Enhancing Risk Management and Governance in the Region's Banking System to Implement Basel II and to Meet Contemporary Risks and Challenges Arising from the Global Banking System

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Session 3.1

Value at Risk

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Value at Risk

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Plan

- What is risk?
- How can we measure risk?
- Some experiments
- VaR as a useful risk measurement tool
- Three approaches to calculating VaR
- VaR applied to loan portfolios
- Conclusion

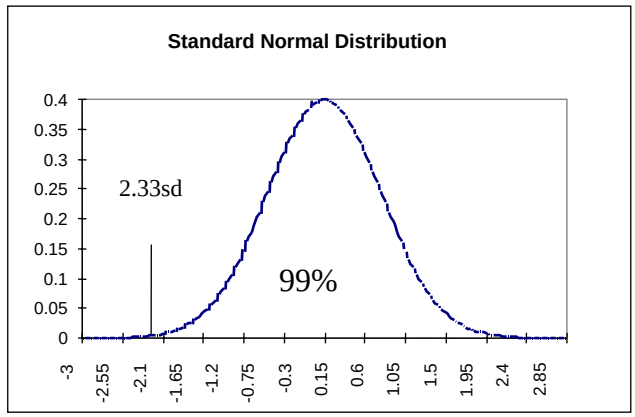
Risk

- Risk
  - variability of future values of key economic variables
  - possibility of both ups and downs
  - danger plus opportunity
  - technical measurement
    - standard deviation (volatility) of probability distribution of future outcomes
    - measures the dispersion around expected value weighted by the probability of occurence

Probability Distributions

- One way of quantifying risk is to describe outcomes and probability of occurrence in terms of a probability distribution
- Most people have heard of the normal or bell-shaped distribution
- The normal distribution can be described by its mean and standard deviation

Normal distribution



99% of the distribution lies to the right of a point 2.33 standard deviations to the left of the mean

Risk quantification

- Risk is measured as standard deviation of returns
- Then translated into dollar amounts for a particular situation
- What is a one standard deviation price movement in a particular market (eg the price of oil)?
- A tolerance for risk is defined either in terms of a probability or number of standard deviations
- For example, there is a 66% probability of a one standard deviation movement either way
- These concepts can be described in one term -

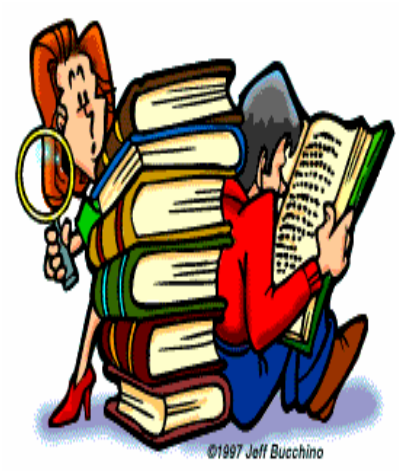
Value at Risk - VaR

- VaR is a measure of the minimum loss that would be expected over a period of time for a pre-specified small probability
- For example a VaR of $1 million over the next day at a probability of 0.05 implies that the firm would expect to lose at least $1 million over the next day 5 percent of the time - one day in twenty
- Or the firm can expect not to lose more than $1m over the next day 95 percent of the time

VaR

- VaR is a useful device for measuring the market risk of a portfolio
- It is useful in management reporting
- Three attributes are required when reporting a VaR:
- A dollar amount
- A level of confidence
- A time horizon or planning horizon

Quiz – Experiment 1



- Hersch Shefrin, “Beyond Greed and Fear”, Harvard Business School Press, 2000.

Overconfidence

- Count an answer as a hit if the correct answer lies between your low guess and your high guess
- Count an answer as a miss if the right answer falls outside the range between your high guess and your low guess
- What score did you get?
- Someone who is well calibrated should miss no more than one question.

