

Measuring market risk in Norwegian financial institutions

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This article discusses two methods for analysing market risk in the Norwegian banking sector and in life insurance companies. The two methods, Value at Risk (VaR) and stress tests, are commonly used in individual institutions, but have been adjusted here for use on the available aggregate statistical data from the banking and insurance sector. The methods have to be simplified for use on these aggregate data, but the analyses nevertheless provide an indication of the vulnerability of the institutions viewed as a whole. Our analyses show that the market risk of commercial and savings banks, viewed in relation to total assets, is low. The market risk of life insurance companies is higher, but has fallen in recent years.

1 Introduction

Market risk is the risk of assets declining in value as a result of fluctuations in market prices. Financial institutions' portfolio of financial instruments consists of equities, fixed income instruments (bonds, notes and short-term paper) and derivatives. Market risk for equities relates to the possibility of equity prices falling, and for fixed income paper to the possibility of interest rates rising. The market risk associated with derivatives depends on the specific derivative position. For special derivative positions, even small changes in the prices of the underlying assets may result in a sharp fall in the value of the derivatives.

There are substantial differences between market risk in Norwegian banks and life insurance companies, a fact that has been fully illustrated by the sharp fall in equity prices in recent years. Norwegian banks own a relatively small amount of fixed income paper and very few equities (see Table 1)¹, so the direct impact on banks of the fall in equity prices has been limited. Because of their long-term obligations, life insurance companies invest a substantial share of their capital in equities and

long-term bonds. At the end of 1999, over 30 per cent of their total assets were invested in equities. They were severely hit by the fall in equity prices, and had to sell equities to reduce their risk. In 2002, they purchased considerable amounts of bonds. This, along with the reclassification of some securities from the category fixed income paper held as current assets, brought about a sharp increase in the category 'bonds to be held to maturity', and they accounted for 30 per cent of total assets by end-2002.² About two-thirds of these bonds had maturities after 2005. 'Bonds to be held to maturity' are to be regarded as fixed assets, and are not included in the insurance companies' holdings in Table 1.³ The reclassification of bonds to the category 'to be held to maturity' reduces market risk in the short term, but may also reduce the flexibility of fixed income management.

There are several methods for measuring market risk. In this article, Value at Risk (VaR) and stress tests are presented. VaR is a measure of the market risk associated with 'normal' fluctuations in securities markets, while stress tests are used to measure the effect of dramatic price changes.

Table 1 Composition of financial institutions' securities portfolios at 31 December 2002 ⁺

	Commercial banks	Savings banks	Life insurance companies
Total assets (TA)	NOK 887.9 billion	NOK 681.3 billion	NOK 414.2 billion
Share of TA in securities portfolio	8.7 %	7.0 %	39.6 %
<i>Composition of securities portfolio</i>			
Norwegian fixed income paper	61.7 %	66.7 %	52.8 %
Foreign fixed income paper	31.3 %	21.2 %	28.5 %
Norwegian equities	5.7 %	11.7 %	7.6 %
Foreign equities	1.3 %	0.6 %	11.1 %

⁺ Banks' securities portfolios include securities classified as both current assets and fixed assets. Life insurance companies' securities portfolios include only securities classified as current assets.

Source: Norges Bank, banking and insurance statistics

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¹ One reason for the low equity share is that Section 24 of both the Commercial Banks Act and the Savings Banks Act stipulates that the recorded value of banks' holdings of equities and units must not exceed 4 per cent of their total assets. The Norwegian Banking, Insurance and Securities Commission may grant exemption from this provision.

² The regulation relating to annual accounts etc. for insurance companies defines 'bonds to be held to maturity' as bonds that the company has the intention and means to hold to maturity. The general rule is that when bonds classified as 'hold to maturity' are reclassified or sold, the company may not classify new bonds as 'hold to maturity' for the next three accounting years.

³ Fixed assets are assets intended for permanent ownership or use. Other assets are current assets.

