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Quantifying the components of the banks' net interest margin

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Non-technical summary

Research Question

The net interest income is for the majority of banks in Germany the by far most important source of income. In this paper, we investigate how the bearing of credit risk, term transformation and the liquidity and payment management for its customers contribute to the net interest income.

Contribution

The above mentioned functions and their potential impact on a bank's net interest income are well documented in the empirical literature. However, little is known about the concrete value of the different contributions to the net interest income. In this study for the year 2012, we carry out a quantification of the different components of the net interest income of the banks in Germany. The idea is to estimate the costs (including opportunity costs) of performing the above mentioned functions. We assume that in the long run earnings equal costs and we apply these costs as the contributions to a bank's net interest income.

Results

For the median bank nearly half of the net interest income (47%) is due to the payment and liquidity management for the customers. More than one third (35%) of the net interest income stems from term transformation and 16% of the net interest income results from bearing credit risk. Other contributions to the net interest income can be due to a difference in the volumes of interest bearing assets and liabilities and due to a bank's strong market position.

Nicht-technische Zusammenfassung

Fragestellung

Der Zinsüberschuss ist für das Gros der deutschen Banken die mit Abstand wichtigste Einkommensquelle. In diesem Papier wird untersucht, wie das Tragen von Kreditrisiken, die Fristentransformation und das Zahlungs- und Liquiditätsmanagement für die Kunden zum Zinsüberschuss beitragen.

Beitrag

Die oben beschriebenen Funktionen und deren potentieller Einfluss auf den Zinsüberschuss einer Bank sind in der empirischen Literatur gut dokumentiert. Wenig ist allerdings über die konkrete Größe der einzelnen Beiträge zum Zinsüberschuss bekannt. In dieser Studie wird für das Jahr 2012 eine quantitative Zerlegung des Zinsüberschusses für deutsche Banken durchgeführt. Die Idee ist, für jede der oben beschriebenen Funktionen die dabei entstehenden Kosten (einschließlich Opportunitätskosten) abzuschätzen. Unter der Annahme, dass langfristig die Erträge den Kosten entsprechen, werden diese Kosten dann als Beiträge zum Zinsüberschuss einer Bank angesetzt.

Ergebnisse

Auf das Zahlungs- und Liquiditätsmanagement für die Kunden entfällt für die durchschnittliche Bank fast die Hälfte des Zinsüberschusses (47%). Aus der Fristentransformation stammt für die durchschnittliche Bank gut ein Drittel des Zinsüberschusses (35%) und aus dem Übernehmen von Kreditrisiken 16% des Zinsüberschusses. Andere Beiträge zum Zinsüberschuss können dadurch entstehen, dass sich zinstragende Aktiva und zinstragende Passiva nicht genau entsprechen oder dass eine Bank eine starke Markstellung hat.

Quantifying the Components of the Banks' Net Interest Margin¹

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Abstract

Using unique data sets on German banks, we decompose their net interest margin and quantify the different components by estimating the costs of the various functions they perform. We investigate three major functions: namely, liquidity and payment management for the customers, the bearing of credit risk, and term transformation. For the year 2012, the costs of liquidity and payment management correspond, in the median, to 47%, the bearing of credit risk to 16%, and earnings from term transformation to 35% of the net interest margin, respectively. However, looking at the period 2005-2012, earnings from term transformation seem to account for a much smaller share (about 20%) of the median bank's net interest margin.

Keywords: Net interest margin, credit risk, term transformation, liquidity and payment management

JEL-Classification: G21

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1 Introduction

For most banks, the net interest margin is by far the most important source of income. At the same time, seen from the perspective of the real economy, the banks' net interest margin is considered to be the cost of financial intermediation. In this context, the net interest margin is the wedge between what the borrowers have to pay for their loans and what the ultimate lenders actually receive. The aim of this paper is to account for both perspectives. For this purpose, we decompose this important economic variable, thereby helping to gain a better understanding of the banks' intermediation functions. The main issue we want to address in this paper is the quantification of the components of the banks' net interest margin.

We investigate banks' major intermediation functions: namely, the bearing of credit risk, term transformation, and liquidity and payment management for their customers. The idea behind our approach is to estimate the costs associated with performing these functions. Under the assumption that, at least in the long run, costs are covered by earnings, we assume that the earnings from performing the various functions can be derived from the respective costs.

Banks grant loans which are subject to the risk of default. Banks carefully select and monitor their borrowers. Nevertheless, some of these borrowers cannot make their interest payments and are unable to pay back their debts. This is especially true of risky loans which have been given to firms in cyclical industries or which are not well collateralized. In this paper, we not only take into account the expected losses of the credit exposure, but also estimate a credit risk premium. Moreover, banks hold bonds which also expose them to credit risk and should therefore earn them a decent remuneration.

The banks' term transformation consists in granting long-term loans and taking in short-term deposits. As the term structure of interest rates tends to increase with maturity, term transformation is advantageous for banks. However, if the interest rate level rises, banks' earnings from term transformation decrease because rising interest rates usually have a greater impact on funding costs than on interest income. These differences in impact are due to the fact that the maturities of banks' liabilities are usually shorter than the maturities of their assets. This means that within a given time span of, say, one year,

the share of liabilities that has to be renewed at what are now unfavorable conditions is larger than the new business on the asset-side which benefits from the more favorable interest rates.

Another main function of banks is to perform liquidity and payment management for their customers. They carry out money transfers for their customers, they provide cash in the ATMs, and they enable their customers to store their money. This function also includes the administrative expenses when customers take out a loan. Often, customers do not pay directly for these services, but pay for them indirectly in terms of reduced interest rates on their deposits and mark-ups on the loans. For instance, customers' money placed in current accounts is remunerated only at a low rate (if at all), whereas the remuneration of time deposits is geared to capital market rates.

Most papers that deal with banks' net interest margin derive qualitative statements: for instance, that a bank's market power is positively correlated with its net interest margin. By contrast, our paper aims at making quantitative statements: for instance, that the earnings from term transformation account for a certain percentage of a bank's net interest margin.

A bank's bearing of credit risk is the function that receives the most attention, especially in academia. Term transformation is also an often-discussed issue, perhaps because of its intuitiveness and owing to bank failures caused by excessive term transformation. Surprisingly, in our empirical study, neither the bearing of credit risk nor the earnings from term transformation are the most important sources of a bank's net interest income. Instead, liquidity and payment management for the bank's customers turns out to be the most important source. In our study for the German universal banks, we show that, in 2012, liquidity and payment management account for 47% of a bank's net interest income, followed by earnings from term transformation (35%) and by the bearing of credit risk (16%), respectively.

The paper is structured as follows. In Section 2, we briefly review the literature in this field and state our contribution. Section 3 is about the banks' functions and how we quantify their contribution to the banks' net interest margin. In Section 4, we describe the data and Section 5 gives the empirical results. Section 6 concludes.

