

# Moral hazard on the financial markets caused by application of advanced risk-management model VAR

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**Abstract** Moral hazard is a concept that has been associated with the mortgage crisis in the US, where large mortgage banks were encouraged to provide loans to almost anyone without quality collateral. After the collapse of these banks, the US government and the US central bank (Fed) invested the capital into these banks to provide them sufficient liquidity. This is an example of moral hazard, where financial institutions can take risks and in case of catastrophic scenario these banks and the management of these banks are not threatened that they would have to be responsible and they follow a simple rule: "too big to fail". The aim of the article is an application of advanced model VaR (Value at Risk) through a time series of income for the corresponding period of the investment portfolio, which consists of eight assets and further the application of this model on stock index SP500, to assess this method in terms of moral hazard. It is primarily about the relevance of this method in practice.

**Keywords** Moral hazard, Value at Risk, Stock index, Currency pair, The Incremental VaR

## 1. INTRODUCTION

Moral hazard is something that we can incorporate into the mechanisms of expansion, though it is not directly related to this. This moral hazard relates to the irrational behavior of primarily the banks. With the securitization processes and the establishment of CDO (Collateralized Debt Obligation) and other products such moral hazard swelled to enormous proportions. The U. S. Securities and Exchange Commission (SEC) has allowed investment banks to raise debt, enabling to raise the leverage of 15:1 to 40:1, which means that a very small decrease in assets values would mean a catastrophic loss.<sup>1</sup> Investment banks, but also mortgage banks allowed to provide more mortgages and by securitization of these loans transferred the credit risk to other entities. These banks used to treat risk also VaR method and a portfolios that is valued using this method. Such valuation calculations were further reported to authorities in the area of regulation (SEC, Fed, etc.). These institutions therefore did not have relevant information on structured

products resulting from mortgage loans i.e. CDO and CDO packages.

Risk management and VaR devote mainly writers like Flaherty, Gourhey, Natarajan<sup>2</sup>, who put in the controversy VaR method in light of the crisis of 2008-2009 and propose new methods of risk management with regard to financial innovation and the emergence of more sophisticated structured products. Furthermore, well known statistician Taleb<sup>3</sup> focuses at this method and his work provides a comparison of this method with the life of the turkey and on examples - several portfolios with the application of several methods for calculating VaR - summarizes the major drawbacks of the VaR method as relevant indicator for risk management.

The aim of this work is the application of the advanced VaR model through time series of income for the corresponding period of the investment portfolio, which consists of eight assets and the application of this model in stock index SP500, to assess this method in terms of moral hazard. It is primarily about the relevance of this method in practice.

## 2. ADVANCED VAR MODEL

Moral Generally, this model gives an estimate of the maximum potential losses of the given portfolio of assets. In fact, it is a statistical estimate determining the worst possible loss of the investor, which may occur at a certain level of probability within a certain time frame. In this part of the work, I want to address in particular advanced model so-called marginal and incremental and component VaR, which are often referred to as components or elements also responsible for expanding the model itself. These "elements" are applied to the particular sample of portfolio containing 8 assets.

<sup>1</sup> MUSÍLEK, Petr. *Trhy cenných papírů*. 2nd edition. Praha: Ekopress, 2011. Ekonomie (Key Publishing). ISBN 978-80-86929-70-5, p. 230.

<sup>2</sup> FLAHERTY, Joseph, Gabrielle GOURGEY a Sanjay NATARAJAN. *Five Lessons Learned: Risk Management After the Crisis*. [online]. 2013, 1 [cit. 2016-08-24]. Available from: <http://www.europeanfinancialreview.com/?p=894>.

<sup>3</sup> TALEB, Nassim. *The black swan: The impact of the highly improbable*. New York: Random House Trade Paperbacks. 2010. pp. 425-445. ISBN: 978-081-2973-815.

### 2.1 Marginal VaR

Marginal VaR expresses sensitivity to the amount invested in the *i*-th asset, in the financial instrument, etc. (Marginal VaR =  $\delta VaR / \delta x_i$ ).<sup>4</sup>

### 2.2 Incremental VaR

It determines the VaR sensitivity to increment of a specific asset in the portfolio. In practice, this means that the investor has a portfolio *x* and purchases, invests into some other asset *y*, which is added to this portfolio. This changes the allocation and thus the sensitivity, which should be quantified.