Value at Risk (VaR)

VaR is a measure of the potential loss of value of a portfolio of assets in a given period of time for a given confidence level. Example: A VaR sum of NOK X, given a one-sided confidence level of 95 per cent and a period of 1 day, means that the probability of a fall in value in excess of X during the next 24 hours is 5 per cent. This means that on average losses can be expected to exceed VaR every 20th day.⁴

Most VaR models use historical data to estimate a probability distribution for the return on the portfolio. Given assumptions about the confidence level and time horizon, VaR is then estimated on the basis of this probability distribution.

Stress testing

Stress tests are used to estimate the change in value of the portfolio in the event of predefined market shocks. Common stress test scenarios are sharp falls in equity prices and steep rises in interest rates (see Fender and Gibson (2001)). Stress test scenarios should involve dramatic, but not totally improbable price movements. When choosing scenarios, it is usual to study previous situations with stress in financial markets. However, the choice of a concrete scenario is highly subjective.

The Norwegian Banking, Insurance and Securities Commission, for instance, uses two stress test scenarios to assess the risk-bearing capacity of life insurance companies (see the Banking, Insurance and Securities Commission (2003)). The first scenario consists of a 20 per cent price fall in equity markets, while the other consists of a 20 per cent price fall in equity markets combined with a general rise in interest rates of 1 percentage point.

2 Our VaR model

This chapter provides a brief description of fundamental assumptions in the model. We use a parametric VaR model.⁵ This involves an assumption that the return on assets follows a specific type of probability distribution, in this case normal distribution. The parameters that determine the normal distribution are estimated from historical price data as described below.

The return for a period is measured as the logarithmic price change, and the logarithmic price changes are assumed to be normally distributed. In principle, the expected return and the standard deviation of the expected return should be estimated for each asset. The expected return for a period is normally estimated as the average return, \bar{r}_i , over a certain number of periods. Our VaR model is based on daily data, and we choose to set the expected daily return equal to zero. This has proved to be a reasonable approach, as the difference between 0

and the 'actual' daily return is small, and there is considerable uncertainty associated with the estimation of returns (see Luenberger (1998)).

Our VaR model uses an exponentially weighted moving average of historical observations to estimate future variances and covariances (see Rakkestad, 2002). The formula for calculating the standard deviation (volatility) of asset i for the last V periods is:

$$(1) \quad \sigma_{i,t+|t|} = \sqrt{\frac{1-\lambda}{1-\lambda^V} \cdot \sum_{u=1}^V [\lambda^{u-1} \cdot (r_{i,t+1-u} - \bar{r}_i)^2]}$$

where $\sigma_{i,t+|t|}$ is the estimate after period t for the volatility of asset i in period $t+1$, $r_{i,t}$ is the logarithmic return on asset i in period t and $\lambda \in (0, 1)$ is the weighting parameter. The lower the value of λ , the greater the effect on the latest return figures. Our VaR model uses $\lambda = 0.94$. In calculating the daily volatility in (1), the average for the sample is set at 0, $\bar{r}_i = 0$, and return data for $V = 250$ days are used. However, using $\lambda = 0.94$ means that far fewer days are effectively used, because very little weight is attached to the most remote observations. The covariances between different assets are calculated in the same way as in (1).

The estimated volatility of the return for a period can be converted to the estimated volatility of the return over T periods by means of the formula: $\hat{\sigma}_{i,t+T|t} = \sqrt{T} \cdot \hat{\sigma}_{i,t+|t|}$. In the VaR model, this formula is used to convert daily volatility to estimated volatility for a 10-day time horizon. Conversion is carried out in the same way for the covariances.

Ideally, the volatility of each asset, as well as the covariances between the returns on the different assets, should be taken into account when calculating VaR for portfolios. With large securities portfolios it is often impractical to take account of all the assets in this way. The calculation process can be simplified by assigning assets to a smaller number of reference categories. We use this type of assignment in our VaR model. The market values of the assets assigned to the various reference categories as a share of the total market value of the portfolio are represented by portfolio weights which together form a portfolio weight vector. The estimated volatility of the portfolio is found by pre- and post-multiplying the covariance matrix for the reference categories by the portfolio weight vector. The return profile of the portfolio is then given by the normal distribution with expectation 0 and the estimated standard deviation (volatility). The VaR of the portfolio is then calculated on the basis of this normal distribution.

