**WEEK 3** HOW CAN WE REDUCE RISK?
FURTHER READING: WHAT IS NORMAL DISTRIBUTION?

To use the Black-Scholes option pricing model we assume the stock price follows a lognormal distribution, which is equivalent to assuming the natural logarithm of the stock price follows a normal distribution.
The normal distribution is symmetrical and is defined by its mean and its standard deviation. We can standardise a normal distribution so that it has a mean of zero and a standard deviation equal to one. A standardised normal distribution looks like this:
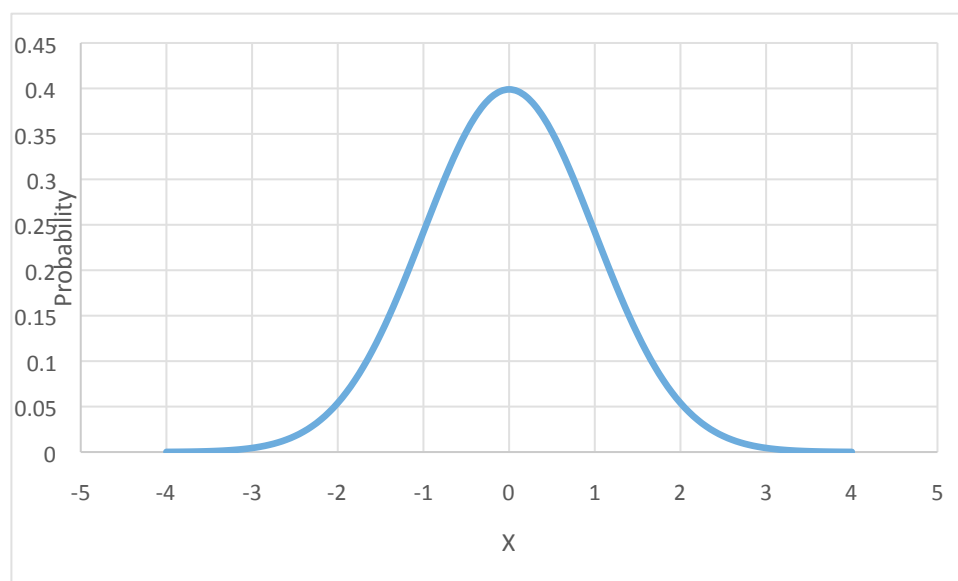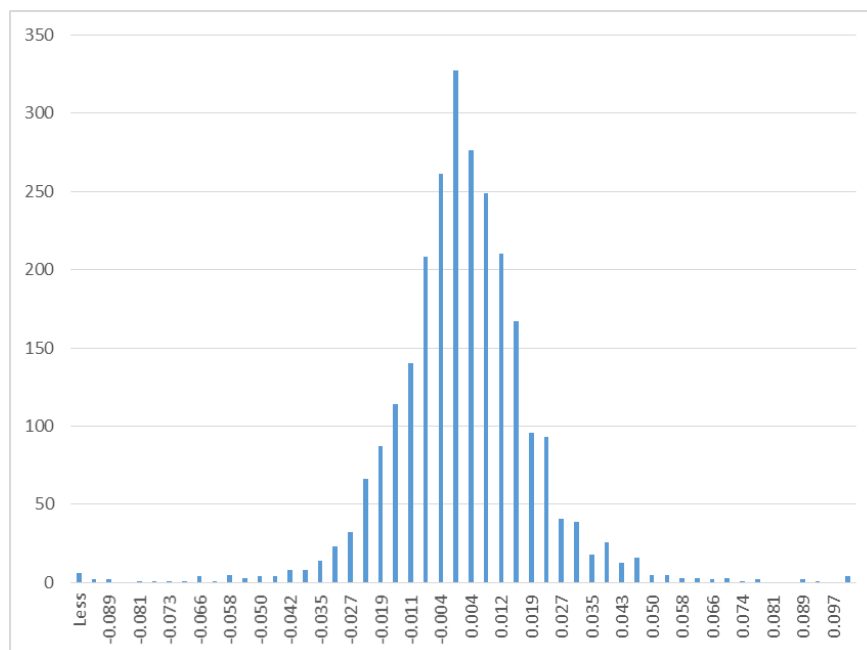

Standardised normal distribution

We can use statistical tables of the standard normal distribution to find the probability of X being less than a specified value. This feature is used in the Black-Scholes option pricing equation.

The 'bell' shape of the normal distribution indicates the probability of observing events close to the average is higher than the probability of observing extreme events (which are represented by the thin 'tails' of the distribution). For example, in the standard normal distribution the probability of observing a value which is less than –3 (minus three standard deviations from the mean) is very small, only 0.0013 or 0.13%.

After the financial crisis of 2008 there has been much debate concerning whether stock prices, and the return from holding stocks, actually follow a normal distribution. For example, consider the daily stock price of a company (we have used the BT Group, the UK telecommunications company) over ten years. We can calculate the daily return (the difference in the natural logarithm of the stock price from one day to the next), and then plot a histogram of these returns. This shows the possible daily returns on the horizontal axis and how many times these occur over the ten years.

BT Group, histogram of daily stock returns

Compare this to the standard normal distribution. The middle of the bell shape is the same, with small positive and negative returns occurring frequently. But look at the tails of the distribution of returns on BT shares. The chart shows that extreme returns (positive and negative) occur more frequently than we would expect if the return followed a normal distribution. We say the distribution of BT returns has 'thicker tails' compared to a normal distribution.