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ESTIMATION OF MARKET RISK BY MEANS OF INDICATORS VAR AND SHORTFALL

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Possibility of application of indicators VaR and Shortfall for an estimation and management of market risk is under consideration in this article. We suppose that the portfolio from shares of the several companies is created. It is necessary to estimate market risk both for all portfolios as a whole, and for its emitters. The numerical realisation is based on one-day historical data of a course of 6 shares of the different companies on RTS in 2007 is carried out.The number of modeled scenarios, which we should use for finding a Var-indicator with Monte-Carlo method is analysed. Found VaR and Shortfall values in an investigated portfolio, reflect the most risky investments and show the ways of improvement VaR a portfolio as a whole. The analysis of adequacy degree of the constructed model is carried out. The question of a portfolio optimisation doesn't take under consideration in the article.
Key words: VaR, Shortfall, market risk, correlation, portfolio, profitableness, time horizon, confidential interval

В данной статье рассматривается возможность применения показателей VaR и Shortfall для оценки и управления рыночным риском. Предполагается, что создается портфель из акций нескольких компаний. Необходимо оценить рыночный риск как для всего портфеля в целом, так и для его эмитентов. Осуществлена численная реализация, основанная на однодневных исторических данных курса 6 акций различных компаний на РТС в течение 2007 года. Проанализировано число моделируемых сценариев, которое необходимо использовать при нахождении VaR-показателя с помощью метода Монте-Карло. Найденные значения VaR и Shortfall в исследуемом портфеле отражают наиболее рисковые вложения и показывают пути улучшения VaR портфеля в целом. Проводится анализ степени адекватности построенной модели. Вопрос оптимизации портфеля в данной статье не рассматривается.
Ключевые слова: VaR, Shortfall, рыночный риск, корреляция, портфель, доходность, временной горизонт, доверительный интервал

INTRODUCTION

The market risk is possibility of discrepancy of economic object condition characteristics to the values expected by persons, making the decision under the influence of market factors. Apllying the concept VaR (value at risk), the concept of risk connected with possibility only of failures, losses and negative consequences is usually used. [3]

For structurization of a problem and an efficient control choice, it is necessary to carry out classification of market risks. Classification of risks should correspond to specific goals of each research and be lead from positions of the system approach. It is possible to point out following segments of market risks: interest rate risk; exchange rate risk; price risk

of the share market, or equity risk; price risk of the commodity markets, or commodity risk; risk of the market of derivative financial tools (derivative risk) [2].

The risks, related with any concrete actives or enterprise passives, cannot be considered separately. Any new economic decision should be analyzed from a position of its influence on changes of profitableness and risk of all set of assets and liabilities (portfolio) of the enterprise. The portfolio is understood as a set of assets (liabilities) or other blessings which represents the composit (compound) assets (liabilities) having parametres of risk (profitableness). It changes under the influence of a combination of two factors: change of structure of a portfolio (of portfolio structure); change of risk (profitableness) making a portfolio.

Management of risk is carried out by means of following stages: construction of criterion of management on the basis of the revealed preferences on risk of the subject of risk; portfolio diagnostics (the analysis of parametres of risk) taking into account conjuncture fluctuations; portfolio optimisation by criterion of management, being based on brave indicators (for example, VaR).

For management of market risks it is necessary to carry out the preliminary analysis of an available portfolio taking into account degree of risk of its each component and a portfolio as a whole. There are two important indicators which characterise risk: variability of financial indicators; exporsure criteria of duration to their consequences. Separate corporations cannot supervise volatility of financial tools, but they can adapt the exporsure for these risks.

Measurement of linear exporsure to movement of financial variables is designated by means of various indicators. So, in the market of tools with the fixed income exporsure to movement of interest rates is measured by a duration. In the share market exporsure to the market factor as a whole is measured factors beta. In the market of derivative tools exporsure to change of the price of a base active is measured by factor delta. There are also indicators of exporsure of the second order (square-law exporsure) to changes of financial tools. So, camber measures variability of a duration in process of interest rate change, and an indicator the scale measures delta change at change of the price of a base active. It is possible to represent exporsure parametres graphically by means of a risk profile (risk profile). The risk - profile is the schedule of dependence of change of an economic indicator from change of the influencing factor.

At measurement of market risks as a casual variable take the profitableness of financial active. There is a concept arithmetic, or discrete profitableness, and at long-term planning the geometrical or continuously increased profitableness is used. Volatility (the standard deviation) is a square root of an estimation of a dispersion of profitableness and measures risk of an active as degree of values disorder of profitableness round the expected level. The time intervals, for which parametres are calculated, can be the most various. There is an aggregation problem, i.e. volatility expression and expected profitableness for the different periods. In risk-management practice the approach which is based on two assumptions is widely used: about efficiency of the market also that throughout all period of time profitableness distribution remains to be constants.