⁴ $\frac{1}{1-0.95} = 20$

⁵ The model is based largely on the VaR model RiskMetrics developed by JP Morgan (see RiskMetrics Group (1996) eller <http://www.riskmetrics.com/research.html>).

3 Underlying data

To run a VaR model, both holdings data and market data are required. For stress tests, holdings data are sufficient. Daily market data are readily available from various suppliers of data, but both the frequency and the quality of the available holdings data are lower. An account is provided below of available holdings and stress test data for Norwegian banks and life insurance companies.

Banking statistics

The data source for banks is Report 11 in Official accounts reporting for banks and finance enterprises. This report is based on quarterly reporting and contains some holdings and stress test data for individual banks. Stress test data are reported to provide an indication of the market risk of banks' holdings of securities.

The banking statistics data on equities and fixed income instruments are split up into data on Norwegian and foreign securities, respectively. For equities, only the total market value of the holdings of each bank is supplied. It would have been desirable to have information regarding country and sectoral distribution of equities, but the available information can be used to provide a rough estimate of the market risk of the equity holdings. The statistics on fixed income paper are more detailed. The breakdown into five maturity intervals makes it possible to reach more precise conclusions regarding the market risk associated with fixed income paper.

The stress test data contain changes in the value of the fixed income paper given interest rate increases of 1 and 2 percentage points. There is also information about the change in value of equity and interest rate derivatives for a 30 per cent fall in equity prices and for interest rate increases of 1 and 2 percentage points.

Insurance statistics

The data source for the insurance companies is Report 11 in Official accounts reporting for insurance companies. Unlike the banking statistics, the insurance statistics are broken down by country, showing companies' holdings of equities, fixed income paper and units in securities funds that are classified as current assets. This provides a useful basis for assessing the market risk associated with the equity holdings of life insurance companies. In contrast to the banking statistics, there is no overview of the maturities of fixed income holdings. The lack of information about maturity composition means that estimates of the interest rate risk of life insurance companies will be approximate. Because fixed income paper represents a higher share of their total holdings than previously, interest rate risk represents a

larger share of the total market risk of life insurance companies today. The insurance statistics contain the same kind of stress test data as the banking statistics.

Adaptation of the VaR model to the underlying data

The coverage of banking and insurance statistics data has been taken into account in the development of the VaR model. There are insufficient statistics on derivative positions to allow derivatives to be included in the model. Derivative positions in a portfolio may result in either increased or reduced market risk compared with the same portfolio without derivatives. This depends on the reason for using derivatives in the portfolio. The fact that the VaR model does not include the effect of derivatives on market risk is therefore a drawback. Because of inadequate underlying data, exchange rate risk is not taken into account either.⁶

Assignment to reference categories

In order to simplify the calculation process in our VaR model, the different types of assets are assigned to a limited number of reference categories. Because of the different data coverage of the two sets of statistics, different reference categories are used for banks and for life insurance companies.

Reference categories with maturities of 0, 1 and 10 years are used for banks' fixed income paper. Holdings in each of the maturity intervals in the banking statistics are assigned to the two closest reference categories in such a way that the average maturity for the assigned holdings is equal to the average maturity of the holdings in question. In all, the VaR model for banks operates with eight reference categories: one for Norwegian equities, three for Norwegian fixed income securities and the same four categories for foreign securities.

The insurance statistics show companies' holdings of all equities, fixed income securities and units in securities funds classified as current assets, broken down by country. We have found it appropriate to use three geographical regions: Norway, Europe, and the US plus the rest of the world. There is no direct information on the maturities of fixed income securities, but the information regarding the change in value of fixed income securities in the event of a general rise in interest rates of one percentage point is used to estimate the average duration of fixed income securities holdings at about 4 years. All fixed income securities are assumed to have this maturity. This results in a total of six reference categories in the VaR model for life insurance companies: one for Norwegian equities, one for European equities, one for US equities and three corresponding categories for fixed income securities.

