VALUE-AT-RISK METHODS AND MODELS AND THEIR APPLICATION

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The concept of Value-at-Risk (VaR) was used for the first time by large financial institutions at the end of the eighties for measuring risks in portfolios. This period was characterised by huge exchange-rate volatility and rapid growth in the use of derivatives useful for managing currency and interest-rate risks. Modern derivatives such as forwards, future swaps and options assist in managing exchange-rate and interest-rate volatility. Since these times there has occurred a boom in the use of VaR, which has ceased to be merely a matter of internal interest to financial institutions - regulatory authorities have begun to take an interest in them too. In April 1995 the Basel Banking Supervision Committee proposed that banks in calculating their capital adequacy be enabled to apply their own VaR models for market risk with the use of certain parameters determined by the Committee. Similar measures were implemented in the same year also in the USA: by the Federal Reserve Fund and the Securities and Exchange Commission. The European Commission directive on capital adequacy, which has been in force since 1996 has allowed for the use of VaR models for calculating capital adequacy for positions held in foreign currencies, where this counted on a rapid expansion in the use of VaR also for calculating capital needs for other market risks.

VaR methods

Financial models include a number of ways for expressing risk, which may be used to measure the market risk of a bank, an investment portfolio or financial instruments. The most important ways include: variance of past yields, standard deviation of yields for a certain previous period, maximum loss in a set of possible scenarios, the Monte Carlo computer simulation and VaR models. Standard VaR models include all types of market risks, i.e. interest, stock, commodity and currency risks. Successful world banks presently use VaR models also for measuring credit risk. The further development of the application of these models envisages their expansion also for measuring operational and legal risks.

VaR models allow an estimate to be made of the value of risk in a portfolio as the maximum volume of loss in the case that the portfolio would have to be held for a certain fixed period according to past experience with a certain rate of certainty (as a rule 95 or 99%). In other words, if the future is like the past, the volume of loss estimated by the risk models will occur every 20 days or every 100 days, depending on the degree of certainty set, naturally only if the company does not manage to take preventive measures in order to reduce such a loss.

At present various methods exist for determining VaR, the most important of which are considered to be: the variance-covariance method (also termed the analytical method), the historical simulation method and the Monte Carlo probability simulation method.

The **variance-covariance method** allows an estimate to be made of the potential future losses of a portfolio through using statistics on volatile values in the past and correlations between changes in their values. Volatilities and correlations of risk factors are calculated for a selected period of holding the portfolio and the historical period through using historical data. VaR derives from the distribution of the probability of risk factors of change in the value of the portfolio, where the simplest models envisage a normal distribution of risk factors and their stable correlation. In using this method it is necessary to take into consideration in particular the fact that:

- movements in market prices do not have always a normal distribution -they exhibit so-called heavy tails, which means a tendency to have a relatively more frequent occurrence of extreme values than does a normal distribution,
- models may not appropriately depict market risk ensuing from extraordinary events,
- the past is not always a good guide to the future, for example correlation forecasts may founder.

The **historical simulation method** is based on data of losses that a bank would have suffered in a given portfolio in a past period. This method is simpler compared to the previous, since it does not require demanding work breaking down the probability of risk factors and determining correlations between risk factors. The disadvantage is the need for a sufficient quantity of historical simulations.

The **Monte Carlo method** is founded on the generation of a large number of simulations (scenarios) of

the development of a portfolio's value. Each simulation is created through a combination of randomly generated values of risk factors from their probability distribution. The result of the simulations is the generation of probability estimates of the VaR.

It is important to mention that all models of measuring risk are based on different mathematical models and statistical relationships with varying degrees of reliability. Therefore, at present there are no preconditions for the definition of a single "correct" model of measuring risk. It is however important to have an understanding of the overall characteristics and properties of the models as well as their demands in terms of data input, since the correctness of determining the VaR and quality of management decisions thus adopted depends also on the correctness of input, for example, on the types of probability distribution as well as the parameters of these distributions.

The use of information technology now provides almost unlimited possibilities for programming ever more perfect models. Since many banks have only recently moved toward using special programming systems for managing risk, an assessment has not yet been made of the results of new information technology applications in this field. Those programming systems which allow an increase in the quality of risk management in the framework of financial institutions' integrated information systems are becoming the centre of attention among managers.

