Quantifying the Interest Rate Risk of Banks: Assumptions Do Matter*

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Quantifying the Interest Rate Risk of Banks: Assumptions Do Matter

Abstract

This paper analyzes the robustness of the standardized framework suggested by the Basel Committee on Banking Supervision (2004b) to quantify the interest rate risk of banks. We generalize the Committee's model and use not publicly available data on the German universal banking system to study the impact of different model specifications on the estimated level of interest rate risk: the number and boundaries of the time bands, the distribution of business within the time bands, amortization rates, coupons, and the economic maturity of non-maturing deposits. We find that the respective estimates are very sensitive to these values. Depending on the model specification, banks can easily be judged as both as high-risk and as low-risk banks. We conclude that banking supervisors and banks should spend more effort on developing a reliable approach for measuring interest rate risk as the standardized framework can lead to significant misjudgments.

Keywords: Interest rate risk, Basel Capital Accord, accounting-based approach, banking supervision, model evaluation

JEL classification: G18, G21

1 Introduction

Interest rate risk is one of the crucial risk for banks. It naturally arises in the banking book from the basic banking business when banks act as asset transformers, i.e. they lend out long-term and refinance short-term. This causes a maturity mismatch between assets and liabilities, closely related to a repricing mismatch, and results in a duration gap (e.g. Schmidt et al., 1999; Allen and Santomero, 2001).[1] Due to its character as systematic risk, interest rate risk is especially important to the stability of the financial system. A well known example for a crisis where interest rate risk played an integral role is the Savings and Loan Crisis in the US during the 1980s, within which more than 550 of the approximately 4,000 savings and loan institutions failed (e.g. Federal Deposit Insurance Corporation, 1997).

The new Basel Capital Accord (Basel II, See Basel Committee on Banking Supervision, 2004a) aims to strengthen the stability of the financial system and establishes detailed mandatory capital requirements for credit risk and operational risk. Surprisingly, there are no mandatory capital requirements for interest rate risk in the banking book. It is rather to be supervised under pillar 2 ("supervisory review process") of Basel II. To support this pillar, the Basel Committee published principles for the management and supervision of interest rate risk (See Basel Committee on Banking Supervision, 2004b).

Banking supervisors are advised to be especially attentive to those banks, called "outlier banks", whose economic value in relation to its regulatory capital declines by more than 20%

[1] Other sources of interest rate risk for banks are given by embedded options and different interest rate pass-through policies for asset and liability positions (basis risk), even if there is no repricing mismatch (e.g. Basel Committee on Banking Supervision, 2004b).

if a "standardized interest rate shock" occurs.[2] The Basel Committee on Banking Supervision (2004b) stresses that "banks' internal measurement systems should, wherever possible, form the foundation of the supervisory authorities' measurement of, and response to, the level of interest rate risk". Acknowledging that not all banks are able to quantify their interest rate risk adequately, the Basel Committee provides a standardized framework as a possible model to obtain information on the interest rate risk in the banking book. Similar approaches are already applied by national supervisory institutions such as the Federal Reserve (e.g. Houpt and Embersit, 1991).

This paper aims to evaluate whether the Basel Committee's standardized framework itself is adequate and robust enough to assess the interest rate risk of banks. This issue is highly important to both banking supervisors and banks: if assumptions of the standardized framework turn out to be too restrictive or inadequate, banking supervisors might misjudge a bank's interest rate risk and, hence, might react inappropriately when relying on the standardized framework. Additionally, this might cause inappropriate bank-internal risk management decisions as internal risk measurement systems are often based on ideas similar to the Basel Committee's proposal. Hence, it is crucial for banking supervisors and banks to understand how the underlying assumptions affect the model implied level of interest rate risk. To the best of our knowledge, this paper provides the first robustness analysis for this kind of approaches.

For this purpose, we develop and apply a generalization of the Basel Committee's model to analyze the effects of different economically sensible assumptions within the framework: the number and boundaries of the time bands, the distribution of business within the time bands,

[2] See Section 2.1 for details.

amortization rates, coupons, and the economic maturity of non-maturing deposits. To base our analysis on a realistic setting we consider the interest rate risk of the aggregated German universal banking system, i.e. a hypothetical bank that can be interpreted as an "average German universal bank". Therefor, we make use of not publicly available data provided by the Deutsche Bundesbank. These contain the on-balance-sheet positions of the German banks, whereas detailed information on the use of derivatives is not available.[3] By incorporating these data, we are also able to shed some light on the interest rate risk of the German universal banking system ex derivatives as a by-product of our analysis.[4]

We find that the estimates of the interest rate risk vary substantially depending on the model specification. For example, banks such as the "average German universal bank" can easily be identified as both a very risky outlier bank as well as a low-risk bank showing the great dependence of the Basel Committee's framework on the model assumption. Therefore, the standardized framework in its current specification is of very limited use for supervisory and risk management purposes.

The remainder of the paper is organized as follows. Section 2 presents the Basel Committee's approach to quantify the interest rate risk and generalizes this approach by relaxing the assumptions. Section 3 describes the data sources for our analysis. In Section 4 we estimate the

[3]Note that disregarding derivatives does not affect our major results. Incorporating derivatives would adjust the estimated level of interest rate risk but the effects of the assumptions concerning the on-balance-positions remained unchanged.

[4]Although still little is known about the interest rate risk in the German banking system, there are indications that the level of interest rate risk is comparatively high (e.g. Committee of European Banking Supervisors, 2006; Deutsche Bundesbank, 2006). Entrop et al. (2007) analyze the determinants of the interest risk on an individual bank level but do not report the level of interest rate risk.

interest rate risk according to the suggestions of the Basel Committee. In Section 5 we apply the generalized model to analyze the impact of different, economically relevant assumptions on the estimates to get insights into the robustness of the Basel Committee's approach. Section 6 concludes.

2 Model

2.1 Definition of interest rate risk

The Basel Committee on Banking Supervision (2004b) points out that there are several possible ways to define and measure interest rate risk. For supervisory purposes, the Committee suggests to estimate the level of interest rate risk for exposures to G10 currencies by the decline of a bank's economic value in relation to its regulatory capital following a standardized interest rate shock. This shock is given by an upward and downward 200 basis points parallel movement of the term structure.[5] Approximating the interest rate sensitivity by the duration, we here similarly define the interest rate risk as follows:

$$IRR^{bank} = 0.02\,\frac{PV^{bank}\;MD^{bank}}{RC^{bank}}, \tag{1}$$

where PV^{bank} denotes the present value of the bank portfolio, i.e. the difference between the present value of interest rate-sensitive assets and liabilities, which is commonly referred to as "net portfolio value" (e.g. Office of Thrift Supervision, 2000), MD^{bank} is its modified duration referred to as "duration gap" (e.g. Toevs, 1982), and RC^{bank} is the bank's regulatory capital.

