Oesterreichische Nationalbank

Guidelines on Market Risk

Volume 3

Evaluation of Value at Risk-Models

Guidelines on Market Risk

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

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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

Volume 3 of the Guidelines on Market Risk primarily targets those Austrian credit institutions which intend to employ a value-at-risk (VaR) model to calculate the regulatory capital requirement against market risk. One of the preconditions for use of VaR models is a positive evaluation report on the model by the Oesterreichische Nationalbank. This guideline aims at providing interested banks with information on the evaluation procedure pertaining to internal models as well as on the key factors this process centers on. With this guideline the OeNB wishes to lend support to the credit institutions concerned at an early stage, i.e. during model implementation, in hopes of streamlining the evaluation procedure later on.

Furthermore, this volume also addresses those credit institutions whose risk management systems incorporate or will in the future incorporate a VaR model, even though that model is not used to compute regulatory capital requirements.

Last, but not least, this publication should even be of interest to institutions for which - due to size or business policy - use of a VaR model is currently out of the question. One or the other section of this guideline may prove relevant for their risk management as well.

The six-volume Guidelines on Market Risk including this publication on the evaluation of value-at-risk models were authored by the Risk Managment Unit of the Financial Markets Analysis and Surveillance Division: Thomas Breuer, Gerhard Coosmann, Gabriela de Raaij, Annemarie Gaal, Gerald Krenn, Ronald Laszlo, Manfred Plank and Burkhard Raunig.

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

The authors

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Introduction

This guideline is composed of three chapters. The first chapter presents the general principles which the evaluation of VaR models rests on.

The second chapter, which consists of 12 sections, provides a rundown of the guidelines and criteria applied in the drawing up of the evaluation report. The requirements for internal models and for their integration in the organizational framework of a credit institution are listed. In this context, it should be pointed out that this document does not claim to be conclusive as it may need to be adapted and extended in the future due to new scientific findings and statutory adjustments.

The suitability of an internal model may only be assessed in connection with the credit institution that uses a particular model, as the applicability of VaR models, apart from the underlying VaR methodology, hinges especially on the structure of the respective credit institution as well as the integration of the model into risk control in general. Section 2.1 details the critieria with respect to the organizational structure, the individual responsibilities and the duties of the management. The requirements for the VaR methodology[1] used are presented in section 2.2. Section 2.3 deals with the factors relevant for the integration of the model. Effectively monitoring and controlling market risk is guaranteed not only through the implementation of a VaR model; what is more, the credit institution has to ensure that the model be adequately integrated into its risk measurement system.[2] Section 2.4 sets out the guidelines on analyzing the trading book. The suitability of the internal model depends on the portfolio structure of the credit institution's trading book.[3] The criteria for evaluating the data input are outlined in section 2.5. To be able to adequately measure the market risk of the trading book, position data must be compiled completely and correctly and the suitability of the market risk factors and their regular updating must be ensured. Section 2.6 describes the rules on evaluating the estimation methods for yield curves and variance-covariance matrices of the market risk factors. The requirements for stripping and mapping procedures are spelled out in section 2.7. As just for a very small portfolio numerous market risk factors need to be taken into account, the computation of variance-covariance matrices places high requirements on computer capacity. This is why an attempt is made to limit the number of market risk factors and to map the remaining market risk factors by means of an appropriate mapping method to selected market risk factors. Section 2.8 dwells on valuation models reflecting the connection between the underlying market risk factors and the market values of the financial instruments. Section 2.9 highlights the points to be considered in

[1] *This point also refers to aspects of the implementation of the model.*

[2] *It is, for instance, necessary that the credit institution has a separate organizational unit in charge of risk control, an effective reporting and information system, etc.*

[3] *It is possible that institutions with a trading book that is fairly straightforward as to the risk structure will be allowed to use models which will not be permissible for institutions managing portfolios composed of complex financial products.*

computing the total value at risk and the regulatory capital requirement. The structure chosen by the credit institution for the variance-covariance matrices[4] plays a role in calculating the total exposure. Once the above-mentioned aspects of a risk model have been evaluated, the model-based value-at-risk figures computed on a daily basis need to be compared with the trading outcome over a specific observation period. These backtesting criteria are elucidated in section 2.10. Section 2.11 provides an overview of the requirements for stress testing. Stress testing involves the generation of various scenarios by a credit institution with the objective of assessing the current portfolio under those scenarios. Finally, the risk measurement system must be subjected to regular reviews by the credit institution's internal audit division. How such audits are to be performed is defined in section 2.12.

The third and final chapter lists the documents the Oesterreichische Nationalbank requires for drawing up the evaluation report and which are to be submitted to the OeNB at the time a credit institution applies for authorization of its internal model. The OeNB will handle the document requirements case by case; in other words, depending on the applicant credit insitution, the OeNB may request additional documents or not request particular documents listed in chapter 3. This list at hand should therefore be regarded as a sample of what documents are usually required.

[4] *The structure results from the modeling of correlations between the risk categories of the market risk factors.*

1 General Principles for the Evaluation of VaR Models

1.1 Filing

Pursuant to § 26b Banking Act[5], credit institutions have the option of determining the regulatory capital requirement[6] for general and specific risk in debt instruments and stocks as well as for positions in commodities and foreign currency according to an internal risk model of their own choosing. The internal model must comply with a recognized value-at-risk concept.[7] The models must be submitted to the Federal Ministry of Finance for approval by the Minister. As part of the approval procedure, the Oesterreichische Nationalbank (OeNB) must draw up an evaluation report on the internal risk model and its integration into the risk management system of the credit institution.

1.2 Filing Documents

The credit institution shall indicate which risk categories the internal model covers. If the model calculates the specific risk in addition to the general market risk, this is to be explained separately in the application for approval of the internal model. An independent expert opinion is to be attached to the application.[8] For the purpose of preparing its evaluation report, the OeNB requires additional documents from the filing credit institution which are listed in Part C of this guideline. Whenever possible, these documents should be placed at the OeNB's disposal when the application is filed.

1.3 Advance Contact

Credit institutions considering filing for approval of a model should establish contact with the OeNB before officially filing their applications. Such advance contacts help avoid any misunderstandings that could impede or delay the evaluation process.

1.4 Initial Meeting

The evaluation begins with a presentation of the procedures at the credit institution. The following representatives of the credit institution should attend the presentation: the member of the executive board responsible for risk control, the heads of the risk control, trading and

[5] *Bankwesengesetz (BWG).*
[6] *Referred to as "own funds requirement" in the Austrian Banking Act.*
[7] *The term value at risk is hereafter abbreviated as VaR.*
[8] *§ 26b para 3 Banking Act.*

internal audit departments and key employees involved in the risk control process. The credit institution is to explain how risk management is organized and how the internal model was developed. This is also the time to clarify who the contact will be for each of the special areas. Any questions regarding the documents supplied to the OeNB at the time the application was filed (see Part C) are to be sorted out and the manner of proceeding is to be settled.

1.5 On-Site Inspection

In order to enhance the efficiency of the inspection to be conducted at the site, OeNB employees are to be furnished with the appropriate infrastructure, e.g. a room that can be locked, telephone line, etc.

