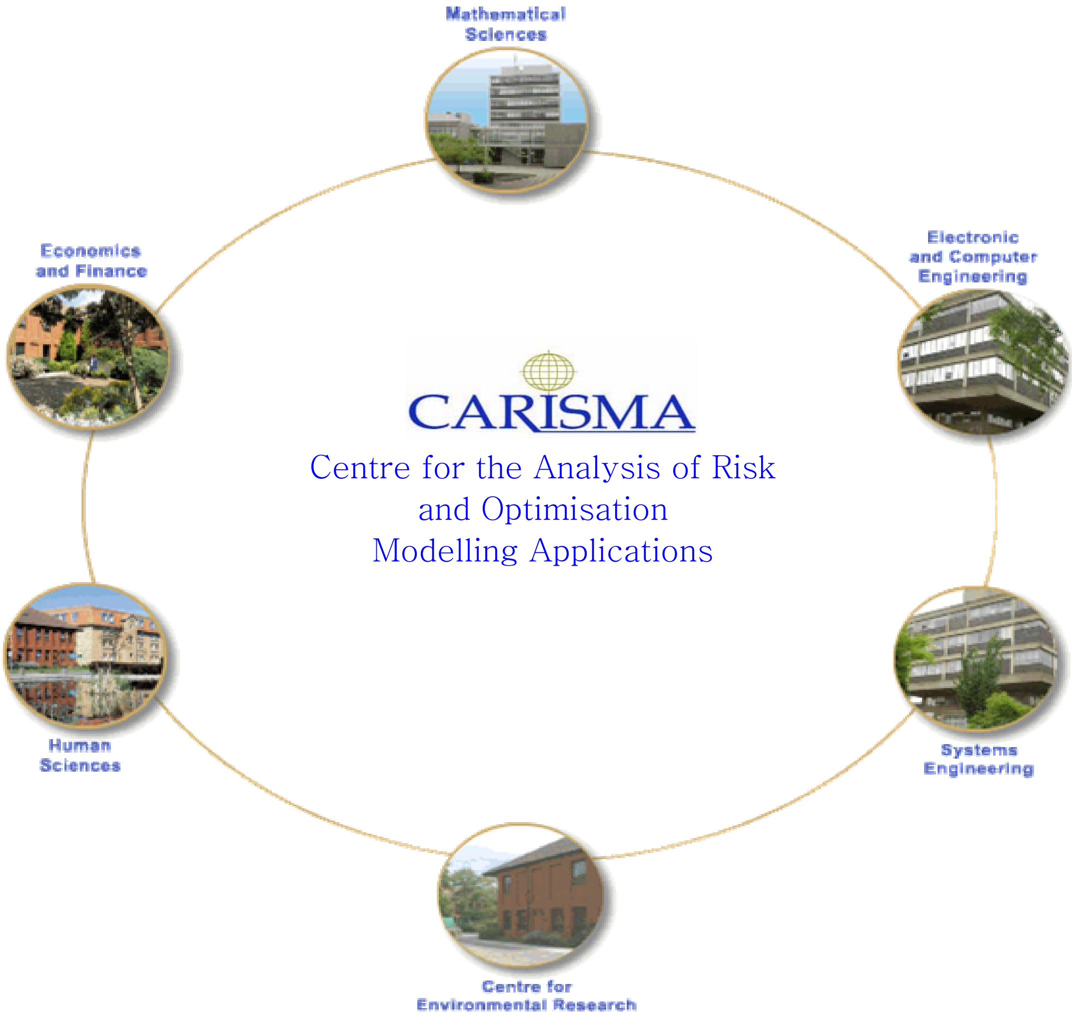

Using @RISK to calculate portfolio performance

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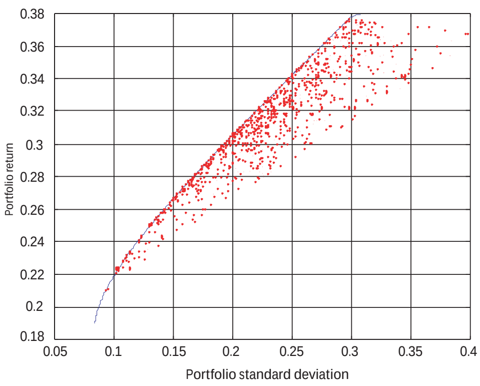
Measurements of risk are one of the most researched areas in finance. Various measures such as sensitivity and volatility have been suggested to capture the risks inherent in any portfolio of assets. However, these measures capture the variation of the market variable rather than the risk of losses. Risk analysis with @RISK produces results that are direct reflections of our uncertainty towards the distributions and/or parameters on which VAR and CVAR depend

