VALUE AT RISK (VAR) AS A MARKET RISK MEASURE

VRIJEDNOST POD RIZIKOM (VAR) KAO MJERA TRŽIŠNOG RIZIKA

NATASHA KOZUL,
University of London

Abstract: *Market risk is the potential loss on investment due to fluctuations in the market value of traded position that cannot be hedged or diversified away. Value at Risk (VAR) is a standard measure of market risk, adopted by all financial market participants. Its use in risk management is a legal and regulatory requirement. VAR is a single number that defines risk as mark-to-market loss on a fixed portfolio over a fixed time horizon, assuming normal markets. This paper presents and compares several VAR methodologies: parametric, historical, historical simulation and stochastic (Monte Carlo) simulation. It can be shown that, despite excessive computational requirements and reliance on sophisticated mathematical models; Monte Carlo simulation is a superior to alternative VAR measurement methods, due to its flexibility and adaptability.*
Keywords: *VAR, value at risk, Monte Carlo simulation, historical simulation, market risk.*

Abstrakt : *Tržišni rizik je potecijani gubitak vrijednosti investicije zbog fluktuacija u tržišnoj vrijednosti finansijskog proizvoda, koji se ne može ukloniti ili umanjiti raspoloživim berzanskim strategijama. Vrijednost pod Rizikom (VAR) je standardna mjera tržišnog rizika, prihvaćena od strane svih participanata na finansijskom tržištu. Njeno korišćenje je zakonska i regulatorna obaveza. VAR je numerička vrijednost koja definiše rizik kao pad vrijednosti investicionog portfolija (procijenjen na osnovu trenutnih cijena na berzi) u specifičnom vremenskom periodu, pod pretpostavkom normalnog tržišta i određenog nivoa vjerovatnoće. Ovaj rad predstavlja i upoređuje nekoliko VAR metodologija: parametarsku, istorijsku, istorijsku simulaciju i stohastičnu simulaciju (Monte Karlo metodu). Može se vidjeti da je Monte Karlo simulacija, uprkos velikoj potrebi za računarskom brzinom i snagom, kao i za sofisticiranim matematičkim modelima, superiorna u odnosu na alternativne VAR metode, zbog svoje fleksibilnosti i prilagodljivosti svim tržišnim uslovima.*
Ključne rijeci: *VAR, Vrijednost pod rizikom, Monte Karlo simulacija, istorijska simulacija, tržišni rizik.*

JEL Classification: C22; G22;
Review; Recived:April 29, 2010

1. Introduction

Market risk is the potential loss on investment due to fluctuations in the market value of assets involved. Specifically, for derivatives products it is the negative impact that the fluctuations in the underlying security market value would have on the value of the derivative. Some of the risk can be diversified away or hedged and the remaining factors that could potentially incur losses on investment are deemed market risk. It arises from the characteristics of the instrument as well as unforeseen circumstances in the market as a whole. Hence the potential for losses is always present and market risk management reduces to calculation of probability of adverse circumstances and the financial impact they would have. Reserving sufficient funds to cover potential losses, thus avoiding default, is the legal and regulatory requirement for all market participants.

2. Historical development of VAR

Financial risk has always been a concern of financial institutions and regulatory bodies. Nevertheless, the concept of VAR emerged only recently, triggered by the stock market crash in 1987. Historically, market crashes occur rarely and their probability is too low to be included in product valuation models. Nevertheless, when they occur they impact several, often uncorrelated, markets; thus cannot be ignored. VAR was developed as a systematic way to segregate extreme events, which are studied over a long period of time and included broad historical market data [1], from daily valuation and trading, which uses short-term data in specific markets. In the early 1990s this concept was formalized in investment banking to represent a single, uniform measure of market risk. VAR was chosen as it was the only common risk measure that could be both defined for all businesses and aggregated without strong assumptions. In 1997, the U.S. Securities and Exchange Commission ruling that public corporations must disclose quantitative information about their derivatives activity lead most major banks and trading companies to comply by including VAR information in their financial statements [2].

Worldwide adoption of the Basel II Accord, beginning in 1999, gave further incentive to the use of VAR [2].