[5] Alternatively, the interest rate shock may be based on the 1st and 99th percentile of the yearly interest rate change.

In contrast to the risk measure proposed by the Basel Committee that equals the absolute value of (1), the measure IRR^{bank} is monotone in the bank's duration gap and, therefore, can become negative. This allows for a straightforward interpretation: for a bank with a positive duration gap IRR^{bank} refers to the loss (gain) of economic value in relation to its regulatory capital when interest rates increase (decrease) by 200 basis points. The opposite holds when the duration gap of the bank is negative.

2.2 The Basel Committee's approach

The Basel Committee on Banking Supervision (2004b) suggests a standardized framework to calculate the interest rate risk in the banking book. Comparable models are already applied by banking supervisors, such as the Economic Value Model (EVM) by the Federal Reserve that aims to quantify the interest rate risk of US commercial banks (See Houpt and Embersit, 1991, Wright and Houpt, 1996, Sierra, 2004, and Sierra and Yeager, 2004). Other similar models include Bennett et al. (1986), Patnaik and Shah (2004), and Entrop et al. (2007).

In line with these models, the Basel Committee suggests to calculate the interest rate risk on the basis of time bands. These time bands show the outstanding amount of interest rate-sensitive assets and liabilities broken down by their remaining time to maturity (in case of fixed-rate instruments) or repricing period (in case of floating-rate instruments). The Basel Committee exemplarily proposes that the following time bands may be used: i) up to 1 month, ii) 1 to 3 months, iii) 3 to 6 months, iv) 6 to 12 months, v) 1 to 2 years, vi) 2 to 3 years, vii) 3 to 4 years, viii) 4 to 5 years, ix) 5 to 7 years, x) 7 to 10 years, xi) 10 to 15 years, xii) 15 to 20 years, and xiii) over 20 years. For some positions, like non-maturing deposits, the behavioral (economic) maturity differs from the legal maturity. The Basel Committee suggests to slot these positions into the time bands according to guidance of national supervisors, however, the assumed economic maturity of non-maturing deposits should be no longer than 5 years. Interest rate derivatives such as swaps and futures held in the banking book are to be duplicated by basic instruments such as zero, fixed- or floating-rate bonds that can then be assigned to the respective time bands.

In the next step, a modified duration is assigned to each time band that corresponds to a position situated in the middle of the time band and that yields 5%. These durations are subsequently summed up, weighted with the relative outstanding amount of the time bands in order to calculate the bank's duration gap MD^{bank}. To calculate the risk measure (1) the present value of the bank's assets and liabilities PV^{bank} is approximated by the book value.[6]

2.3 Generalization of the Basel Committee's approach

The framework of the Basel Committee presented in Section 2.2 is intuitive but the assumptions are rather strict. Therefore, we generalize the framework to analyze the effect of the model assumptions on the estimation of the interest rate risk: we allow for different numbers and boundaries of time bands as well as for different distributions of the business within the time bands, different amortization rates, and different coupons.

The actual information available to banking supervisors or external analysts differs between countries. The generalized model can capture current (and possible future) reporting practices

[6]The present value of fixed-rate instruments generally equals its book value if and only if the coupon rate equals the discount rate, i.e. the adequate market interest rate (See Appendix A). However, business that is contracted with customers on the asset side (liability side) can be expected to yield a higher (lower) coupon than the market interest rate, resulting in a present value higher (lower) than the book value.

in different countries like the US or Germany. We assume that banks report the outstanding amount for each interest rate-sensitive on-balance-sheet position broken down by the remaining time to maturity or repricing period, respectively. For each position *pos* there are $|N^{pos}|$ time bands available: $RTM^{pos,n}$ with $n \in N^{pos}$ denotes the amount of position *pos* with a remaining time to maturity within the time band $(h^{pos,n}_{lower}; h^{pos,n}_{upper}]$.

The "location parameter" l determines the distribution of the remaining time to maturity T of the business within a time band:[7]

$$T = h^{pos,n}_{lower} + l \ \left(h^{pos,n}_{upper} - h^{pos,n}_{lower}\right) \quad \text{with} \quad 0 \leq l \leq 1. \tag{2}$$

$l = 0$ ($l = 1$) implies that the complete outstanding amount is in the lower (upper) end of the time band, whereas values between 0 and 1 imply a concentration within the time band. Due to the linear approximation of the interest rate sensitivity, any distribution of maturities within a time band can be represented by a concentration of all business at a certain point in time.

The amortization rate a is defined as the continuously compounded rate of business that is redeemed before maturity, c refers to the continuously compounded coupon rate, and r denotes the continuously compounded market interest rate.

The calculation of the present value $PV^{pos,n}(l,a,c,r)$ and the modified duration $MD^{pos,n}(l,a,c,r)$

[7] For simplicity, we omit indices and superscripts when considering T. Although we define time bands $(h^{pos,n}_{lower}; h^{pos,n}_{upper}]$ to be left-open we allow here for $l = 0$ as $h^{pos,n}_{lower}$ represents the infimum of all possible maturities within the time band.

of the business in a certain time band is straightforward (See Appendix A):[8]

$$PV^{pos,n}(l,a,c,r) = \left(\frac{c+a}{r+a} - \frac{c+a}{r+a}e^{-(a+r)T} + e^{-(a+r)T}\right) RTM^{pos,n}, \tag{3}$$

$$MD^{pos,n}(l,a,c,r) = \frac{\left(\frac{c+a}{(r+a)^2} - \frac{c+a}{(r+a)^2}e^{-(a+r)T} - \frac{c+a}{r+a}Te^{-(a+r)T} + Te^{-(a+r)T}\right) RTM^{pos,n}}{PV^{pos,n}(l,a,c,r)}, \tag{4}$$

where T is defined according to (2).