2 Literature

There is a vast amount of literature on the banks' net interest margin. In principle, this literature can be divided into three strands. The first is about bank characteristics and market conditions that qualitatively explain the banks' net interest margin. Starting with a dealership model, which goes back to Ho and Saunders (1981), banks are considered as risk-averse dealers between depositors and borrowers of funds. This model has become fundamental in designing empirical models that explain how banks set their interest rate margins. Theoretical refinements have been suggested during the intervening period. Examples of these are Angbazo (1997), Mc Shane and Sharpe (1985), Maudos and Fernández de Guevara (2004), Carbó and Rodríguez (2007) and Entrop, Memmel, Ruprecht, and Wilkens (2012). Their studies extend the basic model by introducing, for example, credit risk, interaction between credit and interest rate risk, term transformation, uncertainty with respect to money market rates and the role of non-interest income business. Furthermore, Maudos and Fernández de Guevara (2004), and Saunders and Schumacher (2000) highlight administrative costs as a major determinant of the banks' interest margin. In addition, there are empirical papers that analyze the banks' net interest margin without a theoretical model for deriving the determinants; for example, English (2002), Memmel and Schertler (2013) and Gunter, Krenn, and Sigmund (2013). By contrast, as stated earlier, we do not try to find further determinants of the net interest margin, but to quantify the different contributions made by performing the banks' intermediation functions.

The second strand of literature deals with the pass-through of capital market interest rates to bank rates, which has been extensively discussed in the literature (e.g. De Bondt, 2005; ECB, 2009; Weth 2002; Schlüter, Busch, Hartmann-Wendels, and Sievers, 2012). While most of this literature is about the question of how completely and rapidly banks adjust their rates to changes in market rates, some of these papers analyze the determinants of interest pass-through parameters. By contrast, our interest in the speed of the banks' pass-through is that this speed is one key determinant of the bank's term transformation: Banks with a strong market position are able to have a large gap between the legal and the actual maturity of the deposits. Using data on banks' own assessment of their exposure to interest rate risk, we do not have to estimate how

quickly a single bank adjusts its rates to changes in the market rates, but can make use of this interest rate risk exposure data.

The third strand is about the quantification of different components of the net interest margin. Memmel (2011) performs this quantification for the German banks' term transformation. While we make use of the same technique, we quantify all components of the net interest margin, not only the term transformation. Costa and Nakane (2005) provide a quantitative decomposition of Brazilian banks' lending spread, i.e. the difference between the loan rate and a maturity equivalent swap rate. They concentrate on the modeling of the administrative costs related to loan granting. By contrast, we try to extract the entire costs associated with a bank's interest income-generating activities, especially the costs of the customers' liquidity and payment management. In addition, the authors neglect – by definition – the contribution of term transformation (because this component is not included in the lending spread), and model the costs due to loan losses in a rather elementary way. For Macedonia, Georgievska, Kabashi, and Manova-Trajkovska (2011) examine the difference between a bank's lending rate and its deposit rate, which is close in economic terms to the net interest margin. They quantitatively decompose this difference, but their modeling is rather elementary and they also neglect the role played by term transformation. Our contribution is to undertake a thorough modeling of all major components of the banks' net interest income and to use very suitable data sets on German banks.

3 Decomposing the net interest margin

In this section, we explain how we measure the costs and earnings of the various intermediation functions; namely, the bearing of credit risk, term transformation, and liquidity and payment management for the customers. In addition, we discuss technical adjustments of the net interest margin.

3.1 Credit risk

We can divide the cost of bearing credit risk into two components. The first consists of the expected losses in the credit portfolio. The second is the premium for bearing this risk.

We assume that the expected loss rate of a loan depends on the loan's initial maturity and the industry of the borrower. We further assume that the expected loss rates are time-dependent and that a bank uses the then prevailing expected loss rates when it sets the rates that it charges for newly granted loans. Therefore, the contribution to a bank's net interest margin that covers the expected losses in the bank's credit portfolio is a weighted average of past and current expected loss rates for different maturities and industries. For the estimation of this contribution, we divide a bank's credit portfolio into different industries and maturity brackets. The breakdown is such that we can optimally use the information included in the Bundesbank's borrowers statistics (See Section 4). Let $\mu_{t,j,k}$ be the expected credit loss rates in time t for industry $j = 1, \dots, 28$ and maturity bracket $k = 1, 2, 3$ and let $w_{t,i,j,k}$ be the corresponding weights in the credit portfolio of bank i . Given the expected losses in the credit portfolio are fully taken into account when loan rates are set, the contribution to a bank's net interest income due to expected losses (in euro) in the credit portfolio $E(L_{t,i})$ of bank i in time t can then be expressed as

$$E(L_{t,i}) = loan_{t,i} \cdot \left(\sum_{j=1}^{28} w_{t,i,j,1} \cdot h_{0,1} \cdot \mu_{t,j,1} + \sum_{j=1}^{28} w_{t,i,j,2} \cdot \left(\sum_{l=0}^4 h_{l,2} \cdot \mu_{t-l,j,2} \right) + \sum_{j=1}^{28} w_{t,i,j,3} \cdot \left(\sum_{l=0}^7 h_{l,3} \cdot \mu_{t-l,j,3} \right) \right) \quad (1)$$

where $loan_{t,i}$ is the bank's credit volume in time t and $h_{l,k}$ is a function to weigh the current ($l = 0$) and past ($l > 0$) expected loss rates making use of the information about the loans' different initial maturities (See the section A.1 in the appendix and Table 1).² The first maturity bracket ($k = 1$) encompasses the loans with an initial maturity of up to one year, the second bracket those with an initial maturity of more than one and up to five years, and the third bracket contains loans with an initial maturity of more than five years, where we assume, for reasons of data availability, that there is no loan with an initial maturity of more than eight years. The expected credit loss rates $\mu_{t,j,k}$ are estimated as the three-year average of the actual corresponding nationwide loss rates. We use a three year horizon (instead of the loss rate in a given year) to reduce the noise in the estimation.

² Bolt, de Haan, Hoerberichts, van Oordt, and Swank (2012) also model the banks' net interest margin as a function of past and current interest rates and expected loss rates. However, their dataset is much less granular (no maturity breakdown and no industry breakdown), so that they have to strongly rely on simplifying assumptions.

Maturity bracket k		Function $h_{l,k}$ with time passed l (in years)							
		0	1	2	3	4	5	6	7
1	Up to 1 y	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2	More than 1 y up to 5 ys	40.2%	30.6%	17.5%	9.0%	2.7%	0.0%	0.0%	0.0%
3	More than 5 ys	15.7%	15.7%	15.7%	15.7%	15.7%	12.5%	7.0%	2.2%

Table 1: Weights of past and current expected credit loss rates, calculated with yearly averages. See the appendix for the derivation of the weighting function $h_{l,k}$ and Equation (1).