Modern portfolio theory, which combines consideration of both mean and variance of portfolio returns, provides the framework for measuring the performance of a portfolio. This mean-variance (M-V) framework attributed to Markowitz, provided financial institutions and portfolio managers with a powerful tool that allowed them, for the first time, to utilise the concepts of risk and return in a combined paradigm. Despite the progressive acceptance and wide-spread use of the M-V framework and its numerous extensions, there has been a considerable debate among academics and practitioners on the validity of variance as a representative measure of risk. Deciding which types of risk to mitigate is the first dilemma of a financial institution and requires considerable attention. Focusing on one particular risk category may lead to a hedged portfolio for a particular source of risk but may result in exposure to other sources of risk. This issue becomes more challenging when optimisation models are used. For instance, optimisation may result in minimisation of the risk included in the model but the solution may be sensitive to other sources of risks that were not considered and better measured by another metric.

The incorporation of risk in the investment decision process should also reflect the benchmark relative to which a financial institution or individual assesses its portfolio performance. Portfolio performance can be measured relative to a benchmark index or an alternative investment opportunity. In this case, the risk measure is also a function of a target level of return. The standard deviation in this case would then reflect the deviation of the asset returns from the expected target return (eg, FTSE100). In particular, the portfolio return approach is mostly suitable for maximum return strategies, whereas the target return framework is suitable for 'index tracking' or 'goal achievement' strategies. These two approaches lead to different asset mix decisions and, therefore, choosing the appropriate risk framework becomes the second dilemma for financial institutions.

We discuss a number of alternative performance measures and calculate two of them – value-at-risk (VAR) and conditional-value-at-risk (CVAR) – using @RISK. @RISK is the Risk Analysis and Simulation add-in for Microsoft Excel®. @RISK uses a technique known as Monte Carlo simulation to allow the user to take all possible outcomes into account. The performance measures can be categorised into symmetric and asymmetric measures. The symmetric measures quantify risk in terms of probability-weighted dispersion of returns around a specific reference point, usually the

Figure 1. Efficient frontier



expected value. Two of the most well-known and widely applied risk measures in this group are Markowitz' variance or standard deviation and the expected or mean absolute deviation (MAD) of Kono and Yamasaki (1991). The asymmetric measures quantify risk according to results and probabilities below reference points, selected either subjectively or objectively. Such risk measures include the Expected value of loss from Domar and Musgrave (1944), Roy's (1952) Safety first, the Semi-variance proposed by Markowitz (1959), Value-at-risk – VAR – (JP Morgan, 1993) and its extension Conditional VAR – CVAR – (Uryasev (1998)), and Fishburn's a-t criterion (1977).

Performance measures can be calculated for the current portfolio of assets a decision-maker is evaluating, or they can be calculated for an efficient portfolio. An efficient portfolio is one that lies on the efficient frontier. The efficient frontier represents the combination of portfolios whose standard deviation is a minimum at each level of return. In this article we use @RISK to determine the efficient frontier and then calculate performance measures from this reference point.

Calculating the efficient portfolio

We begin with three stocks, Microsoft, Intel and GE. Using 10 years of historical data, from July '93 through July '03, and sampling 12 monthly growth rates from the 10-year history, we generate 10,000 price realisations for July '04, via Monte Carlo simulation using @RISK.

Next, given a starting set of weights for each stock, 35% for Intel, 40% for Microsoft, and 25% for GE, we calculate the portfolio return for each realisation. Next, we use the Excel Solver to find one portfolio that is on the efficient frontier. We use Solver to find the set of weights that minimises the standard deviation of the portfolio returns subject to having the mean of the returns being at least 37.5%. Next, repeatedly perform this calculation for different values of required return in the range (5.0% through 37.5%) in discrete increments. The result can be seen in figure 1. The red dots represent the plot of numerous portfolio standard deviation-return combinations. The black line is the Solver-calculated efficient frontier – that combination of portfolio return-standard deviations that is the lowest for each possible return value.

