of the money market accounts is always proxied using 6-month par yields. Asset and liability par yields are estimated bank-individually using quarterly discretization of their asset and liability maturity. Therefore, the *asset and liability term spreads* are the difference between the duration-implied yield minus the 6-month par yield, and the *asset-liability term spread* is the difference between the duration-

[12] 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 for maturities ranging from one to five years.

implied asset and liability par yields. Drawing on the empirical finding that excess returns are positively linked to term spreads, we expect loan fees a^* in Equation (11) to be reduced, and deposit fees b^* in Equation (10) to rise with increasing term spreads. This translates into expected negative effects on all three bank margins to be examined.

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 risk levels, a point already stressed by Gambacorta and Mistrulli (2004), capital in excess of minimum regulatory requirements, or in short *excess capital*, seems in general a more adequate proxy for risk aversion.

In a study investigating loan and deposit rates, rather than bank margins, Gambacorta (2008) finds well capitalized banks adjust loan rates less drastically than lower capitalized counterparts, which in return face a higher decline in loan volume (Gambacorta and Mistrulli, 2004). As interest margins capture joint effects of volume and rates charged, no direct conclusions for the impact of excess capital on bank margins can be drawn. From a theoretical point, excess capital should be related to higher interest income and lower expenses.

Interest rate risk: Previous studies, based on models with the assumption of equal loan and deposit maturity, modelled IRR only as the volatility (or variance) of specific interest rates (Ho and Saunders, 1981; Saunders and Schumacher, 2000; Maudos and Fernández de Guevara, 2004; Maudos and Solís, 2009). Angbazo (1997), on the contrary, applies an on-balance sheet interest risk measure, 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 (Flannery and James, 1984). 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. Using the information on volumes and maturities of different lender and borrower types, we calculate modified *duration gaps* to proxy for on-balance IRR.[13] An important issue when modelling IRR is the effective maturity assigned to de facto non-maturing savings deposits, as 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 (see also Purnanandam, 2007), and the other half is assigned its legal maturity. Revisiting the fact that the IRR in deposit

[13]For the different lender and borrower clientele maturity brackets and the calculation of modifies maturity gaps, see Appendix B.

fees in Equation (11) is defined as interest risk in liabilities minus the asset side hedge, the duration gap proxy is expected to lead to lower fees a^* charged, corresponding to higher interest expenses. 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, ultimately leading to higher expenses, instead of refinancing themselves cheaper on the money market.

Gambacorta and Mistrulli (2004), and Gambacorta (2008) employ a similarly detailed IRR measure based on maturity ladders of different assets and liabilities. Examining loan volume, Gambacorta and Mistrulli find banks operating with higher duration gaps are more vulnerable to reducing lending as a consequence of monetary shocks. Focussing on short-term rates, Gambacorta finds, in line with the predictions of our model, that a bank's IRR is indeed positively linked to increases in lending rates, but, against our prediction, negatively to deposit rates. Effects on lending rates are, however, stronger than those on deposits, supporting the prediction that net interest income is positively affected.

The previous authors base their findings on the impact of maturity transformation on the bank capital channel (van den Heuvel, 2002). Banks with larger maturity gaps are more vulnerable to positive interest rate shocks and suffer from drops in interest income as proportionally more liabilities have to be refinanced at higher rates. This constrains future capital accumulation and leads to reduced lending in the case that equity becomes sufficiently low. Therefore, banks with higher maturity gaps are supposed to increase lending rates and decrease deposit rates more drastically.

In addition to duration gaps, we also include the annual *volatility of weekly 6-month LIBOR rates* to proxy for the magnitude of unexpected changes in the prices of the underlying securities. As our model contains two IRR sources that offset one another via covariance terms, it cannot directly be derived how the change in a single risk source affects margins from a theoretical point of view. From an empirical perspective, higher volatility should align with higher rates charged and paid, and, as previous studies documented (Gambacorta, 2008), higher NIMs.

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 (RWA) 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.

Credit-interest correlation (CI-corr): 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 (CI-corr). 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 the term premia charged in the yield curve using revolving portfolios, as income from term transformation contributes substantially to German banks' net interest income (Memmel, 2011).

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 net provision income (Lepetit et al., 2008).[14] Cross-selling assumes that banks are willing to forego traditional interest generating income for *non-interest income (NII)*, mainly provisions.