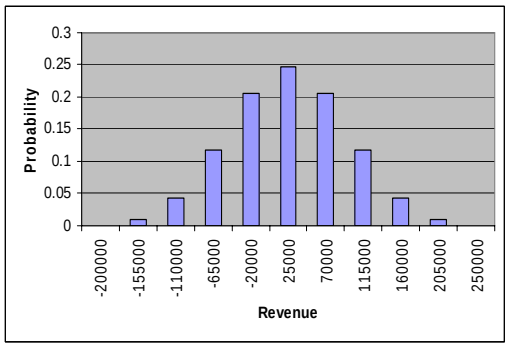
Lessons

- If you are overconfident then you will have more than one miss in the eight questions
- For risk management in order to have accurate confidence intervals we need to get reliable estimates of likely changes in interest rates, default frequencies etc
- We use history and statistics to develop a reliable VaR number

Experiment 2

- Imagine that you have a portfolio of 10 loans that will turn out to be “good” or “bad”.
- At the end of the year good loans earn a profit of $25,000 each and bad loans lose $20,000 each
- There is a 50% chance of making a good loan and a 50% chance of making a bad loan
- Write down the number that you think you will have a 5% chance of earning less (losing more) than.
- Best outcome is 10 ◈ $25,000 (all good loans)
- Worst outcome is 10 ◈ -$20,000 (all bad loans)

Outcomes



- Probability of loss = 38%
- For 10 tosses the VaR at a 5% confidence level is -$110,000
- How close was your VaR estimate?
- I am 95% confident that I will not lose more than $110,000 on my loan portfolio

Recall….

- There are three things necessary to document the VaR number:
  - A dollar amount
  - A level of confidence
  - A time horizon or planning horizon
- VaR is a tool to aggregate risks in to a single number
- It relies on models and/or market data….

Issues in Determining Value at Risk

- VaR is a single dollar amount that portfolio losses are not expected to exceed, with a specified degree of confidence, over a specified horizon, under normal market conditions.
  - What method will be used to calculate VaR?
  - What is the position ?
  - What is the time frame of interest ?
  - What are the critical financial prices causing exposure ?
  - How do we determine the probability of possible losses from position ?
  - What confidence level do we want to have ?
  - How do we determine whether calculated VAR is acceptable ?

VaR - methods of calculation

There are three main approaches to the calculation of a VaR number for a portfolio

1. The analytical method also called the variance-covariance method
2. The historical simulation method
3. The Monte Carlo simulation method

Each method has strengths and weaknesses

Three methods

- All methods can take comovements into account.
- The analytical technique assumes a normal distribution
- Historical simulation takes a current portfolio and 'pushes' it through past market data, to calculate gains and losses on the portfolio if the market behaved as it did in the future
- It then arranges outcomes from lowest to highest
- Monte Carlo simulation uses a model to simulate outcomes

Example- Historical simulation

- The historical method estimates the portfolio's performance by collecting data on the past performance and using it to estimate the future probability distribution
- Assume 500 days of past data
- Arrange portfolio outcomes from largest loss to largest profit
- The VaR at 95% will be the 25th observation