1.6 Final Meeting

The most important results of the evaluation are presented in the final meeting, which is to be attended by the responsible members of the executive board and the other representatives of the departments involved. After the final meeting, the OeNB generally does not have any activities to be conducted at the credit institution. The credit institution is informed of the prospective date by which the evaluation report will be delivered by the OeNB to the Federal Ministry of Finance. All together, the OeNB can take up to five months to appraise the model.

1.7 Conditions and Recommended Multiplication Factor

In the case of deficiencies not resulting in an overall negative evaluation, the evaluation report will contain a recommendation to the Federal Ministry of Finance that approval of the model be made contingent on certain conditions. The conditions will be assigned deadlines by which the deficiencies are to be corrected. The Ministry shall endeavor to allow the credit institution a reasonable amount of time to satisfy the conditions. This period of time commences upon delivery of the notification.

The multiplier to be applied will be determined by the Federal Minister of Finance based on the evaluation report submitted by the Oesterreichische Nationalbank.[9]

[9] *§ 6 para 1 Regulation on Internal Models for the Limitation of Market Risks.*

1.8 Reports after Model Approval

For credit institutions whose models have been approved, § 26b para 5 No 1 lit b Banking Act stipulates requirements for reporting on stress testing and backtesting to the OeNB. The stress testing and backtesting results are used to assess whether the model's approval can be upheld.[10] The requirement of reporting on stress testing to the OeNB is a periodical one and is specified more precisely in § 2 para 5 No 2 Regulation on Internal Models for the Limitation of Market Risks. It is required that backtesting be reported on both a regular basis and as made necessary by specific events. For details, refer to § 5 para 3 and § 6 para 4 Regulation on Internal Models for the Limitation of Market Risks.

As regards stress testing, the OeNB is to receive at least the report which is submitted to the executive management.[11]

In the case of backtesting, in addition to the reports required by law the OeNB shall be provided with daily VaR measures and the corresponding trading outcomes.

Furthermore, in accordance with § 26b para 6 Banking Act credit institutions whose models have been approved shall

- immediately report to the OeNB any changes in the model, the model's assumptions or the transactions included in the model and indicate whether these changes are material in nature;

- immediately report the elimination of criteria pursuant to § 26b para 5 Nos 1-3 Banking Act; and

- submit a system description of the model every three years.

[10] *§ 26b para 7 Banking Act.*
[11] *§ 2 para 5 No 1 Regulation on Internal Models for the Limitation of Market Risks.*

2 Qualitative and Quantitative Standards for the Evaluation of VaR Models

2.1 Organization and Responsibilities

This section is devoted to organizational structure, the responsibilities, powers and procedures stemming from it and the duties falling to executive management.

2.1.1 Organizational Structure

The value-at-risk measures derived from the organizational units of the filing credit institution and credit institution group (e.g. the credit institution as a whole, the central institution, branches in a Member State or a third country, subordinate institutions) are to be integrated into the model in a uniform and continual manner.

Credit institutions shall therefore organize their workflow and related procedures in such a way as to guarantee that all relevant transactions and VaRs can be captured completely and time-continuously. An organizational chart covering the following points must be provided for the evaluation:

- Structure of the credit institution (credit institution group) and its activities on the domestic market and abroad;
- Organizational setup stating the names of the persons involved in the credit institution's trading activities (including foreign offices);
- Description of the distribution of duties among the offices involved in trading.

2.1.2 Procedures and Responsibilities

All procedures relating to the VaR model are to be documented in writing and the employees concerned must be familiar with them. Care shall always be taken to relay information correctly and completely. Should there be any changes in a given procedure, they are to be entered in the risk management handbook without delay upon approval and brought to the attention of employees.

The areas of responsibility and powers accorded to all organizational units concerned must concur with the principles laid down in the risk management handbook and be devoid of

responsibility conflicts. Accordingly, the credit institution shall establish a separate organizational unit for risk management. This unit is to be independent of the trading department and be provided with sufficient resources.

2.1.3 Management Duties

Within the scope of its overall corporate responsibility and duty of care, the executive management shall ensure and verify that the necessary framework conditions are in place. The following are management tools that are instrumental in accomplishing this task:

- An appropriate reporting system and corresponding meetings;
- a limit allocation process based on the credit institution's risk capacity; and
- a risk management handbook documenting all important procedures and criteria for the VaR model and risk control.

Even if a credit institution has good organizational control mechanisms and a clearly defined division of powers, in order for overall risk management to be efficient, management must actively participate in the risk management process. The executive board member responsible for risk control must have the necessary modeling know-how.

Risk control shall present the impact of possible stress situations to management, whose task it is to evaluate this impact.

2.2 Model Approach

2.2.1 General Remarks

The value at risk of a portfolio is defined as the loss that is exceeded at a predetermined holding period of T days with a probability of x%. Therefore, on the basis of reliable statistics the applied risk models must be able to indicate, in regard to a given quantile, a limit (expressed in monetary units of a reference currency) for the maximum possible loss of a portfolio between two given points in time. Thus, a VaR model must be able to quantify the change in the value of a portfolio between two given points in time. These changes in value are determined by the changes in market prices and market indices.

Consequently, stochastic modeling is indispensable in determining the VaR as a quantile of a forecast distribution. This stochastic modeling is the main distinction between VaR calculations and estimating changes in the value of a portfolio via specific scenarios used by the credit institution on an ad-hoc basis.

For supervisory purposes, all VaR models must assume a holding period of ten business days, a one-sided confidence interval with a confidence level of 99% and use at least one year of historical market data.

Requiring a ten-day holding period means that all relevant calculations have to be based on price movements over a period of ten days. Scaling the one-day holding period to the required ten-day holding period by multiplying it by the square root of 10 is, for example, admissible if the underlying market risk factors are independently and identically distributed.

2.2.2 VaR Methodology

VaR methodology is generally composed of two main pillars. On the one hand, the stochastic model is necessary to be able to depict the future trends of market risk factors. The correlation between the individual market risk factors is to be duly accounted for. On the other hand, within the model the market value of the individual positions contained in the portfolio, consisting of traditional financial instruments such as stocks and bonds as well as such derivative products as futures and options, must be calculated using the price-determining market risk factors with the aid of suitable valuation models. In certain cases it is permissible to replace the valuation formula with the leading mathematical terms of the Taylor series expansion, although from a supervisory perspective, in the case of options, the delta, gamma and vega risks must be taken into consideration at least.

When using these approximations, it should be noted that they are only valid locally and even then only if the corresponding price functions are differentiable for their entire definition range. Many exotic options (e.g. barrier options) and structured products do not possess this differentiable quality. Such problems can also arise for the options book as a whole, even if the price function of each individual option is differentiable.

There are three main categories of model approaches that are at present used to calculate VaR:

- The variance-covariance approach,
- historical simulation,
- Monte Carlo simulation.

The variance-covariance approach: This method is a parametric approach to analytical calculation of VaR. Assuming normal distribution of market risk factors, normal distribution of profit and loss is implied for a portfolio. Given these assumptions, the VaR can be computed from the empirically determined variance-covariance matrix of the market risk factors and the sensitivities of the financial instruments (derived from valuation models) regarding the underlying market risk factors. When this approach is adopted, the more complicated financial instruments have to be broken down into simple underlying instruments and their cash flows have to be distributed over defined maturity buckets (mapping). Non-linear products are usually accounted for by using Taylor approximations.