⁶ As a result of Section 13 of the Regulation relating to insurance companies' investment management, the exchange rate risk of life insurance companies is nevertheless limited.

Reference indices

Each reference category must be linked to a reference index. The equity categories are linked to broad market indices, while the fixed income categories are linked to government securities with the appropriate maturity. The underlying data for the reference indices are the index values for equity indices and yields for fixed income securities. The yield of a fixed income security with n years to maturity is converted to a price on the basis of the assumption that the yield applies to a zero coupon bond ⁷.

Through the allocation of assets to reference categories, the VaR model is based on the assumption that developments in the value of the securities holdings of financial institutions mirror developments in the reference indices chosen.

This is a somewhat unrealistic assumption, as the equity holdings are not as well diversified as the equity indices chosen, whereas the holdings of fixed income securities are more broadly diversified than the government securities chosen.

4 Results

In calculating VaR for financial institutions, a one-sided confidence level of 99 per cent and a time horizon of 10 trading days (2 weeks) have been used. Securities holdings at 31 December 2002 and price movements up to 16 May 2003 form the basis for the calculations. The fact that such relatively old holdings data have to be used in the model is a weakness. It will affect the results from banks to a limited extent, as experience shows that there are small changes in the composition of their holdings from one quarter to the next. The composition of life insurance companies' holdings changes more frequently, so a lack of updated holdings data may affect the quality of the results reported for these companies.

The stress test used for financial institutions is a 30 per

cent fall in equity prices combined with a 1 percentage point general rise in interest rates. With this scenario, it is possible to use the banking and insurance statistics stress test data that relate to changes in the value of holdings of fixed income securities and equity and interest rate derivatives. The fall in value of equity holdings as a result of a 30 per cent fall in equity prices is calculated on the basis of the holdings data.

Market risk in banks

Volatility estimates at 16 May 2003 indicate that VaR constitutes a very small share of the securities portfolio value of both commercial and savings banks (see Table 2). VaR is somewhat higher for savings banks, because equities make up a somewhat larger share of their portfolio and the maturity of their fixed income securities is a little longer. The reported VaRs indicate a less than 1 per cent probability of the securities holdings of commercial and savings banks' falling more than 0.6% and 1.0%, respectively, during the next 2-week period. By way of comparison, the corresponding VaR estimates were 1.7% and 2.7% at end-September 2001. The difference can be attributed largely to higher volatility (wider price fluctuations) in September 2001, and illustrates how VaR is influenced by volatility in securities markets.

The stress test also indicates that market risk in savings banks is higher than in commercial banks. Although the decline in the value of the securities portfolio is estimated at 6.5%, this is equivalent to less than 0.5% of savings banks' total assets. The main reason for the relatively large difference between savings and commercial banks is the higher equity holdings of savings banks, which are 'severely penalised' by the stress test. All in all, market risk in banks is low because of their very limited equity holdings and relatively limited holdings of fixed income securities.

Table 2 Estimated market risk, based on holdings at 31 December 2002 and price movements up to 16 May 2003.

	Commercial banks	Savings banks	Life insurance companies
Value of securities portfolio	NOK 77.6 billion	NOK 47.4 billion	NOK 164.0 billion
Total assets	NOK 887.9 billion	NOK 681.3 billion	NOK 414.2 billion
Value at Risk (VaR)			
Volatility of securities portfolio (annualised)	1.3 %	2.2 %	3.6 %
VaR (as a percentage of portfolio value)	0.6 %	1.0 %	1.7 %
VaR (as a percentage of total assets)	0.05 %	0.07 %	0.7 %
Stress test			
Decline in value (as a percentage of portfolio value)	2.2 %	6.5 %	8.2 %
Decline in value (as a percentage of total assets)	0.2 %	0.4 %	3.2 %

Source: Norges Bank, banking and insurance statistics

⁷ A zero coupon bond is a bond that does not pay any interest during its life. The price of such a bond is therefore always lower than the nominal value of the bond. In practice, large portions of the bond portfolio will consist of bonds with fixed coupon payments.