Exposure
-14.3802
-13.885
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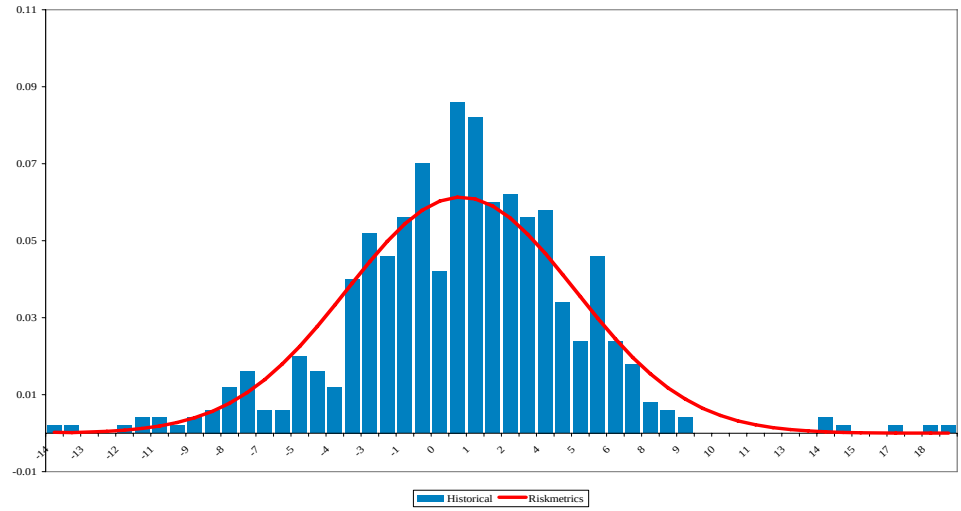
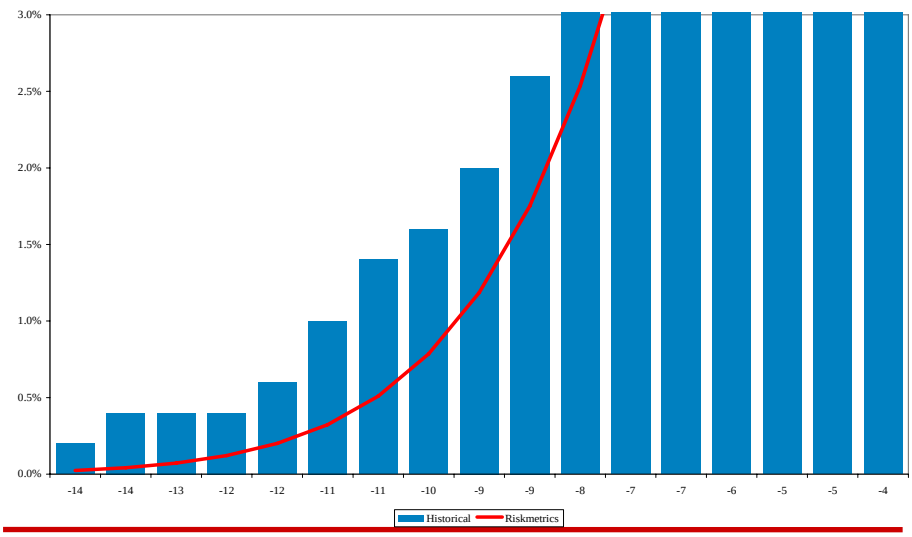
Distribution of portfolio returns



Fat-tails



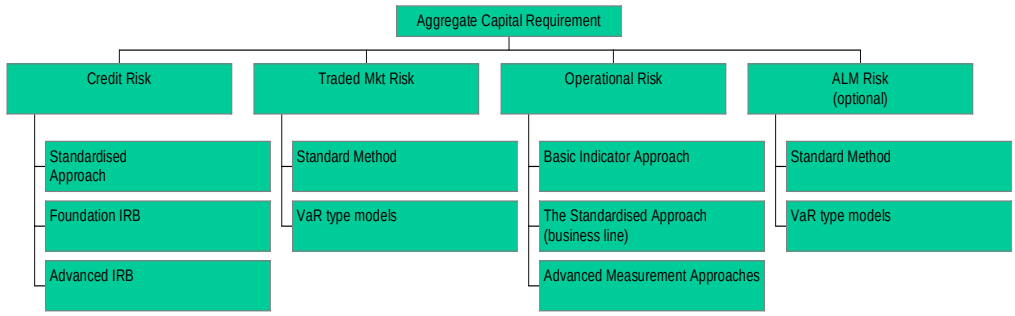
Examples

- LTCM had capital of $4.7b and a monthly (95%) VaR of $448m in April 1998 . On August 21 1998 it lost $551m (more than 10 times daily target vol)
  - Why?
- Signs of a bad model
  - In the case of UBS, 2007 saw its first exceptions since 1998...In the third quarter of 2007, UBS reported 9 exceedances at 99%. (Risk, February 2008).
  - The period without excessions was 100 times less likely than the 9 exceedances assuming a good model.