Historical simulation: In this approach VaR is determined based on the history of the market risk factors underlying the financial instruments. Each historical observation constitutes a scenario. With the aid of the valuation functions of the financial instruments, either full valuation or Taylor approximation is used to value the individual financial instruments for each scenario. The changes in the value of a portfolio resulting from the individual scenarios are ranked in ascending order and the desired quantile of the profit/loss distribution is then determined.

Monte Carlo simulation: The basic principle of the Monte Carlo simulation is very similar to that behind historical simulation. In contrast to historical simulation, the scenarios on which valuation of the individual financial instruments and the value of the portfolio are based are generated using random number generators. The parameters (volatilities and correlations) of the stochastic processes, which are the basis for the simulations, are determined empirically from the history of the market risk factors. As with historical simulation, the resulting changes in the value of the portfolio are ranked in ascending order and the desired quantile of the simulated profit/loss distribution (and hence the VaR) is then determined.

2.2.3 Requirements for the VaR Model

Models for calculating value at risk must be based on a solid theoretical concept and adequately capture the potential risk inherent in a trading book. It must be possible to calculate VaR for individual financial positions as well as for the entire trading book (and for subportfolios and individual risk categories) of a credit institution.[12] Furthermore, the model must be flexible enough for new financial products to be integrated into the existing model without great difficulty. The model is to be applied consistently and continually.

Value-at-risk approaches are based on specific statistical assumptions about the stochastic processes of the market risk factors. The better the model can illustrate reality, the more complicated it will generally be to determine the value at risk and the more computer power this will require. Consequently, in actual practice a compromise will be sought between model assumptions that are as close as possible to reality, mathematical complexity and required computer capacity. It is important for the credit institution to be familiar with the assumptions postulated by the model and to be aware of the advantages and disadvantages of the chosen approach, particularly regarding its trading book.

Occasionally it is necessary to reexamine the appropriateness of the assumptions on which the model is based, as they may no longer be justified owing to changes in the composition of the portfolio or other circumstances. The credit institution shall explain the manner in which it proceeded and the results of the examination.

A credit institution's trading book is usually comprised of positions in a wide variety of linear and non-linear financial products. In the internal model, the positions held by the credit institution must be correctly included and valued. The credit institution must therefore demonstrate that the model adequately captures the financial products contained in the trading book. The methods used in the model for valuing the individual financial products are to be explained precisely and documented in detail. These methods should be consistent with the valuation models used in trading.[13]

[12] *In § 26b Banking Act, legislators distinguish between the following categories of risk:*

- *General and specific risk inherent in debt instruments*
- *General and specific risk inherent in stocks*
- *Commodities positions*
- *Exchange rate risk.*

[13] *For a detailed presentation of the requirements for valuation models and stripping and mapping methods, see sections 8 and 9.*

For each financial instrument involved, the model must be able to capture the linear risks (at least delta and vega) and the non-linear risks (at least gamma). The credit institution shall provide detailed documentation of the methods applied and the assumptions made.

The credit institution can use the internal model to calculate not only the market risk, but also the specific risk. Specific risk is comprised of idiosyncratic risk, event risk and default risk. The credit institution must state which parts of specific risk are captured for which risk category in the VaR model. Furthermore, the credit institution must state exactly which approach has been adopted for modeling the specific risk and on which assumptions the approach is based. The credit institution must be able to prove that the model:

- explains historical price changes in the portfolio positions,
- captures concentrations in the portfolio regarding the magnitude and change in the portfolio's composition,
- is robust throughout the credit cycle and
- adequately captures the specific risk (this is to be proven with the aid of backtesting results).

2.3 Integration of the Model

The internal risk model is to be used not only to determine the regulatory capital requirement, but also in risk management. Proper integration of the model in the risk management system is thus a prerequisite for approval of the model.

2.3.1 Risk Control

Legislators prefer a credit institution to have a separate organizational unit responsible for risk management. This unit must be independent of the trading department and have sufficient resources at its disposal.

Effective risk control helps a credit institution to achieve objectives and targets and to implement strategies successfully so as to minimize its possible losses. Moreover, risk control is responsible for making sure that both legal provisions and those laid down internally in the risk management handbook are implemented and observed throughout the credit institution.

A key aspect is that risk control must be independent of trading departments in order to avoid conflicts of interest. This means that risk control, at the very least, does not receive its instructions from the same authority as the trading department.

2.3.2 Introduction of the Model and Model Audits

Before a model can actually be put into operation, there must be a sufficient trial period. The test results of the trial are to be preserved for the evaluation of the model. As the internal audit department has to audit the use of the model on a regular basis, the internal audit department is expected to conduct an audit, in particular, when the model is introduced.

Risk control is responsible for ongoing maintenance of the model. The related responsibilities and – in the case of major changes – the flow of information to the Federal Ministry of Finance and the OeNB are to be specified. Documentation of the model is to be kept up to date. It must be correct, consistent and comprehensive in form so that all of the calculations contained therein can be easily followed and understood.

Each change made to the model must be recorded in the documentation to ensure that what occurs in actual practice tallies with the formal documentation.

2.3.3 Daily Reporting

Risk control shall report the results of using the model on a daily basis. To ensure that the reports can be used for daily business as stipulated in the provisions, an appropriate deadline for preparing and relaying the reports must be fixed. The flow of risk-related data and information between and within organizational units of the credit institution or group of credit institutions must also be laid down in the risk management handbook.

The OeNB shall be furnished with all reports including the addressee list. The deadlines must correspond with those for the requested trading book data.

2.3.4 Limit Control

For individuals and organizational units involved in trading, the limits are to be defined in keeping with the model being used and adjusted in accordance with the institution's risk capacity. The limits are to be approved by management or another appropriate body and evaluated periodically.

In distributing and controlling the limits at branch offices, the credit institution shall indicate how the limit process is administrated (centralized/decentralized). The individual steps and systems must be documented in order to keep the procedure uniform.

The allocation and distribution of limits to individual trading areas shall only be done in coordination with risk control.

The individuals and organizational units involved are to be informed of the limits and their utilization. Risk control shall review the limits and take the appropriate countermeasures when limits are exceeded.

2.3.5 Risk Analysis when Introducing New Products

Before a decision can be taken on introducing new products, analyses of all of the departments concerned – risk control in particular – should identify their risk profile. All points relating to this (e.g. responsibilities, product specifications, system compatibility) are to be defined in the risk management handbook.

In introducing new products, particular care must be taken to ascertain whether this constitutes a major change and therefore invokes the duty to notify the Federal Ministry of Finance and the OeNB.

2.3.6 Risk Management Handbook

Risk management shall be documented in a handbook. Risk control is responsible for putting together and adapting the risk management handbook. Utmost care shall be taken to use the handbook uniformly throughout the credit institution and/or group.

The risk management handbook is to be submitted to management for approval not only upon its introduction, but also whenever a significant change occurs. The procedure for revisions should be included in the documentation. All departments affected shall have access to the risk management handbook at all times.