### 2.3 Component VaR

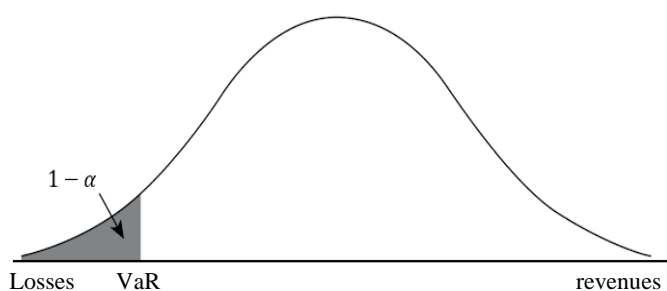
It is specific VaR of individual assets in the whole portfolio. This VaR has the following characteristics:

- Component VaR of *x* assets of the entire portfolio may be approximately equal to the incremental VaR for that component.
  - The sum of all components VaR of the portfolio may equal VaR of the entire portfolio.
1. Characteristics cannot be met, because the nonlinearity in the calculation of VaR does not allow it.
  2. Characteristics can be met when applying Euler's theorem.<sup>5</sup>

### 2.4 The maximal potential loss vs distribution of revenues

In the financial sector it is very important at the outset to determine the method of distribution of revenues. In the financial world, normal (linear) revenue distribution is not optimal because of different reactions and movements.

Fig. No. 1: Distribution of revenues (normal distribution) and determination of the maximal loss



Source: Own construction.

The maximal loss is determined as follows:  $(1 - \alpha) * 100\%$  quantile.

Quantile is the measure of the probability distribution of the random variable. It describes points where the distribution function of the random variable passes the given value.

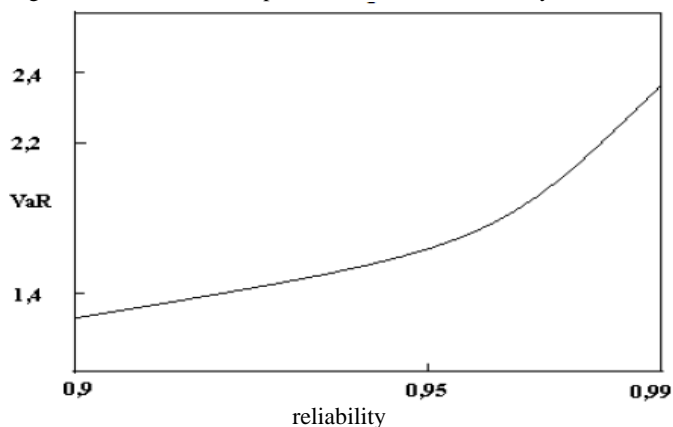
- This distribution is very common assumption of distributions.
- For this distribution therefore applies:  $(1 - \alpha) * 100\%$  quantile of normal distribution.

- $VaR = W \delta_{\mu-\alpha}$ , where  $\delta_{\mu-\alpha} = (1 - \alpha) * 100\%$  = quantile of normal distribution, *W* = corresponds to the value of the portfolio.

### 2.5 Time horizon and reliability

Reliability level is set to 95 % or 99 %. In the older literature is also reliability level of 90 %. The time horizon is given as 1, 10, 30, 250 days.

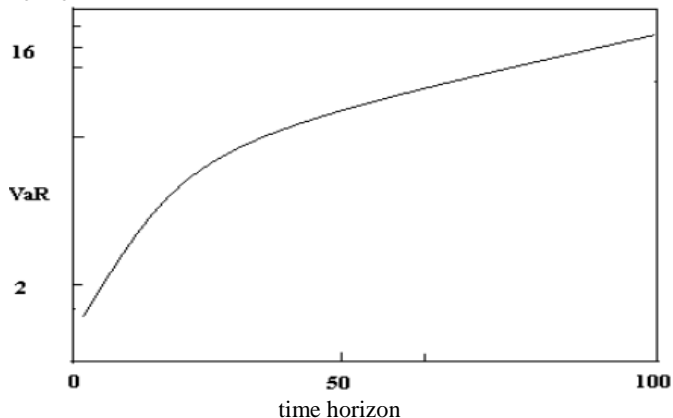
Fig. No. 2: The relationship between VaR and reliability



Source: Own construction.

At higher reliability the accuracy of the VaR estimate increases and the curve is rising.

Fig. No. 3: The relationship between VaR and the length of the time horizon



Source: Own construction.

The chart shows the opposite relationship, when with the longer (increasing) time horizon of exploration the resulting VaR declines, which reduces the predictive value of the desired results for the investor i.e. the maximal possible potential loss.