So far, we have only estimated the expected losses in the credit portfolio. However, when a bank prices a loan, not only do the expected losses have to be covered, the bank also needs to earn a risk premium. We assume that this risk premium $\lambda_{t,i}$ is proportional to the expected losses,³ i.e.

$$\lambda_{t,i} = \delta \cdot \frac{E(L_{t,i})}{loan_{t,i}} \quad (2)$$

We estimate the factor δ with the following regression:

$$NIM_{t,i} = \alpha + \beta \cdot \phi_{t,i} + \gamma' x_{t,i} + \varepsilon_{t,i} \quad (3)$$

where $NIM_{t,i}$ is the net interest margin (net interest income over total assets), $\phi_{t,i} := E(L_{t,i}) / TA_{t,i}$ is the expected losses in the credit portfolio over total assets, and $x_{t,i}$ is a vector of bank-specific characteristics. This vector $x_{t,i}$ includes all the other variables that we use to explain a bank's net interest margin, that means the contributions from the bond portfolio (as explained below in this subsection), from term transformation (Subsection 3.2), from the payment and liquidity management (Subsection 3.3) and from the other components (Subsection 3.4). The factor δ is equal to the coefficient β if one is subtracted. The euro amount for expected losses in the credit portfolio and the corresponding risk premium is then computed as

$$Credit_{t,i} = (1 + \hat{\delta}) \cdot E(L_{t,i}). \quad (4)$$

³ If we interpret the risk premium as a contribution to the unexpected loss in the Basel formula, the relationship between the probability of default (a measure for the expected losses) and the unexpected losses are not linear, but strictly monotonic increasing. In this context, Equation (2) can be seen as an approximation.

In addition, banks hold bonds as well. Here, we use a bank's holdings of bonds issued by non-banks multiplied by the bonds' premium over the yield of government debt. By contrast, we neglect the credit risk contribution stemming from government bonds (and loans). We do so, because we use the yield of government bonds as our benchmark for risk-free assets. Furthermore, for most banks, the positions in government bonds and loans tend to be minor ones, which means there is hardly any difference in our results in terms of whether we use zero or any other reasonable credit risk premium for government bonds.

3.2 Term transformation

A bank's earnings from term transformation cannot be observed directly. There is no such item in the bank's financial statement, unlike, say, write-downs in the credit portfolio. However, banks in Germany have to report their exposure to interest rate risk in the banking book, and we use this information to gauge a bank's earnings from term transformation, as done in Memmel (2011). His idea was to investigate a passive trading strategy in risk-free government bonds with the same interest rate risk exposure as the bank under consideration. Under the assumption that the same risk exposure yields the same return, the net interest income of this passive trading strategy will be equal to the banks' earnings from term transformation. The benchmark models (See, for instance, Fama and French, 1992, and Carhart, 1997) for the stock market state that the expected return of a share, not the actual return, is the same if the share has the same exposures to the risk factors. By contrast, in our paper, we assume that the actual return is the same. We believe that this is justified, because the returns of bond portfolios (of the same currency and without default risk) are much more highly correlated than the returns of stock portfolios.

The passive trading strategy consists in revolvingly investing in 10-year par yield bonds, where this position is funded by revolvingly issuing 1-year par yield bonds. Our timely discretion is at monthly intervals. This means that, each month, a 10-year bond that was issued ten years ago at par comes due and the sum is then reinvested in the 10-year bond that is now issued at par. The interest payments of the different bonds are collected during one year and constitute the interest income of the strategy. Accordingly, the interest expenses of the passive trading strategy consist of the interest payments on the 1-year bond. The euro amount of the passive trading strategy is not

relevant for our purposes, but for the ease of exposition, we assume that its volume is €1,000.

Let $BPV_{\tau,i}$ and $BPV(TS)_{\tau}$ be the basis point value, i.e. the loss in euros in the case of a one basis point parallel shift of the term structure, for bank i and the passive trading strategy, respectively, at the end of month τ and let $Ni(TS)_{\tau}$ be the net income (in euro) of the passive trading strategy in month τ , then our estimate $Term_{t,i}$ for the earnings from term transformation (in euro) of bank i in year t are

$$Term_{t,i} = \sum_{\tau=12 \cdot t - 11}^{12 \cdot t} \frac{BPV_{\tau,i}}{BPV(TS)_{\tau}} \cdot Ni(TS)_{\tau} \quad (5)$$

For scaling purposes, the measure $Term_{t,i}$ is divided by either the bank's total assets ($TA_{t,i}$) or its net interest income ($Ni_{t,i}$).

3.3 Liquidity and payment management for the customers

As stated above, banks perform liquidity and payment management for their customers. Performing such a function causes costs for bank branches and staff. We assume that, at least in the long run, these costs are covered by corresponding earnings, for instance by mark-ups on loans or by reduced bank rates for customer deposits. A bank's profits and loss account has a position on administrative costs, which comprise personnel costs as well as other administrative costs, such as depreciations on fixed assets and amortizations on intangible assets. However, these costs include not only costs that result from interest generating activities, but also costs from fee and trading business. In order to extract the portion of operating costs which arise from liquidity and payment management, we adopt two approaches and compare the outcome for robustness reasons.

In the first specification (Equation (6)), we explain a bank's operating costs by different sources of income, namely interest income and fee income. In doing so, we estimate the following function for the period 1993 to 2012:

$$OC_{t,i} = \alpha + \beta_1 \cdot NIM_{t,i} + \beta_2 \cdot FEE_{t,i} + \delta \cdot T_t + u_i + \varepsilon_{t,i} \quad (6)$$

with $OC_{t,i}$ as operating cost relative to total assets, $NIM_{t,i}$ as the net interest margin and $FEE_{t,i}$ as income from fees and commissions over total assets. We conduct a panel

regression with bank-fixed effects in order to control for unobservable heterogeneity.⁴ A time trend variable (T) accounts for technological changes which affect cost development. We expect δ to be negative, since costs have been declining through the observed period. Income shares are considered as proxies for outputs in interest-generating and fee-income-generating activities. In doing so, we divide operating costs into three parts: a part which is directly associated with interest income, a part which is caused by running fee-income business, and a residual which contains fixed costs and costs stemming from other income sources, e.g. trading income. To be more precise, variable costs directly related to net interest income are calculated as $\hat{\beta}_1 \cdot NIM_{t,i}$.

In the function above we do not consider trading income explicitly as an output component, since this income source is very volatile and often takes on negative values. Therefore, the appropriateness of net trading income as a proxy for the extent of trading activities may be limited. As we use fixed-effects regressions, we do not assume serious problems due to omitted variable bias. In order to test the appropriateness of this assumption, we run a robustness check, where we introduce a variable which covers other income components (i.e. it covers trading income and other non-interest income), to total assets. As $TRADE_{t,i}$ often takes on negative values, we only consider cases where this variable is positive.