2.4 Analysis of the Trading Book

The trading book (including all foreign branch offices) is to be presented to the OeNB on certain dates which will be fixed for the credit institution by the OeNB. Most of these dates are *prior* to evaluation of the model, although as a rule the credit institution is notified of another date *after* evaluation of the model is underway. The trading book data should be transmitted using an appropriate electronic data medium. Agreement should be reached in advance on which file format and field specifications are to be used.

All organizational units in which trading takes place should appear in the documents. This applies especially to domestic and foreign subsidiary credit institutions and branch offices. It is desirable that the product categories traded by each unit be named and the focus of trading be described. The units whose positions are captured in the model are to be indicated separately. Reasons are to be given for positions of units that are not included in the model.

The credit institution must present the documentation in which the internal criteria are laid down for the allocation of transactions to the trading book. In particular, transfers of entries between the books are to be listed and justified within a period of time specified by the OeNB. For the sake of verifying the proper assignment of positions in the trading or banking book, an excerpt of selected products from the banking book is also required.

The objective of analyzing the trading book is to ascertain which risks are inherent in the portfolio and which market risk factors are required.

Particular attention is paid here to the following:

- Depiction of the book's structure

- Description of trading activities and strategies- arbitrage transactions- options strategies- market maker functions, etc.

- Listing of instruments
  - interest rate instruments
  - stock instruments
  - commodities instruments
  - FX instruments and
  - linear versus non-linear instruments

- Volume of the positions– depiction of volume– consideration of delta equivalents for options

- Geographical distribution by- country – currency

- Materiality of the risks[14].

The data shall be delivered in the form of raw data (individual positions) and processed data (aggregated data), whereby the credit institution must be informed in due time of the exact specifications of the desired aggregation. The table of contents for the documents will give an example of a possible form of aggregation.

Particular attention is to be paid to instruments with complex terms of issue. Structured issues and issues containing exotic options are to be described in detail. The credit institution shall attach to the documents at least the issue prospectus, the valuation method and the type of hedging.

The following guidelines should be observed in specifying the risk factors:

Debt instruments

For each currency in which a credit institution enters into interest rate risks there are yield curves to be taken into account that contain at least six risk factors (often referred to as maturity buckets, time buckets or interest rate risk zones). The number of factors as well as their position are to be defined commensurate with the volume and type of transactions involved. A larger number of risk factors is required for complex strategies in order to adequately capture the interest rate risk. A credit institution whose activities are focused on the market for short-term interest rate instruments (money market instruments, interbank money market, FRAs, etc.) will thus have to move the position of the necessary maturity buckets to the short end. On the other hand, a credit institution whose activities cover the whole spectrum of maturities has to take more maturity buckets into consideration. The position and number of interest rate risk zones can vary from one currency to the next.

By the same token, a credit institution must employ factors for the spread risk, i.e. the risk of a change in the differential between the yields of securities issued by the government and other interest rate instruments (swaps, bank bonds, etc.) if it has taken up positions with the intention of utilizing this risk.

Stocks

The internal model must take into account risk factors for every stock market in which the credit institution has significant positions. The institution shall state the criteria used to establish

[14] *According to the Basle Recommendations, the model must take into account risk factors for those positions in which there is significant exposure.*

the minimum size as of which a position is to be considered significant. Either time series of the market indices or time series of the individual stock prices can be used as risk factors. If indices are used, the individual securities can be expressed in the form of beta equivalents. If the position in one stock exceeds 5% of the total position in stocks, the use of an individual risk factor for this stock is required by law.

Exchange rates (and gold)

As the VaR calculated with the aid of an internal risk model is expressed in the domestic currency of the credit institution, every net position in foreign currency carries a foreign currency risk. Consequently, risk factors are required for all exchange rates between the domestic and a foreign currency in which the credit institution has significant exposure. The institution shall state the criteria used to establish the minimum volume as of which a position is to be considered significant.

The Austrian Banking Act provides that the foreign currency risks of the credit institution as a whole (trading and banking books) are to be covered by capital. Thus, the credit institution can use the internal model for the foreign exchange risk of both the trading book and the banking book. The filing documents must state the extent to which the currency positions are captured in the model.

Commodities

For commodities in which the credit institution only holds positions that are immaterial in volume[15], it suffices to take into account simple risk factors. In using a simple risk factor, it is sufficient, for example, to use only one risk factor for all types of crude oil. The credit institution shall explain why a particular factor was chosen as a simple market risk factor.

If the volume exceeds the 1% threshold, the convenience yield must be used for this commodity.

[15] *In contrast to the EU Directive, the Austrian Banking Act (BWG) precisely specifies that a position of immaterial volume refers to all commodities positions smaller than 1% of the attributable capital resources of the credit institution or the consolidated attributable capital resources of the credit institution group.*

2.5 Data Input

2.5.1 Position Data

In addition to the market risk factors, position data also constitute crucial input factors for the internal model. For this purpose, the credit institution must guarantee the completeness and correctness of the position data. The documentation pertaining to position data is examined as part of the off-site analysis and shall contain the following points:

2.5.2 Data flow

The flow of business data from the system in question all the way to the value-at-risk model must be clearly visible. The documents shall show

- by way of diagrams the routing of documents involved in capturing positions, distinguished according to the locations of trading;
- from which departments (front, middle, back office) the position data come that are used as input for the risk model;
- which systems are used for which locations of trading and which products are covered by these systems;
- which interfaces are necessary;
- which audits have been conducted to ascertain the correct functioning of the data flow;
- which input parameters (including reference sources per financial instrument) are used for the VaR model;
- how the inclusion of off-system trades in the VaR model is ensured.

Consolidation and filtering

An exact description of the consolidation is particularly important, as it reveals which products from which organizational units are combined in a portfolio to calculate VaR. For this purpose, the structure of the entire portfolio shall be depicted, which also shows how individual financial

instruments are identified in terms of their origin (e.g. trading desk, branch office). The credit institution is to document how double counting is prevented.

2.5.3 Market Data

Using an internal model to calculate risk places great requirements on the data set of market risk factors. The time series of market risk factors constitute the basis for estimating the variance-covariance matrices that are used in parametric methods and Monte Carlo approaches. In historical simulation methods the individual observations are included in the value-at-risk calculation as scenarios.

In order to be able to make daily value-at-risk calculations, the time series of the market risk factors must be updated periodically.[16] Thus, the credit institution must see to it that the user of the model has implemented the necessary methods and procedures. The length of the observation period is to be at least one year for all time series. It is important that the time series be updated reliably and in a timely manner.

In order to guarantee effective use of the model, the quality of the data must be ensured. The data must come from reliable sources. Consequently, it is to be ascertained whether the credit institution receives its data from reputed data suppliers. The names of the data providers and the interfaces for the reception of data are to be indicated. If the credit institution collects the data itself, it shall describe the criteria applied for collecting data and how these data are provided continually and consistently for use in the model. The credit institution should implement standard criteria to verify the quality of data. The exact criteria and procedures used to ensure the quality of data are to be detailed. The procedure to be followed after identifying dubious data items is to be described. Furthermore, it must be indicated which method the credit institution has chosen for editing defective data items and filling in missing data items.