### 3. APPLICATION OF ADVANCED MODEL VAR N

Applications a) on a sample – portfolio of 8 assets, which include gold, Euro, British pound, SP500, DAX, Brent, APPLE, IBM.

Based on the portfolio above, its composition is diverse, because it consists of commodities, stocks, currencies and stock indexes. Each of these financial instrument represents a portion of the market of economy. Shares, stock market indices = capital market, gold, petroleum Brent = commodity market, the British pound (GBP) and

<sup>4</sup> CIPRA, Tomáš. *Finanční ekonometrie*. 2nd edition. Praha: Ekopress, 2013. pp. 487-501. ISBN: 978-80-86929-93-4.

<sup>5</sup> KHINDANOVA, Irina a Svetlozar RACHEV. *Value at Risk-Recent Advances*. 2004. Working paper. University of California, Santa Barbara and University of Karlsruhe, Germany.

Euro = foreign exchange market. To make it easier. For each of these financial instruments is determined a fixed investment positions in the amount of 100,000 US dollars (USD).

Time period: 05. 01. 2015 - 05. 07. 2016.

Method of VaR calculation: Variance and covariance.

Prerequisite: normal revenues distributions with parameters  $\mu = 0$  and  $\delta = 0.087$ .

Covariance matrix used for calculation is shown in Table. No. 1.

Tab. No. 1: The covariance matrix

Asset	Gold	BRENT	EURO	GBP	APPLE	IBM	SP500	DAX
Gold	<b>0,00011</b> 57	- 0,00001 27	- 0,00000 15	0	0,00000 15	0,00000 12	0,00000 11	0,00000 17
BRENT	- 0,00001 27	<b>0,00040</b> 8	0,00000 69	0,00000 2	0,00000 62	- 0,00001 5	0,00000 25	0,00000 7
EURO	- 0,00000 15	0,00006 9	<b>0,00002</b> 54	0,00001 13	0,00000 3	0	0,00000 02	0,00000 17
GBP	0	0,00000 2	0,00001 13	<b>0,00001</b> 62	0,00000 02	0,00000 07	0,00000 08	0,00000 1
APPLE	0,00000 15	0,00000 62	0,00000 03	- 0,00000 03	<b>0,00003</b> 58	0,00094 04	0,00004 04	0,00001 47
IBM	0,00000 12	- 0,00000 15	0	0	0,00013 13	<b>0,00003</b> 58	0,00004 86	0,00001 47
SP500	0,00000 11	0,00000 25	0,00000 02	0,00000 02	0,00004 86	0,00040 4	<b>0,00005</b> 78	0,00002 11
DAX	0,00000 17	0,00000 07	0,00000 17	0,00000 17	0,00001 47	0,00014 7	0,00002 11	<b>0,00011</b> 58

Source: Own calculation.

Result of application: Determination of maximal loss that will not be with 95% reliability exceeded the following day i.e. 06. 07. 2016.

Application b) on the stock index SP500. All parameters are the same as by application a).

### 3.1 Component VaR of various financial instruments in the portfolio

Components of various financial instruments in the portfolio with 95% reliability are given in the Tab. No. 2.

Tab. No. 2: Components of various financial instruments in the portfolio with 95% reliability

Financial instrument	Component VaR in %	Value in USD
Gold	7,79	1 175,06
Petroleum BRENT	30,52	3 458,72
EURO	2,18	745,56
British pound	3,35	541,89
APPLE	17,37	1 989,41
IBM	13,24	1 245,55
SP500	14,58	1 347,65
DAX	10,97	1 875,32

Source: Own calculation.

Component VaR = 100 %, i.e. one whole (sum).

is something that we can incorporate into the mechanisms of expansion, though it is not directly related to this. This moral hazard relates to the irrational behavior of primarily the banks. With the securitization processes and the establishment of CDO (Collateralized Debt Obligation) and other products such moral hazard swelled to enormous proportions.

### 3.2 Marginal VaR at 95% reliability level

Marginal VaR at 95% reliability level are shown in the Tab. No. 3.

Tab. No. 3: Marginal VaR at 95% reliability level

Financial instrument	Investment position in%	Marginal VaR
Gold	12,5	0,00476
Petroleum BRENT	12,5	0,01865
EURO	12,5	0,00256
British pound	12,5	0,00243
APPLE	12,5	0,01061
IBM	12,5	0,0704
SP500	12,5	0,00647
DAX	12,5	0,00698

Source: Own calculation. (\* VaR of the portfolio amounts to 6 221,23, which is the highest possible loss of the portfolio on 06. 07. 2016 in USD)

### 3.3 The increase of the investment position of gold and VaR

In this example, the investment position of gold in a portfolio of 30 000 USD is increased due to today's high demand for gold, because gold is quite often referred to as a safe asset in situations when turbulences on the financial markets happen.

