CROWN AGENTS INVESTMENT MANAGEMENT

MONTE CARLO SIMULATION

GENERATING SCENARIOS THAT CAN BE USED TO MEASURE PORTFOLIO RISKS

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USING SCENARIOS

- Suppose you want to build a bond portfolio to perform well over the next little while, but without taking on too much risk.
- You have views about how yields of different maturities in different markets will move.
- You have high levels of confidence in some of your views, less confidence in others.
- You have no views on how returns of bonds will move together, so default to using historical return correlations.
- If you can generate scenarios that capture your views on bond returns and risks, as well as on correlations, you have a powerful tool for evaluating the returns and risks of any portfolio of those bonds.

There are a number of ways of achieving this

GENERATING SCENARIOS

- Commonly-used ways of obtaining scenarios include:
  - Just use history
  - Boot-strapping
  - Monte Carlo simulation

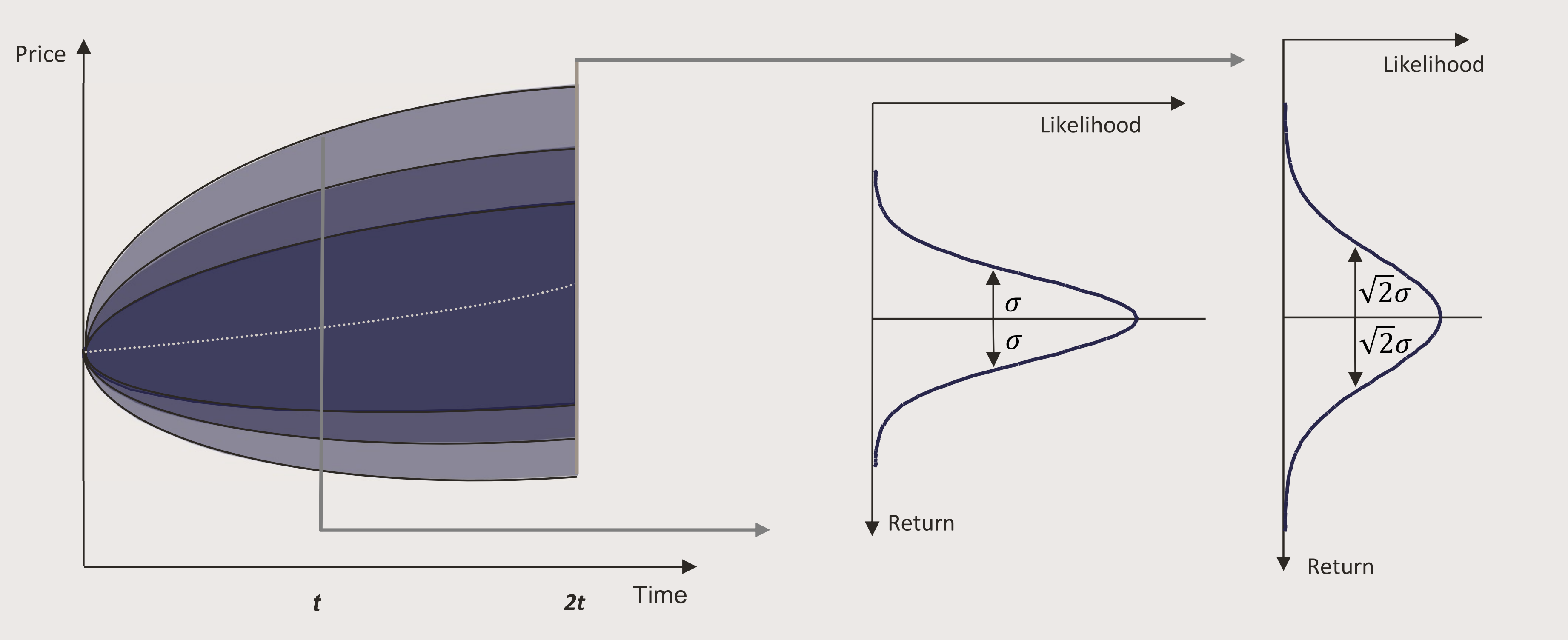
- Once you have a set of scenarios you can see how any given portfolio performs within it

- The range of performances across scenarios gives you a measure of the expected risks and returns of a portfolio and gives you a framework in which you can investigate the effects of changing your portfolio holdings.

Using scenarios helps create robust portfolios which leverage your market views in a risk-efficient manner

THE "STANDARD MODEL"

Returns follow a normal distribution



- Ignoring dividends and coupons, prices evolve such that asset returns are normally distributed
- Uncertainty – the breadth of return possibilities – increases with the square root of time

Our Monte Carlo simulation generates scenarios in line with this model

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Our objectives

- For each asset we want to generate a set of normally distributed returns – in line with the standard model.
- The mean returns and standard deviations of returns to match our chosen values.
- The correlations of returns between each pair of assets also has to match our requirements.

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The steps we'll follow to achieve this:

1. For each asset, we generate a set of uniformly-distributed random numbers between 0 and 1. These sets of numbers will be independent of each other, with correlations close to zero.

2. We'll then convert these to sets of normally distributed random numbers, each set having a mean of 0 and a standard deviation of 1. The sets will still be independent.

3. We'll then use a bit of algebra to convert these independent series of numbers into ones that are correlated as required.

4. Finally we squeeze or expand the series to match the required standard deviations, and shift them to obtain the required means.

THE “BIT OF ALGEBRA”

- It’s possible to factorise any correlation matrix **P** into two square matrices, **L** and **U**, such that:

$$\mathbf{P} = \mathbf{L} * \mathbf{U}$$

and where **L** is a lower triangular matrix, **U** upper triangular, and $\mathbf{L} = \mathbf{U}^{\mathbf{T}}$

- This is known as a *Cholesky decomposition*

- One nice effect of this we can use is that when we multiply our independent random normal series by the **L** matrix, we end up with correlated random normal series – the correlations being in line with the original correlation matrix **P**

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