In the second specification, we take a more detailed view as we use concrete amounts of different outputs (instead of the whole net interest income) to describe costs caused by the banks' liquidity and payment management for their customers. Again, we run fixed-effects panel regressions including the years 2008 – 2012:

$$OC_{t,i} = \alpha + \beta_1 \cdot CARDS_{t,i} + \beta_2 \cdot TRANSACTIONS_{t,i} + \beta_3 \cdot CREDITS_{t,i} + \beta_4 \cdot ATMs_{t,i} + \beta_5 \cdot SECURITIES_{t,i} + \beta_6 \cdot FEE_{t,i} + u_i + \varepsilon_{t,i} \quad (7)$$

$CARDS$ is the number of cards (credit cards, cards with a cash function, with a payment function as well as with an e-money function) a bank hands out to its customers per €100,000 € of total assets. The variable $TRANSACTIONS$ is defined as the number of payment actions taken at the cashiers' desk per €100 of total assets. This variable serves as a proxy for personal customer service. If a bank focuses more on face-to-face service rather than on providing its services via internet and terminals it is expected to face

⁴ We prefer fixed effects to random effects, since the Hausman test has shown systematic differences between coefficients, indicating inconsistency of the coefficients in the random effects specification.

higher administrative costs. We also introduce the amount of automated teller machines per €100.000 of total assets. *CREDITS* comprise customer loans (as a percentage of total assets) as a variable to account for the costs emerging within the loan granting process (e.g. consultancy, monitoring, management and, if the loan engagement fails, liquidation). This type of costs has also to be covered by net interest income. Furthermore, we introduce *SECURITIES* (as a percentage of total assets) as a further output.⁵ As in Equation (6), we include the variable *FEE* because fee-income generating activities are expected to cause further administrative costs.⁶ We also perform a further regression, where *TRANSACTIONS* are separated into whether money is paid in (*PAYMENT-IN*) or paid out (*PAYMENT-OUT*). The reason for this is that paying in could be assumed as more laborious than paying out, and therefore causes higher costs. We furthermore introduce a time trend as in Equation (6). In a further specification we test whether there is a significant interaction between *TRANSACTIONS* and fee-income. Since fee-income generating activities (e.g. selling building savings contracts and insurances) normally require a certain amount of personal service, a bank which is already focused on personal service (e.g. a bank that carries out customers' transaction at the counter) may gain synergies by offering additional fee-products. From Equation (7), operating costs for providing liquidity and payment management ($OC_PLM_{t,i}$) are calculated in our paper as:

$$OC_PLM_{t,i} = \hat{\beta}_1 \cdot CARDS_{t,i} + \hat{\beta}_2 \cdot TRANSACTIONS_{t,i} + \hat{\beta}_3 \cdot CREDITS_{t,i} + \hat{\beta}_4 \cdot ATMs_{t,i} \quad (8)$$

3.4 Other components

There are further components determining banks' interest margins, such as market power and inequality of interest-bearing assets and liabilities. In the interest margin literature, which explains interest margins in a qualitative context, proxies like concentration ratios or Lerner indices are often used in order to account for market power (e.g. Maudos and Solís, 2009; Lepetit, Nys, Rous, and Tarazi, 2008; Maudos and Fernández de Guevara, 2004). Measuring the quantitative part due to market power seems to be rather difficult. One useful attempt to do this might be to interpret the

⁵ Customer loans and securities are often proposed as bank outputs by the literature on cost efficiency. See, for example, Fiorentino, Karmann, and Koetter (2006), Koetter and Poghosyan (2009), Bos, Heid, Koetter, Kolari, and Koos (2005) and Hauner (2005).

⁶ See also Lozano-Vivas and Pasiouras (2010) and Tortosa-Ausina (2003).

fraction due to market power as the difference between the identified components and the actual value of the interest margin. Our calculations indicate little space for market power margins. At this point it has to be mentioned that small markups could also be due to cost and profit inefficiencies rather than reflecting little market power. Thus, banks with market power could suffer from inefficiencies instead of reaping monopolistic rents (see Koetter, Kolari, and Spierdijk, 2012; Koetter and Vins 2008). Particularly when bank fixed effects in the equations for the liquidity and payment management (Equations (6) and (7)) do not fully cover cost-inefficient deviations from the cost function, part of the estimated magnitude of operative costs could reflect market power induced cost-inefficiencies. However, from our point of view, a rather small market power margin does not seem to be implausible. First, we assume that competition in the banking market has increased due to the expansion of direct banks, non-banks and near-banks. Second, it would be expected that small rural banks, in particular, face low competition and, therefore, benefit in terms of higher margins. But this argument is myopic, since savings and cooperative banks, which are located mainly in rural regions, are committed to supporting common public interests, rather than to focusing on profit maximization.

There are also technical issues related to interest margin calculation. We calculate the net interest margin by subtracting interest expenses from gross interest income and divide it by the banks' total assets. This procedure is appropriate when interest-bearing liabilities equal interest-bearing assets. The net interest margin would however be overestimated if interest-bearing assets were to exceed interest-bearing liabilities. We therefore calculate a variable "Other". We assume that a bank obtains its residual funding or invests its surpluses at the interbank market. The contribution to the net interest margin is therefore calculated as

$$Other_{t,i} = 3\text{-month-rate}_t \cdot \frac{q(A)_{t,i} - q(L)_{t,i}}{TA_{t,i}} \quad (9)$$

where 3-month-rate_t is the 3-month-Euribor, $TA_{t,i}$ are the total assets and $q(A)_{t,i}$ and $q(L)_{t,i}$ are interest bearing assets and liabilities, respectively. Note that the difference between interest bearing assets and liabilities may stem from a bank's capital (which in most parts does not count to the interest bearing liabilities). The assumption that a bank borrows or lends the difference in the volumes at the interbank market is a technical

assumption to equalize interest bearing assets and liabilities. We neglect price effects that arise due to the assumed change in the liability structure.

Another issue that has become especially relevant during the recent low interest rate environment is that deposit rates normally take positive values. When market interest rates decrease, banks would normally adjust their loan rates as well as their deposits rates. If the market interest rate level has fallen below a certain threshold, deposit rates cannot be adjusted in the expected dimension (due to, for instance, the lower bound of zero concerning deposit rates), thereby causing a decline in the actual net interest margin. This aspect could contribute to a situation in which the sum of the calculated components (credit risk compensation, term transformation, liquidity and payment management costs, and other components) exceeds the actual net interest margin.

4 Data

For our analysis, we use regulatory data for banks in Germany. Apart from the banks' financial statements (balance sheet, profit and loss accounts), we have quantitative supervisory reports for each bank and each year at our disposal. From these data sets, we take the elementary information about the banks; for instance, their total assets, their operating costs, their net fee income, and their net interest income. This data is available on an annual basis. For our panel regression in section 3.3, we use data from 1993 till 2012. In order to get more detailed information about the payments services a bank provides to its customers we use the payment statistics. This database contains yearly-based information about payment transactions in the German banking system and is available from 2008 till 2012. We use data on the amount of cards a bank hands out to its customers (i.e. credit cards, cards with a cash function, with a payment function as well as with an e-money function), the amounts of payments carried at a cashier's desk and the number of automated teller machines (ATMs) a bank reports.⁷ We apply a relatively moderate outlier treatment, in which we truncate variables used in the Equations (6) and (7) by banking group (i.e. savings, cooperatives, small commercials, and large banks)⁸ at the 1st and 99th percentile. We furthermore account for mergers, as

⁷ Some banks, most of them regional banks, did not report the numbers of ATMs, cards and transaction, which we have treated as missing values.

⁸ Large banks comprise "Landesbanken", "big banks" and central cooperative institutions. We choose this grouping, because individual groups differ in their income ratios due to differences in business models.

the banks that have resulted from the mergers are usually substantially different from the pre-merger banks. In Tables 7 to 10 in the appendix, we provide summary statistics. For determining a bank's exposure to credit risk, we make use of the Bundesbank's borrowers statistics and BISTA statistics. In this data set, the German banks' loan exposure to the real economy is broken down into 28 different industries/sectors and three maturity brackets. The 28 industries/sectors consist of 23 industries in the German real economy (excluding government), three types of loans to German households, the sector of German non-profit organizations, and foreign non-banking firms and households (excluding government).⁹ The data is further broken down according to the loans' initial maturity (three brackets: up to one year, more than one and up to five years, more than five years). This data set not only includes the loan volume, but its valuation changes as well, which allows us to calculate loss rates.