2.5.4 Market Risk Factors

Aside from the position data, the market risk factors are the most important input factors for the internal model. Based on the underlying statistical assumptions about market risk factors, the value at risk of the portfolio is calculated with the aid of the chosen model approach. For some positions in the portfolio, the market risk of the financial instrument can be determined by the market risk factor itself and the corresponding volume of the position (e.g. in spot FX

[16] *§ 26b Banking Act in connection with the Regulation on Internal Models for the Limitation of Market Risks requires that the time series of the market risk factors be updated at least every three months. This is to be seen as a minimum requirement and considered jointly with the type and volume of the transactions effected by the credit institution.*

positions). In the case of more complicated financial instruments, e.g. derivatives, valuation models are used to show the connection between the market risk factors and the financial instrument.

In general, depending on the portfolio the following risk factors must be taken into account:

- Interest rates for specific maturities in each currency,
- spreads,
- stock indices and individual stock prices,
- exchange rates,
- gold prices,
- commodities prices and convenience yields.

For some of the above-mentioned market risk factors, e.g. interest rates, the data on certain maturities is not immediately available, but must rather be determined with the help of estimation methods (see part B section 6 “Estimation Methods”).

Based on the analysis of the trading book on particular dates, the necessary market risk factors are compared by the OeNB with the list furnished by the credit institution of the market risk factors used.

The detailed description of necessary criteria for specifying market risk factors can be found in the preceding section (section 4 “Analysis of the Trading Book”).

2.6 Estimation Methods

2.6.1 Variance-Covariance Matrices

Using parametric methods (variance-covariance approaches) or Monte Carlo methods requires variance-covariance matrices based on the historical time series of the market risk factors. In the case of parametric methods, the variance-covariance matrix provides information on the estimated future distribution of profit/loss, which is crucial input for the analytical determination of value at risk. When Monte Carlo methods are used, the variance-covariance matrix shows the volatilities and correlations of the stochastic processes, based on which the profit/loss distribution is determined via simulation.

To estimate volatilities and correlations from historical time series, various methods of estimation can be applied. In practice, unweighted, exponentially weighted or GARCH methods are usually applied.

Sufficient knowledge of the estimation method used, the underlying statistical assumptions and both the strengths and weaknesses of the chosen method are necessary.

In analytical VaR calculations, it is important that the variance-covariance matrix be positively definite. The credit institution therefore should be able to demonstrate how this mathematical property is guaranteed. Should the estimation approach require methods for verifying the positive definiteness of the matrices, such a method should be foreseen in the internal model of the credit institution.

In order to be able to reproduce the results of the VaR calculations at any time, the credit institution should keep records of the variance-covariance matrices. It should be easy to access historical matrices.

The estimation methods applied should be described in detail in the model documentation.

2.6.2 Yield Curves

Yield curves have a dual significance within the value-at-risk model. On the one hand, interest rates for specific maturities are used as market risk factors and, on the other, they serve as input factors for valuation models.

Generally speaking, yield curves are used to indicate the relationship between the maturity and the interest rate within a risk category at a specific point in time. Risk categories are used in this context to designate, for example, different categories of bonds, whereby determining which

category a bond is assigned to shall reflect the differences in the issuer-related risk (e.g. spread risk).[17]

The credit institution shall calculate the yield curves according to a generally recognized method. The estimation method applied, the underlying assumptions and the related advantages and disadvantages are to be precisely documented. Should different methods be used, the credit institution shall state its reasons for doing so.

It shall be indicated exactly which data have been used, including detailed descriptions of the data sets. In defining several yield curves for a currency, is must be clear which input data are used to determine a specific curve and how the input data are selected. Any potential outliers or smoothing methods are to be precisely documented.

The various yield curves per currency are to express the not perfectly correlated developments between interest rates depending on their issuers, whereby the number of the interest rates curves to be taken into account per currency will depend on the trading activities of the credit institution. By comparing the yield curves of each currency, the OeNB ascertains whether the spread risk has been adequately taken into account.

Using estimation methods can cause problems if the data set is too small or of poor quality. Should default settings be used for this reason, such settings are to be precisely indicated by the credit institution.

Furthermore, the credit institution should document why it deems a given default setting to be justified.

[17] *One example of a possible categorization would be: government bonds, corporate bonds and junk bonds.*

2.7 Stripping and Mapping Methods

Stripping and mapping are used to represent a financial instrument in the form of several instruments that are easier to analyze, and to map the cash flows of these simple instruments to the market risk factors taken into account.

The no-arbitrage principle and the principle of product replication form the basis for stripping and also represent the theoretical prerequisite for modern option pricing theory. The idea here is to use the market risk factors being taken into account to project the product involved and the related market risk factors on a new synthetic product that has the same payoff structure as the original product but, compared to the original product, can generate neither profit nor loss in any possible market situation.

The distribution of cash flows over several maturity buckets in the yield curve creates a diversification effect which can vary from one mapping method to the next. This distribution can be determined by various conditions: Duration-neutral mapping calls for retaining the net present value (NPV) and the duration, whereas risk-neutral mapping foresees retaining the NPV and the risk. There is, however, no mapping method that retains all three at the same time. The credit institution should be aware of which feature of the original cash flow is lost in the adopted mapping method. In view of the resulting risks, it is advisable to quantify this distortion.

It is not possible to map a cash flow of the original product to two neighboring maturity buckets if this cash flow occurs before the first or after the last maturity bucket. A separate decision must be taken as to how to deal with such cash flows. It is advisable to quantify the distortion resulting here as well.

For those mapping methods that retain the risk, the volatility of the original cash flow is required as an input factor. It must be traceable from the documentation how this variable was arrived at.

A crucial element for the precision of mapping is the calculation of the dates of the maturity buckets and of the cash flows generated by the financial instrument. The credit institution should therefore clearly indicate the rules applied in calculating the dates and cash flows (how to deal with weekends and legal holidays, rounding rules, etc.)

2.8 Valuation Models

Options are among the most important derivative financial instruments. In some cases it is possible to derive closed-form valuation formulas for them, e.g. the Black-Scholes formula for valuating European plain vanilla options. In many cases, however, one has to settle for numerical approximations, which generally use Monte Carlo simulations or the finite elements method. For more detailed information on option valuation and calculation of sensitivities, refer to volume 4 of the Guidelines on Market Risk entitled "Provisions for Option Risks" (Gaal and Plank, 1999). To capture the risks inherent in various options, a Taylor approximation of the option price can be used to capture the most important risk factors at least at the local level or a revaluation can be made in a multitude of different market scenarios. The scenarios are generated either through historical simulation or Monte Carlo simulation, which provides the vital link with probability theory concepts. Assessing risk by way of revaluation is always preferable to the various approximation methods, as it enables the user to capture every aspect of the risk profile. If an approximation approach is adopted, at least the delta, gamma and vega risks must be captured. Before using a valuation model, the credit institution is to verify whether the assumptions regarding the instrument to be valued are correct.

Calculation of the dates of the cash flows generated by the financial instruments and the discounting of these cash flows are an integral part of any valuation model and greatly contribute to the precision of the model. The credit institution therefore must be able to clearly indicate the rules applied in calculating the dates (how to deal with weekends and legal holidays, rounding rules, etc.) Discounting shall be done consistently, applying one method (continuous or discrete). The corresponding formula must be included in the model documentation.