Application of historical simulation

We will demonstrate the use of historical simulation in the example of a forward contract, which a company concluded with a bank on 11 February 2003 and by which one month later its secures the transfer of EUR 100 000, undertaking to pay SKK 42.16 per EUR, i.e. SKK 4 216 000. The present value of the forward contract is calculated according to the formula:

$$PV = S_{SKK/EUR} \cdot \frac{\text{EUR } 100\,000}{1 + r_{EUR}\,(1/12)} - 42.16 \cdot \frac{\text{EUR } 100\,000}{1 + r_{SKK}\,(1/12)}$$

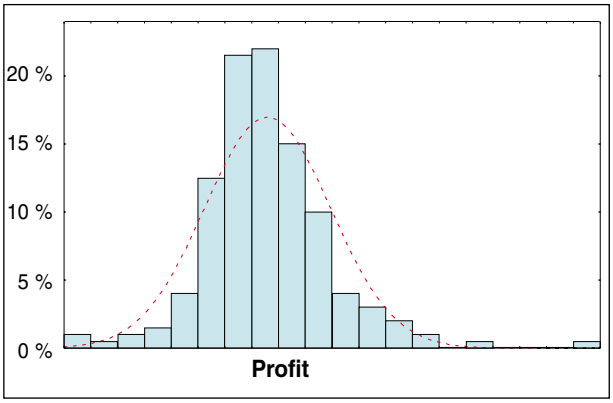
Where:
$S_{SKK/EUR}$ –Spot exchange rate of the koruna
r_{EUR} – LIBOR euro interest rate
r_{SKK} – BRIBOR koruna interest rate

Since the forward exchange rate is set so that arbitrage is not possible, then on the day of concluding the contract, and in the case of the exchange rates 42.03 SKK/EUR, BRIBOR equalling 6.42% and LIBOR equalling 2.808%, the current value of the contract is (approx.) zero. On the day following the concluding of the contract three market factors (two interest rates and the koruna's spot exchange rate) change, whereby the value of the contract also changes. A depreciation of the koruna, a fall in the euro interest rate and a rise in the koruna interest rate increase the contract's value.

The question is, what value will the forward contract have tomorrow, i.e. 12 February 2003? If the changes of the three market factors are favourable, the value will increase, i.e. the firm will record a profit, and in the opposite case the firm will record a loss. For calculating the VaR of a contract, which we define as the fifth (or first) percentile of the distribution of possible profits and losses, we use the historical percentage daily changes of the three factors recorded for the preceding 200 days. The current value of the forward contract is recalculated 200 times using the values of the factors of 11 February 2003 and using the daily percentage changes of the factors over the period from 7 May 2002 to 11 February 2003. The VaR value is then determined from the distribution of calculated profits and losses as the fifth (or first percentile).

The VaR defined as the fifth (first) percentile corresponds to a loss of 23 325 (39 859) koruna

Fig. 1 Distribution of possible profits and losses on a forward contract



Existing VaR models are able to calculate a value at risk; often however they are not able to correctly estimate the development of risk factors in particular in newly-emerging markets. If financial markets do not behave in accordance with modelled results, then the abnormality of the market's movements is not in itself a problem, the problem however is overestimating the reliability of models founded on the assumption that these markets will behave in accordance with past experience. Examining the causes of "global" losses leads us to the fact that for an efficient evaluation of new, in particular qualitative, components of financial risk in current conditions other

instruments are necessary. The developing approach to risk management supplements a set of measurable risks with a portfolio of less quantifiable dangers, which exceeds the boundaries of VaR models.

Conclusion

One of the paths to success for a financial institution is risk management founded upon an evaluation of a set of measurable and non-measurable risks through using modern information technology. Only those financial institutions that best classify possible risks, apply modern models for measuring it and effectively use modern information technology, can gain a competitive edge and thereby also profit. Risk management is currently taking on new dimensions. The developing approach to risk management crosses the boundaries of traditional risk measurement, therefore new more effective instruments are required, which will be ever more difficult to handle. Objective knowledge and conclusions nevertheless remain essential, primarily with regard to seeking ever more modern approaches to financial risk management appropriate to the ongoing globalisation changes in society.