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Which interest rate scenario is the worst one for a bank? Evidence from a tracking bank approach for German savings and cooperative banks

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Discussion Paper
Series 2: Banking and Financial Studies
No 07/2008

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ISBN 978-3–86558–404–5 (Printversion)
ISBN 978-3–86558–405–2 (Internetversion)

Abstract

Interest income is the most important source of revenue for most of the banks. The aim of this paper is to assess the impact of different interest rate scenarios on the banks' interest income. As we do not know the interest rate sensitivity of real banks, we construct for each bank a portfolio with a similar composition of its assets and liabilities, called 'tracking bank'. We evaluate the effect of 260 historical interest rate shocks on the tracking banks of German savings banks and cooperative banks. It turns out that a sharp decrease in the steepness of the yield curve has the most negative impact on the banks' interest income.

JEL classification: G12, G21

Keywords: Interest Rate Risk, Stress Testing

Non technical Summary

Interest income is the most important source of revenue for most banks. Stress testing concerning the banks' interest rate income is therefore of great importance. Individual banks can carry out such stress tests relatively easily because they have the necessary information (future cash flows and the maturity structure of the assets and liabilities). In contrast, outsiders have to estimate the maturity structure of the assets and liabilities from stock price changes or balance sheet data. One goal of this study is to estimate and predict those portions of a bank's interest income that arise from term transformation, ie the portion of interest rate income due to credit spreads and margins is not considered. This is done with the help of tracking banks. A tracking bank is a portfolio of bonds that has the same maturity structure of assets and liabilities as the real bank and that otherwise behaves completely passively. The tracking banks then serve as a means to find out which interest rate scenario has the most negative impact on the banks' interest income. To do so, the impact of 260 different historical interest rate scenarios on the tracking banks are analysed. Under the assumption that the real bank is hit by an interest rate shock in the same way as the tracking bank, one can determine the worst interest rate scenario. From the empirical study for German savings and cooperative banks, we can infer the following results: (i) The tracking banks are able to track the interest income of the corresponding real banks rather accurately. (ii) The interest rate scenario with the most harmful impact on the banks' interest income turns out to be a movement of the term structure in which the short-term interest rates go up sharply and the long-term interest rates remain almost unchanged. This corresponds to a sharp decrease in the steepness of the term structure.

Nicht-technische Zusammenfassung

Der Zinsüberschuss ist für die meisten Banken die wichtigste Ertragsquelle. Stresstests in Bezug auf den Zinsüberschuss sind daher von wesentlicher Bedeutung. Die einzelnen Banken können solche Stresstests relativ einfach durchführen, weil ihnen die notwendigen Informationen (zukünftige Zahlungsströme und die Laufzeitstruktur der Forderungen und Verbindlichkeiten) vorliegen. Außenstehende dagegen müssen die Laufzeitstruktur der Forderungen und Verbindlichkeiten auf Grundlage von Aktienkursänderungen oder Jahresabschlüssen schätzen.

Ein Ziel dieser Arbeit besteht darin, aus bilanziellen Daten denjenigen Teil des Zinsüberschusses einer Bank zu schätzen und vorherzusagen, der sich aus der Fristentransformation ergibt, d.h. derjenige Teil des Zinsüberschusses bleibt unberücksichtigt, der auf Risikoprämien und Margen zurückgeht. Dies geschieht mit Hilfe von sogenannten Tracking Banken. Bei einer Tracking Bank handelt es sich um ein Portfolio aus Anleihen, das dieselbe Laufzeitstruktur der Forderungen und Verbindlichkeiten aufweist wie die entsprechende reale Bank und sich ansonsten vollkommen passiv verhält. Die Tracking Banken dienen dann dazu, herauszufinden, welches Zinsszenario den negativsten Einfluss auf das Zinsergebnis einer Bank hat. Dazu werden die Auswirkungen von 260 verschiedenen historischen Zinsszenarien auf die Tracking Banken untersucht. Unter der Annahme, die reale Bank werde von dem Zinsschock in der gleichen Weise getroffen wie die entsprechende Tracking Bank, lässt sich so das ungünstigste Zinsszenario ermitteln.

Aus der empirischen Untersuchung für deutsche Sparkassen und Kreditgenossenschaften lassen sich folgende Ergebnisse ableiten: 1. Die Tracking Banken können den Zinsüberschuss der entsprechenden realen Banken ziemlich genau nachzeichnen. 2. Als Zinsszenario mit den negativsten Auswirkungen auf den Zinsüberschuss der Banken stellt sich eine Bewegung der Zinsstrukturkurve heraus, bei der die kurzfristigen Zinsen stark ansteigen und die langfristigen Zinsen nahezu unverändert bleiben. Dies entspricht einer starken Abnahme der Steigung der Zinsstrukturkurve.

Contents

Which Interest Rate Scenario is the Worst one for a Bank?
Evidence from a Tracking Bank Approach for German Savings and Cooperative Banks[1]

1 Introduction

For most banks, interest income is by far the most important source of revenue. Stress testing concerning the banks' interest rate income is therefore an important issue.[2] The aim of this paper is twofold: first, to present a method that allows estimation and forecasting of a bank's interest income, using accounting information and, second, to apply this method to find out which interest rate scenario is most harmful for a bank.

