Oesterreichische Nationalbank

Guidelines on Market Risk

Volume 1

General Market Risk of Debt Instruments

2nd revised and extended edition

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Volume 1: **General Market Risk of Debt Instruments**
2nd revised and extended edition

Volume 2: **Standardized Approach Audits**

Volume 3: **Evaluation of Value-at-Risk Models**

Volume 4: **Provisions for Option Risks**

Volume 5: **Stress Testing**

Volume 6: **Other Risks Associated with the Trading Book**

Published and produced by:

Oesterreichische Nationalbank

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Translated by:

Foreign Research Division

Layout, design, set, print and production:

Printing Office

Internet:

http://www.oenb.at

Paper:

Salzer Demeter, 100% woodpulp paper, bleached without chlorine, acid-free, without optical whiteners.

DVR 0031577

The second major amendment to the Austrian Banking Act, which entered into force on January 1, 1998, faced the Austrian credit institutions and banking supervisory authorities with an unparalleled challenge, as it entailed far-reaching statutory modifications and adjustments to comply with international standards.

The successful implementation of the adjustments clearly marks a quantum leap in the way banks engaged in substantial securities trading manage the associated risks. It also puts the spotlight on the importance of the competent staff's training and skills, which requires sizeable investments. All of this is certain to enhance professional practice and, feeding through to the interplay of market forces, will ultimately benefit all market participants.

The Oesterreichische Nationalbank, which serves both as a partner of the Austrian banking industry and an authority charged with banking supervisory tasks, has increasingly positioned itself as an agent that provides all market players with services of the highest standard, guaranteeing a level playing field.

Two volumes of the six-volume series of guidelines centering on the various facets of market risk provide information on how the Oesterreichische Nationalbank appraises value-at-risk models and on how it audits the standardized approach. The remaining four volumes discuss in depth stress testing for securities portfolios, the calculation of regulatory capital requirements to cover option risks, the general interest rate risk of debt instruments and other risks associated with the trading book, including default and settlement risk.

These publications not only serve as a risk management tool for the financial sector, but are also designed to increase transparency and to enhance the objectivity of the audit procedures. The Oesterreichische Nationalbank selected this approach with a view to reinforcing confidence in the Austrian financial market and – against the backdrop of the global liberalization trend – to boosting the market’s competitiveness and buttressing its stability.

Gertrude Tumpel-Gugerell

Vice Governor

Oesterreichische Nationalbank

Today, the financial sector is the most dynamic business sector, save perhaps the telecommunications industry. Buoyant growth in derivative financial products, both in terms of volume and of diversity and complexity, bears ample testimony to this. Given these developments, the requirement to offer optimum security for clients' investments represents a continual challenge for the financial sector.

It is the mandate of banking supervisors to ensure compliance with the provisions set up to meet this very requirement. To this end, the competent authorities must have flexible tools at their disposal to swiftly cover new financial products and new types of risks. Novel EU Directives, their amendments and the ensuing amendments to the Austrian Banking Act bear witness to the daunting pace of derivatives developments. Just when it seems that large projects, such as the limitation of market risks via the EU's capital adequacy Directives CAD I and CAD II, are about to draw to a close, regulators find themselves facing the innovations introduced by the much-discussed New Capital Accord of the Basle Committee on Banking Supervision. The latter document will not only make it necessary to adjust the regulatory capital requirements, but also requires the supervisory authorities to develop a new, more comprehensive coverage of a credit institution's risk positions.

Many of the approaches and strategies for managing market risk which were incorporated in the Oesterreichische Nationalbank's Guidelines on Market Risk should – in line with the Basle Committee's standpoint – not be seen as merely confined to the trading book. Interest rate, foreign exchange and options risks also play a role in conventional banking business, albeit in a less conspicuous manner.

The revolution in finance has made it imperative for credit institutions to conform to changing supervisory standards. These guidelines should be of relevance not only to banks involved in large-scale trading, but also to institutions with smaller voluminous trading books. Prudence dictates that risk – including the "market risks" inherent in the bank book – be thoroughly analyzed; banks should have a vested interest in effective risk management. As the guidelines issued by the Oesterreichische Nationalbank are designed to support banks in this effort, banks should turn to them for frequent reference. Last, but not least, this series of publications, a key contribution in a highly specialized area, also testifies to the cooperation between the Austrian Federal Ministry of Finance and the Oesterreichische Nationalbank in the realm of banking supervision.

Alfred Lejsek

Director General
Federal Ministry of Finance

Preface

This guideline, which deals with the general market risk inherent in debt instruments according to § 22h of the Austrian Banking Act and the decomposition of interest rate products pursuant to § 22e of the Austrian Banking Act, attempts to illustrate - via a number of examples - a possible way of treating these issues in the context of the standardized method.

Chapter 1 provides an overview of the legal regulation and an introduction into the calculation methods, i.e. the maturity band approach and the duration method.

Chapter 2 elaborates on the breakdown of interest rate products. It includes a description of the most common products and the decomposition into their underlying components. Numerous examples and graphic illustrations are meant to elucidate and enhance the reader's understanding of interest rate products.

Finally, in chapter 3 a case study is presented that exemplifies the calculation of the regulatory capital requirement for a selected sample portfolio both according to the maturity band and the duration method.

The Annex comprises a summary of the breakdown methodology used in chapter 2 as well as a brief presentation of the duration concept.

The authors would like to thank Annemarie Gaal, Alexandra Hohlec, Gerald Krenn, Alfred Lejsek, Helga Mramor, Manfred Plank, Gabriela de Raaij, and Burkhard Raunig for their valuable suggestions and comments.

Vienna, March 1998

Gerhard Coosmann
Ronald Laszlo

Preface to the Second Revised and Extended Edition

The interest with which the first edition of this guideline was met by the banking community bore testimony to the great demand for an in-depth interpretation of the pertinent legal provisions. For this reason this guideline is published in a second revised edition as volume 1 of the Guidelines on Market Risk. This new edition now also incorporates currency forwards, currency options and high yield bonds. In addition, it describes calculations based on the price delta which are applicable to caps and floors, which allow for a uniform and consistent treatment of all interest rate instruments.

The author would like to extend thanks to Annemarie Gaal, Manfred Plank and Ronald Laszlo for their valuable suggestions and comments. Special thanks are due to the head of the division, Helga Mramor, who promoted the production of this series of guidelines on market risk.

Vienna, September 1999

Gerhard Coosmann

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1 Introduction

In line with the second major amendment to the Austrian Banking Act, starting with January 1, 1998, credit institutions are, among other things, obliged to hold regulatory capital for interest rate instrument transactions which are exposed to general market risk. General market risk of interest rate positions refers to potential rate fluctuations which are prompted by changes in the market interest rate and may thus not be traced back to issuer-specific features (specific risk).

§ 22h of the Austrian Banking Act stipulates two alternative standard procedures for computing the regulatory capital requirement for covering general position risk: the maturity band method and the duration method. Moreover, § 22e paras 6 and 7 of the Austrian Banking Act provide for a sensitivity approach, which requires formal approval though.

The two standard methods virtually deal with three risk components: change in the interest rate level (parallel shift of the yield curve), inversion of the yield curve and basis risk. Basis risk is about the fact that interest rate instruments with the same maturity may be characterized by differing performance. When long and short positions in dissimilar instruments are juxtaposed, which have nearly identical residual maturities, this risk might very well result in losses. Losses may also incur since the asset-side and liabilities-side maturities within the maturity bands do not have to be completely identical. As these risks are traditionally low compared to other risk factors, they must be collaterized with regulatory capital at a marginal rate (10%) only.

The most significant difference between the maturity band and the duration methods lies in the degree of accuracy: While the duration method takes account of each individual position with its exact modified duration, the weighting factors of the maturity band method merely consider the mean duration per maturity band. Owing to the greater degree of accuracy, the regulatory capital requirement, as a rule, is somewhat lower when calculated according to the duration method.

1.1 Maturity Band Method (pursuant to § 22h para 2 of the Austrian Banking Act)

Zone	Maturity bands		Weighting (in %)	Assumed interest rate change (in %)
	Coupon of 3% or more	Coupon of less than 3%		
Column (1)	Column (2)	Column (3)	Column (4)	Column (5)
Zone (1)	up to 1 month over 1 up to 3 months over 3 up to 6 months over 6 up to 12 months	up to 1 month over 1 up to 3 months over 3 up to 6 months over 6 up to 12 months	0.00 0.20 0.40 0.70	-- 1.00 1.00 1.00
Zone (2)	over 1 up to 2 years over 2 up to 3 years over 3 up to 4 years	over 1 up to 1.9 years over 1.9 up to 2.8 years over 2.8 up to 3.6 years	1.25 1.75 2.25	0.90 0.80 0.75
Zone (3)	over 4 up to 5 years over 5 up to 7 years over 7 up to 10 years over 10 up to 15 years over 15 up to 20 years over 20 years	over 3.6 up to 4.3 years over 4.3 up to 5.7 years over 5.7 up to 7.3 years over 7.3 up to 9.3 years over 9.3 up to 10.6 years over 10.6 up to 12.0 years over 12.0 up to 20.0 years over 20.0 years	2.75 3.25 3.75 4.50 5.25 6.00 8.00 12.50	0.75 0.70 0.65 0.60 0.60 0.60 0.60 0.60

Traditionally interest rate volatility tends to be greater on the short rather than the long end of the yield curve. For this reason the assumed interest rate changes of 100 basis points in the money market field fall to 60 basis points in the long position. These assumptions are based on statistical analyses of the Basle Committee on Banking Supervision (which have not been published though).

The weights in column (4) result from the product of the assumed interest rate changes with the modified durations, which were set as follows: The modified duration of a notional security, which has a coupon of 8%, a yield of 8% and a residual maturity in the middle of the maturity band, was calculated per maturity band.

Since the interest rate sensitivity of bonds with smaller coupons exceeds that of bonds with higher coupons, an additional line was drawn at 3% for the classification of coupons.

To compute the regulatory capital requirement, the respective net positions of the corresponding currency are assigned to the corresponding maturity band at the time of their interest rate maturity – i.e. at the time of repayment or at the next interest rate fixing date – and are multiplied by the respective weight in column (4). All underlying instruments principally are to be assigned at the present value. With bonds the present value corresponds to the market value. The market value is the product of the principal amount and market price including accrued interest ("dirty price"). The residual maturity is to be calculated in line with the respective capital market conventions (e.g. 30/360, actual/actual, etc.).

Example:

Principal amount	10,000,000	Accrued interest	1,060,763,889
Market price	99.5	Dirty price	100.56
Settlement day	04.10.99	Market value	10,056,076.39
Maturity	15.07.02	Residual maturity	4.82 Jahre
Coupon	5,875	Mod. duration	4.05
Frequency	1		

After that the net positions must be differentiated between long and short positions and added separately. In vertical and horizontal hedging the open positions within the maturity bands and between the duration zones are netted out.

Vertical Hedging

Vertical hedging refers to the setting off of the sums of the respective long and short positions of a given maturity band. The remaining basis risk is considered in the individual maturity bands at 10% of the closed weighted position.