Use of VaR in banks

- At the beginning of 1998 in the US (1997 for the European community) regulators allowed certain large banks discretion to calculate the capital requirement for market risk using the VaR approach.
- Correlations are taken into account
- VaR is to be measured at the 99% confidence level over a ten day horizon
- Models are backtested

Basel 2: structure



Market vs credit risk

- VaR applied to market risk seeks to answer the question: “If tomorrow is a bad day, how much will I lose on tradable assets such as shares, bonds, currency?”
- VaR applied to credit risk seeks to answer: “If next year is a bad year how much will I lose on my loans and loan portfolio?”

The Market Risk Capital

- The VaR measure used by regulators for market risk is the loss on the trading book that can be expected over a 10-day period 1% of the time
- The capital requirement is

$$k \times \text{VaR} + \text{SRC}$$

where k is a multiplicative factor chosen by regulators (at least 3), VaR is the 99% 10-day value at risk, and SRC is the specific risk charge (primarily for debt securities held in trading book)

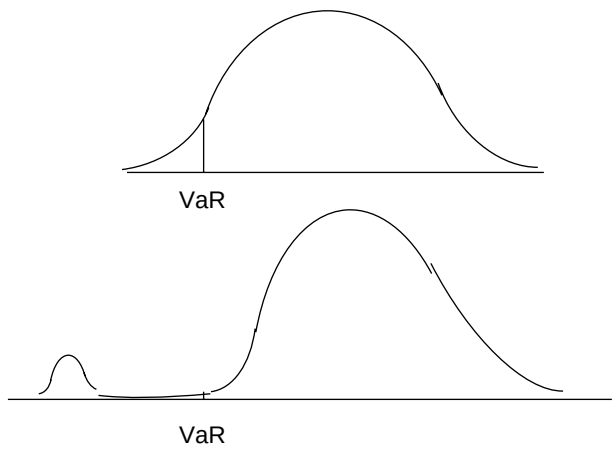
Credit VaR

- Loans are not publicly traded
- However using
  - available data on a borrower's credit rating
  - the probability that the rating will change over the next year
  - recovery rates on defaulted loans
  - credit spreads and yields in the bond (or loan) market
- It is possible to calculate the market value and the volatility of the loan portfolio
- These methods form the basis for the internal models approach under the new BIS standards

VaR vs. Expected Shortfall

- VaR is the loss level that will not be exceeded with a specified probability
- VaR does not specify the maximum possible loss
- Expected shortfall is the expected loss given that the loss is greater than the VaR level (also called C-VaR and Tail Loss)
- Two portfolios with the same VaR can have very different expected shortfalls

Distributions with the Same VaR but Different Expected Shortfalls



Conclusions

- VaR is a powerful tool for consolidating in a single number, risk across a portfolio of assets
- It provides a mechanism for containing risk within acceptable limits
- It is a powerful communication tool and for consolidating a measure of risk across portfolios
- It **does not** predict the size of the maximum loss
- VaR is used by regulators to set minimum capital requirements
- CreditVaR can be used to measure the risk of a loan portfolio
- It forms the basis of the new BIS standards