The idea is as follows: We do not know the consequences of an interest rate shock for a real bank, because we lack information about its future cash flows. Therefore, for each real bank, we construct a bank with a similar maturity composition, called 'tracking bank', and we presume that the real bank and its tracking bank are hit by an interest shock in the same way. Analyzing the effects of an interest rate shock on the tracking banks, we transfer the results to the real banks.

The method of determining the interest sensitivity is comparable to performance measurement in portfolio theory: To measure the performance of a fund, one composes a portfolio with the same systematic risk (see, for example, Jensen (1968)) as

[1]The opinions expressed in this paper are those of the author and need not reflect the opinions of the Deutsche Bundesbank. I thank Oliver Entrop, Barry Williams and the participants at the Deutsche Bundesbank's research seminar and the SGF 2008 Annual Meeting for helpful comments.

[2]The banking crises in the US during the eighties and early nineties was in part due to interest rate risk. According to the Federal Deposit Insurance Corporation (1997) more than 9% of all banks in the US failed during this crisis.

the fund under consideration. The loadings of the systematic risk factor(s)[3] allow us to judge the extent to which the fund's return is determined by certain risk factors. The systematic risk factors in our case are the yields of investment strategies that consist in investing in default-free bonds of different maturities.

Having established a tracking bank for each German savings bank and cooperative bank, we calculate the change in the interest income for each tracking bank for 260 historical interest rate scenarios in Germany.

It turns out that our tracking bank approach is able to explain a substantial part of the cross sectional and time series variation of a bank's (net) interest income. Concerning the worst interest rate scenario, we find that a scenario with a sharp decrease in the steepness of the yield curve, ie the short-term rates go up sharply and the long-term rates barely move, has the most negative impact on the bank's net interest income in the year after the shock and in the second year after the shock.

The paper is structured as follows: Section 2 gives a short overview of the literature in this field. In Section 3, we describe the model, and Section 4 gives a description of the data. Section 5 states the estimation results, and Section 6 is about finding the interest rate scenario with the worst impact on the banks. Section 7 concludes.

2 Literature

This paper contributes to two strands of the literature on the banks' interest income. First, we present a new method to estimate a bank's interest rate risk exposure that arises from term transformation. Our innovation is that we model the banks' interest income with tracking banks instead of interest rates. Second, we contribute to the literature on stress testing of the banks' interest income.

Provided the banks' future cash flows and the maturity composition of their assets and liabilities are known, the income from term transformation is relatively easy to determine. However, outsiders lack this information. Therefore, many studies rely on stock returns or on accounting-based data to assess a bank's exposure to

[3]See Sharpe (1963) for a one-factor-model and Fama and French (1992) for a three-factor-model.

interest rate risk arising from term transformation (For approaches based on stock returns, see Staikouras (2003) for an overview and Czaja et al. (2006) for a recent application; for accounting-based approaches, see Houpt and Embersit (1991) and Sierra and Yeager (2004)).

Often, the economic value perspective is chosen, which estimates the loss in the bank's present value given a certain change in the yield curve. The earnings perspective is common as well (see, for example, van den End et al. (2006)), especially when analyzing traditional commercial banking as the business model and when analyzing the short term effects on the profit and loss account.[4] In this paper, we choose the earnings perspective and not the economic value perspective for two reasons. First, we look at small and medium-sized banks which are primarily engaged in commercial banking. Second, we are interested in the effects of the interest rate changes on the banks' profit and loss accounts in the near future, ie in an horizon of one or two years.

Mostly, the accounting information of one point in time is used to assess the banks exposure to interest rate risk. A counter-example is the work by Entrop et al. (2008). They use time series of accounting information and they can show that this additional information considerably improves the estimation of the bank's duration gap. Their calculation is, however, time-consuming, involves quadratic programming and works best when there are no structural breaks in the time series of the bank's balance sheet data. In this paper, we use the banks' accounting information of one point in time. The neglect of the time series information may reduce the precision of our estimates. However, the calculation is much less time-consuming and there does not arise the question of how to deal with banks for which there are fewer observations than the length of the time series. This question is relevant because there was a merger wave among German savings and cooperative banks in the period under consideration (See Kötter (2005)).

To assess the stability of the financial system, many central banks in Europe carry

[4]For a more detailed discussion of the the two different perspectives see Basel Committee on Banking Supervision (2004).

out interest rate risk stress tests using information of the banks' balance sheets.[5] The methods described in this paper can help to design scenarios for interest rate stress tests and to interpret the results.

3 Modelling Interest Income and Expenses

For each bank, we create a passively behaving bank with a similar maturity structure. This bank is called a 'tracking bank' and serves us as an approximation of the respective real bank.[6] The tracking bank is assumed to follow a passive, stationary business model, ie it reinvests the funds that become due in investments of the same kind: when a five-year-loan matures, the bank hands out a new loan with five years of maturity. The same applies to the bank's financing. In detail, we have the following assumptions.

1. The composition of the tracking bank's balance sheet remains unchanged in the course of time. Whenever a loan or a bond matures, the bank replaces it with a loan or a bond of the same initial time to maturity.

2. In theory, this replacement of maturing bonds and loans is continuous. However, we choose monthly discretion, ie the difference between the points in time t and $t+1$ is one month.

3. There exists only one sort of financial instrument: bonds (or loans) of different initial maturity that quote at par when issued and that redeem the whole principal at maturity.