The credit institution shall pay special attention to the correct scaling of the input parameters and particularly the choice of volatility (smile effect).

If the trading and risk control departments of the credit institution apply different valuation models for the same financial instruments, this must be documented.

In the case of exotic options, the calculated sensitivities sometimes have little or no meaning as a result of non-monotone payoff structure. An example of this is the sensitivities of barrier options near the barrier. In the documentation the credit institution should refer to the problems presented by valuing exotic options.

2.9 Aggregation

The value-at-risk model of a credit institution is used not only for internal risk management, but also to determine the regulatory capital requirement for market risk. For supervisory purposes, the regulatory capital requirement shall be the higher of (a) the VaR measure of the previous trading day or (b) the arithmetic mean of the VaR measures on each of the preceding 60 business days multiplied by a factor of 3 to which, if applicable, a "plus" has to be added depending on the quality of the model.

The regulatory capital requirement calculated based on VaR should cover the general market risk and, where applicable, the specific risk inherent in the trading book. Hence, a credit institution must structure its entire trading book appropriately and aggregate partial results to be able to calculate the VaR for the regulatory capital requirement. Legislators have also allowed credit institutions the possibility of applying the standardized approach to individual risk categories ('partial use of partial models'). If a credit institution makes use of this option, the risk numbers from the internal model and the standardized approach have to be added together to determine the required regulatory capital.

In order to render the calculation of the regulatory capital requirement transparent, the individual aggregation steps throughout the entire aggregation process must be clearly traceable.

Furthermore, the credit institution shall indicate between which risk categories correlations are used in the model and how the total VaR is determined from the risk categories. Should the internal model be combined with the standardized approach to calculate risk, it must be stated for which risk categories the standardized approach is used and for which the VaR model is applied.

2.10 Backtesting

2.10.1 General Remarks on Backtesting

In backtesting the daily VaR measures are compared with the daily trading outcomes over a given observation period. As trading losses in excess of the VaR are only supposed to occur with a specific probability contingent on the confidence level used in calculating VaR, these comparisons can be used to evaluate the quality of the model. If the risk positions are properly captured in the model, the number of cases in which the trading loss exceeds VaR (which is known as an exception) should not be that great relative to the confidence level applied and the chosen observation period. Based on this premise and presupposing certain statistical assumptions, statistical significance tests can be used to determine whether the model has properly captured the value at risk. Backtesting is to be used to examine the statistical model underlying the internal model as well as the pricing models applied in the internal model. Therefore, in valuing portfolios market prices are to be used wherever possible, i.e. wherever prices of a liquid market are available.

In performing backtesting, the problem arises that the VaR is calculated on the basis of a static portfolio, whereas in practice the trading portfolio is subject to constant change. Consequently, for the purposes of backtesting, it is permissible to compare the VaR with the hypothetical trading outcome as opposed to the actual outcome.[18] The hypothetical trading outcome is arrived at by revaluing the portfolio underlying the VaR calculation. If actual trading outcomes are used, the elements distorting the trading outcome (e.g. fee income) should not be taken into consideration.[19] Even if it is permissible by law to use both the actual trading outcome and the hypothetical outcome for backtesting,[20] the OeNB gives preference to using the hypothetical outcome for the purpose of validating the model, since the actual trading outcome is also influenced by the conduct of the brokers, hence a factor exogenous to the model.

Should backtesting reveal weak points in the model, such points are to be corrected. Backtesting should also help encourage the credit institution to further enhance the quality of its model, because pursuant to the traffic light approach too large a number of exceptions[21] results in a higher regulatory capital requirement.

[18] *§ 5 para 1 Regulation on Internal Models for the Limitation of Market Risks: "In backtesting, the risk measures calculated daily are to be compared ex post with the hypothetical trading outcome … or the actual daily trading outcome."*
[19] *§ 5 para 1 Regulation on Internal Models for the Limitation of Market Risks.*
[20] *This option also exists in the Capital Adequacy Directive II.*
[21] *§ 6 para 1 Regulation on Internal Models for the Limitation of Market Risks.*

2.10.2 Legal Requirements for the Parameters Used in Backtesting

Regarding the holding period to be applied in backtesting, the statutory regulation currently in force foresees that this period can be one day.[22] In view of the fact that the Capital Adequacy Directive II, which has yet to be implemented in Austrian law, dictates a compulsory one-day holding period and the statistical problems associated with using a holding period longer than one day[23], it is the opinion of the OeNB that credit institutions should use a one-day holding period even now in their backtesting. Even if passages in the law do not explicitly state the confidence level to be applied in performing backtesting, given the intent of backtesting it follows that this confidence level should be the same as that used in calculating the regulatory capital requirement, i.e. 99%. This coincides with the statements issued by the Basle Committee on Banking Supervision.[24]

2.10.3 Backtesting Computations and Analysis

As part of the evaluation, the credit institution shall explain precisely how it carries out the computations necessary for backtesting. This explanation is to include the necessary input data and the flow of these data, indicating the source from which they were taken and the time sequence of the flow of data. Furthermore, the time sequence and order of events in performing the backtesting computations are to be presented.

It shall be precisely stated according to which concepts the VaR for use in backtesting and the corresponding trading outcome are calculated. In particular, information is to be provided on whether the backtesting VaR differs from the VaR used for the regulatory capital requirement. This may be the case, for example, if the vega risk is not properly captured in the model and flows into the capital requirement VaR by way of an exogenous vega add-on. Consequently the valuation of options for the purpose of calculating the trading outcome should be performed using pricing formulas with volatility kept constant and the vega add-on should be subtracted from the VaR used to calculate the regulatory capital requirement so that the backtesting VaR can be compared with the trading outcome. Generally speaking, the VaR for backtesting and the computed trading outcome should correlate in that both quantities contain the same risks. This can make it impossible to comply with the requirement that market prices be used wherever possible in valuing portfolios (only in this way can the valuation models contained in the internal model also be backtested). Such difficulties can arise if, for example, the vega risk or the specific risk are not captured in the model. Therefore, in order for the backtesting to be truly valuable,

[22] *§ 5 para 1 Regulation on Internal Models for the Limitation of Market Risks.*
[23] *Serial correlation of backtesting results.*
[24] *Cf. "Supervisory framework for the use of backtesting in conjunction with the internal models approach to market risk capital requirements", Basle Committee on Banking Supervision, January 1996.*

internal models should be extended over the course of time so as to take in the gamma and vega risks as well as the specific risk.

Furthermore, the credit institution shall explain the manner in which the causes of exceptions are analyzed, how it handles the occurrence of repeated exceptions, how the model can be adapted in this case and which statistical methods are used to analyze the data collected in backtesting (the VaR measure and the trading outcome for each day).

Moreover, the credit institution shall furnish information on how the performance of backtesting has grown historically, whether additional backtesting is performed by the credit institution using methodology above and beyond the legal requirements (e.g. retrograde backtesting) and how well the backtesting module is integrated into the rest of the VaR model.