Value at Risk

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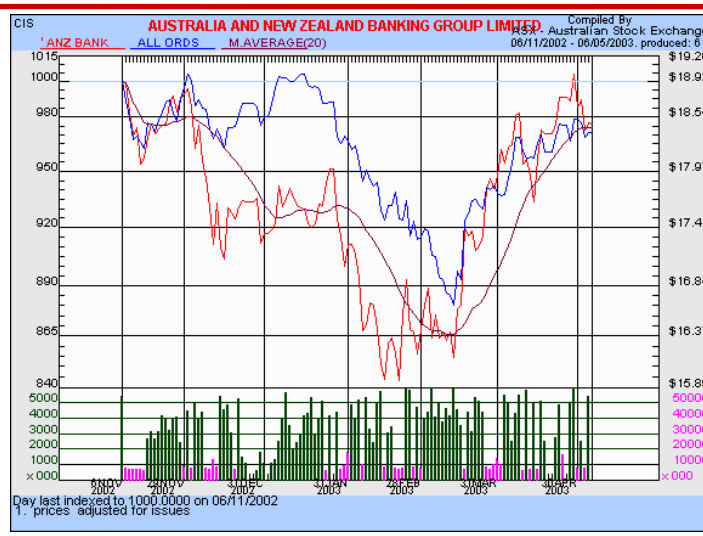
VaR for a single asset portfolio

- The date is 6 May 2003
- Suppose you hold a portfolio of 1000 ANZ shares
- The shares are trading at $18.48 (AUD)
- The volatility of returns on ANZ shares over the past 12 months has been measured as 21% p.a.
- How could you measure the risk of your portfolio over the next month?

ANZ share movements



VaR for a single asset portfolio

- We need to specify a confidence level and a time horizon
- Suppose the confidence level is 99%, time horizon we are given is 1 month
- Standard deviation over 1 month is 0.21/⌦12 = 0.06
- Standard deviation of price change is $18.48◈0.06 = $1.11
- Now assume price changes are normally distributed
- The area under the normal distribution carries information about probabilities
- A 99% confidence level is 2.33 standard deviations
- There is a 1% probability that you will lose more than 2.33 ◈$1.11=$2.58 on one ANZ share

VaR for a single asset portfolio

- On 6.5.2003 holding the portfolio of ANZ shares that is worth $18,480, I am 99% confident that I will not lose more than $2580 over the next month.
- The probability that I will lose more than $2580 over the next month is 1%.
- Note that reporting the VaR does not give any idea of what the largest possible loss might be.

VaR for multi-asset portfolios

- Diversification across different securities causes the risk of a portfolio to be lower than the risk of individual security investments
- The lower the correlation between pairs of assets the greater the benefits of diversification in reducing the risk of the portfolio
- The correlation coefficient measures the scale of the comovement between pairs of assets on a scale from -1 to + 1

1. The analytical method

- A market making bank in foreign exchange calculates aVaR for the trading desk
- Having the currency data enables the bank to calculate correlation structure and the variance- covariance matrix
- This allows the bank to calculate a one-standard deviation movement (in dollars) of our portfolio over the next trading day
- Now assume that the distribution of profits and losses on the portfolio is normal
- If we want a 95% level of confidence
- We need a 1.65 standard deviation movement

Example

- Let's use as an example a two currency portfolio, AUD and NZD
- We have 500 days of data for each currency
- We have measured the volatilities of each currency and their correlations (the covariance matrix)
- We also know how much the value of our portfolio changes for a 1% move in each currency (our exposure)
- We are interested in calculating the VaR over the next trading day

Data - Example

Delta			10,000	-9,000
	aud	nzd	aud(%ret)	nzd(%ret)
11/13/00	1.922338	2.531005		
11/14/00	1.926782	2.525253	0.230947	-0.22753
11/15/00	1.923077	2.513826	-0.19249	-0.45352
11/16/00	1.923077	2.495633	0	-0.72637
11/17/00	1.927154	2.498751	0.211763	0.12486
11/20/00	1.944769	2.528445	0.909889	1.181363
11/21/00	1.961554	2.55037	0.85938	0.863388
11/22/00	1.906578	2.501251	-2.84269	-1.94475
11/23/00	1.915709	2.5	0.477784	-0.05001
11/24/00	1.912046	2.501251	-0.19139	0.050013
11/27/00	1.901141	2.464268	-0.57197	-1.4896

10/14/2002	1.830161	2.092926	0.365363943	0.66750352
10/15/2002	1.828154	2.087683	-0.109749417	-0.25083625
10/16/2002	1.829157	2.088555	0.054859652	0.04176237