Horizontal Hedging

In horizontal hedging the remaining open weighted positions of the maturity bands are added up per maturity zone by long and short positions and contrasted. So as not to consider unparallel changes in the yield curve, the matched positions of zones 2 and 3 are backed with 30% and those of zone 1 with 40% of regulatory capital.

In a further step the unmatched positions of adjacent zones are to be set off.[1] The regulatory capital requirement for matched positions between adjacent maturity zones amounts to 40% of the matched positions. Once the positions of zones 1 and 3 have been matched, the matched position needs to be covered with 150% of regulatory capital. This high ratio takes into account that the risks resulting from opposite positions in maturity bands far apart may accummulate if an unparallel shift occurs in the yield curve.

After the final setting off the full amount of the remaining open weighted positions is to be bakked with regulatory capital.

The following table provides an overview of the capital backing factors required for matched weighted positions.

Balanced (Closed) Weighted Positions

Zone	Within a maturity band	Within a maturity zone	Between adjacent maturity zones	Between nonadjacent maturity zones
1	10 percent	40 percent	40 percent	
2	10 percent	30 percent	40 percent	
3	10 percent	30 percent	40 percent	150 percent (Zones 1 and 3)

[1] *The order in which the adjacent zones are being set off may alternate, i.e. either zones 1 and 2 followed by zones 2 and 3 or first zones 2 and 3 followed by zones 1 and 2 are set off.*

1.2 Duration Method (pursuant to § 22h para 3 of the Austrian Banking Act)

In addition to the maturity band method outlined above, the duration method based on the mathematical indicator duration may serve as the second possible method for computing the required regulatory capital.

The Austrian Banking Act does not envision maturity bands for the duration method, but only three duration zones:

Zone	Modified duration (in %)	Assumed interest rate change (in %)
1	0 to 1.0	1.00
2	over 1.0 up to 3.6	0.85
3	over 3.6	0.70

First of all, you calculate the modified duration of the respective net position and record it in the corresponding maturity zone. Then you multiply the computed modified duration by the assumed interest rate change. This way you arrive at the rate change of the net position bound to occur if the interest rate changes by the assumed amount.

From then on you proceed as with the maturity band method to calculate the regulatory capital requirement, as the concept of the duration method is based on the same procedures as the maturity band method.[2] Differences merely concern the capital backing factors in hedging. Balanced positions within the same maturity zone need to be backed by just 2%, which is why opposite positions may almost completely be set off.

Using the modified duration allows, however, for a more precise presentation of the interest rate risk inherent in a given portfolio, since the entire payment flow of the respective securities is factored into the caclucation of the modified duration.

Yet its main conceptual flaw is that each cash flow is discounted at the same interest rate and a flat yield curve is thus assumed.

[2] *Strictly speaking, the maturity band method represents a simplified version of the duration method.*

1.3 The Sensitivity Approach (pursuant to § 22e paras 6 and 7 of the Austrian Banking Act)

The most accurate method, no doubt, is what is called pre-processing, i.e. decomposing straight bonds into synthetic zero coupon bonds, and measuring the portfolio's sensitivity (change of the portfolio's present value upon interest rate movements) by means of realistic yield curves. As this approach is considerably more complex and its implementation might be more difficult as well, the OeNB must examine and the Federal Ministry of Finance must approve of such an approach.

It is not permissible, however, to strip bonds into synthetic zero coupon bonds and then process such bonds according to standard procedures. It is expected that banks which are technically capable of pre-processing either submit a sensitivity approach or a proprietary model for approval.

2 Interest Rate Products and their Components

2.1 Characteristics of Interest Rate Products

2.1.1 Underlying Instruments

As outlined in chapter 1, a detailed regulation applies for interest rate risks in the context of the standard procedures according to which various positions are to be assigned to the respective maturity bands or duration zones. When it comes to assigning interest rate derivatives, it is important to take note of several issues. Derivatives basically are to be broken down into a combination of *underlying instruments (i.e. straight bonds, floating rate notes and zero coupon bonds)*, which then may be categorized according to the respective bands. *Straight bonds* have a coupon attached that remains constant over the entire maturity. The repayment of capital is effected once the maturity has expired. By contrast, *with floating rate notes* the coupon payments are tied to a variable reference interest rate. *Zero coupon bonds* are marked by just one cash flow: redemption at the end of the maturity. Straight bonds in the pure sense of the term, i.e. excluding any specific add-on features (such as call/put options, caps, floors, etc.) are often dubbed *plain vanilla bonds*. Pursuant to § 22h para 2 Banking Act, straight bonds must be categorized by residual maturity. Floaters, in contrast, stay assigned to the respective maturity bands only up until the next interest rate adjustment. This is based on the idea that the interest rate risk of floating rate notes is thus limited to the period up to the next rate adjustment. It is easy to prove that the rate of a variable-rate bond is 100 at the time when rates are reset.

Let's take a look at a three-year floating rate note whose rates are adjusted annually. This bond has a principal of 1 and coupons to the amount of the expected one-year interest rates $E(r_{i,j})$. The actual interest rate pattern is given by r_1, r_2 and r_3. Therefore the price of the bond results from the sum of the expected payments as discounted by the interest rates valid for specific periods:

$$P = \frac{E(r_{0,1})}{(1+r_1)} + \frac{E(r_{1,2})}{(1+r_2)^2} + \frac{E(r_{2,3})+1}{(1+r_3)^3} . \qquad (1)$$

When the first interest rate is fixed $((E(r_{0,1})=r_1)$ and the expected one-year interest rates are substituted by the respective forward rates ($f_{1,2}$ und $f_{2,3}$), we get the following equation:

$$P = \frac{r_1}{(1+r_1)} + \frac{f_{1,2}}{(1+r_2)^2} + \frac{f_{2,3}+1}{(1+r_3)^3} . \qquad (2)$$

The equation may be transformed so as to:

$$P = \frac{(1+f_{2,3})(1+f_{1,2})(1+r_1)}{(1+r_3)^3} = 1 \qquad (3)$$

because $(1+f_{2,3})(1+f_{1,2})(1+r_1) = (1+r_3)^3$

The same process is repeated after one year: the by then two-year floater would again be valued at 100.

2.1.2 Composite Interest Rate Products

Interest rate products that consist of several elements must first be broken down into their plain vanilla components, which then may be assigned to the respective bands.

With composite interest rate products a distinction must be made between the following two categories:

Symmetric Interest Rate Derivatives

- FRAs
- Futures
  - Interest rate futures
  - Bond futures
- Forward transactions
- Swaps
  - Plain vanilla swaps
  - Basis swaps
  - Forward swaps
- Currency forwards

Asymmetric Interest Rate Derivatives (Interest Rate Options)

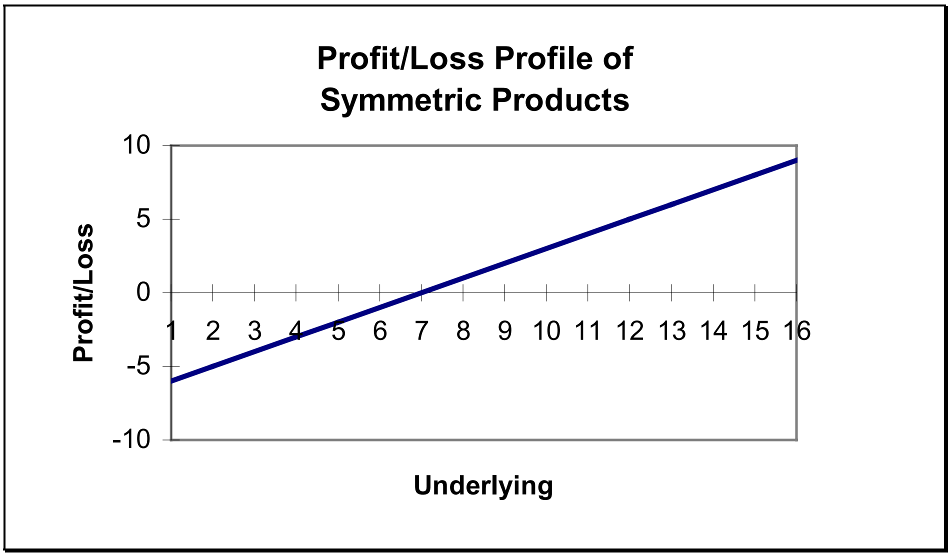
- Option on an interest rate (=option on an FRA)
- Option on an interest rate future
- Option on a bond
- Option on a bond future
- Caps

- Floors
- Currency options

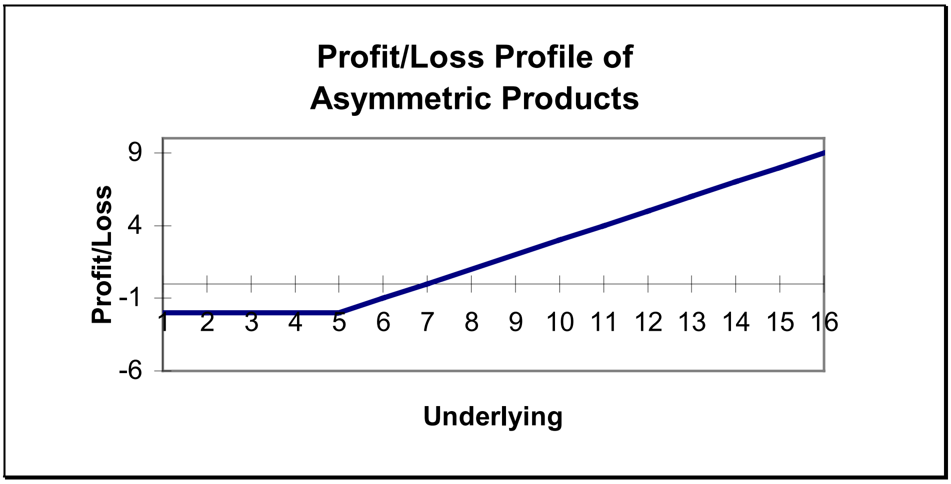
Structured Interest Rate Derivatives

- Reverse floater
- Leveraged floater
- FRN with cap
- FRN with floor
- Collars
- Collar floater
- Swaptions
- Bonds with embedded swaptions
- Bonds with call / put options
- High yield bonds

Symmetric products show a balanced profit / loss profile. The buyer or seller of such products has the right and the duty to assume the interest payment obligation underlying a given transaction. When the value of the underlying instrument changes, on which the symmetric interest rate product is based, profits and losses are principally infinite.



By contrast, the buyer of an asymmetric product only has the right, but not the duty, to assume the underlying interest payment obligation. As this right is only used when favorable to the buyer, the potential for profit is basically unlimited, while the loss potential is limited to the amount of the premium. All such transactions are similar to insurance deals, which is also reflected by the fact that a premium has to be paid for asymmetric products.