Implicit interest payments (IIP): We also include a proxy for *implicit interest payments (IIP)* 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

[14] 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.

in Germany, only below market rates. As these reserves implicitly increase the cost of funding by foregone interest income, they are likely to be priced into deposit rates. A 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, 2009) 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 the theoretical fees charged do not correspond to (net) interest income and expenses, we need to control for the risk premia earned through coupon payments. Ignoring the credit risk premia charged in loans, which are controlled for by the credit risk variable, we apply Memmel's (2008) approach to proxy for the interest income and expenses generated from coupon payments of passive investment strategies in government bonds. We use the information on different maturity brackets employed to generate duration gaps and the yield curve of German government bonds to capture the variation in banks' interest income and expenses. Assuming (i) stationary business models, where assets and liabilities due are always replaced with funds of identical maturity, and that (ii) business volume has been generated equally over the past, the interest income and expenses from market transactions can be modelled as revolving portfolios of moving averages of past government par yields.[15] These portfolios capture both bank-individual balance sheet maturity characteristics and the shape of the yield curve when contracts have been initiated and model potential earnings from passive term transformation strategies.[16] This approach is intended to capture the effect of controlling for changes in the level of interest rates by including a monetary policy indicator, as conducted in Gambacorta's (2008) study.

[15] See Appendix C for the creation of revolving portfolios for different lender and borrower clienteles and further assumptions made for modelling par yields.

[16] Memmel (2011) proves the ability to explain the time series behavior of changes in the internally calculated interest risk exposures of German commercial banks using revolving portfolio strategies.

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 sample. Average total assets are EUR 1,017 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 substatially larger duration gaps. As other banks have the highest net intest income though they are less heavily involved in term transformation seems to make them earn interest income through credit risk premia. And indeed, other banks have 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) - the difference between interest income and interest expenses divided by total assets - as a widely used measure of commercial banks' core business profitability.[17] Empirical findings have been compared to the 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 loan and deposit pricing separately. We are the first to examine the influence of different factors on the interest income margin (IIM) - defined as interest income divided by interest-earning assets - and the interest expense margin (IEM) - defined as interest expenses to interest-paying liabilities. The reduced form regression equation of the model is given by:

$$BM_{it} = \alpha_i + \sum_{j=1}^{J} \beta^j TM_{it}^j + \sum_{k=1}^{K} \gamma^k BS_{it}^k + \sum_{l=1}^{L} \delta^l ME_t^l + \sum_{m=1}^{M} \eta^m RP_{it}^m + \varepsilon_{it} \tag{13}$$

for $t = 1, ..., T$, indicating the time period, and $i = 1, ..., N$ as the number of banks in the sample.[18] BM is the bank margin examined and will be one of the three bank margins introduced. TM refers to a 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 predicted to influence the theoretically derived optimal intermediation fees. ME represents macroeconomic variables with a common influence on bank margins. Finally, RP represents a vector of revolving portfolios included to capture a bank's income from balance sheet-specific maturity transformation strategies.

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

[17]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.

[18]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 premia, the single-step approach seems more adequate. It allows the revolving portfolios and the variables proxying for the interest risk in the intermediation fees to be correlated.

they should now explain, we instrument Lerner indices with their own first difference. Furthermore, non-interest income 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. Stock and Yogo (2005) tabulate the critical value for a test with two endogenous regressors based on homoskedastic standard errors that the maximum bias between the OLS and 2SLS estimates is 5% to be 11.04. 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 derived from our theoretical model, namely the bank's market power, its operating costs, its expected excess holding period returns, its risk aversion, its interest rate risk and its credit risk, and the correlation between these two risks.

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. 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.

The impact of variables related to interest rate risk and returns have to be interpreted as fee charged after controlling for the earnings from term transformation with "revolving portfolios”.[19] For the term spread included as an instrument for excess returns from term transformation, we find the expected negative coefficients. However, this effect is economically not so relevant: about a 4 basis points reduction for 100 basis points change in the term spread. The coefficient is only found 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 term transformation.

In a similar vein, also the interest risk proxies have to be interpreted as additional net interest income in surplus of the term transformation income. Here 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. During a period from 2005-2009, Memmel (2011) estimates the income generated from term 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. 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.