The present values and the modified durations of the business within single time bands can be aggregated to the net portfolio value and its duration gap as follows:

$$PV^{bank} = \sum_{\substack{pos\in POS^A \\ n\in N^{pos}}} PV^{pos,n}(\cdot) - \sum_{\substack{pos\in POS^L \\ n\in N^{pos}}} PV^{pos,n}(\cdot), \tag{5}$$

$$MD^{bank} = \frac{\sum\limits_{\substack{pos\in POS^A \\ n\in N^{pos}}} MD^{pos,n}(\cdot)\ PV^{pos,n}(\cdot) - \sum\limits_{\substack{pos\in POS^L \\ n\in N^{pos}}} MD^{pos,n}(\cdot)\ PV^{pos,n}(\cdot)}{PV^{bank}}, \tag{6}$$

where POS^A (POS^L) refers to the set of all asset (liability) positions.[9] These values in turn determine the level of interest rate risk according to (1).

Given this generalization, the standardized framework proposed by the Basel Committee on Banking Supervision (2004b) and presented as in Section 2.2 can be obtained by setting $l = 0.5$, $c = r = 0.05$, and $a = 0$. In this case, the business is assumed to be non-amortizing and concentrated in the middle of the time bands. It yields 5% and its present value equals its book value.

[8]In line with the suggestions of the Basel Committee on Banking Supervision (2004b) we assume default-free cash flows and apply the "standard" modified duration, acknowledging that the duration of a defaultable cash flow may differ from the duration of a respective default-free cash flow (e.g. Jacoby and Roberts, 2003).

[9]In case of $PV^{bank} = 0$, the modified duration (6) is not well defined. The interest rate risk measure (1) is then given by $IRR^{bank} = 0.02\ \frac{\text{numerator of (6)}}{RC^{bank}}$.

3 Data

To assess the impact of different model assumptions on the interest rate risk of banks with reasonable dimensions of the interest-rate sensitive business we use not publicly available regulatory data for all German universal banks as of December 2005. All data is provided by the Deutsche Bundesbank. After excluding banks with incomplete data our sample represents 92.4% (1,785) of all German universal banks (1,932). To consider a representative "average German universal bank" corresponding to the German universal banking system in the following analysis we aggregate the data for each position across all banks. We include 3 interest rate-sensitive asset positions ("interbank loans", "customers loans", and "debt securities held") and 4 interest rate-sensitive liability positions ("interbank liabilities", "customers liabilities", "debt securities issued", and "savings deposits"). These positions represent 97.0% and 92.8% of all assets and liabilities, respectively. As detailed information on off-balance-sheet positions such as interest rate derivatives in the banking book is not available, we do not consider these instruments.

The time bands available to German banking supervisors are rather broad. Most asset and liability positions are broken down into only 4 time bands: i) up to 3 months, ii) 3 to 12 months, iii) 1 to 5 years, and iv) more than 5 years. In contrast, to estimate the interest rate risk according to the Basel Committee and to assess the impact of the number and the boundaries of available time bands we need more detailed sets of time bands. To obtain these values we make use of the Time Series Accounting-Based Model (TAM) recently proposed by Entrop et al. (2007).[10] The

[10] To estimate the TAM in the specification according to Entrop et al. (2007) we use, analogously to them, German regulatory and accounting data from the time period of January 1999 to December 2005: the data schedule pursuant to the auditor's report ("Sonderdatenkatalog") that is yearly reported and the monthly balance sheets statistics ("Monatliche Bilanzstatistik") which contain a breakdown of the bank's assets and liabilities by

TAM integrates time series of different accounting-based regulatory data sources to estimate the monthly maturity structure of a bank's assets and liabilities. Based on this detailed structure, we can synthetically generate the amount of business within the time bands we use in our analysis in the following by simply aggregating the respective monthly amounts.

To calculate the measure of interest rate risk (1) we use regulatory capital ("own funds") from Principle I.

4 Interest rate risk according to the Basel Committee and reference scenario

In this section we analyze the model suggested by the Basel Committee on Banking Supervision (2004b). We therefore assume that the complete outstanding amount of a position within a time band is concentrated in the middle ($l = 0.5$), bears a coupon of 5% ($c = 0.05$), and is not amortized ($a = 0$).[11] Further, we assume that the market interest rate equals the coupon ($r = c = 0.05$). Finally, we have to assign a certain economic maturity, or equivalently an interest rate sensitivity, to savings deposits as the most important kind of non-maturing deposits for German banks. Although they are de jure short-term liabilities they can have a rather high interest rate sensitivity (e.g. Hutchison and Pennacchi, 1996; Jarrow and van Deventer, 1998; O'Brien, 2000; Dewachter et al., 2006), because the development of the deposit rates and

remaining time to maturity and initial maturity, respectively. An extensive description of the TAM is beyond the scope of this paper, we therefore refer to Entrop et al. (2007) for details.

[11] The longest time band available to the Deutsche Bundesbank reports the outstanding amount of more than 5 years. We therefore cannot reliably estimate the long-term maturity structure in detail. Hence, we assume a maximum possible maturity of 10 years.

the volume of deposits are sticky. This yields a duration higher than that of other short-term instruments. As already described in Section 2.2 the Basel Committee suggests to slot non-maturing deposits into the time bands, however, the assumed economic maturity should be no longer than 5 years. In line with Houpt and Embersit (1991) we therefore initially set the modified duration of the savings deposits to 2.5 years.

The time bands suggested by the Basel Committee on Banking Supervision (2004b), the respective modified durations[12] as well as the outstanding amount of assets, liabilities, and net positions on the basis of the TAM are shown in Table 1.[13] The table shows that there are more (less) long-term (short-term) assets than respective liabilities clarifying that German banks on average still act as maturity transformers. In the following, this specification will be referred to as "reference scenario".

[Table 1 about here.]

For the reference scenario we calculate a level of interest rate risk of 30.9%, i.e. the aggregated German universal banking system would loose (gain) 30.9% of its own funds if interest rates increase (decrease) by 200 basis points. However, this number has to be interpreted with caution due to the impact of the simplifying assumptions whose effects we analyze in the remainder of this paper. Furthermore, off-balance-sheet positions are omitted. These can be assumed to reduce the interest rate risk of single banks on average (e.g. Schrand, 1997), whereas the impact

[12] The modified durations slightly differ from those in Basel Committee on Banking Supervision (2004b) as our analysis is based on continuously compounded rates, See Section 2.3.

[13] The positions are not monotone decreasing in the remaining time to maturity. This result is somewhat contraintuitive, but in line with the findings of the Deutsche Bundesbank (2006) who reports that German banks recently contracted more long-term interest rate-sensitive positions.

on the banking system as a whole is still unknown.