[5] The results are often reported in the central banks' financial stability reports; see for instance Deutsche Bundesbank (2006), De Nederlandsche Bank (2006) and Oesterreichische Nationalbank (2006).

[6] To our knowledge, we are the first to model a bank's interest income in this way. Giebel et al. (1999), pp. 65-85, use a similar approach to replicate the cash flows of non maturing deposits, for instance savings accounts.

4. Whereas the principal is reinvested at maturity, the interest paid contributes to the bank's interest income (in the case of an asset) or to the interest expenses (in the case of a liability).

5. All bonds and loans are default-free.

A tracking bank can be seen as a portfolio of investment strategies $S(T)$. These strategies $S(T)$ consist in investing each month the constant part $1/T$ in par-yield-bonds with maturity T. As one can see, these strategies are in accordance with the assumptions of the stationary tracking bank: the money collected from redemption in a certain month corresponds to the amount invested. The interest income is withdrawn each month. This interest income yields in month t

$$z_t(T) = \frac{1}{12}\bar{r}_{t-1}(T) \tag{1}$$

with

$$\bar{r}_t(T) = \frac{1}{T}\sum_{i=0}^{T-1} r_{t-i}(T), \tag{2}$$

where $r_t(T)$ is the yield of par bonds with maturity T in time t.[7] In other words, the yield of the Strategy $S(T)$ equals the moving average of the interest rate (divided by 12 to get the monthly yield).

As we only observe the interest income once a year, we sum up the last 12 monthly interest incomes to obtain the income for the whole year, i.e.

$$\begin{aligned} Z_t(T) &= \sum_{i=0}^{11} z_{t-i}(T) \\ &= \frac{1}{12}\sum_{i=0}^{11} \bar{r}_{t-1-i}(T) \\ &= \frac{1}{12\,T}\sum_{i=0}^{11}\sum_{j=0}^{T-1} r_{t-1-i-j}(T), \end{aligned} \tag{3}$$

if t is a multiple of 12. From Equation (3) we see that the current interest income of strategy $S(T)$ is the weighted sum of past par-bond-yields with a maturity of T months.

[7] We assume that the bonds pay each month 1/12 of the coupon.

As mentioned above, the tracking bank is a portfolio of investment Strategies $S(T)$. Let $w(T_k)$ with $k = 1, ..., K$ be the share of the total assets that is invested in the strategy $S(T_k)$, then we can calculate the tracking bank's interest income (I) and expenses (E) (normalized to the bank's total assets) as

$$Z_t^j = \sum_{k=1}^{K_j} w(T_k) \cdot Z_t(T_k) \text{ with } j = I,\ E \tag{4}$$

For instance, assume the tracking bank revolvingly hands out loans of one-year, four-year and six-year maturity and the weights of one-year-loans, four-year-loans and six-year-loans are 20%, 30% and 45%, respectively; then the normalized interest income is

$$Z_t^I = 0.2 \cdot Z_t(12) + 0.3 \cdot Z_t(48) + 0.45 \cdot Z_t(72).$$

Please note that the weights need not sum up to 100 percent: usually, banks hold non-interest-bearing assets such as real estate and shareholdings as well. In case of the liabilities the difference to 100% is even greater, because the banks' capital does not count among the interest bearing liabilities. Further note that the maturity is given in months (and not in years), ie the share of loans with an initial maturity of four years is denoted as $w(48) = 0.3$.

Even if we knew the real bank's maturity composition, the interest income and the interest expenses of the real bank and the tracking bank would differ considerably. Nevertheless, given the available information, the tracking bank approach seems to be superior to other approaches (See Section 5).

Differences may be due to the following reasons:

1. The real bank does not need to behave as passively as the tracking bank. It is likely that the bank increases the term transformation in times of a steep yield curve. Moreover, in times of an economic boom the bank will hand out more loans than during recessions or financial crisis.

2. The real bank does not charge and pay the default-free interest rate of government bonds. In fact, one major function of a bank is to give customers access to the capital market and to take on credit risk. Therefore, banks tend

to charge more for the loans and pay less for the deposits than the interest rate of the corresponding government bond. By contrast, the tracking bank charges and receives the interest rate of default-free government bonds.

3. Real banks deal as well in much more complicated financial instruments than straight, default-free bonds (See Assumptions 4 and 5). For instance, they are engaged in off-balance-sheet activities, such as interest rate swaps and options.

Besides the differences mentioned above, there is the problem that the maturity composition of a bank's assets and liabilities is not known exactly, at least to outsiders and to the supervisory authorities. At best, the assets and liabilities are broken down into different maturity brackets and into different lender and borrower groups. The assumption is that the bank spreads their money equally over all the different initial maturities (we assume initial maturities in six-month steps). For instance, assume that a bracket covers all the loans to banks from more than one to up to three years of initial maturity. This assumptions of spreading the loans equally makes the bank in our example invest one-quarter into bank loans with 18-month, 24-month, 30-month and 36-month initial maturity, respectively.

