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Estimating Risks and Resolving Paradoxes

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SMU Professor Lim Kian Guan uses sophisticated mathematical tools to extract information out of options data and provide more accurate risk estimates.

AsianScientist (Sep. 1, 2014) – By Rebecca Tan – All of us have to estimate risk in our daily lives, from crossing the road to sharing personal information on the Internet, with varying degrees of repercussion. But for large organisations such as banks and governmental financial institutions, the failure to accurately forecast risk could have an effect that is nothing short of catastrophic.

Recognising the need for regulation in the financial sector, groups such as the Basel Committee on Banking Supervision have proposed international standards, such as the Basel I, II and III accords. In essence, these guidelines help banks to predict the amount of risk and stipulate a level of capital that they should hold to relate to the expected financial and operational risks.

> “A lot of banks still rely on the methods based on the internal model-based approach to evaluate market risk, which basically boils down to using historical time series data. The banks collect price data on assets which they have positions in, and from those historical prices, they will use econometrics methods to estimate risk,” explains Professor Lim Kian Guan from the Singapore Management University (SMU) Lee Kong Chian School of Business.
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> “But all these methods require two things: firstly, an assumption of a specific time series model, and secondly, a restricted number of parameters, which means that the predictions are not flexible enough to account for the all changes in the marketplace. In that sense, it is still not very satisfactory,” he says.

Calculating risk from stock options data

The problem with existing methods is that they often do not capture “black swan” events, a concept popularised by writer Nassim Nicholas Taleb to describe unexpected events that have a significant impact.

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“We’re talking about drastically bad, huge losses several standard deviations away from the mean,” Professor Lim says. “These catastrophic events are represented by the extreme tails of the probability distribution curve. Unfortunately, they are currently not very well predicted because people have been using stationary distributions such as normal distributions to estimate risk, which do not reflect events at the extreme tails.”

Seeking a more accurate way to calculate risk, Professor Lim turned to options data. An option gives the buyer the right, but not the obligation, to buy or sell a particular asset at a specified price by a fixed date. By using a mathematical framework, it is possible to extract information on moments of the underlying asset prices from the options. These moments refer to quantities such as mean, variance, skewness and kurtosis, he says.

> “Rather than just relying on the history of stock prices for example, using information on stock options allows us to infer a lot more about the underlying risks. Furthermore, we can extract information on several moments at any one point in time, which can change as soon as the next set of liquid data is available for updating. This gives us a lot more information which makes the estimation of risk more robust,” he explains.
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> “One of the methods I have used involved taking four moments and fitting them into a generalised hyperbolic distribution. A lot of research in the past was only using two moments, but with four moments you can catch very nice extreme tails which are the bane of the problems in analysing systemic risk. From the generalised distribution, after transformation by a calibrated Radon Nikodym derivative, you can then calculate many risk measures such as Value-at-Risk and Conditional Value-at-Risk.”

Mathematics, the common language

In order to use options data, however, some serious mathematical legwork is required. Traditionally, the historical time series data used to calculate risk follows empirical probability distribution, or the actual likelihood that the banks measure to make their forecasts. Options data, however, yield the underlying moments that do not follow empirical probability distribution, falling instead under a different distribution known as the equivalent Martingale measure.

> “Therefore, to use options data requires some technical treatment to relate the empirical distribution and the equivalent Martingale measure, an endeavour which is by no means trivial. In other words, every time we use derivatives like options to give us more information, we need to tie the two sets of probabilities together so that they will give us a better richer idea of the risk situation,” Professor Lim says.

Although mathematicians and statisticians were the first to work on the problem of relating the two types of probability distribution, Professor Lim notes that the field has seen growing interest in the last decade from economists seeking to address anomalies that have so far eluded explanation.

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“For example, the standard asset pricing model doesn’t quite explain the excess volatility observed in the market where the predicted patterns of consumption are too smooth. There is also the issue of excess put premium. So there’s a whole rich tapestry of problems that financial economists have been working on that could potentially be solved by an understanding of the relationship between empirical and risk neutral distributions,” he notes.

Of paradoxes and paradigms

Perhaps one reason that economists are only just beginning to resolve anomalies using a mathematical approach is that the two fields think of the same problems in two very different paradigms, Professor Lim muses.

> “I certainly hope to see that the set of problems economists are working on based on what they call pricing kernel puzzle can be understood in terms of what the mathematical probabilists call topological distance between the empirical and equivalent martingale measures. I hope to see some unification so that we can talk in two different languages but can still understand each other.
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> “Not only would this understanding help us grasp the issue of risk in a richer way, but it could also explain what are currently thought to be paradoxes, which to me are not really paradoxes but just problems which we have not yet solved. To me, this is the most interesting part of the research, and I think the whole area will see some exciting breakthroughs soon,” he says.

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