The Role of Analytics in Modern Day Risk Management

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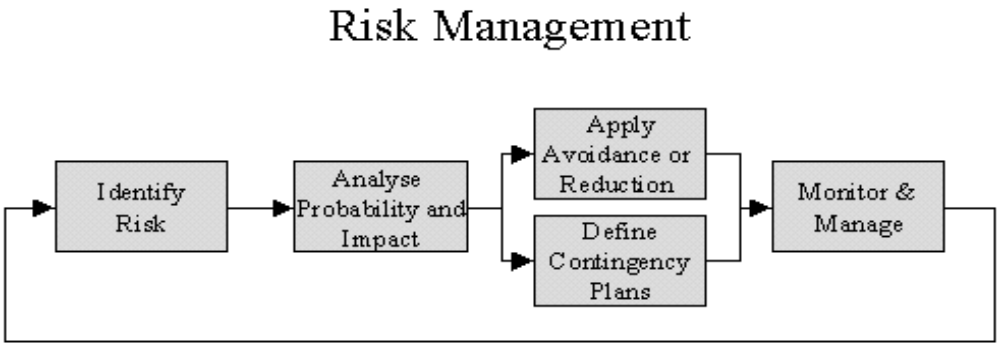
As most people work on developing the perfect strategy to pre-empt stock market volatility, institutions all over the world are using risk assessment techniques to identify and quantify the risks involved in any activity. These can be used to take appropriate action to reduce or eliminate any obvious or potentially harmful elements to that risk. Even a simple task like choosing to drive to work requires a risk assessment, although not a computational one; you can do shorthand probability in your head. Though the cost of being wrong is high, the risk is relatively low (a 5 percent probability of being seriously hurt in a car accident) and easily mitigated by wearing a seat belt.

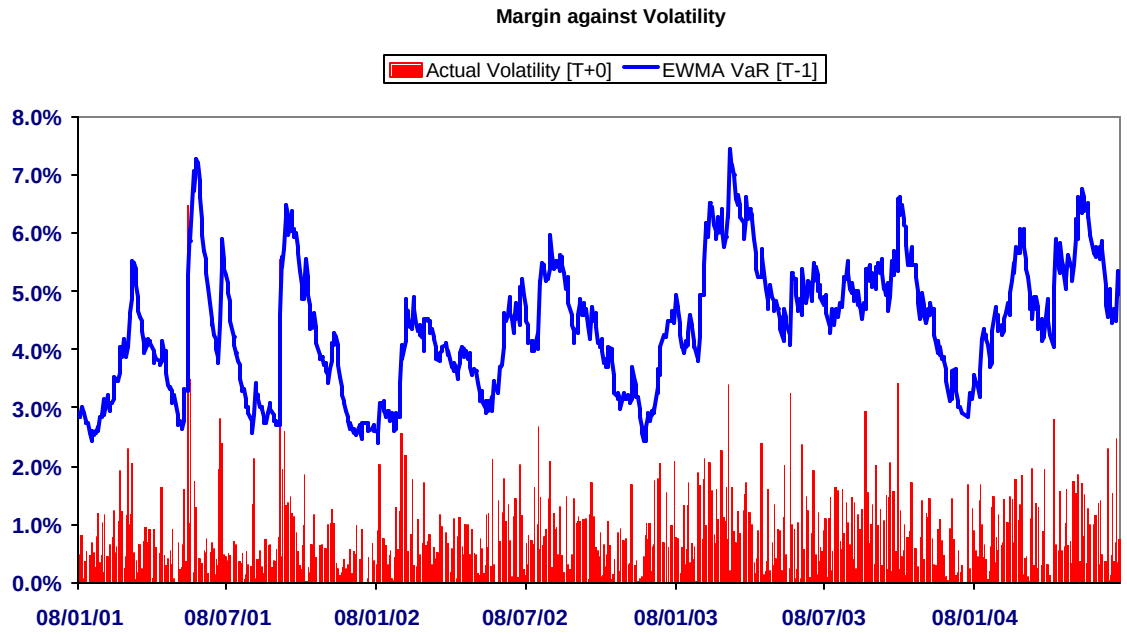
Analyzing past data alone has proven to be more than helpful in risk management. But when coupled with future predictions and associated probabilities, it can actually enable you to prevent or minimize adverse occurrences. Here's how simple it can be at times:



At the National Commodity Exchange Ltd. (NCEL), we employ modern day *Value at Risk (VaR)* techniques to quantify risk and interpret volatility. VaR is a method of assessing risk that uses standard statistical techniques routinely used in other technical fields. Formally, VaR measures the worst expected loss over a given time interval under normal market conditions at a given confidence level. Based on firm scientific foundations, VaR provides users with a summary measure of market risk. It answers the question "how much can I lose with x per cent probability over a given time horizon".

For instance, NCEL might tell a user that the daily VaR of their trading portfolio at the 99% confidence level is Rs. 35,000. Simply put, there is only 1 chance in a 100, under normal market conditions, for a loss greater than Rs. 35,000 to occur on that particular user's trading portfolio. Most importantly VaR measures risk using units that the user very easily understands: Rupees or a percentage of the total. The user can then decide whether they feel comfortable with this level of risk. If not, the process that leads to the computation of VaR can then be used to decide where to trim the risk.

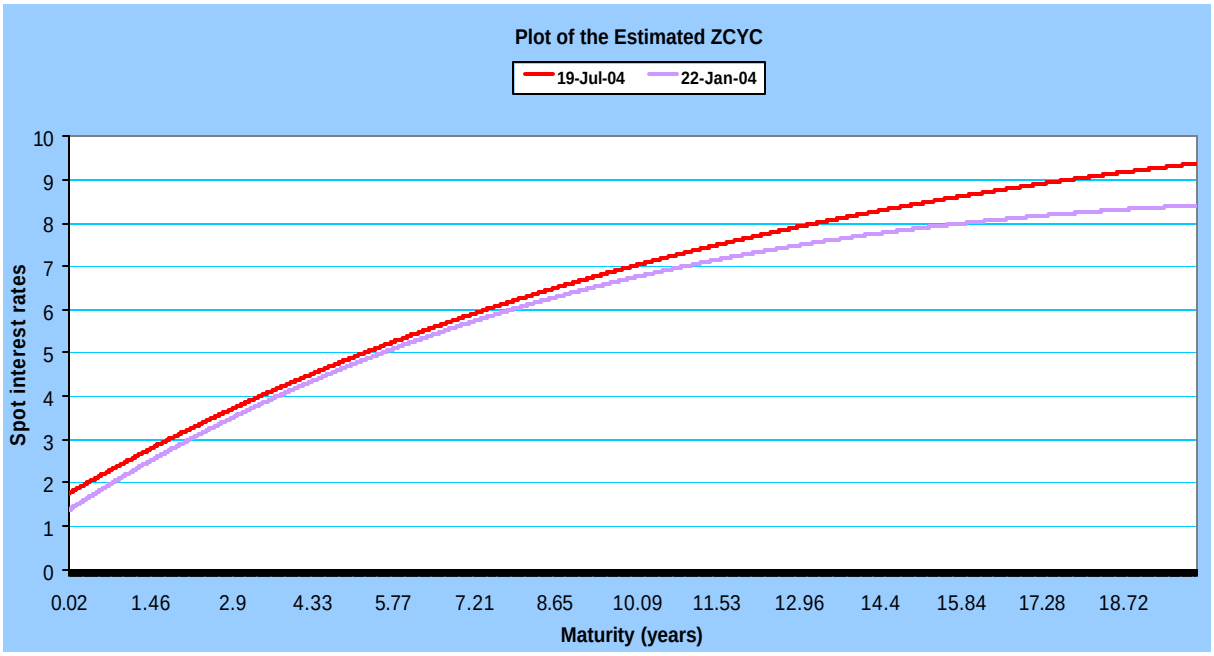
VaR at NCEL is also used to determine initial margins and clearing limits for members based on historical volatility, rather than giving them a static figure based on their investment amount. A sample of three years of gold prices is taken to predict volatility for any given day with an exponentially weighted moving average of daily returns. The blue line in the following graph shows the margin requirement we calculated for a particular day on gold futures and the red bar below it shows the volatility that day (which would occur after our calculation). In a three and a half year interval we see only two breaches of our margin.