The analysis of the impact of different assumptions on the modified duration of savings deposits is straightforward, since the interest rate sensitivity of cash flows is additive. If we separate the bank portfolio into the on-balance-sheet positions excluding the savings deposits, and the savings deposits, the interest rate risk measure (1) can be represented as follows:

$$IRR^{bank} = IRR^{bank}_{ex\ savings} - 0.02\,\frac{PV^{savings}\ MD^{savings}}{RC^{bank}}, \tag{7}$$

where $IRR^{bank}_{ex\ savings}$ denotes the interest rate risk of all positions but savings deposits, $PV^{savings}$ the economic value of savings deposits[14], and $MD^{savings}$ the modified duration assigned to savings deposits. As the amount of savings deposits in the aggregated German banking system is about twice as high as the regulatory capital, (7) implies that increasing the modified duration $MD^{savings}$ by one year results in a lower interest rate risk measure of 400 basis points. Given the range of 0 to 5 years for the economic maturity as proposed by the Basel Committee on Banking Supervision (2004b), the estimates for the interest rate risk can vary up to 20 percentage points. This implies, for example, that given a bank ex savings deposits with an interest rate risk of 20% that has savings deposits and regulatory capital in the same relative amount as the German banking system, the bank could be regarded as an outlier bank (assigning no interest rate sensitivity to savings deposits) or to have no interest rate risk at all (assigning a modified duration of 5 years to savings deposits).

[Figure 1 about here.]

[14] In line with the models proposed in the literature and the earlier assumptions we approximate the present value of savings deposits by their book value. Since the book value can be assumed to be higher than the economic value (e.g. Hutchison and Pennacchi, 1996), the impact is overestimated.

Figure 1 shows the impact of the modified duration of savings deposits on the estimated interest rate risk in the reference scenario. In line with the considerations above, the estimated interest rate risk decreases from 30.9% to 20.9% when the modified duration of savings deposits increases from 2.5 to 5 years, and increases to 40.9%, when the modified duration decreases to 0 years. This means that – depending on the assumptions on the economic maturity of savings deposits – the aggregated German universal banking system would loose (gain) between 40.9% and 20.9% of its own funds when interest rates increase (decrease) by 200 basis points.

The considerations above clarify that the estimates of the interest rate risk vary substantially due to different assumptions concerning the economic maturity of the savings deposits. Thus, even within the framework suggested by the Basel Committee on Banking Supervision (2004b), banks and banking supervisors have significant possibilities to influence the interest rate risk quantified. In the following section we analyze how the estimates of the interest rate risk vary when we relax the economically relevant assumptions set by the Basel Committee on Banking Supervision (2004b).

5 Sensitivity of the results to different assumptions

5.1 Distribution of maturities within the time bands

In this section we analyze the problems that emerge because banks do not report the detailed cash flow structure, but only the outstanding amount in certain time bands, making it necessary to assume a certain distribution of maturities within the time bands. The Basel Committee on Banking Supervision (2004b) suggests to assume that the total outstanding amount is concentrated in the middle of the time bands. This assumption is in line with the methodology of the Federal Reserve (e.g. Houpt and Embersit, 1991) and others (e.g. Bennett et al., 1986; Patnaik and Shah, 2004). However, it is not necessarily true nor plausible, since a concentration in the middle of the time bands is equivalent to a uniform distribution. As short-term business consists of former long-term business and new short-term business, it would be rather reasonable to assume that the business is more concentrated in the short end of the time bands.

To analyze the impact of different assumptions concerning the distribution of maturities within the time bands we calculate the interest rate risk varying the location parameter l as defined in (2), while the remaining parameters are specified according to the reference scenario described in Section 4. Note that the location parameter is not relevant for savings deposits as there are no time bands available but a modified duration is directly assigned to them. Figure 2 shows the results. The solid line refers to the case where both assets and liabilities are located in the same part of the time band. The dotted line refers to the case where assets and liabilities are located in the opposite part of the time bands, i.e. $l^{assets} = 1 - l^{liabilities}$. The reference scenario is represented by $l = 0.5$, resulting in a level of interest rate risk of 30.9% as shown in Section 4.

[Figure 2 about here.]

The solid line has some interesting implications. First, the further the business is assumed to be concentrated in the lower ends of the time bands, the lower is the implied level of interest rate risk, basically because there is more interest rate-sensitive business within the time bands on the asset side than on the liability side ex savings deposits (See Table 1). Furthermore, the assets are more concentrated in the long-term time bands that have a broader range and are, consequently, more affected by different assumptions on l. Second, depending on the assumptions the estimates on the interest rate risk vary for some 11 percentage points. Since the Basel Committee on Banking Supervision (2004b) refers to an outlier bank as a bank with a level of interest rate risk of 20% or more, the range of 11 percentage points is obviously quite large in order to distinguish outlier banks from non-outlier banks. As to be expected the level of interest rate risk varies even more when the assets are concentrated in the opposite side than the liabilities. In this case, the model implied interest rate risk even varies by 42 percentage points. Altogether, this underlines the relevance of a proper assumption of the maturities within the time bands for estimating the interest rate risk of banks. Misspecifications of the maturity distributions can result in strongly biased estimates.

5.2 Number and boundaries of the time bands

The Basel Committee on Banking Supervision (2004b) suggests a reporting framework that is intended to be a guideline for national supervisors. However, the actual reported number of time bands differs between countries. We therefore also examine whether the number and boundaries of the time bands can affect the model results substantially. Accordingly, we repeat the analysis of Section 5.1 for different sets of time bands. First, we use the time bands available to the Deutsche Bundesbank, which are very broad as described in Section 3. Second, we use the reporting framework suggested by the Basel Committee on Banking Supervision (2004b) (See Table 1), third, we consider semi-annual time bands, and finally monthly time bands.[15] Figure 3 shows the results in dependence of the location parameter l.

[15] As described in Section 3, we apply the TAM to synthetically create the respective time bands from the Bundesbank data.

[Figure 3 about here.]

Figure 3 suggests that a large number of time bands of equal length should be preferred to a smaller number of time bands. This is clear because the sensitivity of the level of interest rate risk to the location of the business within the time bands is larger for broader time bands. This effect is especially pronounced for banks that have more long-term assets than long-term liabilities (as in our case, See Table 1) in combination with reporting frameworks such as the German and the Committee's framework that have broader time bands for longer maturities. Assuming the actual German reporting practice, the estimates of the interest rate risk may vary by 28 and, as already shown in Section 5.1, for the Committee's proposal by 11 percentage points.[16] Instead, the estimates are nearly not affected by the location parameter when semi-annual and monthly time bands are considered.