Let $x_{t,i,j}$ be the normalized interest income contribution of the maturity bracket j of asset class i to the normalized interest income Z_t^I of the tracking bank, then the following relationship holds, given the assumption of equally spread maturities within a bracket:

$$Z_t^I = x_{t,1,1} + x_{t,1,2} + \ldots + x_{t,i,j} + \ldots + x_{t,N,M_N} \tag{5}$$

where N defines the number of asset classes and M_i is number of brackets into which the asset class is broken down. Let us return to the example from above, ie. the bracket for loans with more than one year and up to three years of initial maturity. Denote this bracket with $i = 1$ and $j = 3$. Assume that the assets in this bracket account for 15% of the bank's total assets. In this case, we obtain

$$x_{t,1,3} = 0.15 \cdot (0.25 \cdot Z_t(18) + 0.25 \cdot Z_t(24) + 0.25 \cdot Z_t(30) + 0.25 \cdot Z_t(36))\,.$$

However, Equation (5) holds only for the tracking bank; in reality, we only observe the interest income of the real bank, denoted by R_t^I. As the tracking bank and the real bank do not act identically, the contributions $x_{t,i,j}$ do not enter with the weight of 1 into the equation and there remains a residual. We therefore estimate the following regression:

$$R_t^I = \alpha + \beta_{1,1}\ x_{t,1,1} + \beta_{1,2}\ x_{t,1,2} + \ldots + \beta_{N,M_N}\ x_{t,N,M_N} + \varepsilon_t, \tag{6}$$

where R_t^I is the normalized interest income of the real bank. Please note that we estimate the regression (6) as a panel regression, ie for reasons of simplicity, the indexes for the banks are left out. Note as well that a similar equation is estimated for the bank's liabilities.

The better the assumptions made for the tracking bank fit to the real bank, the closer the coefficients $\beta_{i,j}$ will be to one. The constant α will be estimated separately for each bank. The higher this constant, the more the bank is able to charge margins above the risk free interest rate.

4 Data

The Deutsche Bundesbank estimates the yield curve for government bonds using the method of Svensson (1994).[8] This method is a further development of the Nelson and Siegel (1987) method and approximates the real yield curve by a function depending on six parameters. We use monthly data of these parameter estimates from January 1980 to August 2007. Having established an entire yield curve for each month, we calculate the implicit yield of bonds quoted at par and the year-end interest income of the various investment strategies $S(T)$. In Table 1, the summary statistics of the interest income for the strategies $S(T)$ with different initial maturity T is given. The period is from 1990 to 2006, ie 17 observations. The mean return of the different strategies increases with the initial maturity. In the period under consideration, term transformation has been a lucrative source of revenue. The revolving investment in papers of six-month maturity yields on average an interest income of 4.62%,

[8] See Schich (1997) and Deutsche Bundesbank (1997).

whereas the the revolving investment in 10-year(=120-month) bonds yields an interest income of 6.56%. The relationship between mean return and initial maturity is monotone and slightly concave, ie the increases in mean return become smaller the longer the initial maturity. By increasing the initial maturity by one year, one augments the mean interest income by approximately 20 basis points. At the same time, the income volatility decreases as the initial maturity increases. However, this result may be slightly misleading: not only the earning volatility counts but the volatility of the economic value as well, and, from an economic value standpoint, strategies based on bonds with long maturities are quite risky.

To construct the different interest scenarios, we make use of the same data set from above. Starting in 1986, we calculate for each month and each maturity the year-to-year change in the interest rate. This procedure yields 260 overlapping scenarios for interest rate changes.[9] In Table 2, the summary statistics is given concerning these interest changes. The volatility of the interest rate changes is about 1 percent. As expected, the volatility is the smaller, the longer the maturity. For the six-month interest rate, the volatility is 1.22%, and it gradually goes down to 0.85% for the volatility of the 10-year interest rate. Basel II stipulates an interest rate stress test for the banks' banking book. This stress test consists of an upward and downward 200 bp parallel shift of the yield curve or, equivalently, a parallel shift of the first and 99th percentile of the yearly interest rate changes (See Basel Committee on Banking Supervision (2004)). Looking at the corresponding percentiles in Table 2, we see that the two alternatives lead to shocks of approximately the same severity, especially when looking at the longer maturities. For short term interest rates, however, the year-to-year change may be up to 300 bp.

We restrict our analysis to the savings banks and to the cooperative banks in Germany. The banks of these two sectors are relatively homogeneous; they account for more than 80% of all German institutions and they generate the vast majority of

[9]Another possibility of constructing interest rate scenarios would be to analyze the dynamics of the parameters that govern the yield curve (See Diebold and Li (2006)) instead of looking at the entire yield curve. This approach would be especially relevant, in case one wanted to attach probabilities to the scenarios.

their business with the classical banking activities, ie by handing out loans and by receiving deposits. In Table 3, we give summary statistics on the variable of interest, ie the banks' net interest income normalized to the banks' total assets.[10] In 1998, there was a major break in the time series. Therefore, we use the period from 1999 to 2006. During this period, the interest margin was 2.47% for the median bank. However, from 2003 onwards, we see a decline in this margin. The number of banks in the sample continuously fell from more than 2,500 in 1999 to about 1,600 in 2006. This decrease in number was due to a merger wave in the German savings bank and cooperative bank sector (See Kötter (2005)).

The maturity composition of the banks' assets and liabilities can only be approximately inferred from the data available to us. We make use of the information from the Deutsche Bundesbank's monthly balance sheet statistics. The monthly balance sheet statistics are broken down into different assets and liabilities and into different initial maturity brackets. Table 4 gives this breakdown of the initial maturities for different assets and liabilities.