Calculation of performance measures

With the efficient frontier calculated, we choose the portfolio with weights Intel = 0.351, Microsoft = 0.596 and GE = 0.054. The mean and standard deviation of this portfolio are 0.375 and 0.502, respectively. VAR and CVAR are defined below and calculated.

VAR

The rationale of any risk measurement system and summary statistic is to facilitate risk reporting and control decisions. A former chairman of JP Morgan, Dennis Weatherstone, demanded to know every day by 4:15 pm the total market risk exposure of the firm. This prompted the launch of RiskMetrics, and a program that provided the required information, thus popularising VAR. The β-VAR of a portfolio is generally defined as the possible maximum loss over a given holding period, assuming a confidence level β. If β-VAR is positive, the portfolio needs to be adjusted to be less risky. A negative β-VAR indicates that the portfolio can accommodate a more risky position. The measure VAR is used by financial institutions to quantify current trading exposures especially since the Basel Committee accepts VAR as a risk measure. VAR also monitors customer credit exposure, sets exposure limits and enforces collateral requirements. In addition, VAR can be used as a summary risk measure across different financial instruments and business activities. VAR as a measure is an approximation of the maximum reasonable loss an institution can expect to realise from all its financial exposures.

The VAR can be calculated from the data described above. Using the portfolio with mean return = 0.375 and standard deviation = 0.502, the 95% VAR is –0.29 – 0.375 = –0.665. That is, there is a 95% chance that the portfolio return could decline 0.665 relative to the target return of 0.375.

CVAR

Embrecht et al (1997) and Artzner et al (1997, 1999), introduced CVAR, also known as excess loss, mean shortfall, or expected shortfall, which is a meaningful extension of VAR

Figure 2. Plot of VAR and CVAR

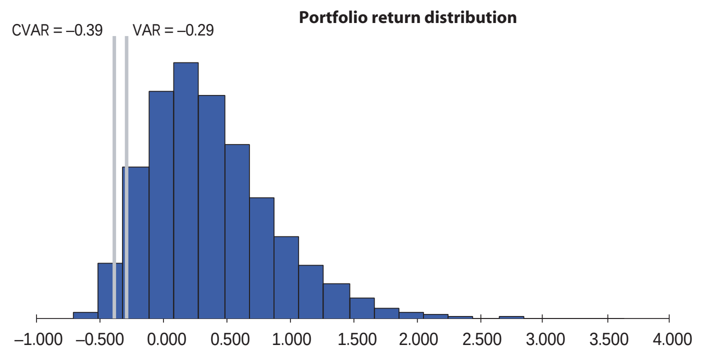
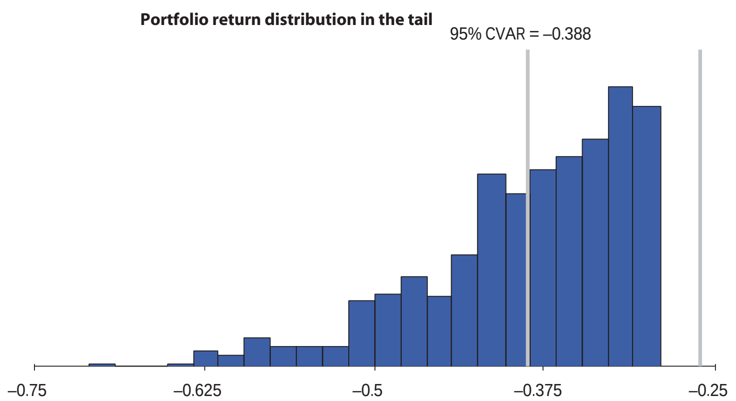


Figure 3. Plot of CVAR



as it focuses on the behaviour of the 'tail'. The definition of CVAR at a specified level β (β = 0.95 or 0.99) is the mathematical transcription of the concept 'average loss in the worst (1–β) cases' . The 95% CVAR for our portfolio is -0.388. That is, there is a 95% chance that the average return could be as low as –0.388. This calculation can be done easily in @RISK using the filtering capability. For this conditional distribution, eliminate all observations except the lowest 5% of the 10,000 realisations. The graph of this tail is shown in figure 3.