For given small or large location parameters the results can vary substantially between the different reporting practices. This strongly supports the request for the convergence of national reporting practices as otherwise the level of interest rate risk cannot be compared across countries. Of course, the identification of outlier banks in different countries should not depend on the national reporting practice.

[16] Of course, the variations are even larger, if we assume that the business of assets and liabilities is concentrated in the opposite sides of the time bands (See Section 5.1). In this case, the interest rate risk can even become negative, varying by 113 percentage points, when we assume the actual German reporting practice (not shown here).

5.3 Amortization payments

We can expect that parts of the business are amortized before the maturity date. In general, a higher amortization rate results in a lower interest rate sensitivity of a position. Since amortization payments are primarily on the asset side, higher amortization rates should result in a lower interest rate risk measure of the bank. In this section we analyze whether different assumptions regarding the amortization rate of customers loans have a substantial impact on the estimates of the interest rate risk. Figure 4 shows the results for 5 different distributions of maturities within the time bands. The remaining parameters are specified according to the reference scenario.

[Figure 4 about here.]

Obviously, different (economically reasonable) amortization rates can change the implied interest rate risk substantially. For example, for $l = 0.5$, an amortization rate of 25% decreases the level of interest rate risk from 30.9% (reference scenario, $a = 0$) to 9.0%. The higher the amortization rate, the lower is the interest rate risk measure. The influence of different amortization rates is lower (higher) for smaller (larger) maturities, i.e. the more business is assumed to be concentrated in the short (long) end of the time bands: for a concentration in the short end of the time bands ($l = 0$) we obtain estimates for the level of interest rate risk of 25.0% to 8.1%, a range of about 17 percentage points. In contrast, if the business is assumed to be concentrated in the long end of the time bands ($l = 1$), we obtain estimates of 36.5% to 9.4%, which corresponds to a range of about 27 percentage points.

5.4 Coupon payments

The reference scenario assumed coupons and market interest rates to be equal. In reality, banks charge a higher level of interest rate for customers business on the asset side and pay less interest for customers business on the liability side, for example due to market power (e.g. Hutchison and Pennacchi, 1996). A coupon higher (lower) than the market interest rate, however, results in a higher (lower) interest rate sensitivity of a position, since the coupon payments are also sensitive to changing interest rates. Hence, the interest rate risk measure should increase with a higher spread between coupons and market interest rates as the interest rate sensitivity of the asset side increases whereas the sensitivity of the liability side decreases. However, it is unclear, whether the impact is substantial. To analyze this effect, we subsequently vary the spread between the coupon rate c and the market interest rate r for customers loans and customers liabilities. Figure 5 shows the results.

[Figure 5 about here.]

As expected, the model implied level of interest rate risk increases monotonically with an increasing spread. Assuming a spread of 3% yields a level of interest rate risk of 35.9%, i.e. the estimates differ from the reference scenario ($c = r$) by about 5 percentage points.

Since the impact of assumptions on the coupon is higher for positions with a higher maturity, the estimates of interest rate risk are affected more if business is more concentrated in the long-term end of the time bands (i.e. for higher l). Assuming a concentration in the short end of the time bands (i.e. $l = 0$), the interest rate risk increases from 25.0% to 28.6% when the spread increases up to 3%. A concentration in the upper end increases the model implied interest rate risk from 36.5% to 43.1%. Compared to the effects from relaxing the other assumptions discussed above, these ranges seem to be small. However, we stress here again that they are large enough to make a non-outlier bank a clear outlier bank and vice versa. The coupon payments gain even more relevance if banks are considered that have more customers assets and liabilities, relative to their total assets, than the "average German bank".

6 Concluding remarks

In this paper we analyzed the robustness of the standardized framework of the Basel Committee on Banking Supervision (2004b) to assess the interest rate risk of banks. We therefore generalized the Basel Committee's model by relaxing the critical assumptions and analyzed both the model suggested by the Basel Committee and the generalized model in several economically relevant specifications. The practical impact of our analysis is achieved by using data for all German universal banks.

Our analysis shows that the estimates of the level of interest rate risk change substantially when the Committee's assumptions on the distribution of maturities within the time bands, the number and boundaries of the time bands, the amortization payments, and the coupon payments are varied. Even when we stick to the model specification of the Basel Committee, the estimates can vary considerably, since the Committee allows for a rather broad range of the economic maturity of non-maturing deposits.

For banks having a positive duration gap, the assumption of no premature amortization of customers business clearly overestimates the interest rate risk of the bank. Ignoring spreads between coupons of customers business and market rates leads to an underestimation. In contrast, the assumption of a concentration of business in the middle of the time bands can result in a significant bias into both direction. The same holds for the maturity of non-maturing deposits and the reporting practice, i.e. the number and boundaries of the time bands.

We did not include interest rate derivatives positions in our analysis as these data are not available for German banks. Derivatives can be expected to reduce the interest rate risk on average. However, this does not affect our results as including derivatives would adjust the level of interest rate risk but the sensitivities to the assumptions on the on-balance-positions remained unchanged.

Our analysis has several policy implications: it clarifies that the Basel Committee's standardized framework can easily misjudge the level of interest rate risk of banks by far. Therefore, estimation results have to be treated with caution. Moreover, as the direction of the bias is ex ante unclear for a single bank, the Committee's model does not even provide a conservative estimate, i.e. the results cannot be assumed to be always above the "true" interest rate risk. Therefore, a ranking of banks based on the standardized model implied interest rate risk need not necessarily be consistent with a ranking that is based on the "true" risk. This also implies that the Committee's model cannot be expected to appropriately distinguish between low-risk and high-risk banks. The later is of particular relevance as this means that the standardized model cannot reliably identify outlier banks supervisors should be especially attentive to.

Our results support the main requirement by the Basel Committee on Banking Supervision (2004b). Banks should be forced to set up and use comprehensive internal models to quantify their exposure to interest rate changes since a uniformly specified and too simple model can lead to large discrepancies of the "true" and the measured exposure. Of course, this will only work if the internal model is bank-individually based on reliable and traceable model specifications. For example, given the relevance of non-maturing deposits for the (German) banking system, it is in particular essential to obtain a sound methodology to calculate the exposure of non-maturing deposits to changes of interest rates. In any case, supervisors should be sceptical of internal models that are too closely related to the standardized framework. The deliberated use of internal models would not only result in a better quantification of the interest rate risk for supervisory purposes but would also motivate banks to study this very relevant source of risk more deeply and handle it with the necessary care.