Additionally, we make assumptions concerning the distribution of the initial maturities in the brackets (See Section 3): The maturities are assumed to be equally distributed in the brackets in which the discretion is six months. However, there are three exceptions: (i) For the brackets with daily maturity, we apply the strategy $S(3)$ based on the three-month interest rate to avoid the high volatility of the overnight money interest rate. (ii) The longest maturity for the brackets *more than two years* and *more than five years* is 96 months. (iii) For the savings accounts, we assume a tracking portfolio that is composed of equal shares of the six-month- and the 114-month-strategy (for the *up to three month*-bracket) and of equal shares of 12-month and 120-month strategy (for the *more than three month*-bracket).[11]

In Table 5, we report the composition of the banks assets and liabilities. On average,

[10]For more information on the Bundesbank's banking data see Memmel and Stein (2008).

[11]From talks with practitioners of the savings banks and cooperative banks sector, we know that the average duration for savings accounts is assumed to be approximately three years. There are, however, more sophisticated approaches to determine the interest rate risk of of non-maturity deposits, see for instance O'Brien (2000) and Ellis and Jordan (2001).

the positions included in our analysis account for 91.4% of a bank's assets and for 88.7% of the liabilities. By far the largest asset position is "loans to non-banks" (on average 62.2% of total assets). Savings accounts account on average for one-third of the banks' funding, at least for the relatively small banks in our sample.

5 Estimation Results

We report the regression results for Equation (6). This equation was separately estimated for the assets with the interest income as the dependent variable and for the liabilities with the interest expenses as the dependent variable. Please note that we additionally include as explanatory variables the coverage of assets *(sum of assets included)* and the coverage of liabilities *(sum of liabilities included)*, respectively. The Hausman (1978) test clearly rejects the hypothesis of a random-effects model. We therefore estimate a fixed effects regression with heteroscedasticity robust covariance matrix. Table 6 gives the estimation results for the interest income. In accordance with expectations, the estimated coefficients are all highly significantly positive, but some of them differ significantly from one. The estimated coefficients fit especially well for the positions "Loan to non-banks"; here the coefficients are close to one. The explanatory power is satisfactorily high as can be seen from the different coefficients of determination (R-squared); the overall R-squared is 73%. The corresponding estimation results for the liabilities are shown in Table 7. As with the regression for the interest income, the coefficients are highly significant, but differ from one. The cross-sectional explanatory power (R-squared between) is a bit lower than in the case of the interest income (42.9% vs. 62.9%).

We are primarily interested in the net interest income. To see whether our method is a real improvement, we compare its in-sample explanatory power with two alternative models. The first alternative model consists in using the interest income of the strategies $S(12)$ and $S(60)$ as explanatory variables. The second alternative model uses dummies for each year to capture the interest rate dynamics. Let R be the normalized net interest income of the real bank and let $\hat{R}$ be its in-sample estimate; we estimate the following fixed-effects panel regression

$$R_{t,i} = \alpha + \beta \hat{R}^j_{t,i} + \varepsilon_{t,i}, \tag{7}$$

where j denotes the three different methods to be compared, ie the method of using a tracking bank, of using the interest income of the two strategies $S(12)$ and $S(60)$ and of using year dummies. Table 8 shows that the proposed method of using tracking banks leads to the best results. As we estimate Equation (7) as a fixed-effects-regression, there are three different coefficients of determination (in the following R-squared, R-sq). The within R-squared states how well the model can explain *changes* in the net interest income of a bank. The within R-squared for the tracking bank model is 28.4% and is much higher than the respective R-squared of the other two models (13.8% and 19.1%). The between R-squared tells by how far the *cross-sectional variation* in the explanatory variables can explain the cross-section of the banks' net interest income. The tracking bank model is able to explain roughly one-fifth of the cross sectional variation in the net interest income; the corresponding measures for the other two strategies are close to zero.[12] The overall R-squared is the squared correlation between the net interest income of the real bank and the fitted net interest income. This measure combines the *time series* and *cross-sectional* goodness of fit. The tracking bank model yields a goodness of fit measure of 22.3%, which is far above the fit for the other two models. We carried out the same analysis using interest rates instead of the corresponding moving averages, ie the interest incomes of the strategies $S(T)$. The results were significantly in favor of the interest incomes of the strategies $S(T)$.

To sum up, to explain a banks' net interest income, it is recommendable to include the information contained in the monthly balance sheet statistics and to use moving averages of interest rates instead of the interest rates themselves.

[12] As the methods *Interest income of the two strategies $S(12)$ and $S(60)$* and *Year dummies* have no cross sectional variation, their between R-squared should numerically be zero. However, the panel is unbalanced and the missing values induce some cross sectional variation, so that the between R-squared is numerically different from zero.

6 Looking for the Worst Interest Rate Scenario

In this section, we apply the tracking bank method to find out which interest rate scenario is most harmful to the banks. The measure of harm is the change in the standardized net interest income one year and two years after the interest rate shock, respectively.