AUD and NZD portfolio

- We calculate the mean and standard deviation of portfolio profits and losses over the 500 days
- Mean = .2465 (USD 000s)
  Standard deviation = 4.187 (USD 000s)
- Therefore assuming a normal distribution for profits and losses a 95% VaR on the portfolio is USD6,662
- That is we are 95% confident that over the next day we will not lose more than USD6,662
- We are 99% confident of not losing more than USD9,757 over the next day

Variance-covariance approach mathematics

- To calculate the VaR of a portfolio.
- Set up the problem in a spreadsheet
- Calculate the variance-covariance matrix (V) of the (usually daily) returns
- You are given the delta (sensitivity of the position in each currency to a movement in the underlying)
- The delta (D) is given as the dollar change in the position for a 1% movement in the currency
- For a 99% VaR

$$VaR = 2.33 \times \sqrt{D \times V \times D^T}$$

The analytical method - problems

- Actual historical distribution of financial price movements not normal
  - "fat tails" common
- Stability versus relevance of historical estimates
  - long data period increases stability
  - short data period increases relevance
- Choice of appropriate expected change in financial price as basis for calculation
  - zero versus some theoretical measure

2. Historical simulation

- The historical method estimates the portfolio's performance by collecting data on the past performance and using it to estimate the future probability distribution
- Assume 500 days of past data
- Arrange portfolio outcomes from largest loss to largest profit
- The VaR at 95% will be the 25th observation
- For our NZD/AUD example, the VaR at 95% is USD7,405
- Recall that the VaR measured using the analytical approach was USD6,662

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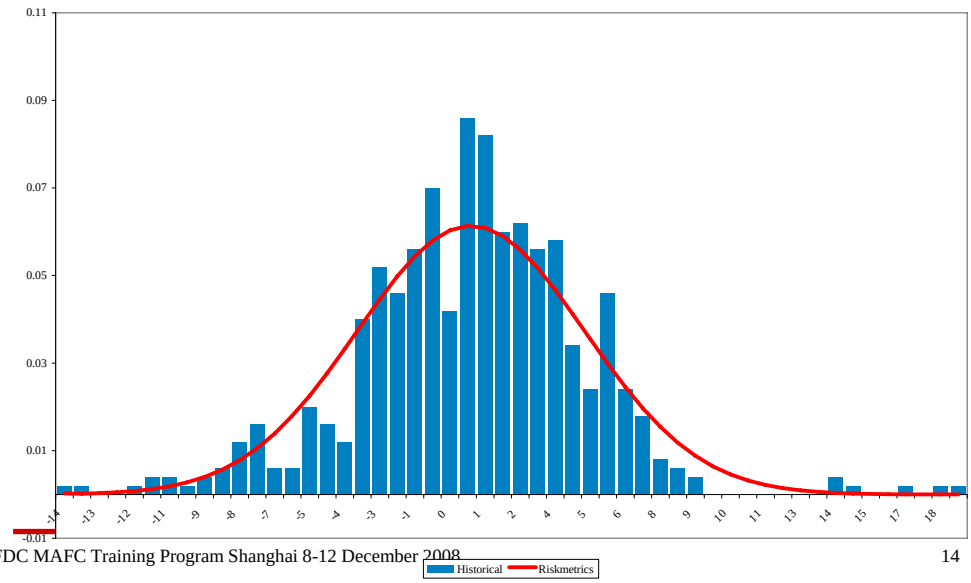
This is the same data for the NZD/AUD portfolio over the past 500 days