A figure of speech we sometimes use to describe overkill is "swatting a fly with a sledgehammer." But, in business, there's really nothing inherently wrong with such a technically inelegant solution; no one cares about the size of the sledgehammer unless it will scare off customers or cause incidental furniture breakage. From a risk analyst's point of view, what you really want to avoid is swatting a one-rupee fly with a Rs. 100,000 sledgehammer. Such a fly-reduction strategy wouldn't be cost-efficient. Therefore our VaR based margins strike a balance between risk aversion and something that gives rise to a fairly liquid market.

At NCEL we have also developed a zero coupon yield curve (*ZCYC*), also known as the Spot Curve or Term Structure of Interest Rates, for Pakistan. This is basically a function that shows what risk free yields the market attaches to any given time to maturity ranging from a fraction of a day to thirty years for example. Yield curves offer a snapshot of interest rates today. Most economists also view them as a tool for predicting future rates. A ZCYC is quite different from a simple yield to maturity curve as it uses a process known as bootstrapping to calculate rates between rates rather than joining two points together on a graph.

Since the T-bills and PIBs offered by the government are not available for every time period, the bootstrapping method is used to fill in the missing figures in order to derive the yield curve. Bootstrapping uses interpolation to determine the yields for Treasury zero coupon securities with various maturities.



In calculating the yield to maturity, all payment flows are discounted to current values at the same rate whereas in estimating the term structure of interest rates (ZCYC), each payment flow is discounted at an interest rate which, depending on the reinvestment date and period, is to be expected according to the current market situation.

Interest rates and yield to maturity of coupon bonds are only identical if a constant discount rate applies to all maturities, i.e. if a horizontal term structure exists. In this case the assumption of reinvestment on which the calculation of yield to maturity is based, is not a constraint. However if interest rates rise with increasing maturity, this rise is under estimated by the yield curve. This means that if the latter has a positive sloe, the yield curve is below the term structure. The opposite applies in the case of a falling yield curve. This can in turn complicate the analysis and interpretation of yield curves for monetary policy purposes. These problems are taken care of by the use of a ZCYC.

The estimation procedure involves smoothening of the ZCYC with the Nelson Siegel method. This method smoothes out the individual kinks in the curve so that the curve is less dependent on individual observations. Abnormalities in individual bonds and segments can therefore, not be identified by looking at the curve. However a curve which is almost free of outliers is produced which is much easier to interpret for the purpose of monetary policy analysis. This method also allows extrapolations beyond the observed maturities which converge towards a defined constant. Other estimation methods can produce implausible values in long term extrapolations such as extremely high interest rates.

Other countries that use Nelson Siegel include the United States of America, United Kingdom, Switzerland, Sweden, Spain, Norway, India, Germany, France, Finland and Canada among others. The Nelson Siegel method has gained popularity in most developed countries and has formed a benchmark against which newer yield curves are determined.

Over the last few years most developed countries, have focused their attention on asset prices. These prices are determined in forward looking markets as opposed to goods

and labor markets where the past plays a major role in determining prices. Market response and expectations of the future are captured and shown by asset prices relatively quicker and can be used to analyze the impact of monetary policies.

As a result, a model that reflects inflation expectations of the market is of vital importance for a couple of reasons. Firstly, expectations of inflation can be used as an input in a central bank's model of inflation. Secondly, in policies that are formulated to target inflation, the difference between the target and actual inflation can be used to determine their credibility. Not only the term structure of inflation but its future path can also be derived from the ZCYC along with future nominal interest rate movements.

Implied forward rates can also be calculated between two periods, t_1 and t_2, from the ZCYC. Comparing the yield curves of two countries can be used to predict currency depreciation.

Our motivation for developing the ZCYC was to obtain a risk free rate to value futures contracts that do not trade on a given day. However, this can also be used to construct a government bond index, to provide default free valuations for corporate bonds and to price all non-sovereign fixed income instruments after adding an appropriate credit spread. Time series of ZCYC also forms an input for VaR systems for fixed income portfolios.