2.10.4 Backtesting at a Subportfolio Level

If full use is not made of the sub-additivity of the VaR (this is the case, for example, when several variance-covariance models are used in a variance-covariance approach and the total VaR is aggregated by adding together the VaR measures corresponding to the individual matrices), as a rule the resulting confidence level is indeed over 99%. For backtesting this means that in cases where the sub-additivity of the VaR is not fully used, no exceptions occur, although there would be exceptions if full use were made of the sub-additivity of the VaR. For the evaluation of the performance of backtesting, the credit institution must therefore indicate the extent to which it has dispensed with the sub-additivity of the VaR. If this is the case, “partial VaRs” at the highest possible level of aggregation shall be identified which actually exhibit a confidence level of 99% with the model approach used. The credit institution shall also perform backtesting regarding these partial VaRs to supplement the backtesting at the overall portfolio level and analyze the resulting exceptions. It is desirable for the results to be reported to the OeNB. The corresponding provisions should be laid down in the risk management handbook.

2.10.5 Organizational Framework for Backtesting

Backtesting must be performed on a daily basis by risk control, which, in particular, is responsible for establishing the trading outcome. The results of backtesting are to be summarized in a report and sent to the appropriate units each day. The steps to be taken and pertinent decision-making powers when exceptions occur shall be documented and brought to the attention of employees. The entire procedure to be followed and the associated responsibilities are to be documented in the risk management handbook.

The highest number of exceptions recorded in backtesting in the previous quarter for a historical period of 250 days is to be reported to the OeNB. The occurrence of a current exception is to be reported to the OeNB within 14 days.

Furthermore, it is desirable for the OeNB to receive the daily backtesting figures (VaR and trading outcome) as well, whereby both the hypothetical and the actual trading outcome figures should be included.

2.11 Stress Testing

This guideline only provides a short description of the principles of stress testing. For more details on stress testing, refer to volume 5 of the Guidelines on Market Risk called "Stress Testing" (Breuer and Krenn, 1999). Requirements for stress testing procedures in credit institutions using a VaR model for regulatory purposes are summed up in section 5 of this guideline.

Stress testing (also called scenario analysis) is based on the assertion that the value P of a portfolio is dependent on risk factors:

$$P = P(\boldsymbol{r}),$$

where the vector $\boldsymbol{r}$ represents the risk factors relevant for the portfolio. Vector $\boldsymbol{r}$ summarizes the condition of that part of the market having an influence on the value of the portfolio. Vector $\boldsymbol{r}$ is referred to as a *scenario*.

In stress testing, scenarios $\boldsymbol{r}_1,\boldsymbol{r}_2,...,\boldsymbol{r}_k$ are defined and it is calculated how much the currently held portfolio is worth in each of these scenarios. These portfolio values are stated as $P(\boldsymbol{r}_1), P(\boldsymbol{r}_2),..., P(\boldsymbol{r}_k)$. By comparing these values to the current portfolio value, it can be judged what losses will be incurred if the portfolio remains constant for a certain time interval and the various market situations defined by the scenarios actually occur at the end of this time interval.[25] Furthermore, stress tests shall identify scenarios that will lead to particularly heavy losses.

As no assumptions are made in stress testing about the probability of occurrence of individual scenarios, stress testing is not a statistical tool for risk analysis. Precisely due to the absence of statistical assumptions, stress testing is suitable for auditing and/or supplementing VaR measures, which are calculated on the basis of statistical assumptions. In auditing the VaR model, the focus is on the statistical model on which the internal model is based. The valuation model on which the internal model is based can only be partially audited, if at all, because the portfolio valuation to be carried out in stress testing is, in turn, founded on a valuation model.

The choice of scenarios is not trivial a task: Stress scenarios shall essentially reflect market trends that are unusual but are nonetheless considered plausible. The requirement for stress scenarios of being both plausible and rare creates a certain discrepancy which can be mitigated by considering scenarios of different severity.

[25] *§ 7 para 1 Regulation on Internal Models for the Limitation of Market Risks: "In the crisis scenarios, the impact of such events [note: in the regulation the term 'events' means 'events of low probability in all significant types of risk'] on positions presenting linear and non-linear price features are to be explained."*

On the one hand, scenarios based on historical data shall be considered, on the other hand, worst-case scenarios which have a particularly severe impact on the current portfolio shall be taken into account. Scenarios based on historical data might underestimate future crises, nevertheless the fact that they have actually occurred in the past renders them plausible and acceptable. Worst-case scenarios, however, also take into consideration scenarios that have not yet occurred. The search for worst-case scenarios can either be carried out in a subjective or in a quantitative way using loss maximizing algorithms (e.g. Monte Carlo simulation).

2.12 Internal Audit

The internal audit department is to review the risk management procedures and the VaR model on a regular basis and therefore must have a good knowledge of modeling. This review must consider both qualitative and quantitative standards. Both risk control and management are to be informed of the results.

Every internal audit should have an audit schedule for the VaR model indicating the frequency and content of the audit.

In particular the audit shall cover the following:

- The appropriateness of the documentation of the system and the risk management procedures,
- the organization of risk management for the entire credit institution,
- the integration of the VaRs into everyday risk management,
- the approval process for the risk models and valuation systems used by employees in the front and back offices,
- reviews of changes made to the model,
- the scope of the market risks captured in the model,
- the quality of the management information system,
- the accuracy and completeness of position data,
- verification of uniformity, recentness of data, reliability and independence of the data sources used in the models,
- the accuracy and appropriateness of the assumptions about volatilities and correlations,
- the accuracy of the model's valuation and risk transformation calculations,
- the proper implementation of backtesting,
- the proper implementation of stress testing.

The internal audit department shall verify the correction of detected defects in due time.

In the course of the evaluation pursuant to § 26b Banking Act, the OeNB shall verify whether the duties assigned to the internal audit department in connection with application of the VaR model were executed properly. In principle, the OeNB proceeds on the assumption that the internal audit department has essentially arrived at the same results in the course of its examination of the model as the OeNB in its evaluation process. Should there be differences in the manner of proceeding or in the results, such differences are to be thoroughly investigated and/or checked with the internal audit department.

3 Required Documents

Organization and Responsibilities

- Organizational chart of the entire credit institution group
- Organizational chart of the main credit institution paying special attention to trading, risk control, back office, internal audit and other departments relevant for the model
- Organizational chart of all branch offices and subsidiaries engaged in trading
- Detailed description of the duties and responsibilities of all organizational units connected with the model
- Description of the duties of the member of the executive board responsible for risk control
- Description of the duties of the member of the executive board responsible for trading

Model Approach

The documents shall contain a detailed description of the entire VaR model. Regarding the use of variables and parameters, care shall be taken to provide a clear and unambiguous description. In particular, the documents are to cover the following points:

- A description of the model approach taken (variance-covariance approach, historical simulation, etc.)
- The underlying statistical assumptions about the distributions of market risk factors and/or the joint distribution of market risk factors
- Approach to modeling non-linear risks
- Approach to modeling the vega risk
- Approach to modeling specific risks
- Procedure for achieving the legally prescribed confidence level and holding period (e.g. scaling method, etc.)
- Determination of sensitivities
- Depiction of the products in the model
- Technical implementation of the model (hardware and software used)
- Measures for ongoing evaluation of the appropriateness of the model
- Test schedule for auditing the internal model

Model Integration

- Organizational chart of the entire credit institution group showing the integration of risk control
- Description of the duties assigned to the risk control department with the names and job descriptions of all employees, including particulars of their qualifications and work experience
- Training schedule for employees in the area of risk control
- Report on model validation
- Test schedule and test results for implementation of the model
- Reports on use of the model including the list of addressees
- Reports drawn up by other departments (e.g. trading, back office) in connection with the risk control process
- Description of the limits system
- Reports on the utilization of daily limits
- Authorization of the currently used limits
- Discretionary power when limits are exceeded
- Examples of analyses conducted for the purpose of introducing new products and their approval
- Copy of the risk management handbook
- Authorization of the risk management handbook
- List of adressees receiving the risk management handbook

Analysis of the Trading Book

- Indication of all risk categories covered in the model (debt instruments and stocks, exchange rates, commodities)

- Indication of the scope of the model in view of the exchange rate risk (trading book only or trading book and bank book)

- List of all organizational units in which trading takes place (particularly with regard to domestic and foreign subsidiaries and branch offices). Units whose positions are captured in the model are to be indicated separately. Reasons are to be given for positions of units that are not included in the model.