Concerning the banks' exposure to interest rate risk, we make use of the Basel interest rate coefficient. This coefficient states the change in the present value of a bank's banking book due to a standardized shock of the term structure of interest rates relative to the banks regulatory capital. In the past, this shock consisted of a parallel shift in the term structure of +130 basis points. Since 2011, the amount of the parallel shift has been set to +200 basis points. To derive a bank's banking book basis point value $BVP_{\tau,j}$, we divide its Basel interest rate coefficient by 130 and 200, respectively, making use of the near linear relationship of the interest rate risk for relatively small shocks, and multiply it by the bank's capital. In accordance with Memmel (2011), we set the basis point value of the passive trading strategy $BPV(TS)_\tau$ to the constant of 0.3716 per 1,000 euros.¹⁰

⁹ To make the manuscript easier to read, we write "industries" instead of "industries/sectors".

¹⁰ The basis point value of the passive trading strategy, i.e. a measure for its interest rate risk, varies in the course of time, depending on the level of interest rates. However, these variations are small and tend to be negligible.

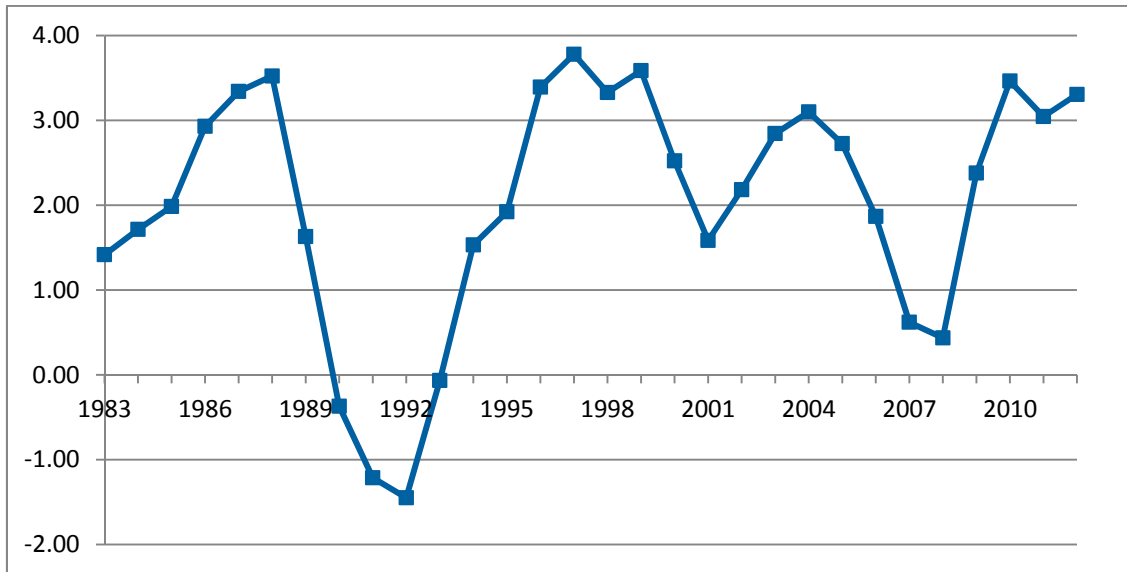


Figure 1: Net income (as an annual percentage) of a passive trading strategy that consists in revolvingly investing in 10-year German par-yield government bonds and revolvingly issuing one-year par-yield bonds.

The net income of the passive trading strategy is based on estimates of the term structure of German government bonds, carried out by the Deutsche Bundesbank (See Deutsche Bundesbank (1997)).

Earnings relative to...		Credit risk	Term transformation	Liquidity/Payment function	Other	Sum
...total assets (in bp per year)	25%-percentile	27.7	58.9	90.9	-0.5	193.8
	Median	34.0	77.0	103.8	1.9	219.9
	75%-percentile	42.8	95.7	118.3	3.2	242.6
...net interest income (in %)	25%-percentile	12.8	27.7	40.9	-0.3	89.9
	Median	15.9	34.9	47.3	0.8	99.5
	75%-percentile	19.4	43.3	54.1	1.4	109.9

Table 2: Remuneration of the different functions of banks in 2012; bp = basis points; n = 1545; “Credit risk” is the sum of the expected losses and a premium for the bank’s credit risk in its loan portfolio (See Equation (4)) plus the contribution of its bond holdings; “Term transformation” is the return of a passive trading strategy scaled by the bank’s interest rate risk exposure (See Equation (5)); “Liquidity/Payment function”: variable costs from liquidity and payment management (See Equation (7)); “Other”: contribution to the net interest margin due to the difference between the volume of interest bearing assets and liabilities (See Equation (9)).

In Figure 1, we show the yearly net income of this strategy since 1983, the first year for which we can calculate the net income. We see that the earnings from term transformation in the years 2011 and 2012 are far above the average since 1983 of 2.04% p. a. Even so, these years are characterized by low (and sometimes negative) interest rates. There may be two reasons for this. First, the steepness of the term structure (the yield of a 10-year par yield bond minus the yield of a 1-year par yield bond) is above its average since 1983, i.e. 1.29% average compared with 1.58%. Second, the passive trading strategy benefits from the higher coupons of past 10-year par yield bonds.

5 Empirical Results

5.1 Quantifying the components

In Table 2, the results for the quantification of the different components are shown. The results are given for 2012 as the median relative to total assets (per year) and net interest income, respectively. We can only carry out the break-down for the year 2012 because, for the credit risk, we need a time series to estimate the contribution to the net interest margin as a weighted average of past and present credit loss rates (see Equation (1)). The data set on credit loss rates only started in 2003 and we use this period of ten years to estimate the contribution of bearing credit risk for the year 2012.

We can derive the following conclusions. First, the component that reflects the costs of the clients' liquidity and payment management is the most important, followed by the component for term transformation and credit risk. In 2012, for the median bank, the costs of liquidity and payment management account for 47% of the net interest income and 104 bp per total assets. The relevant figures for term transformation and credit risk are 35% and 16% of net interest income, and 77 bp and 34 bp relative to total assets, respectively.