Tab. No. 4: Increase of investment position of gold in a portfolio of 30 000 USD and the changes of incremental VaR and component VaR and determining of the overall VaR

Financial instrument	Component VaR-change in USD	VaR portfolio from tab. No. 3	New VaR portfolio
Gold	95,27	6 221, 23	6 347,85
Petroleum BRENT	0*	-	-
EURO	0*	-	-
British pound	0*	-	-
APPLE	0*	-	-
IBM	0*	-	-
SP500	0*	-	-
DAX	0*	-	-

Source: Own calculation. Values in USD. (\* = No changes)

After increasing of investment position of gold in the sum of 30 000 USD, VaR of this portfolio increased. The resulting sum is called incremental VaR, which equals the difference 6 347,85 - 6 221,23 = 126,62. So by adding this investment exposure the maximal possible loss at the 95% reliability level (probability) increases by 126,62 USD.

### 3.4 Marginal VaR at 95% reliability level

In this investment situation, reduction of investment positions in petroleum Brent by 20 000 USD, while increasing investment positions in technology company Apple by 25 000 USD, is simulated.

Tab. No. 5: Reduction and increase of investment position in the portfolio and changes of incremental VaR and component VaR, and determining the overall VaR

Financial instrument	Component VaR-change in USD	VaR portfolio from tab. no. 3	New VaR portfolio
Gold	0*	6 221, 23	6 147,85
Petroleum BRENT	-521,16	-	-
EURO	0*	-	-
British pound	0*	-	-
APPLE	285,45	-	-
IBM	0*	-	-
SP500	0*	-	-
DAX	0*	-	-

Source: Own calculation. Values in USD. (\* = No changes)

The table shows that, thanks to this financial transaction, the total VaR decreased by \$ 73.38 (6 221,23 – 6 147,85) i.e. incremental VaR, therefore, the total maximal potential loss in the portfolio at 95% reliability level has decreased.

### 3.5 Marginal VaR at 95% reliability level

$$\text{VaR} = 100\,000 * \mu_{0,05} * 0,087 = 100\,000 * (-1\,645) * 0,087 = -14\,311,50$$

The maximal potential loss of the stock index SP500 on 06. 07. 2016 with a 95% reliability is 14 311,5 USD.

## 4. WEAKNESSES OF VAR MODEL

Moral Summary of the shortcomings of the VaR model in practical use in professional practice:

- The first weakness is in the methods of calculating this model. It was based on calculation of variances and covariances, but there still exist historical simulations and Monte Carlo simulation. This calculation issue was dealt by T. S. Beder.<sup>6</sup> In her work, she used up to 8 methods of calculating VaR on three very different portfolios. In her work, she calculated the one-day, ten-day VaR and for the historical simulation used the data for the last 100 or 250 trading days. The results showed that there is a large variation in the resulting VaR values. In case of one of the analyzed portfolios there was once determined up to 14 times greater VaR value than by application of another method of calculation.
- The calculation method is based on historical data: This assumption is not always true, because history does not necessarily have to repeat. The calculation uses historical data that is based on the logic that the market gains will behave similarly as in the past. Crisis of 2008-2009 proved the falsity of this assumption.
- The article faces the problem of this method with determining the degree of reliability. In the examples above, it is counted with 95% rate, but for example if rate of 99% in the example b) (stock index SP500) applied, then the difference would be – 5 924,7 USD (20 236,2 - 14 311,5) i.e. that the maximal potential loss on the following day would be by this value higher, which is not negligible.
- Among the most famous professional critics of this model belongs a prominent American statistician and mathematician N. N. Taleb, that similes this method in a poetic metaphor to

turkey. "The turkey is reared and fed 1 000 days. Every day the turkey gets fed, the Statistics Division evaluates that people care about his good life, and it also increases the statistical significance of this statement. One day in November, when the US celebrates Thanksgiving, there is an unpleasant surprise waiting for turkey."<sup>7</sup>

- VaR is not able to accentuate the securitization of assets and the creation of new assets: This problem affects the valuation of structured products, because modern securitization and financial innovation greatly complicate the entire risk management. VaR models cannot evaluate very sophisticated structured products, for example. CBO (Collateralized Bond Obligations) linked to mortgage loans, which were triggers of crisis in the US and then the problems came to Europe through other mechanisms and channels. "It is necessary that for new financial instruments with the absence of the historical basis and of incomplete information about the instrument itself, put financial risk management models great emphasis on the qualitative risk assessment."<sup>8</sup>

## 5. CONCLUSION

Moral The aim of the article was the application of advanced VaR model through time series of incomes for the corresponding period of the investment portfolio, which consists of eight assets and further the application of this model on stock index SP500, to assess this method in terms of moral hazard. It is primarily about the relevance of this method in practice.