Structured products exclusively are such products which are composed of a combination of individual products. The structured product may be regarded as a portfolio made up of a number of components, which may include plain vanilla instruments (straight bonds, FRNs), symmetric (e.g. FRAs) and asymmetric products (options). When a structured product is analyzed, it is therefore important to identify the elements making up the product. Only then may the correct and fair market price as well as the risk of such a product be duly assessed.

The annex to this guideline contains a systematic overview of the composition of the most important interest rate products.

2.2 Symmetric Interest Rate Derivatives

2.2.1 Forward Rate Agreements (FRAs)

Forward rate agreements concern contracts by which the parties agree on the interest rate to be paid on a future settlement day. With a forward rate agreement with a period quoted as, for instance, six against nine months, an interest rate would be agreed on, which would apply for a three-month period commencing in six months' time. At the beginning of the FRA period the contract is settled (in the example at hand after six months), with exposure limited to the difference in interest rates between the agreed and actual rates at settlement. The cash settlement payment is discounted to the present value. No capital movements are involved.

Buyers of forward rate agreements hedge against rising interest rates. If interest rates increase, they will receive a cash settlement payment to the amount of the difference between the agreed FRA interest rate and the actual market rate at settlement. The opposite applies in case of sinking interest rates: then the buyer is obliged to make the respective cash settlement payment. This concept thus offers a (theoretically) infinite potential for profit at rising interest rates and (theoretically) infinite potential losses when rates are on the decline. The purchase of an FRA basically corresponds to future fund-raising and the sale of an FRA to a future investment.

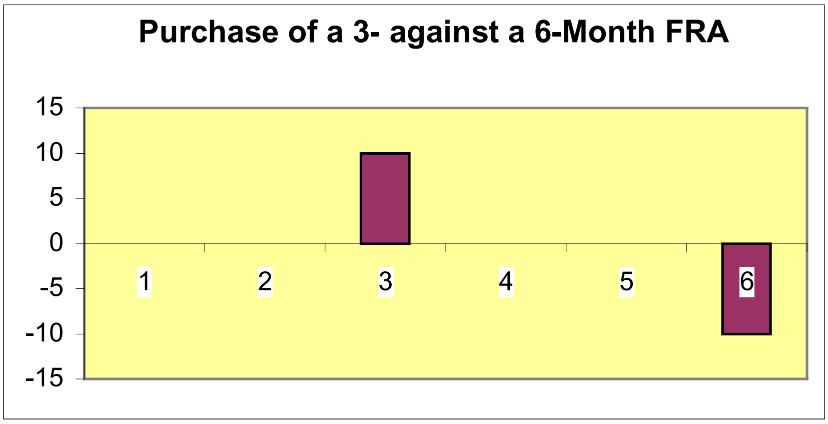
How can an FRA be broken down into its plain vanilla elements? The purchased FRA may be synthetically depicted via two notional zero coupon positions: one short position (liability) up to the maturity of the underlying credit transaction and one long position (claim) up to the settlement of the FRA. The Austrian Banking Act includes provisions on such a case in § 22e para 1 No 2 under "forward rate agreement"; there the decomposition of a sold FRA is exemplified. The principle of dividing the product into two components, namely short and long positions in notional plain vanilla instruments (which is also frequently referred to as the principle of breaking down products into two "legs" with opposite signs), will be applied to all interest rate derivatives.

The following example is intended to illustrate this principle:

Purchase of a 3- against a 6-month FRA, principal: 10 million, interest rate: 5%
This position is broken down into two opposite zero coupon bond positions with a maturity of three months (long) and six months (short). Basically, these positions must be assigned to the respective maturity bands at their net present values. In other words, the synthetic cash flows must be discounted at the current 3-month and 6-month interest rate. Credit institutions encountering difficulties in implementing this provision may, however, also record the nominal values (i.e. 10 million) in column (3) of the table under § 22h para 3 No 4 Banking Act. After all, the resulting error is negligible given the generally short maturities of FRAs. With maturities

of up to 12 months discounting could, as a rule, be neglected, whereas the net present value concept should be seemlessly applied to maturities of one year and more.

As we are talking about synthetic zero coupon bonds, they may be assigned to "Coupon of less than 3%" regardless of the amount of the FRA interest rate actually agreed on. After all, this distinction practically has no effect with maturities of up to 12 months.



2.2.2 Futures

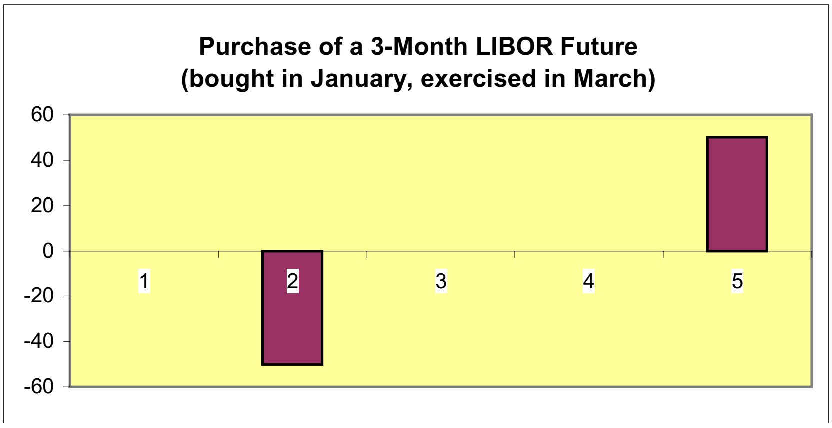
With futures we basically have to distinguish between short-term *interest rate futures* (e.g. future on LIBOR) and *bond futures* (e.g. future on AGB).

2.2.2.1 Interest Rate Futures

Short-term interest rate futures share the same characteristics with FRA deals (as a matter of fact, the prices of these instruments are calculated based on the same principles). They only differ in that interest rate futures represent standardized stock exchange contracts. Take note, however, that during synthetization of an interest rate future via notional underlying transactions the signs are exactly opposite to those of FRAs[3]. The buyer of an interest rate future hedges against sinking interest rates. Consequently, this transaction must be recorded as a long position of the underlying credit transaction and a short position up to the settlement of the future. The legal provisions for the decomposition of money market futures are covered by § 22e para 1 No 1 Banking Act ("interest rate futures").

[3] *This particularity results from the fact that the prices of money market futures are arrived at by subtracting the FRA interest rates from 100. This way both money market and bond futures react to changes in the interest rates in the same fashion.*

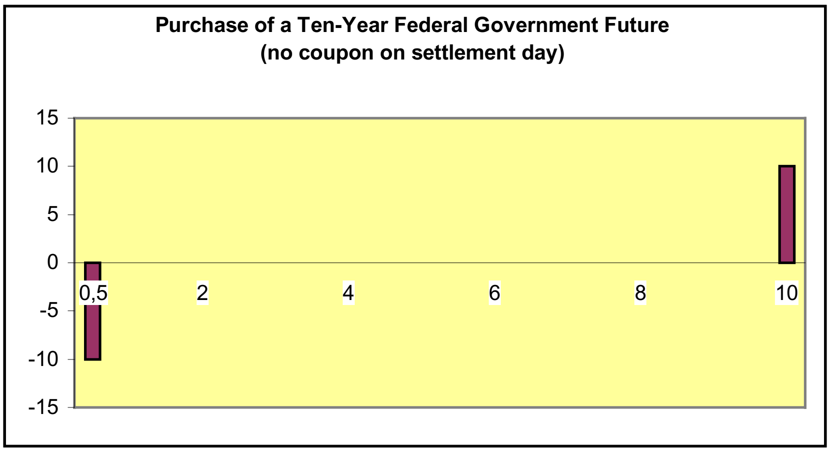
Example:
A future on the 3-month LIBOR valued at 50 million, which was bought in January and becomes due in March, is divided into a 5-month long position (= 3 to 6 months maturity band) and a 2-month short position (= 1 to 3 months maturity band). In all other areas the same principles as for FRAs (recording of net present values or, if the former is not possible, nominal values in the "Coupon of less than 3%" column) apply.



2.2.2.2 Bond Futures

With bond futures the two legs consist of positions in a long-term straight bond and a short-term zero coupon bond (up until the settlement date) with a reversed sign (see § 22e para 1 No 3 Banking Act). The CTD ("cheapest to devilery") bond should, of course, be used for the 10-year position, as this reflects realistic cash flows. The other deliverable bonds or the synthetic bond underlying the futures contract should not be considered for this purpose.

Example:
A future on AGB (principal: 10 million), which was bought in December and is due in June, consists of a long position in the 10-year CTD bond and a short position in a 6-month zero coupon bond. If the bond also comprised a coupon payment in February, an additional short position in a 2-month zero coupon bond to the amount of this coupon would have to be recorded. The long position is to be recorded at the present value (dirty price). The amount of the 2-month zero coupon bond must be calculated as follows: agreed principal times future price times conversion factor plus accrued interest at settlement. This value is discounted to the present value by means of the current yield curve.



2.2.3 Forward Transactions

It goes without saying that forward transactions on bonds, i.e. non-standardized agreements (over-the-counter deals) on selling or buying a bond at a future date, are also broken down into their components according to the method used for bond futures.

2.2.4 Swaps

2.2.4.1 Plain Vanilla Swaps (Coupon Swaps / Generic Swaps)

Here, fixed interest rates are swapped for floating rates. The buyer of a swap pays fixed interest and receives variable interest rates in exchange (payer swap). The opposite is true of the seller of a swap (receiver swap). Coupon swaps may be viewed as a combination of a money market and a capital market security. The buyer of the swap may duplicate this position as a short position in a straight bond and a long position in a floating rate note. Therefore you record a short position in that maturity band which corresponds to the maturity of the swap and a long position until the next interest rate fixing (§ 22e para 4 Banking Act).

2.2.4.2 Basis Swaps

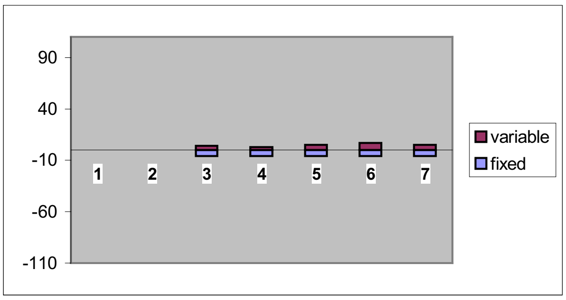
Basis swaps are used for exchanging variable interest rates against like rates (e.g. 3-month LIBOR against 6-month LIBOR). Long and short positions are posted in the bands in accordance with the next interest rate fixings.

2.2.4.3 Forward Swaps

Interest swaps, whose conditions are set today, yet whose life starts only in the future, are called forward swaps. There are no provisions in the Austrian Banking Act that explicitly refer to forward swaps. They may, however, be broken down into their components in an analogous way: one leg up to the bullet maturity of the straight bond and one leg with reversed sign until the first interest rate fixing.

<u>Example</u>:
The purchase of a 5-year coupon swap (payer swap), which commences in two years and has an interest rate of 6%, may be decomposed into a 7-year short position in a 6% straight bond and a 2-year short position in a 6% straight bond. The present values of these synthetic bonds are to be calculated via a topical yield curve.