In many countries, ZCYC is also being used to study the impact on commercial banks equity capital as a result of major shifts in interest rates as recommended by BIS.

We decided to use a six month sample of risk free Tbills and PIBs for the computation of the ZCYC from primary market auctions. A six month sample accurately portrays the current scenario of interest rates today. The entire four year sample was not used simply because the prices and rates of risk free bonds four years ago or even three for that matter are not indicative of the current state of the economy.

The upward sloping yield curve that we produced can be explained by the expectations hypothesis, which states that an upward sloping yield curve implies that investors expect interest rates to rise. A flat yield curve implies that investors expect interest rates to remain unchanged. A downward sloping yield curve indicates that investors expect rates to fall.

Alternatively, proponents of another theory known as the liquidity premium theory believe that, according to the term structure of interest rates, investors are risk-averse and will demand a premium for securities with longer maturities. A premium is offered by way of greater forward rates in order to attract investors to longer-term securities. The premium received normally increases at a decreasing rate due to downward pressure from the decreasing volatility of interest rates as the term to maturity increases.

A ZCYC can be used to make an intelligent decision about the business cycle. Suppose that the economy heads into recession. The default risk of corporate securities increases. Alert fund managers will shift out of all long term corporate securities and into long term default free government securities. Government securities prices will rise and their long term yields will fall. A downward sloping treasury yield curve indicates anticipation of recession.

It is extremely important for us to know how and when to use the yield curve to predict inflation. The short term preference for government securities will always be exerting some pressure on long term yields. However, when the yield curve is sloping upward steeply, it could either be telling us that investors are expecting real rates to rise or that inflation is expected to increase sharply. When we see that the yield curve has a

negative slope (when short rates are higher than long rates) the market is predicting a recession. Except for short periods of time, it's the demand side of the securities market, which controls the shape of the yield curve. In the case of the "humped" yield curve, the higher mid term yields are most likely explained by a need to raise a lot of funds by selling 5 year Treasury bills.

Under a monetary expansion policy, the real interest rate in the loan-able funds market declines. The lower short term real interest rate puts into motion a chain reaction process. Both consumption and investment rise and so the quantity of aggregate output demanded increases. Actually most of the change will be in consumption and the least will be in investment since it is more dependent on long term rates than short term rates. The lower real interest rate then causes a capital outflow and net exports increase. Stocks become more attractive than debt instruments. As stock prices appreciate, wealth increases and individuals become less reluctant to spend. An appreciation in the stock market entices companies to issue additional stock and will in turn make it more attractive for business to spend on plant and equipment. The market value of the firm rises relative to the replacement cost of capital so monetary policy again provides some economic stimulus.

Long term rates are influenced less by monetary policy than they are by real factors such as the demand for investment funds. If the public's expectation is changed in such a way that it expects inflation to be higher in the future, then long term interest rates will rise and not fall.

ZCYC serves as a round-the-clock forum on whether the economy is likely to accelerate or decelerate, one that is based on the interaction between powerful central banks and millions of investors who have real money at stake. It is a simple tool for reading the collective mind of the market and has done a surprisingly good job in other countries of spotting downturns on the horizon.

Monetary policy makers are of the opinion that financial markets are reliable indicators of the economy. Simple financial indicators, such as interest rates, often do better than stock indices in predicting economic recessions, especially at horizons beyond one quarter. The stock market is considered to be much less reliable as a leading indicator for the economy than the yield curve and a popular joke amongst leading US Economists sarcastically states that "the stock market has predicted nine of the last five recessions".

The obvious question I sometimes face is "Can the yield curve predict the stock market as well?" If the yield curve was a perfect leading indicator, there would be a lot more billionaires around. But if the yield curve can predict the economy it should be of some use in gauging the overall risk/reward potential of the stock market as well. That's because both corporate profits and stock prices depend heavily on the strength of the economy.

The idea of this article is to nudge people towards the idea of analytics and show them how imperative it is in modern day risk management. The challenge to the industry is to meaningfully quantify and integrate financial planning and investment management. Quantification permits the evaluation of the relative importance of the determinants for financial success and provides the advisor the basis for determining the most appropriate investment program in terms of most likely and downside portfolio values.