3. Alternative risk metrics

The VAR risk measure defines risk as mark-to-market loss on a fixed portfolio over a fixed time horizon, assuming normal markets. There are many alternative risk measures in finance. Rather than using market prices to define loss, risk measure can alternatively be defined as change in fundamental position value. If, for example, a loan position declines in market price due to interest rate increase; this is not recognized as loss, as long as there is no change in cash flows or credit quality. Other economic parameters, such as loss of market confidence or employee morale, impairment of brand names or lawsuits, can also be included [3].

Rather than assuming a fixed portfolio over a fixed time horizon, some risk measures incorporate the effect of expected trading volumes and periods. Unlike VAR, some risk measures adjust for the possible effects of abnormal markets, rather than excluding them from the risk metrics calculation [3].

4. VAR Definition

A standard measure of market risk, adopted by all financial market participants -VAR., is a regulatory requirement and its definition is precisely defined. VAR is the amount by which the investment *mark-to-market* (valuation of financial instruments compared to the prevailing market prices) value may fall over a specified period of time at a given level of probability. For example, VAR of £50000 at 1% probability for 1 day implies that there is 1% chance that the investment would lose £50000 in value in one day.

Hence the main VAR inputs are:

- unit of measurement (index points, currency etc.)
- time interval
- probability

Approved VAR models

According to Basle agreement, investment banks are approved to use two types of VAR models:

- standardized models, used by general public
- internal models, developed internally by the investment banks

Internal VAR models have to adhere to strict qualitative and quantitative standards and be approved by regulatory authority. Those are:

Quantitative standards:

- 1% probability level
- two-week holding period on all trades
- - calculated VAR should be multiplied by 3, to allow for error margin introduced by potential weaknesses in the internal model

Qualitative standards:

- independent validation of the VAR model by a third party
- integration of the VAR model into risk management
- internal control over data inputs and changes in the model
- separation of trading business from risk management (introduction of "Chinese walls")
- senior management involvement in risk management

VAR calculated in this way tends to be excessively high, thus it is typically breached only once in every four years.

5. VAR measurement

Investment banks and other financial institutions tend to have their internal VAR models, particulars of which are proprietary. Nevertheless, the approaches they take can be classified as:

- parametric
- historical
- historical simulation
- stochastic simulation

5.1 Parametric VAR measurement

Parametric VAR measurement is very popular due to its ease of use and readily available market inputs. It assumes that the investment returns are normally distributed and therefore can be described using variances and covariances of the underlying investments [4]. It uses historical data to estimate variance and correlations of relevant investments, from which the investment returns are derived. This information is used in conjunction with current security prices to derive VAR. The main shortcomings of the parametric approach to VAR (also known as analytical or correlation method) are [5]:

- assumption of normal distribution of asset returns, which is in practice rarely observed.
- correlations between different variables impacting investment returns are implicit in this model, even though the assets may be uncorrelated
- volatility and correlation are assumed to be constant over a period of time
- tends to underestimate market risk due to above assumptions

5.2 Historical VAR measurement

Historical VAR measurement is a non-parametric approach to VAR calculation. It relies on taking a large sample of historical data and plotting the distribution. It is based on the concept of rolling windows, whereby a suitable historical period (6 months to two years) is chosen. Data is sorted into ascending order and the bottom percentile identified. VAR calculated using the same approach as above. The procedure is

repeated for the next day by moving the observation window by one observation and reiterated as necessary.

The pros and cons of this approach are [4]:

- there is no implicit assumption about the distribution of investment returns
- no variance and co-variance estimates
- the shortcoming is that it is computationally extensive and requires complete recalculation on any change in VAR parameters
- implicit in the data collection procedure is the assumption that there is no change in distribution of portfolio returns

5.3 Historical Simulation (bootstrapping)

Historical Simulation (bootstrapping) is used in the case of insufficient historical data on investments. Instead the historical data on parameters that impact the value of investments is used. The investment performance through time is than simulated and VAR calculated as above.

The disadvantages of this approach are [5]:

- hard to identify the relevant price factors
- needs extensive and reliable market data
- extensive computational requirements, as the investments are evaluated using range of inputs many times in order to simulate their historical data.