The procedure is as follows: We assume that the yield curve is unchanged from August 2007 to December 2007. In January 2008, there will be a shock according to one of the 260 historical scenarios. After the shock, the yield curve is assumed to remain unchanged at the new level. For each of the 1,636 tracking banks and each of the 260 interest rate scenarios, we calculate the net interest income for the year 2008 and the year 2009, respectively. These interest margins are compared with the interest margin in the case of no interest shock, the basis scenario, ie we calculate the difference between the income in a shock scenario and in the basis scenario. This procedure yields $1,636 \times 260 = 425,360$ differences in net interest income. To condense the information, we apply two different criteria to find the worst scenario: (i) For each of the 260 scenarios, we calculate the median of the cross sectional change in the net interest income that is caused by a scenario. The lower the median change in the net interest income, the worse is the scenario. (ii) For each of the 1636 banks, we determine which of the 260 scenarios is the worst one in 2008 and in 2009, respectively. The more often a scenario is named as the worst one, the worse is the scenario.

Table 9 gives the median change in the net interest income for the five worst scenarios according to criterion (i). The scenarios are labelled according to the month in which the 12-month-period for the year-to-year-change ends. For instance, the scenario called *1989-05* consists of the changes in the interest rates that occurred from May 1988 to May 1989. The number -0.276, for example, in the third column of Table 9 states, that the median standardized net interest income (= net interest income over total assets) goes down by 0.276 percentage points. From Table 3 we see that the median standardized net interest income is about 2.5%, ie the median change due to the worst scenario causes a reduction of the net interest income by some 11%. Please

note that the 260 shocks are overlapping and therefore not independent. That's why the five worst scenarios according to criterion (i) are clustered around spring 1989. Whereas Table 9 makes a statement for the average (=median) tracking bank, it is important to know if a scenario that is identified as severe for the average tracking bank is severe for a large part of the banks as well. To answer this question, we identified the worst scenario for each bank, and we counted how often each scenario was identified as the worst one (criterion (ii)). Table 10 shows the five scenarios that were most often found to be the worst ones. According to both criteria, scenario *1989-05* is by far the worst. The year-to-year change in the interest rates for this scenario *1989-05* are shown in Figure 1. The curve for the interest rate changes is relatively smooth. This smoothness is due to the fact that the Svennson-method uses a function to approximate the actual yield curve.
From the Tables 9 and 10 as well as from Figure 1, we obtain the following statements concerning the severity of interest rate shocks.

1. From an earnings perspective, the short term interest rates are crucial for the severity of interest rate shocks. The worst of the 260 scenarios is a sharp decrease in the steepness of the yield curve: Whereas the three-month-rate goes up by more than three percentage points, the ten-year rate remains almost the same (See Figure 1).

2. For nearly all of the tracking banks, and therefore presumably for nearly all of the real banks, the worst scenario is the same: a sharp decrease in the steepness of the term structure. For 1,610 out of the 1,636 tracking banks, the scenario *1989-05* has the most negative impact on the net interest income after one year.

3. The effect of an interest rate shock is not restricted to the first year. It turns out that the effects become worse in the second year, as can be seen from Table 9. In addition, the effects become more dispersed and less uniform as can be seen from Table 10.

The Result 1 is not fully in line with the results of interest rate stress tests that apply the economic value perspective as reported, for instance, in Deutsche Bundesbank (2006). When looking at the economic value, the changes in the interest rates of longer maturities are crucial, and the changes in the short-term rates are of secondary importance. It seems as though the earnings perspective and the economic perspective look at the interest rate risk from different angles: Whereas the economic value perspective stresses the present value of the current holdings, the earnings perspective includes the future business as well. However, the earnings perspective puts the emphasis only on the near future, whereas the economic value perspective may give a more comprehensive picture of the bank's situation.
The tracking bank approach of finding the worst interest rate scenario relies on several strong assumptions: for instance, that the tracking bank and the corresponding real bank are hit by an interest rate stock in the same way, and that the composition of the assets and liabilities of a bank remains constant throughout the interest rate shock. Moreover, we look only at the risk due to maturity mismatches, but we neglect the indirect effects of an interest rate change, such as increasing margins in times of a boom. Nevertheless, the tracking bank approach seems to give valuable insights into the sensitivity of the banks' interest income to different interest rate shocks.

7 Conclusion

It seems that, for a large part of German savings banks and cooperative banks, the same interest rate scenario has the worst impact on their interest income: a sharp decrease in the steepness of the yield curve, ie the interest rates of longer maturities are of secondary importance, when looking at the next two years' net interest income. By contrast, when looking at the economic value of a bank, the interest rate changes in the longer maturities seem to be more important. Further work has to deal with the question of how to reconcile the economic value and the earnings perspective.

References

Basel Committee on Banking Supervision (2004). Principles for the management and supervision of interest rate risk. Bank for International Settlements.

Czaja, M.-G., H. Scholz, and M. Wilkens (2006). Interest rate risk of German financial institutions - the impact of level, slope, and curvature of the term structure. Available at SSRN: http://ssrn.com/abstract=912239.

De Nederlandsche Bank (2006). Financial stability overview; September 2006, no 4.

Deutsche Bundesbank (1997). Monatsbericht. 10/1997.

Deutsche Bundesbank (2006). Financial stability review 2006.

Diebold, F. X. and C. Li (2006). Forecasting the term structure of government bond yields. *Journal of Econometrics 130*, 337–364.

Ellis, D. M. and J. V. Jordan (2001). The evaluation of credit union non-maturity deposits. Discussion Paper National Economic Associates.

Entrop, O., C. Memmel, M. Wilkens, and A. Zeisler (2008). Analyzing the interest rate risk of banks using time series of accounting-based data: Evidence from Germany. Discussion Paper Deutsche Bundesbank Series 2, 01/08.