	Operating costs over total assets (OC)			
	Specification I-a	Specification I-b	Specification I-c	Specification I-d
NIM	0.516***	0.482***	0.485***	0.470***
	(0.0762)	(0.099)	(0.074)	(0.095)
FEE	0.605***	0.606***	0.557***	0.557***
	(0.070)	(0.070)	(0.074)	(0.074)
TRADE	-	-	0.883***	0.883***
	-	-	(0.205)	(0.206)
Trend	-	-0.007	-	-0.003
	-	(0.006)	-	(0.006)
Constant	0.837***	0.983***	0.816***	0.883***
	(0.214)	(0.304)	(0.212)	(0.303)
R-squared (within)	45.90%	45.93%	51.16%	51.17
Number of observations	49,617	49,617	43,956	43,956
Number of banks	5,772	5,772	5,706	5,706
Wald-test H0: $\beta_{NIM} = \beta_{FEE}$, p-value	0.37	0.31	0.44	0.45
H0: $\beta_{NIM} = \beta_{TRADE}$, p-value			0.07	0.07
H0: $\beta_{FEE} = \beta_{TRADE}$, p-value			0.15	0.15

Table 3: Decomposition of operating expenses, Specification I: Explaining operating costs by income streams (1993-2012). Robust standard errors in parentheses. ***, **, * denote significance on a 1 percent, 5 percent or 10 percent level, respectively. See Equation (6).

Second, when calculating operating costs that arise from liquidity and payment management, specification I (Table 3) gives us a first hint about the range of the cost share which has to be covered by interest margin. Specifications I-a to I-d suggest that, on average, about 47% to 52% of net interest margin corresponds to administrative costs. This finding is confirmed by specification II-b (Table 4), which makes it possible to calculate the operating costs stemming from liquidity and payment management as

47% of net interest margin in the median in 2012 and as 49% in the median for the period 2008 to 2012.¹¹ The distribution of the cost share in 2012 is shown in Figure 2.

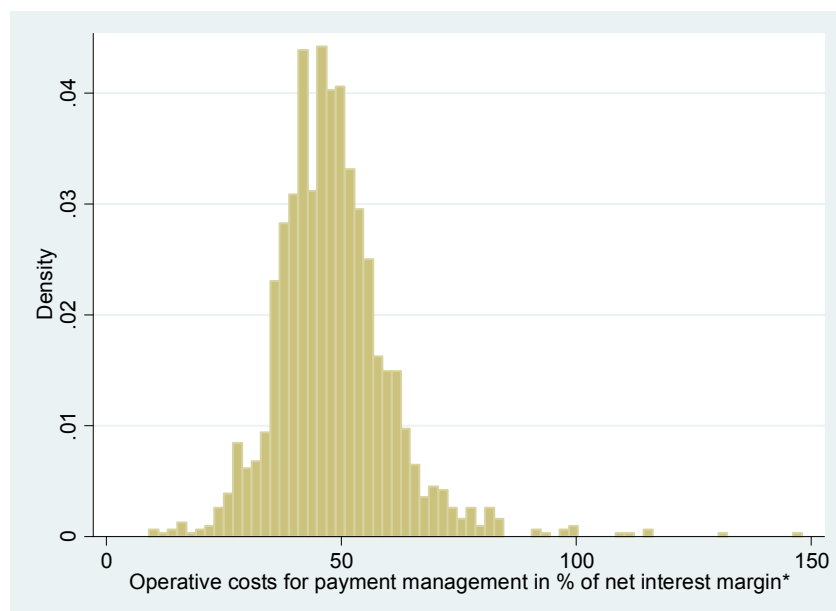


Figure 2: Banks' operative costs for the liquidity and payment management of their customers as a percentage of net interest income margin in 2012. *n = 1550, 1 outlier has been dropped.

Furthermore, we interpret the coefficients in specification II directly as cost unit rates. According to these estimates, a card causes average costs of €80 per year, whereas an additional *ATM* costs, on average, costs €64,000 (including depreciations). As expected, *PAYMENTS-IN* are, on average, associated with higher costs per transaction than *PAYMENTS-OUT*. The coefficient on *FEE* reflects the relatively high personnel costs connected with fee products: For every €100 fee income, €32 operating costs are incurred. Our calculations show that operating costs for securities are negligible, while consumer loans cause €5 administrative costs per €1,000 customer loan. In both specifications, administrative costs are not significantly influenced by time trend.¹² Specification II-d in Table 4 shows no evidence for synergy effects between fee-income

¹¹ We rely on specification II-b in order to calculate operating expenses for the provision of liquidity and payment management, as time trend and interaction term do not play a significant role, but the differentiation between *PAYMENTS-IN* and *PAYMENTS-OUT* does provide further information.

¹² This could be due to a short time horizon. Even in specification I some banks face short time series as we control for mergers.

generating and interest income-related products, as the corresponding interaction term is not statistically significant.

	Operating costs over total assets (OC)			
	Specification II-a	Specification II-b	Specification II-c	Specification II-d
CARDS	0.080***	0.077***	0.077***	0.080***
	(0.011)	(0.010)	(0.010)	(0.011)
TRANSACTIONS	9.598***	-	-	9.922**
	(0.751)	-	-	(4.779)
ATMs	65.379***	64.010***	62.808***	65.784***
	(10.331)	(10.245)	(10.323)	(11.175)
PAYMENTS-IN	-	15.022***	13.957***	-
	-	(2.719)	(2.841)	-
PAYMENTS-OUT	-	6.144***	5.382***	-
	-	(1.620)	(1.805)	-
CREDITS	0.004***	0.005***	0.005**	0.004***
	(0.002)	(0.002)	(0.002)	(0.002)
FEE	0.322***	0.322***	0.321***	0.322***
	(0.110)	(0.109)	(0.110)	(0.113)
SECURITIES	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Interaction FEE and TRANSACTIONS	-	-	-	-0.369
	-	-	-	(5.438)
T	-	-	-0.004	-
	-	-	(0.004)	-
Constant	0.822***	0.818***	0.822***	0.817***
	(0.136)	(0.136)	(0.135)	(0.190)
R-squared (within)	45.71%	45.78	45.79	45.71
Number of observations	8,099	8,099	8,099	8,099
Number of banks	1,844	1,844	1,844	1,844
Wald-test H ₀ : $\beta_{\text{EINZAHLUNGEN}} = \beta_{\text{AUSZAHLUNGEN}}$, p-value		0.030	0.037	

Table 4: Decomposition of operating expenses, Specification II: Explaining operating costs by products and services. Robust standard errors in parentheses. ***, **, * denote significance on a 1 percent, 5 percent or 10 percent level, respectively. See Equation (7).

Third, the component for term transformation seems very high, i.e. roughly one-third of the median bank's net interest margin comes from this source. When we look at Table 5, we see that this component is rather volatile in the course of time and that the year 2012 shows very high term transformation figures. The median contribution of this component over a whole interest rate cycle (here: from 2005 to 2012) has been 44 basis points per total assets and year, and 20% of the net interest margin, whereas the respective 2012-values are 77 basis points and 35%. Memmel (2011), who uses the identical data for the period 2005-2009, obtains 25 basis points relative to total assets and 13% of the net interest margin.

Year(s)	Relative to total assets and per year (in bp)	Relative to net interest income (in %)
2005	56.1	23.8
2006	37.7	17.0
2007	12.3	5.9
2008	9.2	4.6
2009	55.0	24.3
2010	76.5	33.4
2011	61.0	28.1
2012	73.7	33.9
2005-12	44.0	19.9

Table 5: Earnings from term transformation; bp = basis points; median bank; the earnings are calculated as stated in Equation (5).