The following figures illustrate the breakdown of forward swaps into two synthetic straight bonds:



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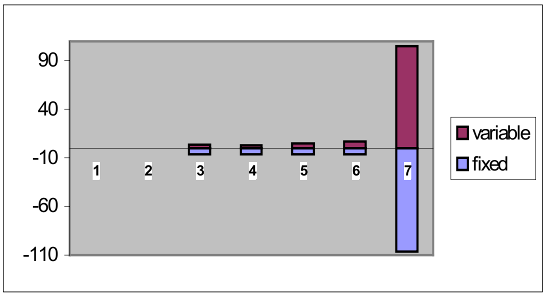

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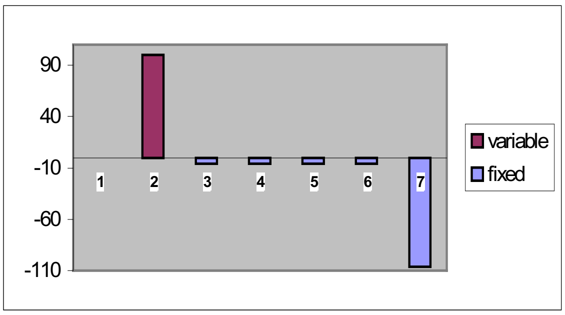

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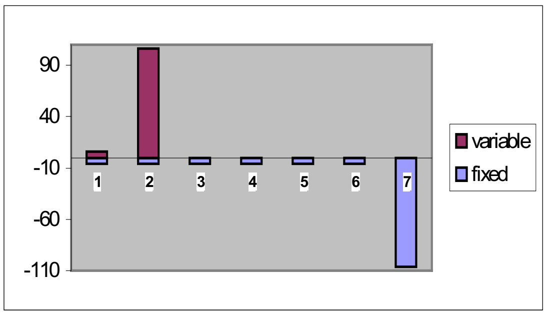

4.

The first figure demonstrates the actual cash flow of the forward swap. In the second figure the hypothetical capital is added both on the assets and the liabilities side. The floating side may be set at the value of 100 at the first interest fixing (figure 3) out of considerations already mentioned (see page 12). To be able to enter a short position in the 7-year straight bond, two more coupons must be created in the first two years, which need to be canceled out by offsetting long positions. The outcome is a long position in a two-year straight bond.

2.2.5 Currency Forwards

Currency forwards refer to a currency swap to be effected at a future point in time, with the exchange rate already fixed at the time the deal is struck. The main risk emanating from such operations is naturally the foreign exchange risk. Interest rate risks are also involved, which have to be taken into account in the standardized approach. Here, the forward transaction must be broken down into a spot position, a borrowing transaction and a lending transaction.

Example:

The purchase of EUR 5 million against USD due in 6 months at a forward price of 1.05 is to be treated as follows with regard to the general interest rate risk:

Assign a EUR long position to the 3 to 6 months maturity band (EUR 5 million, discounted at the current 6-month EUR interest rate) and a USD short position to the same maturity band (USD 5.25 million, discounted at the current 6-month USD interest rate).

2.3 Asymmetric Interest Rate Derivatives

Asymmetric interest rate derivatives have an optional character. Like symmetric transactions, these positions are divided into two legs, i.e. a long and a short position[4]. Here, one position must be recorded until the end of the maturity of the underlying instrument and the other position to the exercise date.

Besides, you should bear in mind that the interest rate changes of the underlying instrument only have an indirect influence on the option premiums. For this reason you need to weight the positions with the respective delta factor. The delta factor indicates the change in the option's value when the value of the underlying instrument changes by one unit. Here the Austrian Banking Act (§ 22e para 2) provides that for listed options the delta published by the stock exchanges may be used. With OTC options the credit institute itself must compute the delta factors via adequate option pricing models.

When you allot the delta weighted positions, it is important to note the sign of the delta (short or long position):

Option position	*Delta*	*Underlying*
bought call	positive	long position
sold call	negative	short position
bought put	negative	short position
sold put	positive	long position

For the purposes of equity capital backing no distinction is made between European (exercise restricted to a specific cut-off date only) and American (exercise period) options. It is assumed that U.S. options are not exercised prematurely.[5]

Moreover, other risks must be taken into account with regard to options. § 22e para 3 Banking Act explicitly refers to gamma and vega risks. A detailed description of simplified procedures on the treatment of these risks is included in the Options Risk Regulation.[6]

[4] *The Austrian Banking Act (§ 22e para 2) does not explicitly stipulate this division into short and long components. Nevertheless interest rate options should be treated this way. Especially with options, whose settlement day is far off in the future, neglecting the leg until settlement day would result in a marked distortion of the risk position. This is e.g. the case with bonds with termination right, i.e. bonds with an attached option (callable bonds).*

[5] *This invariably applies to American calls, but only to a limited extent to American puts.*

[6] *For more information see volume 4 of the Guidelines on Market Risk „Provisions for Option Risks" (Gaal and Plank, 1999)*

2.3.1 Options on Interest Rates (Options on FRAs)

Call options on an FRA are referred to as caplets, put options as floorlets. Such options are decomposed in the same way as the FRA which underlies the option (see section 2.2.1). However, the delta-weighted equivalents of the positions must be assigned to the respective maturity bands. To calculate premiums and sensitivities, you could, for instance, use the Black 76 model[7]:

Premiums:

$$\begin{aligned}
caplet &= \tau L e^{-r(k+1)\tau}\left[FN(d_1) - RN(d_2)\right] \\
floorlet &= \tau L e^{-r(k+1)\tau}\left[RN(-d_2) - FN(-d_1)\right] \\
\text{where :} & \\
d_1 &= \frac{\ln(F/R) + \sigma^2 k\tau/2}{\sigma\sqrt{k\tau}} \\
d_2 &= d_1 - \sigma\sqrt{k\tau}
\end{aligned}$$

Sensitivities:

$$\begin{aligned}
\partial(call) &= \tau N(d_1)e^{-r(k+1)\tau} \\
\partial(put) &= \tau(N(d_1) - 1)e^{-r(k+1)\tau} \\
\gamma &= \frac{n(d_1)}{F\sigma\sqrt{k\tau}}\left(\tau e^{-r(k+1)\tau}\right)
\end{aligned}$$

where:

L = Face value
F = Forward rate
R = Strike
τ = Maturity of the caplet/floorlet
k = Periods up to the beginning of the life of the caplet/floorlet
e = Natural logarithmic base
N = Distribution function
n = Density function
σ = Volatility
r = Riskfree interest rate up to expiry of the caplet/floorlet

Example:

A written call option on a one-year against a two-year FRA is to be broken down and assigned to the respective maturity bands.

Face value: 20 million

Strike: 6%

Forward rate 1- against 2-year: 5.41%

Riskfree interest rate: 5.21%

Volatility: 20%

Given the above parameters, we arrive at the following results:

Premium: ATS 39,413.79

Delta: 0.305

Delta equivalent: ATS 6,093,541

How shall the product be decomposed and assigned to the maturity bands?

A written call option represents a short position in the underlying (see section 2.2). Therefore, you need to divide the delta equivalent of a written FRA position into the two legs and assign them to the maturity bands. It follows that the amount of ATS 6,093,541 is allocated as a long position in the 1 to 2 years maturity band and as a short position to the 6 to 12 months band. The resulting regulatory capital requirement equals ATS 50,570.

Maturity bands		Weight	Open positions		Weighted open positions		Matched band positions	Remaining open band positions		Matched zone positions	Open zone positions	
Coupons >=3%	Coupons <3%		long	short	long	short		long	short		long	short
-1	-1	0%			0,00	0,00	0,00	0,00	0,00			
>1-3	>1-3	0,20%			0,00	0,00	0,00	0,00	0,00			
>3-6	>3-6	0,40%			0,00	0,00	0,00	0,00	0,00			
>6-12	>6-12	0,70%		6.093	0,00	42,65	0,00	0,00	42,65			
Zone 1								**0,00**	**42,65**	**0,00**	**0,00**	**42,65**
>1-2	>1-1,9	1,25%	6.093		76,16	0,00	0,00	76,16	0,00			
>2-3	>1,9-2,8	1,75%			0,00	0,00	0,00	0,00	0,00			
>3-4	>2,8-3,6	2,25%			0,00	0,00	0,00	0,00	0,00			
Zone 2								**76,16**	**0,00**	**0,00**	**76,16**	**0,00**
>4-5	>3,6-4,3	2,75%			0,00	0,00	0,00	0,00	0,00			
>5-7	>4,3-5,7	3,25%			0,00	0,00	0,00	0,00	0,00			
>7-10	>5,7-7,3	3,75%			0,00	0,00	0,00	0,00	0,00			
>10-15	>7,3-9,3	4,50%			0,00	0,00	0,00	0,00	0,00			
>15-20	>9,3-10,6	5,25%			0,00	0,00	0,00	0,00	0,00			
>20	>10,6-12	6,00%			0,00	0,00	0,00	0,00	0,00			
	>12-20	8,00%			0,00	0,00	0,00	0,00	0,00			
	>20	12,50%			0,00	0,00	0,00	0,00	0,00			
Zone 3							**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

	Position	Capital ratio	Regulatory capital requirement
Matched positions in maturity bands	0,00	10%	0,00
Matched positions in zone 1	0,00	40%	0,00
Matched positions in zone 2	0,00	30%	0,00
Matched positions in zone 3	0,00	30%	0,00
Matched positions between zone 1 and 2	42,65	40%	17,06
Matched positions between zone 2 and 3	0,00	40%	0,00
Matched positions between zone 1 and 3	0,00	150%	0,00
Remaining open positions	33,51	100%	33,51
			50,57

[7] See *Hull, p. 392 ff.*

2.3.2 Options on Interest Rate Futures

Options on interest rate futures entitle the holder to enter a futures contract at a previously fixed strike price during a specified period or at a specific point in time. Such an option is broken down in the same way as the underlying futures contract itself (see section 2.2.2.1). Both legs are, however, assigned according to their delta equivalent.

<u>Example</u>:
A call option on a future on the 3-month LIBOR to mature in March, which was bought in January, is broken down into a delta-weighted 5-month long position and a delta-weighted 2-month short position.

2.3.3 Options on Bonds

An option on a straight bond gives the right to purchase or sell a bond at a predetermined rate on a specified future date. In line with the two-leg approach such a position must also be split into a zero coupon bond position up to the exercise date and an offsetting straight bond position up to the bullet maturity of the bond. As this is an option position, both positions must be recorded at their delta equivalent.

<u>Example</u>:
A put with an exercise date in three months' time is purchased on a bond. The agreed strike price is 99 (on the assumption that this price already includes accrued interest). The bond underlying the put is an 8% government bond with a residual maturity of 8.2 years. The current market price (including accrued interest) amounts to 98. The principal amount is 10 million, the price delta of the put option comes to –0.4.
The delta-weighted put is assigned as a short position to the maturity band ranging from 7 to 10 years and a long position to the band covering 1 to 3 months. Since this bond still has a coupon payment due before the exercise date, this coupon is to be offset in the form of a further long position in the 1 to 3 months maturity band.