A simulation model emulates a situation incorporating uncertainty in one or more quantities.In recent years, spreadsheet simulation modelling has become extremely popular, both in academic and corporate communities and especially in the finance sector. The reason for this popularity is due to simulation add-ins such as @RISK. There are two primary advantages to using such an add-in. First, the add-in gives easy access to many probability distributions that the end user might want to apply in the simulation models. Second, as demonstrated in this article, the add-in makes important calculations, such as VAR and CVAR a straightforward exercise. The random number generator in @RISK plays a key role in many aspects of the stochastic analysis, including search and optimisation. If we rely only on built-in Microsoft Excel functions, we are quite limited in the probability distributions used for simulation models. Risk analysis in @RISK is a quantitative method that seeks to first determine the outcomes of a decision as a probability distribution and then measure the associated risk.

Computational procedures

There are various specialist methods to construct the efficient frontier. In this paper, we illustrate building the efficient frontier using @RISK. A detailed discussion of this model is by Winston (2000, 2001).

We assume a universe of three stocks, Microsoft (MSFT), Intel (INTC), and GE (GE). Although the M-V model requires the computation of stock returns and covariance, we approach the estimation of these parameters in a different way. We wish to have the estimates of these parameters a year from now so that our portfolio problem is an annual decision-making model. We enter the last 10 years (01-Jul-93 to 01-Jul-03) of monthly stock prices for MSFT, INTC and GE into the columns of our spreadsheet and compute their monthly returns. Then, we use simulation with @RISK to derive estimates for our model parameters. We sample 10,000 future estimates of each stock return from the rows of our historical data which ensures that each forecast stock return maintains the same correlations with the other stocks as observed in the past.

Mitigation using put options on the assets

The analysis can be extended to include mitigation of exposure if the portfolio VAR does not meet the risk appetite of the decision-maker. One method is to purchase put options for the underlying assets in the portfolio. This exercise is left to the reader.

Summary and conclusions

In this article we have set out how a simulation approach [using @RISK] can be used as a simple but effective financial planning tool. The formal process of risk analysis consists of the following steps: (1) develop the analytical model to address the area of interest; (2) identify the risks, (2) quantify the risks, (3) perform the risk analysis using @RISK, (4) present the results, (5) make the decision based on the decision-maker's risk appetite: mitigate, terminate or proceed.

This methodology can be equally applied to other areas: industrial project risks, environmental risks, public sector and business planning. In all these domains, risk-based planning has become and important and essential management tool.

About Palisade Corporation

Company overview

Founded in 1984, Palisade Corporation has been the leader in the decision analysis software industry. Since the introduction of PRISM, the first Monte Carlo simulation package for the PC, Palisade has refined and expanded the software tools available to executives and academics in the area of risk and decision analysis. Palisade's decision analysis software includes the DecisionTools® Suite: @RISK, TopRank®, PrecisionTree®, BestFit®, and RISKview™. The @RISK Developers Kit, @RISKAccelerator, @RISK for Project, Evolver™, and RISKOptimizer® round out the product line. These programs analyse risk, run Monte Carlo simulations, perform sensitivity analyses, create decision trees and influence diagrams, fit data to distributions, and solve optimisation problems. Palisade's ingenuity in software development is one of the driving forces behind the company's position at the forefront of the industry.
http://www.palisade.com/

The centre for the analysis of risk and optimisation modelling applications (CARISMA)

Executive summary

CARISMA has been set up through the strategic research initiative of Brunel University. The mission of CARISMA is to be a centre of excellence recognised for its research and scholarship in the analysis of risk, optimisation modelling, and the combined paradigm of risk and return quantification. CARISMA's researchers investigate theoretical as well as industrially relevant research problems, collaborate with important industries and network with other international research centres. CARISMA actively pursues industry sponsored research and PhD research students with excellent academic training and industrial experience. For details of current research programmes, professional courses and list of publications visit http://www.carisma.brunel.ac.uk

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