5.4 Stochastic simulation

Stochastic simulation is similar to historical simulation, but instead of relying on historical market data for price factors, it constructs the distributions and parameters for each factor and then runs investment value simulations. It is popularly known as Monte Carlo simulation.

The main advantages of this approach are:

- no assumptions about the investment distribution
- no assumptions about asset returns
- flexibility
- ability to run vast number of scenarios

The disadvantages are:

- excessive computational power is required
- reliance on input parameters
- reliance on sophisticated mathematical models

6. Pros and cons of VAR

VAR is a market-standard measure of risk. However, it does have its disadvantages.

Its benefit are:

- easy to understand
- widely accepted
- a single measure of risk
- easily applied

Its shortcomings are:

- does not account for risk in extreme circumstances
- does not create reliable results for less frequently traded securities, as there isn't enough information
- uses uniform measure for all securities, even though in practice their exposure varies (e.g. two-week holding period is overly excessive for short-term instruments)

7. Conclusions

The fact that VAR is a single uniform measure of market risk across a range of investments is both its advantage and shortcoming. The single number as a risk measure is a convenient and transparent daily indicator of the potential market exposure. The requirement for its calculation imposes discipline on accounting and mark-to-market procedures, as there is a daily deadline to be adhered to. Nevertheless, a single standard regarding the holding period, exposure calculation and mark-to-market is far from ideal. Exotic derivatives products often do not have suitable market data for VAR inputs. Two week holding periods are often deemed excessive for short-term securities. Even the approved internal VAR models still require allowance of error margins, increasing the reported value by three. Despite its rigidity, VAR tends to fail in extreme circumstances, due to the assumption of normal markets and no trading. Once those conditions are breached, it becomes meaningless. Stochastic simulation is superior of all VAR methodologies. It does not pose any assumptions and limitations, hence it can incorporate any scenario, including extreme data inputs.

References:

/1/ Holton, G. (2003), *Value-at-Risk: Theory and Practice*, Academic Press.
/2/ Jorion, P. (2006), *Value at Risk: The New Benchmark for Managing Financial Risk*, *3rd ed.*, McGraw-Hill.
/3/ Dowd, K (2005), *Measuring Market Risk*, John Wiley & Sons.
/4/ Manganelli, S and Engle, R (2001), *Value at Risk Models in Finance*, European Central Bank working paper series, Working Paper N^0. 75.
/5/ Bollerslev, T Engle, R and Nelson, D (1994), *ARCH Models*, Handbook of Econometrics, Elsevier Science B.V.

Zaključak : *Činjenica da je VAR opste prihvaćena i sveobuhvatna metoda za mjerenje tržišnog rizika za sve vrste finansijskih investicija predstavlja i prednost i manu. Jedna numerička vrijednost kao mjera rizika je jednostavna, transparentna i svima razumljiva svakodnevna indikacija o potencijalom finansijskom gubitku usled promijena na tržištu. Legalna obaveza za izračunavanje VAR uvodi disciplinu u knjigovodstvo i finansijku kontrolu, jer se mora poštovati dnevni rok za izračunavanje realne vrijednosti svih otvorenih pozicija na tržištu. Uprokos tome,*

jedinstven standard kad su u pitanju minimalni rok finansijke transakcije, kalkulacija potencijalnog gubitka i procjena trenutne tržišne vrijednosti investicije je daleko od indealnog. Minimalni investicioni period od dvije nedjelje je nerealno dugačak za kratkoročne finansijske instrumente. Takođe, interni modeli, odobreni od strane regulatornih tijela, i dalje moraju da izračunatu vrijednost VAR pomnože sa tri, da bi ostavili dovoljnu granicu za grešku. Uprkos svojoj striktnosti, VAR metodologija je beskorisna u ekstrmenim situacijama na berzi, jer je bazirana na pretpostavci normalnog tržišta. Kad ti uslovi nijesu ispunjeni, rezultati potpuno gube relevantnost i značenje. Stohastička simulacija je superiorna u odnosu na sve respoložive VAR metodologije jer nije bazirana na pojednostavljujućim prepostavkama i ograničenjima, pa se može adaptirati bilo kojem scenariju, uključujući extremne tržišne uslove.