Therefore:	1 to 3 months maturity band	3,960,000 long
		320,000 long[8]
	7 to 10 years maturity band	3,920,000 short

[8] *These two positions have to be stated at the amounts discounted to the market value. See explanations in the context of the sample portfolio, section 3.*

2.3.4 Options on Bond Futures

An option on a bond future gives the right to buy or sell a futures contract on a bond at a predetermined price on a specified future date (or during a specified period, as most quoted options on bond futures are American options). This product is also broken down into two legs. A purchased call consists of a long position in a straight bond and a short position up to the exercise date of the option.

2.3.5 Caps

Caps refer to agreed limits on interest rates. Buyers of caps hedge against rising interest rates. They receive from the sellers the difference between the agreed cap rate and the floating reference rate (e.g. 3-month LIBOR) if the latter exceeds the interest rate cap. A cap may be interpreted as a portfolio of bonds on an interest rate (call options on FRAs), with these options sharing the same strike, while having differing expiry dates. The individual option elements are also frequently referred to as caplets. Such caplets are in the money when the reference interest rate lies above the cap interest rate. When the reference rate underperforms the cap, the caplets are out of the money. To value a cap, it is necessary to value each option element separately; the price of the cap results from the sum total of the prices of the individual options.

Since a cap is simply composed of a series of caplets, it is to be broken down into the individual caplets, which are then to be treated according to the method described in section 2.3.1. Each caplet is to be assigned as a delta-weighted FRA with its two legs to the respective maturity bands. With bought caps, the legs with the longer maturities are to be allocated for each caplet as short positions, while the legs with the shorter maturities are to be recorded as long positions.

2.3.6 Floors

Like caps, floors also represent agreed limits on interest rates. The buyer of a floor hedges against sinking interest rates. When the reference interest rate falls below the agreed floor rate, the buyer of the floor is reimbursed the difference. Floors may also be interpreted as a portfolio of individual options, with each option element referred to as a floorlet. Consequently, a floor is tantamount to a series of put options on FRAs, which have differing expiry dates, yet the same strike price.

Floors are to be broken down in a fashion mirroring that of caps. Each floorlet is to be assigned to the corresponding maturity bands as a delta-weighted FRA with both its legs. With a purchased floor, the legs with the longer maturities are to be recorded as long positions and those with the shorter maturities as short positions (for each floorlet).

2.3.7 Currency Options

A currency option gives the buyer the right but not the obligation to exchange a specific amount of one currency for another currency at a specified exchange rate (strike) on or before a specified date. With a view to capital adequacy, such a transaction is to be treated as a delta-weighted currency future, which needs to be further decomposed in the way outlined in section 2.2.5 (i.e. synthetic spot transaction and two offsetting money market transactions). A model suitable for computing the delta of European currency options is the Black-Scholes Model as modified by Garman and Kohlhagen:

$$c = e^{-r_f T} SN(d_1) - e^{-rT} XN(d_2)$$
$$p = e^{-rT} XN(-d_2) - e^{-r_f T} SN(-d_1)$$
$$\text{where}$$
$$d_1 = \frac{\ln(S/X) + (r - r_f + \sigma^2/2)T}{\sigma\sqrt{T}}$$
$$d_2 = d_1 - \sigma\sqrt{T}$$

where:

S = Current price of the underlying
X = Strike
e = Natural logarithmic base
N = Distribution function
r = Riskfree interest rate
σ = Volatility
r_f = Riskfree interest rate of the foreign currency
T = Maturity of the option

Example:

Consider a purchase of a call on a currency option GBP against USD in the order of GBP 5 million at the following conditions:

Underlying	S	1.61
Strike	X	1.60
GBP interest rate	r_f	5.50%
USD	r	5.80%
Time	T	0.5
Volatility	σ	15.00%
Delta	δ	0.535

which is being decomposed in light of the general interest rate risk as follows:

A delta-weighted GBP long position is assigned to the 3 to 6 months maturity band (GBP 5 million times the delta = GBP 2.67 million) and a USD short position is allocated to the same band (USD 8 million times the delta = 5 million times 1.6 times 0.535 = USD 4.28 million).

2.4 Structured Interest Rate Products

The interest rate instruments discussed so far are often combined and "packaged" in socalled structured products. This way it is possible to generate the most diverse cash flows synthetically. This field is already marked by an immense product diversity; the following chapters deal, however, only with those instruments which are most frequently encountered in practice.

2.4.1 Reverse Floaters

Reverse floaters are bonds with a floating interest rate, where a variable reference interest rate is periodically subtracted from a fixed interest rate (e.g. 12% less 6-month LIBOR). The buyer of a reverse floater benefits from falling interest rates. Unlike with plain vanilla floaters, the price risk of reverse floaters is very high.

This becomes immediately clear when a reverse floater is broken down into its underlying elements: A long position in a reverse floater consists of a long position in two straight bonds, a short position in a plain vanilla floater[9] and a long position in a cap.

To correctly document the cash flow at the time of redemption, the number of straight bonds always has to be greater by one than the number of floaters. The necessity to record a cap results from the fact that the issuing conditions of reverse floaters rule out negative interest. When the market changes in a way that the variable reference interest rate exceeds the fixed interest rate, the buyer of the paper would have to make a payment to the issuer. To avoid this, minimum interest is set at 0%.

Example:
Purchase of a reverse floating rate note
Principal 1 million, interest rate of 12% less 6-month LIBOR, maturity of 10 years, minimum interest 0%

The paper comprises:

- A long position in a straight bond:
  principal 2 million, interest rate of 6%, maturity of 10 years
- a short position in a plain vanilla floater:
  principal 1 million, interest rate of 6-month LIBOR, maturity of 10 years
- a long position in a cap:
  strike price of 12%, maturity of 10 years

[9] *The long position in a reverse floater may alternatively also be interpreted as a long position in a straight bond and a position in a receiver swap.*

The cap is to be broken down into its underlying elements according to the method described above.

Occasionally there are also reverse floaters, such as fixed interest rate less twice variable reference interest rate (socalled turbo reverse floater). In such a case a long position in three straight bonds is juxtaposed by a short position in two FRNs.

Reverse floaters are also often combined with periods of fixed interest rates.
Example: Long position in a bond with 8% fixed interest up to the second year, then 10% less 12-month LIBOR[10], maturity totaling 5 years, minimum interest rate of 0%.
This bond may be broken down into a long position in two five-year straight bonds at 5%, a short position in a five-year floater, a position in a two-year payer swap with a 2% fixed interest rate (for correcting the cash flows of the two first years) as well as a long cap at 10% (forward starting 2 against 5 years).

To determine whether the security was replicated correctly, it is advisable to document the cash flow resulting from the notional underlying instrument and to compare it with that of the composite product:

LIBOR	Time	Reverse floater	2 Straights (5%) long	1 FRN short	Payer swap (2%)		1 Cap long (10%)	Sum total
5	1.0	8.0	10.0	-5.0	-2.0	5.0		8.0
7	2.0	8.0	10.0	-7.0	-2.0	7.0		8.0
9	3.0	1.0	10.0	-9.0				1.0
11	4.0	0.0	10.0	-11.0			1.0	0.0
13	5.0	100.0	210.0	-113.0			3.0	100.0

The LIBOR column reflects a notional LIBOR development. The cash flow of the reverse floater (column 3) is based on this assumed interest rate development. The sum of the hypothetical underlying instruments must produce the same cash flow.

2.4.2 Leveraged Floaters

Leveraged floaters are floating rate bonds, whose current interest rate is designed according to a principle directly opposite to reverse floaters: A fixed interest rate is deducted from a variable reference interest rate (e.g. twice LIBOR less 4%). Minimum interest is zero percent. The buyer of a leveraged floater benefits from rising interest rates. The rate development of such a paper depends on the long-term interest rates: When the long-term interest rates increase, the price of the leveraged floater mounts as well.

Product decomposition:

A long position in a leveraged floater comprises a long position in two floating rate notes and a short position in a straight bond[11]. To rule out negative interest, there are also two long positions in a floor.

Example:

Purchase of a leveraged floater

Principal 1 million, interest twice 6-month LIBOR less 4%, maturity of 5 years, minimum interest 0%

This paper is composed of:

- A long position in a plain vanilla floater:
  principal 2 million, interest 6-month LIBOR, maturity of 5 years
- a short position in a straight bond:
  principal 1 million, interest rate of 4%, maturity of 5 years
- a long position in two floors:
  strike price of 2%, maturity of 5 years

The floors would have to be broken down into their underlying elements according to the method described above.

2.4.3 Floating Rate Notes with Caps

Cap floaters are floating rate bonds whose interest rate must not surpass a certain upper limit. Since issuers want to hedge against rising interest rates, they acquire a cap. The buyer of the floater, on the other hand, sells the cap in order to receive a higher premium on the reference interest rate.

Example:

Sale of a cap floating rate note

Interest 12-month LIBOR[12] plus 0.375%, maturity of 5 years, highest interest rate 6.875%

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[10] *To simplify the example, we chose an annual interest rate adjustment period.*

[11] *The long position in a leveraged floater may alternatively also be interpreted as a long position in a plain vanilla floater and a position in a payer swap.*

[12] *To simplify the example, we chose an annual interest rate adjustment period.*

This paper is to be broken down into a short position in a plain vanilla floater and a long position in a cap with a strike of 6.5%. Full traceability of the cash flow would require that a short position in a straight bond with a rate of 0.375% and a long position in a five-year zero coupon bond be also recorded.

Years	LIBOR	Cap FRN	Short FRN	Long cap	Short straight bond	Long zero	Sum total
1	4	-4.375	-4		-0.375		-4.375
2	5	-5.375	-5		-0.375		-5.375
3	6	-6.375	-6		-0.375		-6.375
4	7	-6.875	-7	0.5	-0.375		-6.875
5	8	-106.875	-108	1.5	-100.375	100	-106.875

The method presented here of decomposing the cap on the variable reference interest rate into a straight bond with a coupon amounting to the cap and an offsetting zero coupon bond position on the bullet maturity should also be used for all plain vanilla floaters with a premium.

When the standard procedures are applied, this method need not, however, be used. The involved cash flows are so minimal that the interest rate risk may be ignored and thus does not pose a significant source of error.

2.4.4 Floating Rate Notes with Floors

Floor floaters are variable rate bonds whose interest rate must not fall below a certain lower limit. Floor floaters protect the investor from interest slipping below a given level. This is done via a purchased floor. The price of the floor is, as a rule, represented by a discount on the variable rate.

Example:

Purchase of a floor floater

Interest LIBOR less 0.5%, maturity of 5 years, minimum rate of 3.5%

This paper is divided into a long position in a floating rate note and a long position in a floor with a 4% strike. To reflect the cash flow exactly, an additional short position in a straight bond with a coupon of 0.5% and a long position in a five-year zero coupon bond need to be recorded. Analogous to cap floaters this method is not required for practical reasons when the standard procedures are adhered to.