Fourth, earnings due to bearing credit risk seem rather low at 16% of the net interest margin, all the more so since not only the loans' expected losses are accounted for, but a risk premium as well (as estimated in Equation (3)). One reason for the rather low contribution of bearing credit risk is due to the fact that the year 2012, for which we carry out the break-down of the net interest margin, was characterized by very low loss rates in the credit portfolio. As stated in Equation (1), the contribution for bearing credit risk is a weighted average of past and present credit loss rates. However, the years 2010 to 2012 which were characterized by low loss rates, have a large weight in the portfolio composition, so that the low contribution need not to be representative for a whole business cycle (See Memmel et al., 2014, Figure 1, for a graphical representation of the

credit loss rate in Germany in the course of time). Another issue is the credit risk premium. If we dropped this risk premium altogether (as suggested by the regression results for Equation (3) in the first column in Table 6), the contribution of bearing credit risk would be even lower (12%). Instead, we take the results of the single variable regression (second column in Table 6), where the coefficient for the expected losses in the credit portfolio is 1.363 (implying a risk premium of 36.3%). We do so, because the variable for the payment and liquidity management includes administrative costs for the loan granting, which may lead to biases in the estimates. An example may explain this: Assume a bank grants a risky loan. For this loan, the probability of default and, therefore, *ceteris paribus* the expected losses are higher. At the same time, this loan has a higher-than-average probability that costly renegotiations and liquidations are necessary, which increases the administrative costs above the average.

Fifth, the component due to the difference between interest bearing assets and liabilities amounts to around 2 basis points, which corresponds to less than 1% of a the median bank's net interest margin. The amount seems relatively small, but one has to take into account that the average 3-month interbank rate was relatively low (0.57% p.a.) in 2012. Sixth, the sum of the four components accounts for nearly 100% of the median bank's net interest income. This finding is in line with the empirical results of Georgievska et al (2011), who find that the sum of the components even exceeds the banks' net interest income by up to 20%. The question is why there is so little left from the interest income to cover the banks' fixed costs or to contribute to the remuneration of the banks' equity. One possible answer could be that some of the costs are not associated with a corresponding money outflow. As long as a bank sets its loan rates such that the expected losses are covered, the money inflow – on average – is equal to or exceeds the money outflow. However, if a bank invests in bonds, it receives interest that covers the expected losses and it receives – on top of this – a credit risk premium, i.e. the costs we derive are, at least in part, opportunity costs. Another possible explanation may be a price setting across different sources of income. For instance, liquidity and payment management is financed by low remuneration of current accounts, but there may also be fees associated with, say, the current accounts.

5.2 Justification of the decomposition

As stated earlier, the results of the decomposition of a bank's net interest margin are not right or wrong. There are no items in the profit and loss account about the exact decomposition. If we define, for instance, earnings from term transformation as the income of a passive trading strategy with the same interest rate risk, then we can only make a point that the calculation is economically sensible or not. To do so, we explain the bank's actual net interest margin by the components we derived.

	Net interest margin (NIM)					
Expected credit losses	0.839***	1.363***				
	(0.184)	(0.278)				
Corporate bonds	1.079***		1.033***			
	(0.1045)		(0.152)			
Term transformation	0.308***			0.466***		
	(0.034)			(0.048)		
Liquidity and Payment Costs	0.814***				0.850***	
	(0.069)				(0.085)	
Other	5.642***					6.960***
	(0.248)					(0.323)
Constant	81.401***	192.039**	214.291**	185.502**	131.985**	214.366**
	(9.526)	(5.902)	(1.556)	(4.236)	(131.985)	(0.998)
R-squared	57.14%	6.07%	3.64%	9.87%	22.84%	26.15%
Number of	1,545	1,545	1,545	1,545	1,545	1,545
Wald-test, p-value: $\beta_{\text{Expected credit losses}=1}$ $\beta_{\text{Corporate Bonds}=1}$ $\beta_{\text{Term Transformation}=1}$ $\beta_{\text{L\&P Costs}=1}$ $\beta_{\text{Other}=1}$	0.383 0.451 0.000 0.007 0.000	0.192	0.828	0.000	0.078	0.000

Table 6: Explanation of the net interest margin for 2012, using cross-sectional regressions. Robust standard errors in parentheses. ***, **, * denote significance on a 1 percent, 5 percent or 10 percent level, respectively; "Expected credit losses" are the expected losses in a bank's credit portfolio as stated in Equation (1); "Corporate bonds" is the contribution to a bank's net interest margin stemming from its bond holdings; for the other variable definitions see Table 2. All variables are divided by the banks' total assets.

In Table 6, we show to what extent the different components can explain the banks' net interest margin. We estimate the relationship as laid down in Equation (3), but only in the cross-section for the year 2012, not as a panel. As explained above, we can only determine the contribution of bearing credit risk for the year 2012, because we need a time series of ten years (which correspond to the period of available data) to estimate the contribution in the tenth year. We see the following results. First, the expected losses in a bank's credit portfolio have an impact on the net interest margin of less than one, at least in the specification where all variables are included. For the reason outlined above, we choose the single variable regression (second column in Table 6); here the coefficient is 1.363. However, we have to admit that this coefficient is only estimated with relatively low precision and that it is not statistically significantly greater than one. This said, we interpret the difference to one as the premium for bearing credit risk. This risk premium is estimated to be about 36% of the expected credit losses.

The composition of the credit portfolio explains about 6.1% of the cross-sectional variation of the banks' net interest margin. Second, the corporate bonds' credit risk premium (including the expected losses) explains 3.6% of this variation. What is more, the coefficient is close to one, the theoretical value. Third, the component for the term transformation is – as all the components – highly significantly positive, but this component is significantly different from one. Memmel (2011) showed that the cross-sectional explanatory power of this variable is relatively low. Therefore, we run a fixed-effects panel regression (results available on request) to see whether the time series estimate of the coefficient is not statistically different from one. The time series estimate is highly significantly positive and greater than the cross-sectional coefficient, but still significantly smaller than one.

Fourth, costs for the clients' liquidity and the payment management explain nearly 23% of total variation, which illustrates the importance of this component. The coefficient is relatively close to one, although statistical equality to one is rejected. Concerning operating costs, we furthermore run tests to justify the appropriateness of the chosen cost function estimated in Section 3.3 in Equation (6) and (7). In specification I-a to I-d we interpret β_1 as the variable unit costs stemming from interest-generating activities. As we assume a linear relationship between operating costs and the income components, variable unit costs correspond to marginal costs. From a theoretical point

of view, cost minimization of products measured in the same unit (here: euros of operating income) requires equal marginal costs in the different product lines. Under the assumption that banks minimize costs, the rejection of the equality of the marginal costs, i.e. $H_0 : \beta_1 = \beta_2$, would give us a sign for misspecification. The corresponding tests are reported in Table 3 and we see that the coefficients are not statistically different.

We also obtain indications that these coefficients do not suffer from omitted variables. Table 3 indicates that coefficients remain stable when introducing the trading income (*TRADE*). We have also tested the equality of the coefficients in this specification. The equality of the coefficients is only rejected when comparing the coefficient for the variable *TRADE* and net interest income. One possible explanation could be that the coefficient for other income sources may be overestimated, since we have ignored negative values. Furthermore, for multicollinearity reasons, we abstain from accounting for non-linearity in both specifications in terms of introducing squared terms.¹³ Comparing specification I and II, specification II seems more advantageous, because, in this approach, a bank's operating costs can be explained by economically meaningful variables that have roughly the same explanatory power as the variables in specification I. We use specification II-b in order to calculate the specific costs, as the differentiation between *PAYMENTS-IN* and *PAYMENTS-OUT* seems useful, although the inclusion of a time trend and the interaction term do not provide any further information.