Securities classified as both current and fixed assets are included in the analysis of market risk in banks. Information on the maturity of fixed income securities makes too small a distinction between current assets and fixed assets for it to be possible to separate them in the analysis. Whether equities classified as fixed assets should be excluded from the analysis is an open question. One argument for including them is that a large portion of the equities classified as fixed assets are priced regularly in organised market places. If the analysis had only been based on equities classified as current assets, the equity holdings of commercial and savings banks would have been reduced by 90 per cent and 69 per cent, respectively. This would have resulted in substantially lower market risk than that reported in Table 2.

Market risk in life insurance companies

The estimates for VaR in life insurance companies are based only on securities classified as current assets. This means that bonds classified as 'hold to maturity', which now account for over 30 per cent of total assets, are not included in the estimates.

The fall in equity prices combined with the sale of equities has sharply reduced the share of life insurance companies' equity holdings in the past three years. This has contributed to reducing market risk. However, VaR as a percentage of portfolio value is still higher than for banks, due to the larger share of equities and longer maturity for fixed income securities. At 16 May 2003, VaR amounted to less than 1 per cent of total assets. The stress test shows a more pronounced effect for life insurance companies than for banks, particularly in terms of the decline in value in relation to total assets.

The notes to the companies' financial statements are a source of further information about the maturities of life insurance companies' holdings of fixed income securities. In the notes, fixed income securities are grouped into three maturity intervals. We have used the information in the notes at 31 December 2002 for one of the large life insurance companies to assign securities to categories with maturities of 0, 1, 5 and 10 years, broken down by region. This maturity classification is assumed to be representative for Norwegian life insurance companies as a whole, and is used in an alternative application of the VaR model. In this application, the three original reference categories for fixed income securities (based on regions) are replaced by twelve reference categories (3 regions combined with 4 maturities). This analysis results in a VaR of 1.4 per cent of the portfolio value, which is less than the result in Table 2. To further improve the prediction capability of the model, it would have been desirable to have more information about the

maturity interval 1-5 years, as a substantial share of life insurance companies' fixed income securities falls within this interval, and there is a large difference in market risk between 1-year and 5-year fixed income securities.

Strengths and weaknesses of the methods

One strength of VaR is that the method takes account of the covariance between different assets (reference categories) and hence the risk reduction achieved through diversification. However covariance is not constant over time. In a crisis situation, previously observed correlations may change radically and the volatility of the equities may increase sharply. In such situations, stress tests are preferable for assessing market risk. It is usual to assume full correlation between different price changes in stress tests, which can be a useful approach in crisis situations.

The assumption in the VaR model that logarithmic price changes are normally distributed is a little dubious. Innumerable empirical surveys show that the probability distributions of logarithmic changes in prices for financial assets are more centred and have heavier tails than the normal distribution. This suggests that the VaR figures reported for the 99% level are on the small side. Another weakness of VaR is that the calculated loss of value only applies to a given confidence level. Thus, VaR provides no indication of properties further out in the tail of the probability distributions.

In many cases, stress tests are a simple way of revealing vulnerability to different risk factors. However, they have a tendency to overdramatise the situation, as they do not take account of the fact that a sharp impact on prices will trigger actions which in the great majority of cases will be capable of mitigating the detrimental effects. Moreover, changes in markets and in exposure to various risk factors may make stress test scenarios outdated in relation to the risk situation in question.

Despite the weaknesses pointed out above, both VaR and stress tests are valuable aids for assessing market risk. As with all use of models, it is important to know what assumptions they are based on and to understand the consequences of these assumptions. Whereas VaR estimates can be said to be based on the assumption that recently observed price fluctuations are representative of price fluctuations in the immediate future, stress tests allow for dramatic price movements which may only occur at intervals of several decades. Stress tests are therefore a good supplement to VaR estimates, and the two methods should be used together to assess market risk.

6 Conclusion

This article has considered the question of market risk in Norwegian financial institutions at an aggregate level with the aid of two analytical methods, VaR and stress testing. It has been necessary to adapt the methods used to the available data, and in consequence there is more uncertainty than normal associated with the results. Not surprisingly, the analysis shows that market risk first and foremost is an important factor in life insurance companies. Market risk in banks is low.

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