In contrast to the microeconomic bank-individual exposure to interest rate shocks, the macroeconomic magnitude of shocks, as proxies by LIBOR volatility, 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,

[19] As the reported maturity brackets for assets and liabilities, unfortunately, do not have matching maturities, we cannot create net revolving portfolios for every single bracket used in explaining income and expenses. Therefore, we create 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.

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 correlation between interest and credit risk is positive, but only of limited economic magnitude.

[Table 3 about here.]

5.3 Separation of interest income and interest expenses

Examining the interest income margin (IIM, for results see Table 4) and the interest expense margin (IEM, for results see Table 5) separately reveals which balance sheet side, loans or deposits, drives the results discovered in the NIM. When we run the regressions separately for the IIM and the IEM, respectively, the share of explained variation (the generalized R^2) increases relative to the regression for the net interest margin, from around 0.54 to 0.87 in both cases.

Lerner indices are significant for interest income as well as for interest expenses, indicating that market power is relevant for both, the pricing of the loan rates as well as the bank's funding. Comparing the magnitude of the coefficients and elasticities, we see that the market power has a much greater impact on the asset-side than on the liability side.

By contrast, operating costs seem to be solely priced on the liability side, not on the asset-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 all other banks) on the liability side.

The term spread, as an indicator by how far banks price expected excess holding period returns from term transformation, does only reveal 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 rates by 15 basis points for a 100 basis point steepness in the yield curve. For liabilities, in contrast, we find the opposite of the expected effect and observe positive coefficients, though only significant for the subsample of cooperative banks. Similar effects can be observed for the pricing of on-balance interest rate risk after controlling for earnings from term transformation. Though we find the expected positive coefficients both in interest income and expenses, these are significant for all samples in the IIM, but again only for cooperative banks in the IEM. Macroeconomic interest rate volatility is priced by all banks in interest income and expenses, except for other banks in the case of the IEM. In his study Gambacorta also found that interest rate volatility influences both, loan and deposit rates significantly positive, and that the impact on loan rates is bigger than that on deposit rates. In contrast to our results, his interest rate risk measure, however has a significantly negative effect on deposit rates.

Concerning a bank's risk aversion (measured by its excess capital), it seems as if there is only an impact on the interest income, not on the interest expenses. Gambacorta (2008) finds that high endowments of excess capital lead to significantly different loan rate adjustments, however not for deposit rates. The other explanatory variables derived from our theoretical model have the expected sign and are significant, at least in the sample of all banks. Note that the theoretical model predicts that the correlation of credit and interest rate risk has an impact on the interest expenses (the theoretical argument is based on risk hedging considerations). The correlation between interest and credit risk is significantly negative for both, income and expenses. 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.

Summarizing, we find especially for interest income the proxies for the theoretical determinants to have significant impact, and therefore the loan fee determinants to drive the results discovered for the net interest income.

[Table 4 about here.]

[Table 5 about here.]

5.4 Robustness checks

In this section, we present some robustness checks on the results outlined above.[20] First, we examine bank margins when revolving portfolios have not been included as control variables for earnings from term transformation. Explanatory power decreases: for the overall sample, it drops to 0.674 for the IIM, and to 0.643 for the IEM (compared with 0.869 in both cases before). Investigating the NIM, excluding the three net revolving portfolios does neither change explanatory power significantly, nor the qualitative results obtained or the significance of the coefficients derived. This explains previous authors' results that all do not control for term transformation earnings in line with the initial model of Ho and Saunders where assets and liabilities have identical maturity.

However, for interest income and expenses the results for variables related to interest risk and returns do change drastically. Whereas the impact of LIBOR volatility is overestimated,

[20] Results are available from the authors upon request.

some coefficients of the microeconomic on-balance risk proxies using the modified duration gap and for the expected excess returns change their sign. The effect of interbank volatility increases by 6 times for expenses, where the moving averages of government bonds seem to have captured part of the effect of changes in interbank rates.

With regard to the effect of the duration gap, we find significantly negative impact on both, income and expenses. These effects are highly significant in all samples, including other banks. Similarly, the coefficients for term spreads switch from negative to positive effects for both, interest income and expenses, although these effects are insignificant in most samples investigated. Moreover, also the the coefficients for the risk aversion partly change their estimated signs, and become negative significant for both, income and expenses in most samples.

We can thus conclude that not controlling with revolving portfolios would lead to a substantial omitted variable bias for all those variables directly (duration gap and term spreads) or indirectly related (excess capital as a risk aversion proxy that can only be interpreted jointly together with the risk component) to interest risk and returns.