If supervisors aim to make their own estimates they should especially call for detailed reports of the maturity and repricing structure of a bank's business' with much tighter time bands than currently discussed. Based on this, they could define several "benchmark models" with different sensible specifications of the remaining relevant parameters. Especially if large differences between the results of the internal model and these benchmark models occur, this should lead to a deeper look on the specification of the internal model.

Appendix A Present value and modified duration

The present value PV of a bond with a face value of 1, a maturity of T, a continuously compounded coupon rate c, and a continuously compounded amortization rate a is given by

$$\begin{aligned} PV &= \int_0^T ce^{-at}e^{-rt}dt + \int_0^T ae^{-at}e^{-rt}dt + e^{-aT}e^{-rT} \\ &= \int_0^T (c+a)e^{-(a+r)t}dt + e^{-(a+r)T} \\ &= \left[-\frac{c+a}{r+a}e^{-(a+r)t}\right]_0^T + e^{-(a+r)T} \\ &= \frac{c+a}{r+a} - \frac{c+a}{r+a}e^{-(a+r)T} + e^{-(a+r)T}, \end{aligned} \tag{8}$$

where r denotes the continuously compounded market interest rate.

If the coupon rate c equals the market interest rates r, we obtain

$$PV|_{c=r} = \left(\frac{c+a}{r+a} - \frac{c+a}{r+a}e^{-(a+r)T} + e^{-(a+r)T}\right)\Bigg|_{c=r} = 1. \tag{9}$$

The modified duration of the bond is given by

$$\begin{aligned} MD &= \frac{-\frac{\partial PV}{\partial r}}{PV} \\ &= \frac{-\left(-\frac{c+a}{(r+a)^2} - \left(-\frac{c+a}{(r+a)^2}e^{-(a+r)T} + \frac{c+a}{r+a}(-T)e^{-(a+r)T}\right) - Te^{-(a+r)T}\right)}{PV} \\ &= \frac{1}{a+r} + \frac{1+(c-r)T}{c-r-(a+c)e^{(a+r)T}}. \end{aligned} \tag{10}$$

For $c = r$ this simplifies to

$$MD = \frac{1-e^{-(a+r)T}}{a+r}. \tag{11}$$

References

Allen, F., Santomero, A. M., 2001. What do financial intermediaries do? Journal of Banking and Finance 25 (2), 271–294.

Basel Committee on Banking Supervision, 2004a. International convergence of capital measurement and capital standards – a revised framework. Bank for International Settlements.

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

Bennett, D. E., Lundstrom, R. D., Simonson, D. G., 1986. Proceedings – A Conference on Bank Structure and Competition. Federal Reserve Bank of Chicago, Ch. Estimating Portfolio Net Worth Values and Interest Rate Risk in Savings Institutions, pp. 323–346.

Committee of European Banking Supervisors, 2006. Draft feedback to the consultation on 'Technical aspects of the management of interest rate risk arising from non-trading ativities under the supervisory review process-CP11'.

Deutsche Bundesbank, 2006. Financial stability review 2006.

Dewachter, H., Lyrio, M., Maes, S., 2006. A multi-factor model for the valuation and risk management of demand deposits. Working Paper No. 83, National Bank of Belgium.

Entrop, O., Memmel, C., Wilkens, M., Zeisler, A., 2007. Analyzing the interest rate risk of banks using time series of accounting-based data: Evidence from Germany. Working Paper, Catholic University of Eichstätt-Ingolstadt and Deutsche Bundesbank.

Federal Deposit Insurance Corporation, 1997. History of the eighties – lessons for the future.

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

Hutchison, D. E., Pennacchi, G. G., 1996. Measuring rents and interest rate risk in imperfect financial markets: The case of retail bank deposits. Journal of Financial and Quantitative Analysis 31 (3), 399–417.

Jacoby, G., Roberts, G. S., 2003. Default- and call-adjusted duration for corporate bonds. Journal of Banking and Finance 27 (12), 2297–2321.

Jarrow, R. A., van Deventer, D. R., 1998. The arbitrage-free valuation and hedging of demand deposits and credit card loans. Journal of Banking and Finance 22 (3), 249–272.

O'Brien, J. M., 2000. Estimating the value and interest rate risk of interest-bearing transaction deposits. Division of Research and Statistics, Board of Governors, Federal Reserve System.

Office of Thrift Supervision, 2000. The OTS Net Portfolio Value Model manual.

Patnaik, I., Shah, A., 2004. Interest rate volatility and risk in Indian banking. IMF Working Paper WP/04/17.

Schmidt, R. H., Hackethal, A., Tyrell, M., 1999. Disintermediation and the role of banks in Europe: An international comparison. Journal of Financial Intermediation 8 (1), 36–67.

Schrand, C. M., 1997. The association between stock-price interest rate sensitivity and disclosures about derivative instruments. The Accounting Review 72 (1), 87–109.

Sierra, G. E., 2004. Can an accounting-based duration model effectively measure interest rate sensitivity? Ph.D. thesis, Washington University in St. Louis.

Sierra, G. E., Yeager, T. J., 2004. What does the Federal Reserve's Economic Value Model tell us about interest rate risk at U.S. community banks? Federal Reserve Bank of St. Louis Review 86 (6), 45–60.

Toevs, A. L., 1982. Gap management: Managing interest rate risk in banks and thrifts. Federal Reserve Bank of San Francisco Economic Review, Spring, 20–35.

Wright, D. M., Houpt, J. V., 1996. An analysis of commercial bank exposure to interest rate risk. Federal Reserve Bulletin, February, 115–128.