In connection with these assumptions and considering formulas for a population mean and a dispersion of not correlated random variables, we receive, that expected profitableness and a dispersion are proportional to time, and the volatility is proportional to a square root of time variable. Therefore at long-term planning the average value dominates, and at short-term - volatility [5].

The examined traditional measures of risk possess following lacks: risk factors cannot be aggregated for the various markets; on the basis of these indicators it is difficult to apply the analysis of management of a portfolio taking into account risk; rather badly allow to supervise risk. In risk-management the approach on the basis of indicator VaR successfully cope with the problems set forth above. VaR is denominated in the given monetary units (base currency) an estimation of dimension which will not exceed expected in a current of the given period of time of loss with the set probability. Indicator VaR usually is not used with reference to the markets which are in a condition of crisis [4].

PROBLEM STATMENT

Let's examine the possibility application of indicator VaR to an estimation and management of market risks. Let we have some portfolio of open positions. VaR of portfolio for given confidential level $p = 1 - \alpha$ and the given period of maintenance of positions t is defined as such value which provides a covering of possible losses of the holder of a portfolio in time t with the probability $p = 1 - \alpha$. A holding period and a confidence level are the key parametres at a finding and interpretation of VaR indicator. The holding period gets out of term of deduction of the given tool in a portfolio or its liquidity, i.e. proceeding from the minimum real term, on which extent it is possible to realise the given tool in the market (to close a position) without an essential a detriment. A confidence level, or probability, gets out depending on preferences on the risk, the supervising bodies expressed in regulating documents or in corporate practice on the basis of estimations of managers.

There are two basic groups of approaches to estimation VaR. Examine the application possibilities of each these approaches [6].

The first group is based on «local valuation» i.e. approximations of function of cost of the financial tool. In this group parametrical methods delta-normal and delta-gamma-beta approach are used. Advantages method delta-normal (covariance method) is that it is simple, supposes analytical representation, does not demand full revaluation of positions, does not demand extensive base of retrospective positions. It is possible to carry that he assumes a hypothesis about normal distribution which not always corresponds to parametres of the real financial market to lacks, and also it badly approaches for an evaluation of risks of actives with nonlinear price characteristics.

The second group uses «full valuation», meaning full recalculation of cost of the financial tool without approximating assumptions. The method of historical modelling and a method of Monte-Carlo concern this group. The method of historical modelling allows to estimate visually and full risk with the account of "thick surpluses" without the assumption of character of distribution, but he assumes presence of an extensive database on all risk factors. The method of Monte-Carlo is conventional by the best, because it does not use a hypothesis about normal distribution of profitableness, shows high accuracy for nonlinear tools and is steady against a retrospective show choice. It is possible to carry technical complexity of calculations and modelling risk to method lacks.

Indicator VaR can be used in risk-management in following purposes: for calculation of limits on open positions; for calculation of sufficiency of the capital and capital distribution between business directions; for an estimation of profitableness of operations taking into account risk.

After definition VaR of a portfolio it is necessary to have an indicator characterising sensitivity of a portfolio to change of its structure. Such indicator is marginal VaR which shows, on what size the risk of a portfolio

will change at small changes of the size of position x_i on the given active or a risk factor. The important characteristic limiting VaR is property of additivity:

$$SVaR = \sum_{i=1}^{n} x_i PVaR_i \qquad (1)$$

By means of (1) it is possible to lead decomposition VaR portfolio on tools (positions) entering into it or risk factors. We will receive following expression for an estimation of the contribution of positions in the general risk of a portfolio:

$$Y_i = \frac{x_i PVaR_i}{SVaR} 100\% \qquad (2)$$

Expression (2) shows percentage contributions of tools to change VaR of a portfolio as a result of change of the size of all positions on the same (small) relative size [1].

Despite the popularity, VaR possesses some of essential lacks:

1. Despite possible big losses which can occur to small probabilities (smaller, than $p = 1 - \alpha$), i.e. there is no information on the worst possible loss outside of possible VaR;

2. There is no information on a kind of distribution of losses: at distributions with different thickness of "surpluses" at certain level of trust same value VaR can be observed;

3. Indicator VaR is not unequivocally definable: for the same portfolio levels of trust of its values can essentially differ. It depends on a way of decomposition of a portfolio on risk factors, volume of sample of historical data and an applied method of calculation.