Another point of concern is the impact of the financial crisis. Therefore, we repeat the regressions for a time period from 2000 to 2007, and exclude the crisis years 2008 and 2009. Results stay qualitatively the same for the IIM, except for operating cost that lead to economically significant lower interest income for savings and cooperative banks. The magnitude of the micro and macroeconomic interest risk premia become more pronounced. Coefficients for LIBOR volatility increase by more than the factor 3, the coefficients for duration gaps increase by the factor 1.5.

For expenses, the coefficients for LIBOR volatility triples. For the effect of the duration gaps we observe, again, switched coefficients signs. The effect becomes insignificant for cooperative banks, but turns negative significant for savings banks, as predicted by Gambacorta (2008). Additionally, we also observe such an effect for the risk aversion proxy, and additionally to cooperative banks we find also for savings banks a positive significant effect against the predictions of our model.

Results for the NIM remain unchanged, except that the coefficients for the term spread all turn insignificant, though they keep their magnitude and significance when income is investigated separately.

In normal times, although predicted by the model, banks seem not to be willing to pay higher expenses for liabilities that reduce the duration gap, and the overall effect becomes only visible when the years of the financial crisis are taken into account. This effect is likely to be due to the attempt of banks to attract deposit inflows after the Lehman default with record high rates. The higher coefficients for interbank volatility are a direct result from the inability of banks to price the turmoil in the money market, especially when one considers that the majority of interest-bearing business has been initiated during times of moderate volatility. Therefore, the current effect of increased interbank volatility will not be reflected in interest income and expenses. Also with regard to passing expected holding period returns on to customers seems less likely during normal times with stable refunding sources.

6 Concluding remarks

In this paper, we analyze how interest risk premia and other risk components are priced in bank margins. 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 risk. 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 measures of unexpected changes in interest rates as well as microeconomic measures of bank-specific exposure to this risk.

We test the model-implied hypotheses for a broad sample of the German commercial banking sector, a bank-based financial system in which term 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 expenses separately. Our main finding is that interest risk premia are priced in both interest income and expenses after controlling for the earnings that arise from bank-specific maturity structure. Private commercial banks, that have direct access to capital markets, charge and pay higher income and expenses only as a consequence of the volatility in interbank rates. These banks seem, therefore, only sensitive to the refinancing interest risk introduced by the original Ho-Saunders model. On the contrary, savings and cooperative banks' interest income and expenses are additionally sensitive to the microeconomic on-balance interest risk measures, capturing the valuation risk introduced by our model. Interest risk premia are most pronounced in (net) interest income, whereas banks are only willing to reduce fees in expenses during times of funding turmoil like the 2008-2009 financial crisis.

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):

$$\frac{i^*{}_L - i - mc\ _L}{i^*{}_L} = \frac{1}{N\epsilon\ _L\,(i^*{}_L)}; \qquad \frac{i - i^*{}_D - mc\ _D}{i^*{}_D} = \frac{1}{N\epsilon\ _D\,(i^*{}_D)} \tag{A.4}$$

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.[21] 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:

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

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

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

[21] 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 Duration gaps

Table 6 gives an overview of the different lender and borrower clienteles and the time brackets reported in the Deutsche Bundesbank's monthly balance sheet statistics.

[Table 6 about here.]

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

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

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)

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

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 $r = 0$, equation (B.2) becomes

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

and equation (B.3)

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

The asset's (liability's) modified duration $D_{mod}(A)$ ($D_{mod}(L)$) is calculated using equations (B.4) and (B.5) employing weighted sums of all brackets of assets (liabilities) reported in Table 6. The weights correspond to the proportion of assets (liabilities) in a given bracket relative to total interest-bearing assets (liabilities). The duration gap is derived as

$$D_{gap} = D_{mod}(A) - D_{mod}(L) \frac{\text{total interest-earning liabilities}}{\text{total interest-paying assets}}. \tag{B.6}$$

Appendix C Revolving portfolios

For each single entry of borrower and lender clienteles and maturities in table 6 we calculate a separate revolving portfolio.

The following assumptions were made for building revolving portfolios (see Memmel, 2008):

- 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).