All in all, there is evidence that the components for credit risk, term transformation, and liquidity and payment management for the customers are sensibly chosen.

6 Conclusion

This paper is about quantifying the components of the banks' net interest margin. The results have several implications. First, the liquidity and payment management for the banks' clients need to be more in the focus of research. Issues like technical progress in the payment management and other efficiency gains could be explored in more detail. Second, stress tests on the banks' net interest margin should take into account the component of liquidity and payment management for their customers. Up to now, such

¹³ Correlations between variables and their squared terms in specification I and specification II are about 90 %.

stress tests have focused mainly on the banks' credit and interest rate risk. Third, there is a contribution to the question of which part of the banks' net interest margin is due to functions that banks perform with an advantage over other market participants. There is little doubt that banks have an advantage in carrying out liquidity and payment management for their customers and the same holds true for the banks' loan granting business. Concerning term transformation, especially the interest rate risk, which accounts for up to one-third of the median bank's net interest margin, the literature says that banks have only limited advantages in bearing this risk. That is to say, banks could hand over their interest rate risk to the markets by means of appropriate positions in interest swaps and no problems seem to arise from information asymmetries or wrong incentives. The same is true of their bond positions.

In this paper, we investigate the German banking system. German banks are said to rely greatly on earnings from term transformation. Nevertheless, there is reason to believe that the large share of the net interest margin that is due to cost and earnings management is a feature that is common to banking systems in many countries.

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Appendix

A.1 Weighting function

In this appendix, the weighting function $h(\cdot)$ is derived, i.e. the function that shows how past and current expected credit loss rates for an industry are to be weighted for the contribution to the net interest margin that covers the expected losses in a bank's credit portfolios (See Equation(1)). The expected loss rates $\mu(t_m, j, m)$ in t_m in the industry j for newly granted loans with maturity m are relevant for today, i.e. in time t , for loans that were granted in time t_m and have not matured yet, i.e. $m > v := t - t_m$. We make two assumptions. First, the expected loss rate in time t_m is the same for all the loans in the initial maturity bracket under consideration, i.e. $\mu(t_m, j, m) = \mu_{t_m, j, k}$. Second, the loan volume for a certain initial maturity m is spread equally across the maturity bracket k , i.e. $g(m, a_k, b_k) = 1 / (b_k - a_k)$, where $g(\cdot)$ is the density, and a_k and b_k are the lower and upper bounds of the maturity bracket k , respectively. In a given time span Δt , the fraction $1 / m \cdot \Delta t$ of loans with initial maturity m has to be renewed to have a constant balance sheet. For $1 \leq a_k < b_k$ and $0 \leq v := t - t_m < a_k$, the expression for the weighting function $h(\cdot)$ is therefore

$$\begin{aligned} h(v, a_k, b_k) &= \frac{1}{b_k - a_k} \cdot \int_{a_k}^{b_k} \frac{1}{m} dm \\ &= \frac{1}{b_k - a_k} \cdot (\ln(b_k) - \ln(a_k)) \end{aligned}$$

where $v := t - t_m$ is the time difference between today t and the point in time t_m in the past.

In the event that $a_k \leq v < b_k$, we can express $h(\cdot)$ as

$$\begin{aligned} h(v, a_k, b_k) &= \frac{1}{b_k - a_k} \cdot \int_v^{b_k} \frac{1}{m} dm \\ &= \frac{1}{b_k - a_k} \cdot (\ln(b_k) - \ln(v)) \end{aligned}$$

As we have only yearly data for the expected credit loss rates, we calculate the yearly average of the weighting function, i.e.

$$h_{l,k} = \int_l^{l+1} h(v, a_k, b_k) dv.$$

For $l \leq a_k - 1$, we obtain

$$h_{l,k} = \frac{1}{b_k - a_k} \cdot (\ln(b_k) - \ln(a_k)),$$

and for $a_k - 1 < l \leq b_k - 1$, the corresponding expression is

$$h_{l,k} = \frac{1}{b_k - a_k} \cdot (\ln(b_k) - (l+1) \cdot \ln(l+1) + l \cdot \ln(l+1)).$$

This can be seen using the formula $\int \ln(x) dx = x \cdot \ln(x) - x + C$. For the first maturity bracket, i.e. $a_1 = 0$ and $b_1 = 1$, the function $h(\cdot)$ and its average $h_{0,1}$ are set to one. The values of the weighting function $h_{l,k}$ are shown in Table 1.

A.2 Summary statistics

Variable	MEAN	MEDIAN	SD
COST	2.535	2.066	4.484
NIM	2.153	2.221	0.731
FEE	1.244	0.688	5.538
TRADE	0.175	0.037	0.893
TRANSACTIONS	0.0223	0.021	0.010
PAYMENT-IN	0.010	0.010	0.004
PAYMENT-OUT	0.013	0.012	0.007
ATMs	0.003	0.003	0.002
CARDS	4.649	4.467	1.659
CREDITS	57.451	58.818	13.195
SECURITIES	22.373	20.816	11.796

Table 7: Summary statistics, calculated for the year 2012 over all banks considered in the Equations (6) and (7).

Variable	MEAN	MEDIAN	SD
COST	2.769	2.441	3.707
NIM	2.587	2.600	0.853
FEE	0.988	0.635	4.352
TRADE	0.191	0.054	0.794
TRANSACTIONS	0.026	0.025	0.012
PAYMENT-IN	0.011	0.011	0.005
PAYMENT-OUT	0.015	0.014	0.008
ATMs	0.003	0.003	0.002
CARDS	4.804	4.600	3.462
CREDITS	55.971	57.414	13.543
SECURITIES	24.859	23.572	11.723

Table 8: Summary statistics, calculated over all banks and periods considered in the Equations (6) and (7).

	NIM	FEE	TRADE
NIM	1.000		
FEE	-0.097	1.000	
TRADE	-0.055	0.340	1.000

Table 9: Correlations, calculated over all banks and periods considered in the Equation (6).

	PAYMENTS- -IN	PAYMENTS- OUT	TRANS- ACTIONS	ATMs	CARDS	FEE	CREDITS	SECURITIES
PAYMENTS- IN	1.000							
PAYMENTS- OUT	0.739	1.000						
TRANS- ACTIONS	0.904	0.954	1.000					
ATMs	0.543	0.423	0.504	1.000				
CARDS	0.242	0.212	0.238	0.365	1.000			
FEE	0.059	-0.068	-0.068	-0.033	0.034	1.000		
CREDITS	-0.066	-0.063	-0.070	-0.130	-0.023	-0.144	1.000	
SECURITIES	0.012	0.024	0.020	0.097	0.0381	0.005	-0.710	1.000

Table 10: Correlations, calculated over all banks and periods considered in Equation (7).