Fama, E. F. and K. R. French (1992). The cross-section of expected stock returns. *Journal of Finance 47*, 427–466.

Federal Deposit Insurance Corporation (1997). History of the eighties - lessons for the future. Study of the FDIC Division of Research and Statistics.

Giebel, R., C. Sievi, and M. Schuhmacher (1999). *Wertorientiertes Management und Performancesteuerung.* Stuttgart: Deutscher Sparkassen Verlag.

Hausman, J. A. (1978). Specification test in econometrics. *Econometrica 46*, 1251–1271.

Houpt, J. V. and J. A. Embersit (1991). A method for evaluating interest rate risk in U.S. commercial banks. *Federal Reserve Bulletin August*, 625–637.

Jensen, M. C. (1968). The performance of mutual funds in the period 1945-1964. *Journal of Finance 23*, 389–416.

Kötter, M. (2005). Evaluating the German bank merger wave. Discussion Paper Deutsche Bundesbank Series 2, 12/05.

Memmel, C. and I. Stein (2008). The prudential database BAKIS. *Schmollers Jahrbuch 128*, 321–328.

Nelson, C. R. and A. Siegel (1987). Parsimonious modeling of yield curves. *Journal of Business 60*, 473–489.

O'Brien, J. M. (2000). Estimating the value and interest rate risk of interest-bearing transactions deposits. Discussion Paper, Board of Governors of the Federal Reserve System.

Oesterreichische Nationalbank (2006). Financial stability report 11.

Schich, S. T. (1997). Schätzung der deutschen Zinsstrukturkurve. Discussion Paper Deutsche Bundesbank Series 1, 04/97.

Sharpe, W. F. (1963). A simplified model for portfolio analysis. *Management Science 9*, 277–293.

Sierra, G. E. and T. J. Yeager (2004). What does the federal reserve´s economic value model tell us about interest rate risk at U.S. commodity banks. *Review/Federal Reserve Bank of St. Louis 86*, 45–60.

Staikouras, S. K. (2003). The interest rate risk exposure of financial intermediaries: A review of the theory and empirical evidence. *Financial Markets, Institutions and Instruments 12*(4), 257–289.

Svensson, L. E. O. (1994). Estimating and interpreting forward interest rates: Sweden 1992 - 94. IMF Working Paper 114.

van den End, J. W., M. Hoeberichts, and M. Tabbae (2006). Modelling scenario analysis and macro stress-testing. DNB Working Paper 119/2006.

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and direct test for heteroskedasticity. *Econometrica 48*, 817–838.

Appendix: Tables and Figures

Maturity	N. of obs.	Mean	Standard dev.	Minimum	Maximum
6	17	4.62	2.37	2.06	9.16
12	17	4.72	2.27	2.21	8.92
24	17	4.99	2.06	2.50	8.83
48	17	5.49	1.62	3.17	8.15
72	17	5.90	1.30	3.92	7.54
120	17	6.56	0.96	4.68	7.66

Table 1: Summary statistics for the yearly interest income (in percent) for the strategies $S(T)$ with different initial maturity T (in months). Time period: from 1990 to 2006.

Matu-	N. of	Mean	Standard	Percentile			
rity	obs.		deviation	1st	10th	90th	99th
6	260	-0.07	1.22	-2.54	-1.65	1.49	2.99
12	260	-0.07	1.21	-2.49	-1.64	1.44	3.11
24	260	-0.09	1.20	-2.79	-1.73	1.58	2.58
48	260	-0.12	1.08	-2.54	-1.56	1.50	2.08
72	260	-0.13	0.97	-2.03	-1.38	1.28	2.15
120	260	-0.14	0.85	-1.58	-1.11	1.04	2.07

Table 2: Year-to-year changes in the interest rate (in percentage points) for different maturities (in months). Time period: from 1986-01 to 2007-08

Year(s)	N. of. Obs.	25th percent.	Median	75th percent.
1999	2563	2.30%	2.55%	2.81%
2000	2314	2.20%	2.51%	2.80%
2001	2118	2.09%	2.37%	2.64%
2002	1967	2.21%	2.50%	2.77%
2003	1838	2.27%	2.56%	2.83%
2004	1769	2.22%	2.52%	2.79%
2005	1690	2.14%	2.43%	2.68%
2006	1636	2.01%	2.29%	2.52%
1999-2006	15895	2.18%	2.47%	2.74%

Table 3: Net interest income over total assets (= standardized interest income) of German savings banks and cooperative banks.

Position	1st bracket	2nd bracket	3rd bracket	4th bracket
Assets				
Loans to banks	daily	up to 1y	1y to 5y	more th. 5y
Loans to non-banks	up to 1y	1y to 5y	more th. 5y	
Bonds	up to 1y	1y to 5y	more th. 5y	
Liabilities				
Loans from banks	daily	up to 1y	1y to 2y	more th. 2y
Loans from non-b.	daily	up to 1y	1y to 2y	more th. 2y
Subordinated debt		no breakdown		
Saving accounts	up to 3m	more th. 3m		

Table 4: Breakdown of the initial maturities of the banks' assets and liabilities according to the monthly balance sheet statistics.