One of measures of the risk, satisfying to conditions когерентности, the indicator of expected losses (expected shortfall) is. It is the statistics, allowing to estimate loss on a portfolio, falling outside the limits VaR. Widespread property of likelihood distributions of profitablenesses of financial actives is the big density of rare or extreme events in comparison with normal distribution (effect of "thick surpluses»). Thus, it is important to know about the losses exceeding set confidential level $p = 1 - \alpha$. In mathematical way it is possible to define size of expected losses as a conditional population mean of losses X which has exceeded VaR:

$$ExpectedShortfall_p(X) = E(X|X > VaR_p) \qquad (3)$$

The indicator of expected losses can be used for definition of the sizes of the sum, sufficient for insurance of the given portfolio upon losses which will exceed VaR.

<div align="center">NUMERICAL EXAMPLES</div>

Let's assume that we plan to create a portfolio from shares of 6 companies:

- *Surgutneftegaz, ap,* ordinary (SNGSP);
- *Surgutneftegaz*, ordinary (SNGS);
- *Rosneft*, ordinary (ROSN);
- T*he Pole gold*, ordinary (PLZL);
- *Gazprom*, ordinary (GAZP);
- *LUKOIL NK*, ordinary (LKOH).

It is necessary to estimate market risk calculation of parametres VaR and Shortfall both for all portfolio, and for separately taken company at

investment on the set quantity of days. For the analysis we will use the historical prices of opening of the portfolio shares in the Russian Trading System (RTS) with depth of calculation daily VaR of a year period (2007) [7] and results from [8].

Let we have seed capital K=100000 convention units and its distribution is uniform on emitters. According to this distribution the quantity of shares of each company is calculated. We also find historical market cost of a portfolio and change of market cost for one day. Analyzing initial data, we will find average daily changes of the prices and volatility (daily) changes of the prices for each of the companies.

Table 1 - Volatility and average indexes

	Volatility (daily) changes of the prices	Average daily changes of the prices
SNGSP	0,026524	-0,000910
SNGS	0,027146	-0,000533
ROSN	0,136737	0,005601
PLZL	0,951863	0,005464
GAZP	0,239071	0,012568
LKOH	1,649605	0,008743

Applying the correlation-covariation analysis, we fill corresponding matrixes of daily changes of the prices.

Table 2 - The correlation matrix of daily price changes

	SNGSP	SNGS	ROSN	PLZL	GAZP	LKOH
EESR	1,000000	0,459275	0,356302	0,264891	0,264064	0,377733
LKOH	0,459275	1,000000	0,536023	0,420497	0,490552	0,615606
RTKM	0,356302	0,536023	1,000000	0,423173	0,542305	0,595011
SNGS	0,264891	0,420497	0,423173	1,000000	0,320440	0,438731
TATN	0,264064	0,490552	0,542305	0,320440	1,000000	0,590938
MSNG	0,377733	0,615606	0,595011	0,438731	0,590938	1,000000

Table 3 - The covariation matrix of daily changes of the prices

	SNGSP	SNGS	ROSN	PLZL	GAZP	LKOH
EESR	0,000702	0,000330	0,001289	0,006669	0,001670	0,016482
LKOH	0,000330	0,000735	0,001984	0,010836	0,003175	0,027492
RTKM	0,001289	0,001984	0,018646	0,054927	0,017679	0,133845
SNGS	0,006669	0,010836	0,054927	0,903569	0,072721	0,687012
TATN	0,001670	0,003175	0,017679	0,072721	0,056999	0,232413
MSNG	0,016482	0,027492	0,133845	0,687012	0,232413	2,713761

With use of a corresponding mathematical apparatus, and also considering historical data, we will receive following indicators of one-day 99 % VaR and Shortfall estimations both all portfolio, and its separate emitters. At a finding of VaR indicator by means of a method of Monte-Carlo imitating modelling of possible scenarios of changes of market prices of shares of emitters for one day forward was carried out. The numerical analysis of necessary quantity of modelled scenarios (table 4) was carried out.

Table 4 - Dependence VaR on number of modelled scenarios

The number of scripts	SNGSP	SNGS	ROSN	PLZP	GAZP	LKOH	Portfolio
500	1096,19	790,46	758,81	929,79	939,07	727,49	3848,81
1000	1055,96	770,94	683,28	856,47	1026,74	770,43	3971,85
1500	986,99	778,59	660,82	799,12	1024,53	806,01	3556,02
2000	1054,69	724,16	713,74	843,13	986,80	769,77	3769,67
3000	1039,29	748,06	690,78	855,68	949,64	767,75	3771,75
4000	1054,58	757,53	678,97	806,74	935,88	779,55	3663,87
5000	1079,13	765,16	709,08	850,37	967,94	784,26	3754,96
6000	1049,85	744,60	674,73	840,02	940,04	748,82	3555,13
7000	1054,86	742,32	671,19	855,74	976,16	758,61	3657,72
8000	1052,22	744,92	693,74	828,55	935,08	767,45	3610,98
9000	1050,25	762,14	718,27	849,21	940,21	756,84	3757,68
10000	1036,69	742,22	680,54	850,62	925,43	771,93	3668,20