2.4.5 Collars

Collars combine caps and floors. The purchase of a collar represents a hedge against rising interest rates. The expense for the cap is reduced by the proceeds resulting from the sale of the floor. Collars are frequently designed in a way that the price of the cap equals that of the floor (= zero cost collar).

Composition: A purchased collar (= long position) consists of a long position in a cap and a short position in a floor. A sold collar (= short position) comprises a long position in a floor and a short position in a cap.

2.4.6 Collar Floaters

Collar floaters are floating rate notes with a maximum and a minimum interest rate. Investors may profit from rising interest rates up to the cap only, on the other hand, they are guaranteed minimum interest even if the market interest rates dip below that level. Therefore the buyer of such a paper has implicitly sold a cap and purchased a floor.

Composition: A long position in a collar floater is made up of a long position in a plain vanilla floater and a short position in a collar (= short position in a cap plus long position in a floor).

2.4.7 Swaptions

A swaption refers to an option to enter a future swap contract with a fixed interest rate already agreed upon today (forward swap).

International conventions are as follows:

	Purchase	Sale
Payer swaption	The right to pay a fixed rate and receive a floating rate.	The obligation to receive a fixed rate and pay a floating rate.
Receiver swaption	The right to receive a fixed rate and pay a floating rate.	The obligation to receive a floating rate and pay a fixed rate.

The buyers of payer swaptions will execute their rights, when the current swap rate exceeds the agreed strike price on the due date.

Since a swaption represents an option on a forward swap, it may be transferred into a delta-weighted forward swap, which is then broken down according to the method already described. The delta is to be computed via a recognized model.[13]

Product decomposition:
Long position in a payer swaption = delta-weighted long position in a forward payer swap = short position in a long-term straight bond (delta-weighted) plus long position in a short-term straight bond (delta-weighted).

Example:
Purchase of a receiver swaption:
Principal 20 million, strike 6%, expiry 2 years, maturity of the swap of 5 years

The position may be viewed as a long position in a (delta-weighted) receiver forward swap. On the assumption that the delta amounts to 0.5, the following breakdown ensues:

10 million long position in a receiver forward swap at 6% =
10 million long position in a 6% straight bond in the 5-7 years maturity band plus
10 million short position in a 6% straight bond in the 1-2 years maturity band

2.4.8 Bonds with Embedded Swaptions

Buyers of a bond with embedded swaptions receive a fixed interest rate in the first couple of years. Then they have the right (but not the obligation) to swap the fixed interest rate for a floating rate. If they do not act on this right, the fixed interest rate will apply up to the bullet maturity of the bond. Investors will make use of this right if the long-term rates are mounting.

A bond with embedded swaptions may thus be seen as a combination of a straight bond and a swaption.

Product decomposition:
Purchase of a bond with embedded swaptions =
Long position in a straight bond plus long position in a payer swaption

Digression: Bonds with fixed and floating interest rate periods
This type of bonds should not be confused with bonds equipped with embedded swaptions, as they do not contain any option element. Such bonds may be easily portrayed as a combination of floaters and swaps.

[13] *Section 3 (Sample Portfolio) features an adequate method for computing the delta of swaptions.*

Example:
10-year bond with a fixed interest rate of 5% during the first five years, a floating rate during the following three years and then again a fixed interest rate of 6% during the last two years.

Product decomposition:
A long position in a floater plus
a long position in a receiver swap at 5% (0 – 5) plus
a long position in a receiver swap at 6% (9 – 10) (forward swap)

2.4.9 Bonds with Call / Put Options

2.4.9.1 Callable Bonds

Callable bonds document the issuer's right to buy back the bond on a certain date (or certain dates) at a rate agreed already today. This call option is used when interest rates are falling.

The investor has therefore implicitly sold the option to the issuer. From the perspective of the buyer of the bond, a callable bond thus consists of a long straight bond and a short call on this bond.

Example:
Callable bond (maturity of 10 years, coupon 6%, principal 20 million, termination right after five years with strike 100). The price delta computed in line with Black 76 amounts to 0.5.

Product decomposition (from the investor's perspective):
20 million long straight bond in the 7-10 years maturity band
Composition of the short call:
10 million short straight bond in the 7-10 years maturity band
10 million long straight bond in the 4-5 years maturity band

2.4.9.2 Putable Bonds

The put option allows the investor to sell the paper prematurely (putable bond). For this reason, a putable bond consists of a long straight bond and a long put on this bond from the investor's perspective.

Example:
Putable bond (maturity of 10 years, coupon 6%, principal 20 million, termination right after five years with strike 100). The price delta computed in line with Black 76 runs to 0.5.

Product decomposition (from the investor's perspective):
20 million long straight bond in the 7-10 years maturity band
Composition of the long put:
10 million short straight bond in the 7-10 years maturity band
10 million long straight bond in the 4-5 years maturity band

2.4.10 High Yield Bonds

Recently numerous bonds were issued which bear very high coupons. Apparently the period of sustained low interest rates made investors seek higher yields. Investors may earn higher yields by selling embedded options, i.e. options that are part of bonds. The resulting premium equals a return that exceeds the prevailing interest rate. Read on for a description of two typical high yield bond products and their decomposition.

2.4.10.1 High Yield Stock Bonds

If you have invested in such paper, you will receive either the invested capital at the date of redemption (= redemption at par) or the number of shares in a given stock as specified in the bond prospectus provided the stock price underperforms a given price (mostly the price recorded at the date of issue) once the bond matures. What is more, such a bond bears a coupon which by far exceeds the prevailing market interest rate.

The issuing credit institution deals with a combination of a bond issue and the purchase of a put option on a stock. The credit institution faces an unlimited profit potential amid sinking stock prices, while the potential loss is confined to the overly high coupon.

It follows that the issuer needs to decompose such a bond into two components: a short position in a straight bond and a long position in a put option on a stock.

2.4.10.2 High Yield Currency Bonds

Like high yield stock bonds, these bonds also pay a coupon considerably exceeding the market interest rate and have asymmetrical redemption features. The amount to be redeemed is tied to the foreign exchange movements of a currency pair specified in the terms of the bond issue. If the exchange rate is above a given value at redemption, the investor receives the invested capital (= redemption at par). If the rate stands below that value, the amount to be redeemed is reduced depending on the exchange rate.

Again, the issuing credit institution deals with a combination of a bond issue and the purchase of a put option on an exchange rate. Thus, the sole difference to the bonds described in section 2.4.10.1 concerns the underlying. The credit institution faces an unlimited profit potential amid a sinking exchange rate, while the potential loss is confined to the overly high coupon.

It follows that the issuer needs to decompose such a bond into two components: a short position in a straight bond and a long position in a put option on an exchange rate. To account for the general interest rate risk, the currency option needs to be treated in line with the procedure detailed in section 2.3.7.

3 Sample Portfolio

Using a sample portfolio, the following chapter deals with the methodology of assigning positions with an interest rate risk into the maturity bands as well as the required decomposition of such transactions. The method corresponds to the two legged approach elucidated in the previous chapter. The individual weighted amounts for the general market risk are computed both according to the maturity band method and the duration method.

3.1 Product Decomposition

The sample portfolio comprises the following positions:

1) A long position in a government bond with a residual maturity of 8.5 years with a coupon of 7% and annual interest payments, a principal of 10 million and a current rate (including accrued interest) of 106.71. The modified duration is 6.51. (BOND)

2) A forward purchase of a government bond in 6 months' time with a principal of 50 million, an agreed forward rate of 118.50 (including accrued interest), a bond equipped with a coupon of 8%, a maturity of 6.25 years, a market rate of 115.96 (including accrued interest). The modified duration of the bond is 4.95. (TBOND)

3) A purchase of an FRA 3/6 to the amount of 100 million. (FRA)

4) A purchase of a 3-month interest rate future to the amount of 50 million, with the settlement day in 1 month's time. (IRF)

5) A long position in a reverse floater 12% - 6-month at LIBOR to the amount of 20 million with a residual maturity of 3.25 years. The next interest fixing is due in three months' time. The interest rate for the current period stands at 4.5%. (REVERSE)

6) A long position in a payer swap to the amount of 10 million with an interest rate of 6%. The maturity of the swap comes to 5 years. The 6-month LIBOR was currently fixed at 5%, the next interest adjustment is due in 6 months. (PAYER)

7) A sold cap with a strike price of 6%, a maturity of 3 years, reference interest rate 12-month LIBOR and a principal amount of 20 million. (CAP)

8) A short position in a payer swaption, a principal of 30 million, strike 7%, expiry 2 years. The maturity of the swap underlying the option amounts to 5 years. (SWAPTION)

The ensuing yield curve serves as the basis for computing the mathematical parameters (present values, durations, etc.). Zero coupon rates and the associated discount factors corresponding to the swap par rates dominating the market were computed via bootstrapping procedures. A flat yield curve of 5% is assumed for the money market (up to one year).

Years	Swap rates	Zero rates	Discount factors
1	5.00%	5.00%	0.9524
2	5.20%	5.21%	0.9034
3	5.40%	5.41%	0.8538
4	5.60%	5.63%	0.8033
5	5.80%	5.85%	0.7526
6	6.00%	6.08%	0.7018
7	6.20%	6.31%	0.6516
8	6.40%	6.55%	0.6020
9	6.60%	6.81%	0.5527
10	6.80%	7.07%	0.5050

ad 1) BOND

The bond is to be assigned as a long position to the 7-10 years maturity band at the market value (current price including accrued interest (= dirty price) times principal divided by 100). The amount is 10,671,000.

ad 2) TBOND

The forward purchase of a bond is to be divided into two legs: a long position in a bond (assignment at market value as above) in the 5-7 years maturity band and a short position in a zero bond to the amount of the agreed forward rate times the principal (discounted to the present value) in the 3-6 months maturity band. Besides, it must be considered that the first coupon of the bond has to be offset by a zero bond (discounted to the present value) (short position in the 1-3 months maturity band).

ad 3) FRA

The purchased FRA 3/6 corresponds to a short position 3-6 months and a long position 1-3 months. For simplicity, in this example the face values are assigned to the respective bands, which is possible with maturities up to one year (see section 2.2.1). Note that normally the present values must be assigned.

ad 4) IRF

The long position in a 3-month IRF with a settlement day in one month's time is divided into a long position 3-6 months and a short position up to 1 month.

ad 5) REVERSE

The reverse floater is to be broken down into the following components:

- A long position in a straight bond with a principal of 40 million, coupon of 6% and a residual maturity of 3.25 years,
- a short position in a floater with a principal of 20 million and next interest fixing three months off,
- a long position in a cap on the 6-month LIBOR with a strike of 12%.

