VaR METHODOLOGY FOR CURRENCIES RISK MEASUREMENT

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Abstract

This paper make a short presentation of VaR methodology applied in portfolio for foreign currencies in agreement with Romanian National Bank rules. In the first part we present theoretical aspect of VaR methodology and NBR rules. In the end of this paper we give an application of VaR methodology for an imaginary portfolio with two currencies.

Key-words: *banking portfolio, statistics, foreign currencies*

1. **Introduction**

A correct approach for a financial risk needs to establish adequate measures for risk evaluation and statistic instruments to give risk magnitude. This paper intends to analyze a frequently used measure in financial institutions which represents a synthesis of modern approach for the concept of risk associated with portfolio. This measure is known as Value at Risk, or VaR.

In 1974, the system of fixed exchange rates (Bretton Woods System) had failed. In the same period appears oil shock as a consequence of wars betweens Israel and Arabian. All this produce severe impact to international financial markets. The partners in international transaction deal with new kind of risks like exchange rates and interest rates volatility and so, a higher currencies risk.

Currencies risk as a component of market risk (which also includes interest rate risk and financial title price risk) was considered from 1996 in First and Second Basel Agreements.

In current Romanian economy the currency risk became more and more important starting with November 2004 when the decision of Romanian National

Bank about currencies liberalization became effective for any Romanian. As a normal consequence, Euro is down from 4.10 lei and higher to 3.50 lei and lower.

Another motivation for higher currencies risk was the increasing of credits in foreign currencies (in special in Euro).

International banking practice works with instruments, methods and methodology to identify, measure and ménage currency risk. The modern measures include Value at risk, Expected tail loss, Shanon entropy, and Fishburn measure. As mathematical method used to determine market risk we may specify parametric method, historical simulation method and Monte Carlo simulation method.

Here we present VaR methodology and an application for this method.

2. **VaR methodology**

Value at risk is a technique to estimate the probability of loss in one portfolio to exceed a given value. Value at risk must answer the following question:

Which is the probability to lose X dollars in next t months (or days)?

VaR gives a partial answer to this question. If a firm announces that his daily value at risk is one million dollars with a trust level of 99% then, in normal market condition, the firm can't lose more than one million dollar with 0.99 probabilities. VaR measures the sensitivity of a portfolio regarding the possible market changes by valueing the risk of different products and mix portfolio based risks.

VaR method is used basically in treasurer department and by account managers in financial institution. The method may be used by any company.

In 1989, the president of J.P. Morgan Investment Bank asked a daily report about bank risks. So, in 1994, was created RiskMetrics Department of J.P. Morgan Investment Bank who propose Value at Risk as risk measure used to inform and educate affair partners. In 1998, this department became independent RiskMetrics Group, a company specialized in consulting and software in risk measure.

The great success for VaR was reached by the consideration it had in G30 Report from 1993 and when Basel Agreement (1996) recommend it to central banks in order to determine capital minimal limit need for commercial banks to cover market risk.

2.1. *VaR definition*

Value at risk ($VaR_{h,\alpha}$) measures maximum lose possible to be obtained for a position or a portfolio of positions in a given period of time, h, and for a lever of trust, $(1-\alpha)$. Lose, or profit, made by a portfolio in h days, is computed as a difference between initial value of portfolio and portfolio value at the end of h days period, using the formula:

$$\Delta W_h = W_0 - W_h$$

where:

- W_o is the initial value for the portfolio (considered as constant);
- W_h is the portfolio value at the end of h days period (which it is a random variable).

It is obvious to observe that if $\Delta W_h > 0$ then $W_h < W_0$ and so we have a portfolio loss.

In this condition, $VaR_{h,\alpha}$ is determined so that:

$$P\left(\Delta W_h < -VaR_{h,\alpha}\right) = \alpha .$$

2.2. *VaR computing*

For effective computing of VaR needs to establish two parameters, time horizon for which the risk is estimated (h) and trust probability (p) or percentage of tolerance at risk ($1-p$).

In VaR appreciation we have two proposals, one made by Basel Committee (a period of 10 days and a trust probability with 99% value) and those of RiskMetrics Group (a period of one day and trust probability with 95% value).

If we set the values for specified parameters, we may use two ways to compute the value for VaR:

- as difference between current value of chosen portfolio and the smallest value of portfolio (named quintile), at time h and probability p ;
- as difference between expected value of portfolio and portfolio quintile, both considered at time h and probability p .