Figures

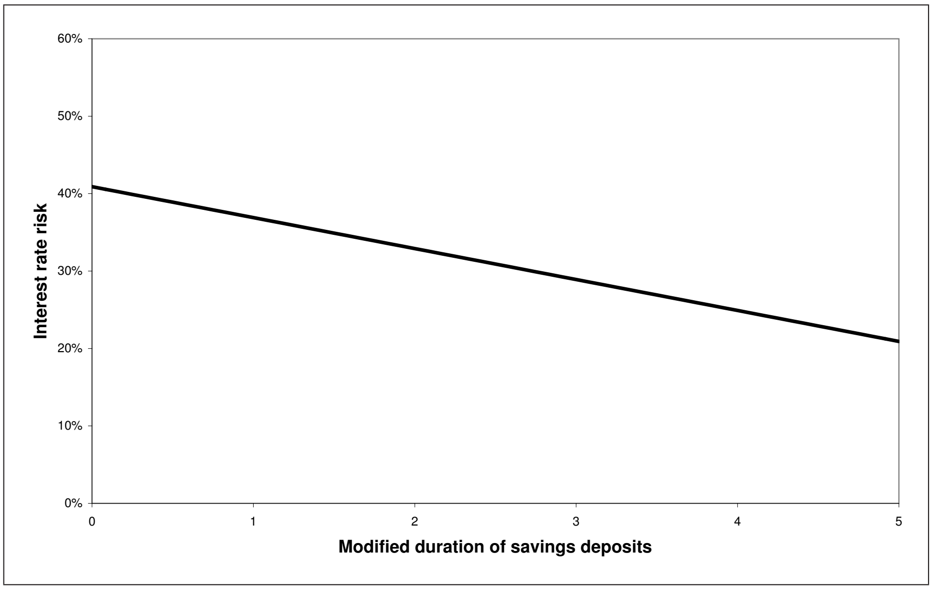

Figure 1: Impact of the modified duration of savings deposits

This figure shows the impact of different assumptions of the interest rate sensitivity of savings deposits on the estimated interest rate risk for a hypothetical bank that corresponds to the aggregated German universal banking system. The parameters are specified according to Section 4.

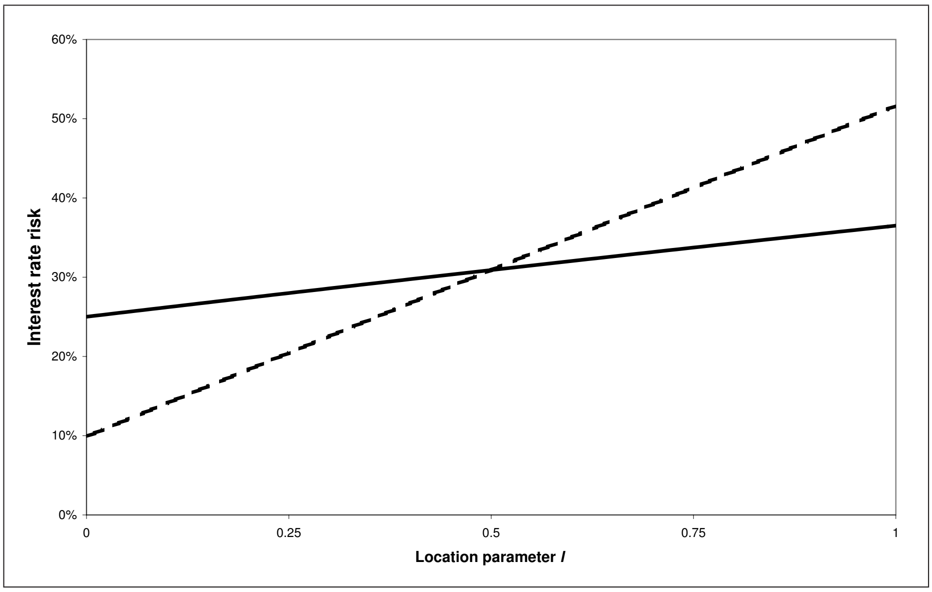

Figure 2: Impact of the distribution of maturities within the time bands

This figure shows the impact of different assumptions on the distribution of maturities within the time bands on the estimates of the interest rate risk. The location parameter l is defined according to (2). It is not relevant for savings deposits as a modified duration is directly assigned to them. The solid line shows the case, when assets and liabilities are situated in the same side of the time bands. The dotted line gives the case, when liabilities are situated in the opposite side of the time bands than assets. The remaining model parameters are specified according to the reference scenario as described in Section 4.

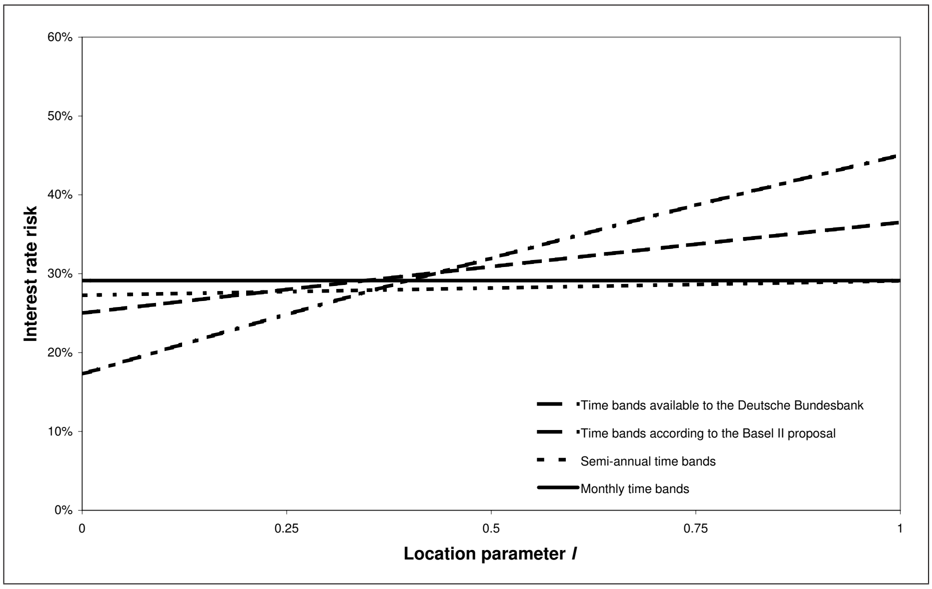

Figure 3: Impact of the reporting framework

This figure shows the impact of different reporting frameworks for different assumptions on the location l of the business within the time bands on the estimates of the interest rate risk. The location parameter is not relevant for savings deposits as a modified duration is directly assigned to them. 4 sets of time band are considered: i) the actual German reporting practice, which contains a breakdown into 4 time bands, ii) the reporting framework according to the Basel Committee on Banking Supervision (2004b), iii) semi-annual time bands, and iv) the exact (monthly) maturity structure as obtained by the TAM. The remaining model parameters are specified according to the reference scenario as described in Section 4.