The article deals with the advanced VaR model, which can be to some extent considered as a tool of financial stability and its analysis. The disadvantage of this method when processing a serious analysis of the stability of financial markets are in particular, as mentioned above, different calculation methods with varying results. This result does not vary only by the method of calculation, but also on the probability level where the VaR is calculated (90%, 95%, 99%). These tools can largely affect the VaR result (intentionally selected historical financial time series accentuating revenues in the times of the boom), and therefore this method is not valid and cannot have a great explicitness or the analysis of financial market stability cannot be based on this method. This method does not involve so-called systemic risk, which is examined in the analysis of financial market stability. Systemic risk is a special type of risk, when the risk in one entity (bank) can then "spill over" into the whole sector, not just banking, but into the real economy sector, because the bank provides loans for households and businesses. VaR completely ignores the characteristics of the individual components of the portfolio and is unable to cope with structured products, but this applies for most models, because the clustering of several assets into one asset cannot be relevantly evaluated. VaR model in terms of the analysis of financial market stability must be complemented by macroeconomic models such as QPM (Quarterly Projection Model), DSGE (Dynamic Stochastic General Equilibrium Model).

Criticism of VaR method as a method for assessing financial stability in light of the crisis of 2008-2009 took place in 2008 between the known expert in the field of risk management Aaron Brown and hedge manager David Einhorn. Both are members of internationally reputable Association of Risk Managers - GARP. Einhorn compared VaR method to the airbag that works all the time, up to the time when car crashes, arguing:

<sup>6</sup> BEDER, Tanya Styblo. *VaR: Seductive but Dangerous*. [online]. USA, Financial Analysts Journal, september/october 1995 [cit. 2016-08-24]. Available from: <http://www.rondvari.com/VaR%20Seductive%20but%20Dangerous.pdf>.

<sup>7</sup> TALEB, Nassim. *The black swan: The impact of the highly improbable*. New York: Random House Trade Paperbacks. 2010. pp. 425-445. ISBN: 978-081-2973-815.

<sup>8</sup> FLAHERTY, Joseph, Gabrielle GOURGEY a Sanjay NATARAJAN. *Five Lessons Learned: Risk Management After the Crisis*. [online]. 2013, 1 [cit. 2016-08-24]. Available from: <http://www.europeanfinancialreview.com/?p=894>.

- This method leads to a massive shift towards risk and financial leverage in financial institutions.
- It is limited to manageable risks.
- Creates incentives to go into greater risk than to eliminate this risk.
- This method was catastrophic, because it created false sense of security for authorities of the financial market.

This method, however, was criticized even at the beginning of its establishment in the famous debate between known American statistician N. N. Taleb and Phillippe Jorionem in April 1997. Taleb presents already at this time facts that fully came out in the crisis in years of 2008 and 2009, when he argued the detriment of the application of this method, using the following arguments:

- VaR method ignores 2 500 years of experience in favor of untested model, which was established by not-traders.
- It gives a false sense of security.
- It can be misused by traders and players on the stock exchanges.

These last two arguments are semantically almost identical with debate in the year 2008.

Theoretically, relations between VaR itself and the parameters such as reliability, normal distribution of revenues and the time horizon (period) can be point out. In section 3.2 is the VaR itself is applied for the period from 05. 01. 2015 - 05. 07. 2016, the maximal potential loss for the following day, i.e. 06. 07. 2016 was sought namely for a) on portfolio, which is composed of 8 assets and for b) the stock index 95 % with certain, selected parameters. In sections 3.3 and 3.4 are listed two practical changes in the portfolio, i.e. increase and decrease of investment position. By increasing investment position in gold, the resulting VaR increased by 126,62 USD, while by the increase and decrease of investment position in the portfolio, on the contrary, during this operation the resulting VaR decreased by 73,38 USD. The calculated maximal potential

loss from the stock index SP500 on 06. 07. 2016 at 95% reliability level is 14 311,5 USD.

### Acknowledgement

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