We consider the following notation:

- W_0 is the current market value of portfolio;
- W_h is average expected value of portfolio at time h ;
- R_m is average profit of portfolio at time h ;
- W^* is quintile that portfolio may record at time h with trust level p ;
- R^* is profit of portfolio corresponding to quintile W^* .

With this notation we are able to write:

$$W_h = W_0 \times \left(1 + R_m\right) \text{ and } W^* = W_0 \times \left(1 + R^*\right).$$

Using the above relations, if VaR is computed related to current value of portfolio, then we have:

$$VaR = W_0 - W^* = -W_0 \times R^*.$$

If VaR is related to average expected value of portfolio then:

$$VaR = W_h - W^* = -W_0 \times \left(R_m - R^*\right).$$

Now, if we consider that the profit of portfolio (which is a ramdom variable) follows a distribution function f, then the value of profit associated this quintile is computed using the formula:

$$1 - p = P\left(R < R^*\right) = \int_{-\infty}^{R^*} f\left(x\right) dx.$$

2.3. *Romanian National Bank requirement for VaR report*

As part of the evaluation for market risk exposure, banks and other financial institution must report their own measures of market risk in the information given by VaR systems at the level of transactional portfolios (Trading Book). The reports must include both quantitative and qualitative information.

Qualitative information includes a short description for VaR system which means:

- type of VaR models used;
- estimation technique;
- description of procedure used to VaR aggregation for different risk factors;
- description of procedure used to assigning and monitoring VaR limits;
- description of technique used to model validation and testing (backtesting);
- other useful information.

Quantitative information includes:

- VaR value at the report moment;
- minimum, average and maximum value in past three months;
- VaR limits at Trading Book level (aggregate limit, limit values on risk factors – interest rate, exchange rate);
- last testing results on VaR system (backtesting).

In agreement with the Romanian National Bank, the VaR reports will result from systems that fulfill a minimal set of standards formed by:

- a minimal holding period of ten days;
- daily VaR evaluation;
- trust level for VaR measures is 99%;
- VaR estimators will use data from at least one year;
- estimations for parameters will not be re-evaluated in a period shorter then three months;
- backtesting will be made for a period no less then 250 days.

2.4. *VaR computing for currencies portfolio in a bank*

VaR computing could be done in three different ways: relative, marginal and incremental.

Relative VaR measures the risk related to a predefined index like S%P 500 or particular indexes which make a characterization for mutual founds.

Marginal VaR measures the contribution of a portfolio position risk to full portfolio. Specifically, this means the measure of VaR modifies if that portfolio position is excluded from the portfolio.

Incremental VaR is related to a marginal VaR and it measures the portfolio risk modification done by a small change in the portfolio position ponders.

Value at risk for a single currency in a portfolio is computed by the formula:

$$GrossVaR = X\sigma_X \alpha\sqrt{T-t},$$

where:

- X is the market value for currency;
- α is the trust level;
- σ_X is the daily volatility;
- $T-t$ is the kipping period.

If a portfolio is formed of n currencies, value at risk for that portfolio is less then the sum of $GrossVar$ computed for each currency due to the existing correlation between currencies. So we have:

$$NetVaR \le \sum_{i=1}^{n} GrossVaR_i,$$

where $GrossVaR_i$ is the value at risk for currency having position i in portfolio.

The last relation may be explain by the fact that portfolio diversification produces a decreasing in risk by compensation between lose for some currencies and profit for other currencies.

Let us note:

- $VaR_{i,a}$ is the $GrossVaR$ for currency i with short position;
- $VaR_{i,b}$ is the $GrossVaR$ for currency i with long position;
- $\rho_{i,j}$ is the correlation coefficient between currencies i and j, for $i \neq j$.

Then, full relation for $NetVaR$ is:

$$NetVaR = \sqrt{\sum_{i=1}^{n}\left(VaR_{i,a}^2 + VaR_{i,b}^2\right) + corVaR},$$

where:

$$corVaR = \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} 2\rho_{i,j} \left(VaR_{i,a} \left(VaR_{j,a} + VaR_{j,b} \right) + VaR_{i,b} \left(VaR_{j,a} + VaR_{j,b} \right) \right).$$

The above formula for $NetVaR$ can be represented in matrix form as:

$$NetVaR = \sqrt{GrossVaR^T \rho GrossVaR},$$

where:

- $GrossVaR = \left(VaR_i \right)_{i=\overline{1,n}}$ is the vector of value at risk for every currency in the portfolio,
- ρ is the matrix of correlation coefficients.

3. **VaR case study for two currencies**

Let us considers the case of two currency, dollar and Euro. We considered the values of these currencies in 187 days taken in 2007, between January 10th and September 28th, from the Romanian National Bank.