The following example does not include the separate decomposition of the cap, as the weighted amounts required for that are minimal. This is so because the cap with a strike of 12% and a market rate of 5% is by far out of the money and thus barely noteworthy. Of course, the cap must be correctly recorded and broken down into its components when the standard procedures are applied.[14]

The computation of the present value and the modified duration of the synthetic bonds is exemplified below:

Years (A)	Cash flows (B)	Discount factors (C) (basis: zero)	Cash value (D)	Discount factors (E) (basis: yield)	A * B * E / 42.430.850
0.25	2,400,000	0.988	2,370,904	0.987	0.01
1.25	2,400,000	0.940	2,256,333	0.936	0.07
2.25	2,400,000	0.891	2,138,420	0.888	0.11
3.25	42,400,000	0.841	35,665,193	0.842	2.73
			42,430,850	Dur:	2.93
		Yields:	5.447%	Mod. dur.:	2.78

- Straight bond long in the 3-4 years maturity band

First the present value is computed via the current yield curve (the discount factors in the C column of the table were used, with linear interpolation having been applied between the gridpoints). This way the yield of 5.447% may be calculated by means of the ISMA method. To determine the duration, the discount factors must be pinpointed anew on the basis of a flat yield curve of 5.447%. The modified duration results from duration / (1+yield).

- Floater short in the 1-3 months maturity band

A cash flow of 20,450,000 (last 6-month LIBOR of 4.5% on a principal of 20 million) with a 3-month discount factor of 0.988 is to be discounted to the present value: 20,202,000.

[14] *The breakdown of the product into its components is demonstrated in example 7 (CAP) in a detailed manner.*

ad 6) PAYER

The long position in the payer swap is broken down into a long position in a bond with a coupon of 6% in the 4-5 years maturity band and a short position in a floater in the 3-6 months maturity band. The present values are calculated by means of the method mentioned under item 5 (REVERSE).

ad 7) CAP

A 3-year cap with one-year fixed interest periods consists of two caplets. The following parameters apply to these two caplets:

	$Caplet_1$	$Caplet_2$
R:	6%	6%
F:	5.41%	5.83%
r:	5.21%	5.41%
k:	1	2
:	1	1
:	20%	20%
L:	20 mio	20 mio

When using the method detailed in section 2.3.1, we obtain the following result:

	$Caplet_1$	$Caplet_2$
Premium:	39,414	99,150
✎:	0.305	0.452
Delta equivalent:	6.093,541	9.041,278

In line with the maturity band method, the delta equivalents must therefore be accounted for as shown below:

Maturity bands		Weight	Open positions		Weighted open positions		Matched band positions	Remaining open band positions		Matched zone positions	Open zone positions	
Coupons >=3%	Coupons <3%		long	short	long	short		long	short		long	short
-1	-1	0%			0,00	0,00	0,00	0,00	0,00			
>1-3	>1-3	0,20%			0,00	0,00	0,00	0,00	0,00			
>3-6	>3-6	0,40%			0,00	0,00	0,00	0,00	0,00			
>6-12	>6-12	0,70%		6.094	0,00	42,66	0,00	0,00	42,66			
Zone 1								**0,00**	**42,66**	**0,00**	**0,00**	**42,66**
>1-2	>1-1.9	1,25%	6.094	9.041	76,18	113,01	76,18	0,00	36,84			
>2-3	>1.9-2.8	1,75%	9.041		158,22	0,00	0,00	158,22	0,00			
>3-4	>2.8-3.6	2,25%			0,00	0,00	0,00	0,00	0,00			
Zone 2								**158,22**	**36,84**	**36,84**	**121,38**	**0,00**
>4-5	>3.6-4.3	2,75%			0,00	0,00	0,00	0,00	0,00			
>5-7	>4.3-5.7	3,25%			0,00	0,00	0,00	0,00	0,00			
>7-10	>5.7-7.3	3,75%			0,00	0,00	0,00	0,00	0,00			
>10-15	>7.3-9.3	4,50%			0,00	0,00	0,00	0,00	0,00			
>15-20	>9.3-10.6	5,25%			0,00	0,00	0,00	0,00	0,00			
>20	>10.6-12	6,00%			0,00	0,00	0,00	0,00	0,00			
	>12-20	8,00%			0,00	0,00	0,00	0,00	0,00			
	>20	12,50%			0,00	0,00	0,00	0,00	0,00			
Zone 3							**76,18**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

	Position	Capital ratio	Regulatory capital requirement
Closed positions in maturity bands	76,18	10%	7,62
Matched positions in zone 1	0,00	40%	0,00
Matched positions in zone 2	36,84	30%	11,05
Matched positions in zone 3	0,00	30%	0,00
Matched positions between zones 1 and 2	42,66	40%	17,06
Matched positions between zones 2 and 3	0,00	40%	0,00
Matched positions between zones 1 and 3	0,00	150%	0,00
Remaining open positions	78,72	100%	78,72
			114,45

The regulatory capital required to cover the cap amount to ATS 114,450.

ad 8) SWAPTION

The short position in a payer swaption (equals a long position in a receiver swaption) may be substituted by a delta-weighted short position in a forward payer swap. Consequently, the position may be broken down into:

- a long bond with a coupon of 7% and residual maturity of 7 years,
- a short bond with a coupon of 7% and residual maturity of 2 years.

To compute the delta factor, for instance, the following Black formula may be used:

$$C = (N \times \sum_{i=T+1}^{T+n} df_{t,i}) \times (r \times N(d_1) - R \times N(d_2)) \qquad (1)$$

with

C = *price of the payer swaption*
N = *principal*
T = *expiry of the swaption*
n = *maturity of the underlying swap*
$df_{t,i}$ = *discount factor from point in time i to point in time t*
t = *date of assessment*
r = *current forward swap rate*
R = *agreed swap rate*
$N(x)$ = *value of the distribution function of the standard normal distribution at point x*

In addition, d_1 and d_2 are defined as follows:

$$d_1 = (\ln(r/R) + \frac{\sigma^2}{2} \times (T-t)) / (\sigma \times \sqrt{T-t})$$
$$d_2 = d_1 - \sigma \times \sqrt{T-t}$$

with σ referring to the volatility of the forward rate.

The delta factor $\delta = N(d_1)$.

When this model is used to calculate the delta for the case at hand, the result is a delta of 0.45 on the assumption of a current forward rate of 6.75% and a volatility of 12%. The application of this delta leads to a short position in the payer swap to the amount of 13.5 million (30 million times 0.45). The present values of the two synthetic bonds are again to be determined via the method described above.

3.2 Maturity Band Method

The following tables summarize how products are assigned to the maturity bands:

Product	Long/ Short	Residual maturity	Amount	Mod. duration
BOND	Long	8.50	10,671	6.11
TBOND	Long	6.25	57,981	4.67
TBOND	Short	0.50	59,250	0.50
TBOND	Short	0.25	3,952	0.25
FRA	Short	0.50	100,000	0.50
FRA	Long	0.25	100,000	0.25
IRF	Long	0.33	50,000	0.33
IRF	Short	0.08	50,000	0.08
REVERSE	Long	3.25	42,431	2.78
REVERSE	Short	0.25	20,202	0.25
PAYER	Short	5.00	10,085	4.22
PAYER	Long	0.50	10,000	0.50
CAP	Long	2.00	1,748	2.00
CAP	Short	1.00	5,463	1.00
CAP	Long	3.00	2,609	3.00
CAP	Short	2.00	3,578	2.00
SWAPTION	Long	7.00	14,106	5.49

(Amounts in thousand)

Maturity bands		Weight	Products	
Coupons >=3%	Coupons <3%		long	short
-1	-1	0%		IRF
>1-3	>1-3	0.20%	FRA	TBOND, REVERSE
>3-6	>3-6	0.40%	IRF,PAYER	TBOND,FRA
>6-12	>6-12	0.70%		CAP
>1-2	>1-1.9	1.25%	CAP	SWAPTION, CAP
>2-3	>1.9-2.8	1.75%	CAP	CAP
>3-4	>2.8-3.6	2.25%	REVERSE	
>4-5	>3.6-4.3	2.75%		PAYER
>5-7	>4.3-5.7	3.25%	TBOND, SWAPTION	
>7-10	>5.7-7.3	3.75%	BOND	
>10-15	>7.3-9.3	4.50%		
>15-20	>9.3-10.6	5.25%		
>20	>10.6-12	6.00%		
	>12-20	8.00%		
	>20	12.50%		

Maturity bands		Weight	Open positions		Weighted open positions		Matched band positions	Remaining open positions		Matched zone positions	Open zone positions	
Coupons >=3%	Coupons <3%		long	short	long	short		long	short		long	short
-1	-1	0%		50,000	0.00	0.00	0.00	0.00	0.00			
1-3	>1-3	0.20%	100,000	24,154	200.00	48.31	48.31	151.69	0.00			
3-6	>3-6	0.40%	60,000	159,250	240.00	637.00	240.00	0.00	397.00			
6-12	>6-12	0.70%		6,094	0.00	42.66	0.00	0.00	42.66			
Zone 1								151.69	439.66	151.69	0.00	287.97
1-2	>1-1.9	1.25%	6,094	22,991	76.18	287.39	76.18	0.00	211.21			
2-3	>1.9-2.8	1.75%	10,789		188.81	0.00	0.00	188.81	0.00			
3-4	>2.8-3.6	2.25%	42,431		954.70	0.00	0.00	954.70	0.00			
Zone 2								1,143.51	211.21	211.21	932.29	0.00
4-5	>3.6-4.3	2.75%		10,085	0.00	277.34	0.00	0.00	277.34			
5-7	>4.3-5.7	3.25%	72,087		2,342.83	0.00	0.00	2,342.83	0.00			
7-10	>5.7-7.3	3.75%	10,671		400.16	0.00	0.00	400.16	0.00			
10-15	>7.3-9.3	4.50%			0.00	0.00	0.00	0.00	0.00			
15-20	>9.3-10.6	5.25%			0.00	0.00	0.00	0.00	0.00			
20-	>10.6-12	6.00%			0.00	0.00	0.00	0.00	0.00			
	>12-20	8.00%			0.00	0.00	0.00	0.00	0.00			
	>20	12.50%			0.00	0.00	0.00	0.00	0.00			
Zone 3							364.48	2,742.99	277.34	277.34	2,465.65	0.00

(Amounts in thousand)

The last step in the calculation concerns vertical and horizontal hedging, in which the open positions may be netted within the maturity bands and between the maturity bands.

	Position	Capital ratio	Regulatory capital requirement
Matched positions in maturity bands	364.48	10%	36.45
Matched positions in zone 1	151.69	40%	60.68
Matched positions in zone 2	211.21	30%	63.36
Matched positions in zone 3	277.34	30%	83.20
Matched positions between zones 1 and 2	287.97	40%	115.19
Matched positions between zones 2 and 3	0.00	40%	0.00
Matched positions between zones 1 and 3	0.00	150%	0.00
Remaining open positions	3,109.98	100%	3,109.98
			3,468.86

(Amounts in thousand)

Vertical Hedging

The smaller of the weighted open long/short position is the matched band position. The sum of the matched band positions (364.48) must be backed for the remaining basis risk by 10% of the regulatory capital.