Distribution of portfolio returns



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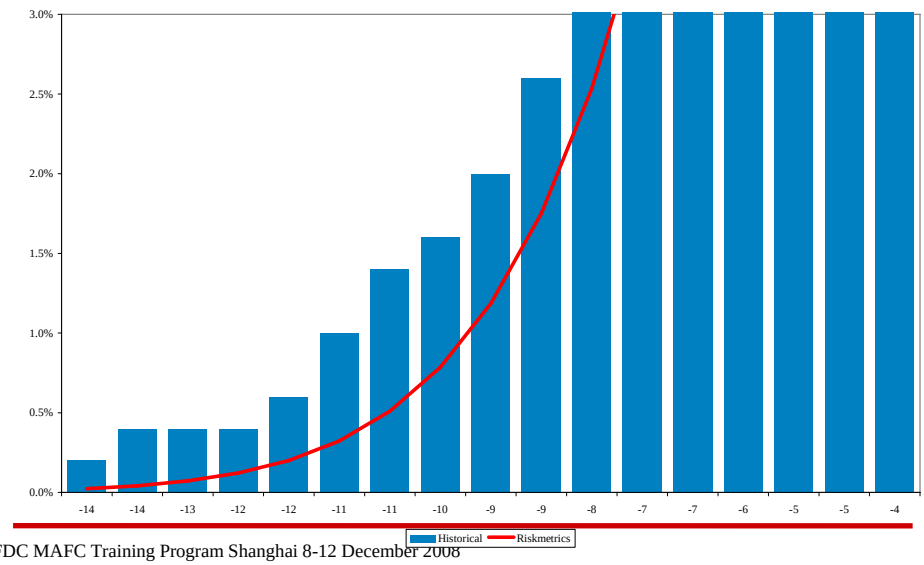


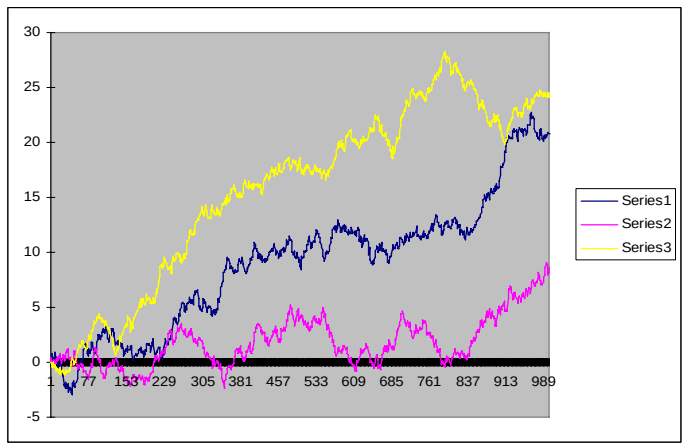
Historic Simulation

- Advantages
  - no prior assumptions necessary about shape of distribution
  - easy to implement
  - calculates value at risk directly
- Disadvantages
  - appropriate historical period to use
  - stability of distribution over time
- Comparison with analytical approach
  - If the distribution you are working with has fat tails then the analytical VaR will usually be smaller than the VaR calculated with historical simulation

3. Monte Carlo simulation

- This method is based on the idea that portfolio returns can be easily simulated
- Simulation requires inputs on expected returns, standard deviations and correlations for each financial instrument
- Monte Carlo simulation is probably the most widely used method by sophisticated firms
- It is flexible because it allows the user to assume the probability distribution.

Monte Carlo Simulation



Monte Carlo Simulation

- Neither analytical nor historical simulation approach can adequately deal with portfolios with options (nonlinear portfolios).
- Monte Carlo simulation allows the whole portfolio to be revalued at the horizon
- Use historic variances and correlations to generate a series of sample paths through price space.
- Revalue the position through each of these scenarios and look at the distribution of price changes.
- A good approach for nonlinear portfolios.

A comparison of the three methods

- All methods can take comovements into account.
- The analytical technique assumes a normal distribution
- Historical simulation takes a current portfolio and 'pushes' it through past market data, to calculate gains and losses on the portfolio if the market behaved as it did in the future. It then arranges outcomes from lowest to highest. It does not make assumptions about the underlying probability distribution.
- Monte Carlo simulation uses a model to simulate outcomes – inputs are important. It can be used for nonlinear portfolios such as options.