First we must specify the function for daily currency efficaciousness. So, if Z_t is the value of given currency at time t, then distribution for currency efficaciousness is computed with:

$$r(t) = \ln \frac{Z_t}{Z_{t-1}}.$$

We consider that f is the distribution for the Euro and g is the distribution for dollar. Both functions are of the same type as r.

As examples, for Euro currency, the first 8 values are given by vector:

$$X = (3.4103, 3.4053, 3.4046, 3.3880, 3.3846, 3.3998, 3.3904, 3.3824),$$

and so first 7 values for f are given in vector:

$$v_f = (-0.00147, -0.00021, -0.00489, -0.001, 0.004481, -0.00277, -0.00236).$$

The correspondent values for the dollar may be specified in vectors

$$Y = \left(2.6241, 2.6252, 2.6378, 2.6175, 2.6086, 2.6322, 2.6198, 2.6110\right)$$

and

$$v_g = \left(0.000419, 0.004788, -0.00773, -0.00341, 0.009006, -0.00472, -0.00335\right).$$

Second step is to compute the efficaciousness volatilities for the period we considered. These volatilities are computed with the formula:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n-1}\left(r(i)-\mu\right)^2},$$

where:

$$\mu = \frac{1}{n-1}\sum_{i=1}^{n-1} r(i).$$

Computed values from the Romanian National Bank data are:

$$\sigma_f = 0.003447186$$

for Euro and

$$\sigma_g = 0.005416078$$

for dollar.

Third step is to compute correlation coefficients for considered currencies using formula:

$$\rho_{fg} = \frac{\sigma_{fg}}{\sigma_f \sigma_g},$$

where:

$$\sigma_{fg} = \sqrt{\frac{1}{(n-1)^2}\sum_{i=1}^{n-1}\left(f(i)-\mu_f\right)^2 \sum_{j=1}^{n-1}\left(g(j)-\mu_g\right)}.$$

At the end of computation we have:

$$\sigma_{fg} = 0.825353373.$$

The matrix of correlation coefficients is:

$$\rho = \begin{pmatrix} 1 & \sigma_{fg} \\ \sigma_{fg} & 1 \end{pmatrix} = \begin{pmatrix} 1 & 0.825353373 \\ 0.825353373 & 1 \end{pmatrix}$$

Next step is to compute the values for $GrossVaR$. For this we considered that quintile values for ten days period are $W_f = 2666058$ for Euro and $W_g = -451636$ for dollar using a 95% trust level, which means that $\alpha = -1.644853627$. With theses values in $GrossVaR$ formula we have:

$$GrossVaR_f = W_f \alpha \sigma_f \sqrt{10} = 47803$$

for Euro and

$$GrossVaR_g = -12715$$

for dollar. The vector for value at risk for (Euro, dollar) portfolio is:

$$GrossVaR = \begin{pmatrix} 47803 \\ -12715 \end{pmatrix}$$

Using matrix form for $NetVaR$ we have:

$$NetVaR = \sqrt{\begin{pmatrix} 47803 \\ -12715 \end{pmatrix}^T \begin{pmatrix} 1 & 0.825353373 \\ 0.825353373 & 1 \end{pmatrix} \begin{pmatrix} 47803 \\ -12715 \end{pmatrix}} =$$
$$= 37993$$

From the above case study it results that for a (Euro, Dollar) portfolio with 95% trust level and ten days period, the lost value is no more than 37,993. This value is possible in the context of 187 days of currencies value between January 10th, 2007 and September 28th, 2007.

It is obvious that if we make changes in the analysis context, then statistical information computed in the first three steps will generate another value for currencies distribution functions, for volatilities and for correlation coefficients and so, the final value for $NetVaR$ will be modified.

5. **Conclusion**

Value at risk method is the common used method to measure market risks. VaR helps risk manager to correctly evaluate of their market activities.

In last period many commercial banks, investment banks, insurance companies, financial investment companies have elaborated their own models for market risk evaluation.

It is recommended that VaR not be applied alone, but with other methods like Expected Tail Loss and Shanon Entropy. This recommendation is made because of VaR method limits, which will be the subject of another paper. VaR method limits appear because:

- VaR uses normal distribution and it is not able to include the characteristics of market extreme critical moment;
- VaR does not consider the operational risks.

The authors' intension is to give here a short example for a VaR model. A VaR model for a complete currencies portfolio will be presented in another paper.

In Romania, only important financial and banking institution due to high costs and complexity of VaR products uses VaR methods.

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