Horizontal Hedging

First the open band positions may be netted within the zones, once the matched band positions have been subtracted. The matched zone positions are the smaller remaining open zone positions. The matched zone positions must be backed with 40% (zone 1) or 30% (zones 2 and 3) of the regulatory capital.

After that you may identify those zone positions that really remain open. First, the open zone positions are netted between zone 1 and zone 2 (287.97). Then the remainder in zone 2 is netted with zone 3. As in the case at hand the same signs apply, netting does not result in matched positions. The regulatory capital requirment for adjacent zones is set at 40%. Finally, opposite positions in zone 1 and zone 3 are closed. As zone 1 was already fully netted with zone 2, the outcome is zero.

All the amounts remaining after the netting process represent the final open position, which has to be backed by 100% of the regulatory capital.

The regulatory capital requirement amounts to 3,468,860.

3.3 Duration Method

The duration method produces the weighted open positions by multiplying each individual position with the associated duration and the assumed interest rate change in the respective zone. The result reflects the value changes of this position when interest rates change to the assumed extent.

The tables below illustrate the assignment of products according to the duration method:

Product	Long/Short	Amount	Modified duration
IRF	Short	50,000	0.08
TBOND	Short	3,952	0.25
FRA	Long	100,000	0.25
REVERSE	Short	20,202	0.25
IRF	Long	50,000	0.33
TBOND	Short	59,250	0.50
FRA	Short	100,000	0.50
PAYER	Long	10,000	0.50
CAP	Short	6,094	1.00
SWAPTION	Short	13,950	1.84
CAP	Long	6,094	2.00
CAP	Short	9,041	2.00
REVERSE	Long	42,431	2.78
CAP	Long	9,041	3.00
PAYER	Short	10,085	4.22
TBOND	Long	57,980	4.67
SWAPTION	Long	14,106	5.49
BOND	Long	10,671	6.11

Zones	Modified duration	Assumed interest rate change	Open positions		Modified duration	Weighted open positions		Matched zone positions	Open zone positions	
			Long	Short		Long	Short		Long	Short
	0 - 1,0	1.00%		50,000	0.08		40.00			
				3,952	0.25		9.88			
			100,000		0.25	250.00				
				20,202	0.25		50.51			
			50,000		0.33	165.00				
				59,250	0.50		296.25			
				100,000	0.50		500.00			
			10,000		0.50	50.00				
				6,094	1.00		60.94			
Zone 1						**465.00**	**957.58**	**465.00**	**0.00**	**492.58**
	> 1 - 3,6	0.85%		13,950	1.84		218.18			
			6,094		2.00	103.60				
				9,041	2.00		153.70			
			42,431		2.78	1,002.64				
			9,041		3.00	230.55				
Zone 2						**1,336.79**	**371.88**	**371.88**	**964.91**	**0.00**
	> 3,6	0.70%		10,085	4.22		297.91			
			57,980		4.67	1,895.37				
			14,106		5.49	542.09				
			10,671		6.11	456.40				
Zone 3						**2,893.86**	**297.91**	**297.91**	**2,595.95**	**0.00**

(Amounts in thousand)

The last calculation steps are to be performed in analogy to the maturity band method. First, vertical hedging within the zones and then horizontal hedging between the zones is carried out.

	Position	**Capital ratio**	**Regulatory capital requirement**
Matched positions in zones	1,134.79	2%	22.70
Matched positions between zones 1 and 2	492.58	40%	197.03
Matched positions between zones 2 and 3	0.00	40%	0.00
Matched positions between zones 1 and 3	0.00	150%	0.00
Remaining open positions	3,068.29	100%	3,068.29
			3,288.01

(Amounts in thousand)

The regulatory capital requirement for the sum total of matched zone positions (465+371.88+297.91 = 1,134.79) amounts to 2%.

The regulatory capital requirement for horizontal hedging as well as for the remaining open positions is identical with those of the maturity band method.

The regulatory capital requirement stands at ATS 3,288,010.

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Annex

1 Duration

In 1938 Frederick Macaulay devised a measure which is used as an approximation for computing the mean maturity of a fixed-interest bond.[15] This indicator, whose unit is time (year mostly), is therefore also referred to as Macaulay duration and corresponds to a weighted average of the maturities of all payments resulting from the bond. The weighting factor of a maturity is the share of the payment of this maturity in the total cash value of the security, the sum total of these weighting factors is thus one. The duration may be viewed as the average duration up to the receipt of the payment from the bond. A zero coupon bond which becomes due in T years has e.g. a duration of T years. A bond with coupons which also becomes due in T years, in contrast, has a duration of less than T years, as some payments are effected before the year T. The amount of this difference depends on the coupon rate of the bond: the lower the coupon rate, the higher the duration of the interest-bearing bond and the smaller the difference in the duration of the respective zero coupon bond.

Let's assume we are at the point 0 in time and look at a bond which at the point t_i in time pays the amount C_i ($1 \le i \le T$). When we use discreet interest rates to compute the cash value, the duration is reflected by the following formula:

$$D = \frac{\sum_{i=1}^{T} t_i \frac{C_i}{(1+y)^{t_i}}}{\sum_{i=1}^{T} \frac{C_i}{(1+y)^{t_i}}} = \sum_{i=1}^{T} t_i \underbrace{\frac{\frac{C_i}{(1+y)^{t_i}}}{\sum_{i=1}^{T} \frac{C_i}{(1+y)^{t_i}}}}_{w_i}, \tag{1}$$

with t_i the time until the i^{th} maturity,
C_i the i^{th} payment,
T the number of payments,
y the internal rate of return and
w_i the weighting factor of the i^{th} maturity.

[15] *Frederick Macaulay, Some Theoretical Problems Suggested by the Movements of Interest Rates, Bond Yields and Stock Prices in the United States Since 1865, National Bureau of Economic Research, 1938*

The following example shows the computation of the duration of a ten-year bond with a coupon of 8% and an internal rate of return of 7%:

Computation of the Macaulay Duration

t	C	1/(1+y)^t	w	t*w
1	8.0	0.9346	0.07	0.07
2	8.0	0.8734	0.07	0.13
3	8.0	0.8163	0.06	0.18
4	8.0	0.7629	0.06	0.23
5	8.0	0.7130	0.05	0.27
6	8.0	0.6663	0.05	0.30
7	8.0	0.6227	0.05	0.33
8	8.0	0.5820	0.04	0.35
9	8.0	0.5439	0.04	0.37
10	108.0	0.5083	0.51	5.13
		Summe	1.00	7.35

Macaulay Duration =	7.35

There is an important relation between the price and the duration of a bond. The price *P* of the bond is as follows:

$$P = \sum_{i=1}^{T} \frac{C_i}{(1+y)^{t_i}} \tag{2}$$

The first derivative of the price according to the internal rate of return is as follows:

$$\frac{\partial P}{\partial y} = \sum_{i=1}^{T} \frac{(-t_i)C_i}{(1+y)^{t_i+1}} = -\frac{1}{1+y} \sum_{i=1}^{T} \frac{t_i C_i}{(1+y)^{t_i}} \tag{3}$$

By combining the formulae (1) to (3), we arrive at the relation between price and duration:

$$-\frac{\frac{\partial P}{\partial y}}{P} = \frac{D}{1+y} \tag{4}$$

The expression on the right side of the equation is called modified duration. It follows therefore that the relative price change due to a change in the interest rate may be approximated to the sign via the modified duration.

The modified duration of the bond from our example above is thus:

$$D_{\text{mod}} = \frac{7.35}{1+0.07} = 6.87 \tag{5}$$

The modified duration may, however, be used as a reliable approximation of a price change only with small interest rate changes. Owing to the convex relation between price and interest rate, the higher derivatives, which – apart from the first derivative – are not considered here, play an essential role.

2 Overview of the Decomposition of Interest Rate Instruments

Instrument		Decomposition	Underlying
	+ FRA	+ short maturity	+ Zero
		- long maturity	- Zero
	- FRA	- short maturity	- Zero
		+ long maturity	+ Zero
	+ Interest rate futures	- short maturity	- Zero
		+ long maturity	+ Zero
	- Interest rate futures	+ short maturity	+ Zero
		- long maturity	- Zero
	+ Bond futures	- short maturity	- Zero
		+ long maturity	+ Straight bond
	- Bond futures	+ short maturity	+ Zero
		- long maturity	- Straight bond
	+ Payer swap	+ short maturity	+ FRN
		- long maturity	- Straight bond
	+ Receiver swap	- short maturity	- FRN
		+ long maturity	+ Straight bond
	+ Payer forward swap	+ short maturity	+ Straight bond
		- long maturity	- Straight bond
	+ Receiver forward swap	- short maturity	- Straight bond
		+ long maturity	+ Straight bond
Options on FRAs			
+ Call	+ delta FRA	+ delta short maturity	+ Zero
		- delta long maturity	- Zero
- Call	- delta FRA	- delta short maturity	- Zero
		+ delta long maturity	+ Zero
+ Put	- delta FRA	- delta short maturity	- Zero
		+ delta long maturity	+ Zero
- Put	+ delta FRA	+ delta short maturity	+ Zero
		- delta long maturity	- Zero
Option on bonds (option on bond futures)			
+ Call		- delta short maturity	- Zero
		+ delta long maturity	+ Straight bond
- Call		+ delta kurze Laufzeit	+ Zero
		- delta long maturity	- Straight bond
+ Put		+ delta short maturity	+ Zero
		- delta long maturity	- Straight bond
- Put		- delta short maturity	- Zero
		+ delta long maturity	+ Straight bond
Caps and floors			
+ Cap	+ delta FRA	+ delta short maturity	+ Zero
		- delta long maturity	- Zero
- Cap	- delta FRA	- delta short maturity	- Zero
		+ delta long maturity	+ Zero
+ Floor	- delta FRA	- delta short maturity	- Zero
		+ delta long maturity	+ Zero
- Floor	+ delta FRA	+ delta short maturity	+ Zero
		- delta long maturity	- Zero

Instrument	Position	Decomposition
Reverse FRN	Long	+ 2 * Straight bond - FRN + Cap
	Short	- 2 * Straight bond + FRN - Cap
Leveraged FRN	Long	+ 2 * FRN - Straight bond + 2 * Floor
	Short	- 2 * FRN + Straight bond - 2 * Floor
FRN with cap	Long	+ FRN - Cap
	Short	- FRN + Cap
FRN with floor	Long	+ FRN + Floor
	Short	- FRN - Floor
Collars	Long	+ Cap - Floor
	Short	- Cap + Floor
Collar FRN	Long	+ FRN - Collar
	Short	- FRN + Collar
Swaptions	+ Payer swaption	+ delta payer forward swap
	- Payer swaption	+ delta receiver forward swap
	+ Receiver swaption	+ delta receiver forward swap
	- Receiver swaption	+ delta payer forward swap
Floating rate bond	Long	+ Straight bond + Payer swaption
	Short	- Straight bond + Receiver swaption
Callable bond	Long	+ Straight bond - Call on bond
	Short	- Straight bond + Call on bond
Putable bond	Long	+ Straight bond + Put on bond
	Short	- Straight bond - Put on bond

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