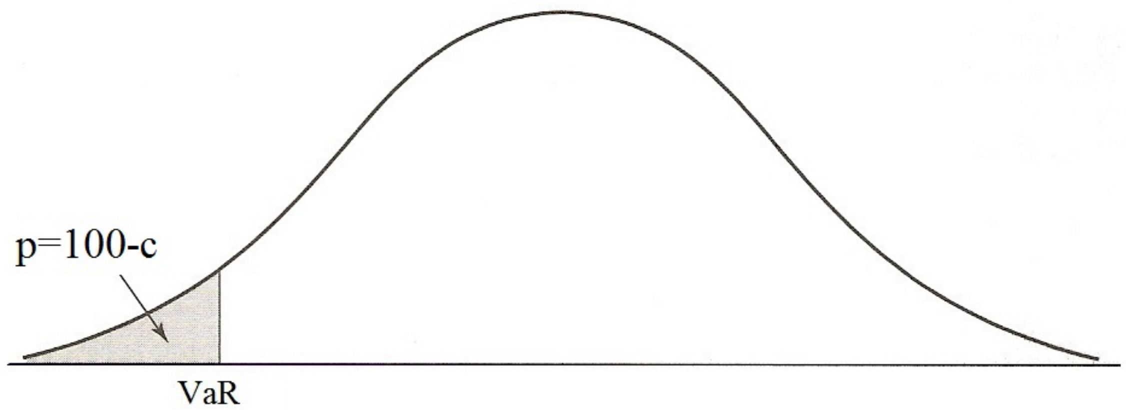
Executive Summary

Value-at-Risk (VaR) is in vogue. Since the 1990s it has continuously gained popularity and acceptance as a valuable risk figure in many different financial sectors. This financial-market risk figure was developed in response to the financial disasters that engulfed Barings, Daiwa, Metallgesellschaft and many other companies (Jorion, 2007). Soon after its launch VaR became a standard measurement for many institutions, banks and regulators. The last point lead to the use of VaR in calculating a bank's required capital reserve (Basel II Accord, 2005). Furthermore J.P. Morgan decided in 1994 to make their RiskMetrics database freely available to all market participants, which can be credited with stimulating scientists and rivals for further research in risk management.

Simply defined, Value-at-Risk is an estimate of maximum potential loss to be expected over a given period a certain percentage of time. More formally, VaR describes the p quantile of the projected distribution of gains and losses over the target horizon. A calculation of the VaR **x** is aimed at making a statement of the following form: "We are **c**% confident that the asset will not lose more than **x** dollars over the next **n** days." In this case c is the confidence interval and n is the time horizon. Both variables are free to choose by the researcher in dependence of his/her goals. However, most commonly the confidence intervals *99%*, *95%* and *90%* are used, whereas the time horizon is often between one and ten days (Hull, 2000). As Figure 1 shows p (100-c) is the quantile which equals the Value-at-Risk.

Figure 1: Payoff distribution and VaR



Source: Hull (2000)

As already mentioned VaR is used in many fields of the financial sector. It can be used to estimate the expected loss of individual products, portfolios and even whole companies, what makes it a tool for the regulatory. In response to the simplistic and insufficient capital requirements in the past, the Basel Committee introduced VaR as a possible influencer of the risk-based capital charges for commercial banks. These institutions are expected to have enough capital in order to be prepared for unexpected losses. In this case the VaR helps to set a minimum capital amount which according to the Basel II Accord (2005) is 3 times the VaR of the company.

There are several methods for computing the Value-at-Risk. On one hand, there are parametric calculations which derive VaR from parameters such as the standard deviation of the payoff distribution and multiplicative factors that depend on the confidence level. According to Jorion (2007), parametric methods can be applied not only to the normal distribution but also to every other distribution where all the uncertainty is contained in σ. The most common parametric methods are the *delta-normal valuation* (DN) and the *Monte Carlo simulation* (MC). The delta-normal method uses partial derivatives of the asset to compute the VaR. Therefore the value of the asset is calculated only once - at the current position. Although the DN can be computed very fast and is amenable to analysis it is not used in this research. The reason is that this method is inadequate for nonlinear instruments, such as option which are the main part of structured products. Monte Carlo simulations in contrast are very much applicable to options and derivatives. This parametric approach generates random price paths of the asset and uses the distribution of their returns in order to calculate the VaR. It can account for fat tails, nonlinear instruments and extreme scenarios. Although MC is a very powerful tool to compute the VaR, one should take into account that it has a relatively high computational time and is thus expensive in use.