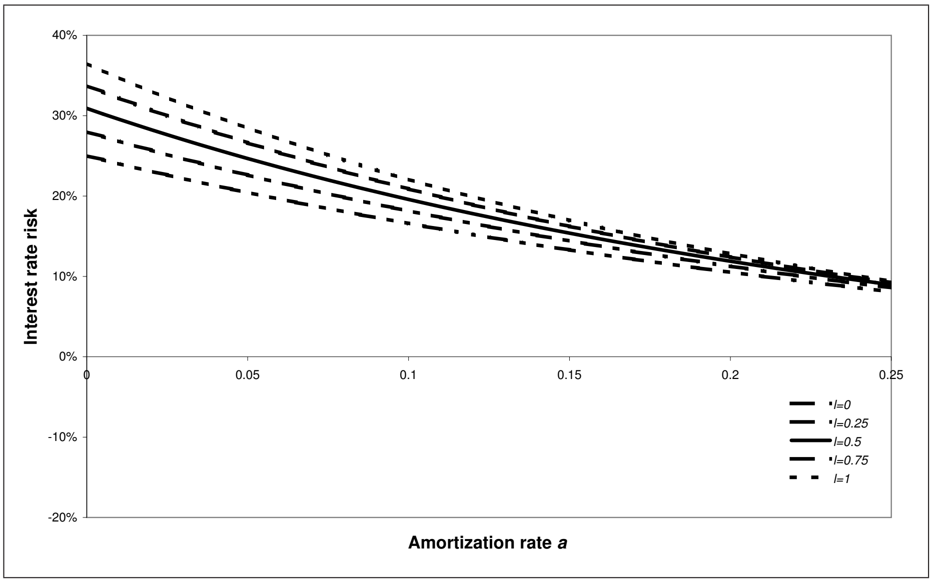

Figure 4: Impact of the amortization rate

This figure shows the impact of different assumptions on the amortization rate of customers loans on the estimated interest rate risk for different location parameters l of business within the time bands. The location parameter is not relevant for savings deposits as a modified duration is directly assigned to them. The remaining model parameters are specified according to the reference scenario as described in Section 4.

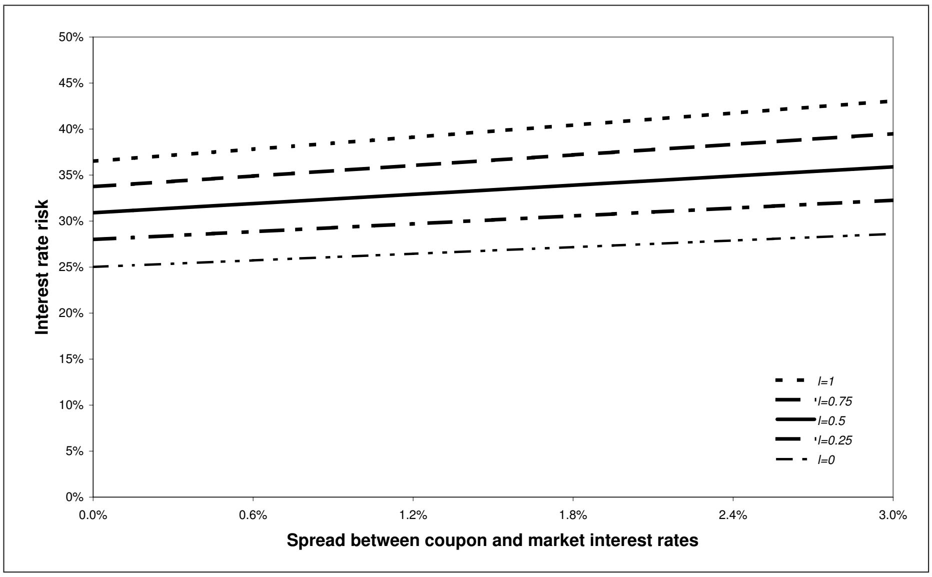

Figure 5: Impact of the spread between the coupon and the market interest rate

This figure shows the impact of different assumptions on the spread between the coupon and the market interest rate for customers loans and liabilities on the estimates of the interest rate risk for different location parameters l. The spread is defined as coupon minus market interest rate for customers loans and market interest rate minus coupon for customers liability. The market interest rate is kept at $r = 5\%$. The remaining model parameters are specified according to the reference scenario as described in Section 4
.

Tables

Table 1: Reference scenario according to the Basel Committee's proposals

Time band	Modified duration	Assets		Liabilities		Net position
		(EUR 10^{11})	%	(EUR 10^{11})	%	(EUR 10^{11})
Up to 1 month	0.04	11.10	22.79	17.49	37.52	-6.39
1 to 3 months	0.17	7.62	15.64	6.58	14.11	1.04
3 to 6 months	0.37	1.61	3.30	1.33	2.84	0.28
6 to 12 months	0.74	3.40	6.97	1.64	3.52	1.76
1 to 2 years	1.45	3.06	6.29	2.62	5.61	0.45
2 to 3 years	2.35	2.44	5.01	2.49	5.34	-0.05
3 to 4 years	3.21	3.96	8.13	2.49	5.34	1.47
4 to 5 years	4.03	2.55	5.23	1.08	2.31	1.47
5 to 7 years	5.18	8.93	18.33	3.76	8.07	5.17
7 to 10 years	6.92	4.04	8.30	1.78	3.82	2.26
Savings deposits	2.50	—	—	5.37	11.52	-5.37
Sum	—	48.70	100	46.61	100	2.09

This table shows the time bands according to the proposals of the Basel Committee on Banking Supervision (2004b). Further, the respective modified durations are shown assuming non-amortizing ($a = 0$) positions concentrated in the middle of the time bands ($l = 0.5$), a coupon rate of 5% ($c = 0.05$), and a market interest rate of 5% ($r = 0.05$). All rates are continuously compounded. Finally, the absolute (in EUR 10^{11}) and relative (in %) outstanding amounts of assets and liabilities, aggregated over all German universal banks and positions in our data set, and the net position in the time bands are shown. These are obtained by estimating the Time Series Accounting-Based Model (TAM) in the specification of Entrop et al. (2007) for a hypothetical bank corresponding to the aggregated German universal banking system. We here only take possible maturities of up to 10 years into account, hence omitting the time bands of 10 to 15 years, 15 to 20 years, and of over 20 years (See Footnote 11).