	N. of Obs.	25th perc.	Median	75th perc.
Sum of assets included	15895	87.4%	91.4%	93.6%
Loan to banks	15895	5.9%	9.7%	14.8%
Loan to non-banks	15895	54.4%	62.2%	68.6%
Bonds	15895	11.5%	16.6%	23.1%
Sum of liabilities included	15895	85.4%	88.7%	90.9%
Loans from banks	15895	10.0%	14.4%	19.6%
Loans from non-banks	15895	30.1%	35.6%	41.7%
Subordinated debt	15895	0.0%	0.0%	0.8%
Saving accounts	15895	29.4%	34.9%	40.7%

Table 5: Composition of the savings and cooperative banks' assets and liabilities normalized to the banks' total assets.

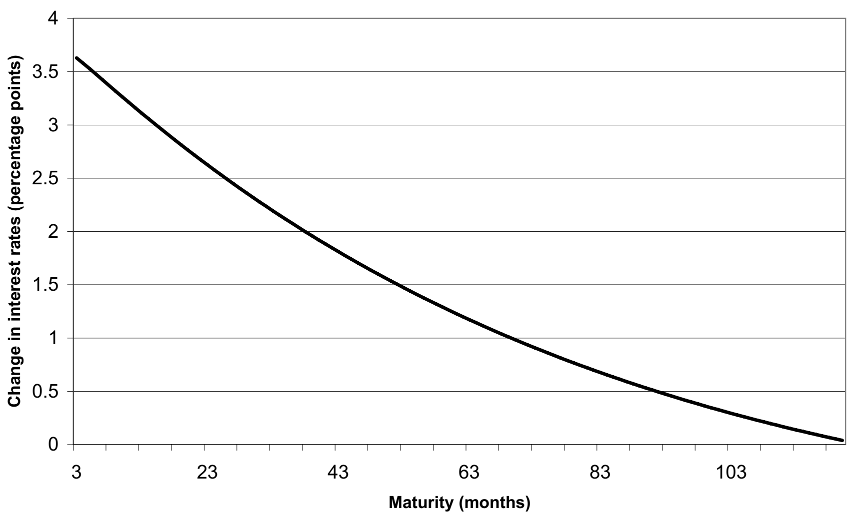

Figure 1: Scenario *1989-05*, year-to-year interest rate changes (from May 1988 to May 1989) for different maturities

	Bracket	Coefficient	Stand. dev.	t-statistics
Sum of assets incl.		-0.006	0.001	-4.22
Loans to banks	1st	0.573	0.024	24.16
	2nd	0.438	0.024	18.52
	3rd	0.609	0.027	22.54
	4th	0.516	0.030	17.22
Loan to	1st	0.991	0.035	28.59
non-banks	2nd	1.190	0.023	52.45
	3rd	0.903	0.010	94.51
Bonds	1st	0.555	0.173	3.21
	2nd	0.761	0.105	7.25
	3rd	0.587	0.012	49.74
Constant		0.018	0.000	56.69
R-sq:	within	0.824		
	between	0.629		
	overall	0.730		
Number of	observations	15895		
	banks	2579		
Estimation	fixed effects			

Table 6: Panel regression with fixed effects; dependent variable: interest income over total assets, White (1980)-correction for the standard errors.

	Bracket	Coefficient	Stand. dev.	t-statistics
Sum of liabilities incl.		0.020	0.001	15.08
Loans from banks	1st	0.604	0.068	8.94
	2nd	0.480	0.033	14.48
	3rd	1.177	0.111	10.60
	4th	0.831	0.015	57.00
Loans from non-banks	1st	0.173	0.013	13.60
	2nd	0.718	0.014	50.46
	3rd	0.882	0.043	20.69
	4th	0.839	0.021	39.91
Subordinate debt		1.406	0.115	12.28
Savings accounts	1st	0.696	0.008	88.91
	2nd	0.531	0.013	40.58
Constant		0.002	0.000	6.92
R-sq:	within	0.864		
	between	0.429		
	overall	0.637		
Number of	observations	15895		
	banks	2579		
Estimation	fixed effects			

Table 7: Panel regression with fixed effects; dependent variable: interest expenses over total assets, White (1980)-correction for the standard errors.

Method	R-sq within	R-sq between	R-sq overall
Tracking bank	0.284	0.195	0.223
Interest income of the 2 strat. $S(12)$ and $S(60)$	0.138	0.019	0.028
Year dummies	0.191	0.022	0.036

Table 8: Goodness of fit for the three different methods according to Equation (7). White (1980)-correction for the standard errors.

Rank	Net interest income 2008		Net interest income 2009	
	Scenario	Change (median)	Scenario	Change (median)
1	1989-05	-0.276	1989-05	-0.338
2	1989-02	-0.252	1989-02	-0.285
3	1989-04	-0.232	1989-04	-0.280
4	1989-03	-0.224	1989-03	-0.253
5	1989-01	-0.209	1989-01	-0.252

Table 9: Median change in the banks' standardized net interest income in percentage points for the five worst scenarios.

Rank	Net interest income 2008		Net interest income 2009	
	Scenario	N. of. Banks	Scenario	N. of. Banks
1	1989-05	1610	1989-05	1489
2	1992-11	7	2001-01	72
3	1989-02	6	1995-12	34
4	1989-03	4	1989-09	14
5	1993-03	4	1993-03	8

Table 10: Number of banks for which the scenario named in the second column (year 2008) and in the fourth column (year 2009) leads to the worst change in the net interest income.

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