- The complete trading book of the positions mentioned in the preceding bullets, in an electronic data medium, on the dates set by the OeNB. The data are to be transmitted in the form of raw data (individual positions) and in processed form (aggregated presentation). Credit institutions are required to aggregate data in the following form:

  Stocks:

  - Exposure broken down by markets, i.e. aggregation through cash positions, options positions (delta-weighted) and index positions (broken down and delta-weighted in the case of index options). The data can be provided in ATS or EUR.
  - Illustration of the individual markets in the form of a pie chart with numerical data.

  Exchange rates:

  - Illustration of the currency dispersion in the form of a pie chart with numerical data.

  Interest rates:

  - Description of total interest rate exposure per currency on all interest rate instruments according to time to maturity (at yearly intervals). This is to be presented in the form of a bar chart accompanied by the appropriate numerical data.
  - Description of interest rate exposure per currency and per interest rate instrument according to time to maturity (at yearly intervals). This is to be presented in the form of a bar chart with the appropriate numerical data.

- Complex issues are to be described in detail (issue terms, payment profile, valuation, hedging)

- Documentation of the internal guidelines for allocating positions to the trading or bank book

- List of all internal deals and transfers between the trading and bank book during a period specified by the OeNB. All transfers are to be documented and justified. Submission of an excerpt from the bank book on specific product categories.

Data Input

- List (including descriptions) of the software used in trading and settlement for capturing positions (this list should show which software is used for which financial instruments in which trading locations)

- Diagram of the routing of documents pertaining to the capturing of positions and broken down by trading location (in particular, this diagram should clearly illustrate the entire flow of data from the front office system all the way to the VaR model)

- Explanation of the identification of individual transactions (exact description of the identifier with an explanation of all abbreviations)

- List of all interfaces from the front office system to the VaR model

- Tests used for subportfolios to verify the correctness and completeness of position data for the VaR model

- Input description of position data in the VaR model (exact description of the input parameters for each type of financial instrument)

- List of all market risk factors used in the model, indicating the sources (e.g. Reuters), the length of historical time series and the frequency of updating

- Interfaces for data delivery

- Description of the procedure implemented to update the historical time series

- Plan of action for problems in daily updating

- Methods and procedures for examining extreme observations

- Procedure for dealing with missing data

- Error reports from data checks

- List of considered market risk factors according to risk category

Estimation Methods

- Method of calculating the returns of market risk factors (logarithmic returns, etc.)
- Description of the estimation method used to determine volatility and covariances
- Analysis of the strengths and weaknesses of the estimation method applied
- Measures taken to examine definiteness of variance-covariance matrices
- Records of variance-covariance matrices used
- Complete description of the approach used to calculate yield curves
- Data base for determining yield curves (e.g. Treasury curve, swap curve, etc.), including an exact description of the input parameters
- Analysis of the advantages and disadvantages of the approach
- Approach used to determine spreads
- Description of the outlier procedure if applicable
- Records of yield curves

Stripping and Mapping Methods

- Principles behind the methods
  - ♦ references to publications stating sources
  - ♦ for internally developed methods: documentation
- Assumptions for the applicability of the method
- Indication of any modifications made to standard formulas
- Scaling and souce of input parameters
- Input parameter formulas with a definition of the variables used
- Enumeration of the maturity buckets used for mapping
- Method used to calculate the dates of the mapping maturity buckets
- Strengths and weaknesses of the method as assessed by the credit institution

Valuation Models

The required documents shall include the following for each valuation model used:

- Principles behind the methods
  - ♦ references to publications stating sources
  - ♦ for internally developed methods: documentation
- Assumptions for the applicability of the model
- Indication of any modifications made to standard formulas
- Source of input parameters
- Input parameter formulas with a definition of the variables
- Scaling of input parameters
- Procedure, result and documentation of all test calculations pertaining to the valuation model
- Strengths and weaknesses of the valuation model as assessed by the credit institution

Aggregation

- All risk categories included in the model for each organizational unit covered
- Time schedule for determining the total value at risk
- Structuring of the total value-at-risk calculation (both for determining the regulatory capital requirement and for internal risk management)
- Description of the aggregations (e.g. where and how correlations between risk categories are taken into account)

Backtesting

- The results of backtesting (VaR measure and corresponding trading outcome) for the last 250 working days are to be furnished. The period of 250 days can be shortened to as little as 30 days upon special request of the credit institution. This special request is to be documented in the filing documents. Should the credit institution avail itself of this possibility, those results not yet furnished at the filing date shall be submitted immediately when the results of the backtesting for 250 working days are ready. If the total VaR is determined by adding partial VaR measures, this must be reported not only for the overall portfolio, but also for levels of aggregation on which a confidence level of 99% is actually reached. This is to be reported in writing and electronically. In the cases of exceptions, any analyses performed by the credit institution are to be communicated to the OeNB.

- Those passages in the risk management handbook relating to backtesting are to be marked In these passages it must be discernible that the backtesting is performed in conformity with the law.

- The principal method for calculating the trading outcome is to be explained (e.g. whether actual or hypothetical results are used, in which cases market prices are used and in which cases valuation models). Any differences between the VaR used for the regulatory capital requirement and the VaR used for backtesting are to be documented and justified.

- Examples of internal reports to the management

- Example of a report to the Federal Ministry of Finance and the OeNB

Stress Testing

- The results of the most recent stress tests performed are to be presented in detail. If stress testing triggered by specific events has already been conducted, this is especially interesting and is to be submitted as well, together with a description of the specific trigger events.

- Those passages in the risk management handbook related to stress testing are to be marked. In these passages the stress scenarios and the trigger events used by the credit institution must be discernible.

- Documentation of trigger events

- Documentation of the choice of scenarios (scenarios based on historical data, determination of worst case scenarios)

- The principal method for calculating the possible losses in the different stress scenarios is to be explained.

- Examples of internal reports to management

- Example of a report to the Federal Ministry of Finance and the OeNB

Internal Audit

- Organizational chart of the entire organization showing the integration of the internal audit department

- Description of the duties assigned to the internal audit department with the names and job descriptions of those employees responsible for auditing the use of the model, including particulars of their qualifications and work experience

- Training program

- Annual audit schedules

- All of the department's audit reports relevant to the model

4 Bibliography

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