To determine the required number of simulated scenarios, Monte Carlo, the rate of standard deviation for the portfolio to price K = 100000 convention units should be used. For the historical period, which is under investigation the figure equals σ_0 = 6085 convention units. Thus the standard fault of obtaining an average value will not exceed the value

$$S_E = \frac{\sigma_0}{\sqrt{n}} \qquad (4)$$

where n - number of experiments. To achieve sufficient accuracy, we assume that the average VaR-portfolio should have an mistake less than 85 convention units. Turning to account (4), we obtain the required number of scenarios n = 5124. Performing the calculation for a given number of scenarios, we obtain the following data (table 5). In this case, the required standard error will be equal

$$S_E = \frac{1603}{\sqrt{5124}} = 22,4.$$

Consequently, we can say with probability 95% that the real value of VaR-portfolio will be VaR_M =(3708,30±44,8) convention units.

Table 5 - VaR and Shorfall 99% level estimation

Method	SNGSP	SNGS	ROSN	PLZL	GAZP	LKOH	Portfolio
Historical	1189,26	776,58	833,33	1124,03	947,37	881,51	4653,21
Monte-Carlo	1027,33	758,84	695,40	842,35	961,79	808,88	3708,30
Var Pareto	1251,99	812,45	788,18	1245,98	1115,23	926,34	4389,42
Var Gamma	1465,42	855,06	809,53	1036,14	1191,02	922,41	4544,24
Shortfall Pareto	2124,17	1027,88	1122,48	2275,43	1797,41	1249,78	5833,14
Shortfall Gamma	2068,44	1037,95	988,23	1195,73	1555,83	1089,93	5532,57
Maximum for the period	3737,68	1612,90	1351,35	1356,59	2315,79	1435,01	8542,52

At uniform distribution of the capital, the analysis of values of table 5 shows, that during the examined period of time investments in the share *Surgutneftegaz, ap* (SNGSP) and *the Pole gold* (PLZL) are subject to the greatest market risks, and the least market risk is characteristic for shares *Rosneft* (ROSN). Hence, having reduced a share of shares *Surgutneftegaz, ap* (SNGSP) and *Pole* (PLZL) in a portfolio and increasing at the expense of them a share of other emitters, it is possible to reduce *gold* considerably VaR portfolio as a whole.

In the form of indicator VaR to real conditions of the market, it is possible to reflect degree of adequacy of model of an estimation of market risk in an amount of surpluses on absolute size of changes of actual indicators over corresponding indicators VaR .

Table 6 - Amount of surpluses VaR

Method	SNGSP	SNGS	ROSN	PLZL	GAZP	LKOH	Portfolio
Historical	7	10	8	8	8	4	5
Monte-Carlo	7	10	11	18	8	10	7
Var Pareto	5	7	8	4	5	4	5
Var Gamma	5	4	8	9	5	4	5

Data in the table **6** represent adequacy of the constructed model.

CONCLUSION

On the basis of the received settlement characteristics it is possible to analyse investments in what shares are subject to the greatest market risk. The calculation of indicators VaR and Shortfall using various methods allows to estimate qualitatively findings of indicators VaR an under consideration portfolio. Direct calculation of the risk parametres allows to make redistribution of the initial capital towards reduction of market risk.

SUMMARY

ОЦІНКА РИНКОВОГО РИЗИКУ ЗА ДОПОМОГОЮ ПОКАЗНИКІВ VAR ТА SHORTFALL

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У цій статті розглядається можливість застосування показників VaR та Shortfall для оцінки та управління ринковими ризиками. Припустимо, що створюється портфель, до якого входять акції декількох компаній. Необхідно зробити оцінку ринкового ризику як для всього портфеля та за окремими його емітентами. Зроблена чисельна реалізація, що базується на одноденних історичних даних курсу 6 акцій різних компаній на РТС протягом 2007 року. Зроблено аналіз кількості змодельованих сценаріїв, що використовуються під час знаходження VaR- показника за допомогою методу Монте-Карло. Знайдені значення VaR та Shortfall у досліджуваному портфелі, відображають найбільш ризикові вкладення та показують шляхи поліпшення VaR-портфеля в цілому. Наводиться аналіз адекватності побудованої моделі. Питання оптимізації портфеля в цій роботі не розглядається.

Ключові слова: VaR, Shortfall, ринковий ризик, кореляція, портфель, дохідність, часовий горизонт, довірчий інтервал.

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