We use intervals of 6 monthes to calculate different revolving portfolios. A revolving portfolio of maturity T consists of investing the share of $1/T$ in such bonds every month. Using bonds that pay monthly par yields y, the annual income from such a strategy $Z_t(T)$ at year-end t, as bank's interest income and expenses can only be observed at that frequency, is the sum of the last 12 monthly coupon interest payments, and can be written

$$Z_t(T) = \frac{1}{12\ T} \sum_{i=0}^{11} \sum_{j=0}^{T-1} y_{t-1-i-j}(T). \tag{C.1}$$

We derive revolving portfolios for all of the above-stated maturity brackets under the assumption that they consist of equally weighted shares of 6-month intervals, e.g. the bracket with maturities up to one year is modelled to encompass 50% 6-month revolving portfolios and 50% 12-month portfolios.

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Tables

Table 1: Variable description

<table>
<tr><th>Variable</th><th>Proxy</th><th>Pred. coeff.</th><th>Use in other studies</th></tr>
<tr><td>Model-derived variables</td><td></td><td></td><td></td></tr>
<tr><td>Market power</td><td>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)</td><td>(+|-|+)</td><td>Maudos and Fernández de Guevara (2004); Maudos and Solís (2009)</td></tr>
<tr><td>Operating cost</td><td>Operating expenses / total (interest-bearing) assets (liabilities)</td><td>(+|-|+)</td><td>Maudos and Fernández de Guevara (2004); Maudos and Solís (2009)</td></tr>
<tr><td>Expected excess holding period returns</td><td>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</td><td>(-|-|-)</td><td>Not used before</td></tr>
<tr><td>Risk aversion</td><td>Excess capital: (Regulatory capital - 0.08 × risk-weighted assets) / total assets</td><td>(+|-|+)</td><td>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)</td></tr>
<tr><td>Banks-specific IRR exposure</td><td>Duration gap: asset duration - liability duration × interest-paying liabilities / interest-earning assets</td><td>(+|+|+)</td><td>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)</td></tr>
<tr><td>Macroeconomic IRR magnitude</td><td>LIBOR volatility: annual standard deviation of the weekly observed 6-month LIBOR rate</td><td>(+|+|+)</td><td>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.</td></tr>
<tr><td>Credit risk</td><td>RWA / total assets</td><td>(+|nu|+)</td><td>Not used before</td></tr>
<tr><td>Credit-interest-spread correlation (CI-corr)</td><td>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</td><td>(?|+|?)</td><td>Not used before</td></tr>
<tr><td>Bank-specific variables</td><td></td><td></td><td></td></tr>
<tr><td>Non-interest income (NII)</td><td>net fee income / total (interest-bearing) assets (liabilities)</td><td>(-|+|-)</td><td>Carbó and Rodríguez (2007); Maudos and Solís (2009)</td></tr>
<tr><td>Implicit interest payments (IIP)</td><td>(non-interest expenses - non-interest income) / total (interest-bearing) assets (liabilities)</td><td>(+|-|+)</td><td>Ho and Saunders (1981); Angbazo (1997); Saunders and Schumacher (2000); Maudos and Fernández de Guevara (2004); Maudos and Solís (2009)</td></tr>
<tr><td>Opportunity cost of reserves (OCR)</td><td>(cash + deposits with central banks) / total (interest-bearing) assets (liabilities)</td><td>(?|+|-)</td><td></td></tr>
<tr><td>Macroeconomic variables</td><td></td><td></td><td></td></tr>
<tr><td>GDP growth</td><td>annual real GDP growth rate</td><td>(?|?|?)</td><td>Carbó and Rodríguez (2007); Claeys and Vander Vennet (2008); Albertazzi and Gambacorta (2009); Maudos and Solís (2009)</td></tr>
<tr><td>Inflation rate</td><td>annual growth rate of consumer price index</td><td>(?|?|?)</td><td>Demirgüç-Kunt and Huizinga (1999); Claeys and Vander Vennet (2008); Maudos and Solís (2009)</td></tr>
<tr><td>Revolving portfolios</td><td>Balance sheet proportion of several lender (borrower) clienteles and maturity brackets × the moving average of par yield government bonds</td><td>(+|+|nu)</td><td>Memmel (2008) explains interest income and expense margins with revolving tracking bank portflios</td></tr>
</table>

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 correlation (CI-corr)	-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
Maroeconomic 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)	
CI-corr	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)	
CI-corr	-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)	
CI-corr	-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: 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.	

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