On the other hand nonparametric methods such as the *historical simulation* (HS) offer a simplified approach to compute Value-at-Risk. The historical simulation goes back in time and replays the past events on the current positions. It assumes, in particular, that the historical prices of a stock can be used to estimate its price in the future. HS is very intuitive and simple to calculate. Furthermore it accounts for fat tails and does not require distributional assumptions which makes it very robust. Unfortunately HS has a very significant drawback - it depends on a historical data set. In turbulent and unstable periods, such as the financial crisis which started in 2007, historical data may bias the calculations.

It is worth to mention that the Monte Carlo simulation and the historical simulation are quite similar, except that the hypothetical changes in price ΔS are computed from stochastic processes in the first case and from historical data in the second case.

This paper concentrates on the calculation and efficiency of VaR for structured products. As a combination of derivatives and classical assets, such as stocks or bonds, these products have more complex and exotic properties than most of the other financial products. As this asset class is relatively young, it has to be proven that methods, which were developed for other assets, are applicable. VaR has been used since its beginning to measure the risk for derivatives and stocks, but does this mean that it can be used on a combination of both? Structured products are booming in Europe, especially in Germany and in Switzerland, and although the market suffered from the financial crisis, the volume of the Swiss derivative market is rising again in 2011 (Stocker, 2011).

One of the reasons for this rise may be the Value-at-Risk figure. In order to return the trust of the investors and to make the structured products market more transparent the Swiss

Structured Products Association (SSPA) launched VaR in July 2009 as a risk measuring and comparing figure (www.svsp-verband.ch). The VaR has already been computed by several issuers and institutions (RiskMetrics, European Derivatives Group etc.) but the computing methods were quite different and not comparable to each other. Since launching RiskMetrics, which was chosen by the SSPA for computing the official VaR, is covering currently more than 85% of the products on the Swiss structured products exchange Scoach. The used computing method is the historical simulation and the VaR itself is for the time horizon of ten days with a confidence interval of 99% . Although it is to be discussed if VaR is an appropriate risk figure for structured products and if the historical simulation is a good computing method, the decision to use VaR on market level seems to be the right idea. According to Hens and Rieger (2009), most of the structured products are emotionally driven and offer a utility gain for investors which is most likely only an illusion. Thus a risk figure which is simple to understand and makes it possible for the investors to compare the risk between products seems to appeal exactly this emotional level, no matter if the chosen computing model fits best or not.

The goal of this study is to examine whether or not the model chosen by the SSPA is appropriate for this market and its environment (financial crisis). Furthermore, one tests the influence of the historical data by comparing the results of the historical simulation with one resp. two years influential time period to the ones obtained via the Monte Carlo simulation. All together, 12 different models (8 historical and 4 Monte Carlo), which vary in their choice of parameters, are be backtested and compared. As a result one aims to be able to make a suggestion which method and parameters for computing the Value-at-Risk fit best for the Swiss structured products market.

All in all over 70'000 VaRs for three different product types are computed and analyzed.

The resulsts from this thesis provide empirical evidence on the fact that Value-at-Risk is not fully applicable to structured products, at least not when it is computed with the two methods, historical simulation and Monte Carlo simulation. Although Value-at-Risk has become the state of the art in risk management, it should not be used and trusted blindly as none of the researched models was able to predict the risk for all products properly. Backtesting shows that almost every model overerstimates the risk and creates too high VaRs. Thus, the goal to find the most accurate and robust VaR calculating method for the Swiss market was not fulfilled. Even the model of the Swiss Structured Products Association (historical simulation for ten-days VaR with a p-value of 1%), which is used for all listed products, has failed.

The failure is attributable to the biased data generated by the turbulent past years, which creates too pessimistic scenarios for the historical simulation and influences indirectly the implied volatility for the Monte Carlo simulations. Thus, both methods create VaRs which are too high and therefore risk is being overrated. Hence the SSPA publishes VaRs which on one hand fail quite rarely but on the other hand unnecessary slow down investments,