Mutual self-awareness and fat tails

Mutual self-awareness among market participants is an important distinction between physical and social systems. David Rowe argues that this is a fundamental cause of the well-documented characteristic of fat tails in the distribution of changes in market data, and should be a key focus of all market risk managers

Years ago, when I taught basic statistics, the one concept I tried to be sure students would remember well into the future was the Central Limit Theorem, sometimes referred to as the Law of Large Numbers. This is the initially somewhat amazing fact that the distribution of sums and averages of random variables exhibit a traditional bell curve or normal distribution even when the individual variables are not normal. While theoretical exceptions exist, this holds true for almost any stable random variable found in nature. Thus it is not surprising that in the early days of modern finance there was some serious debate over whether the distribution of changes in market data departed from a normal distribution in a systematic way.

Today, of course, the presence in such distributions of high kurtosis, more casually referred to as fat tails, is a well accepted fact. Events representing changes of five, six or even more standard deviations from the mean are rare in an absolute sense, but occur far more frequently than would be consistent with a normal distribution. In trying to incorporate such behaviour into market risk analysis, it is important to consider why such persistent departures from the pervasive normal distribution should occur.

A key assumption behind the central limit theorem is that the individual observations of random variables going into an average or sum are statistically independent. This is usually a reasonably good description of the thousands, or even millions, of individual buy and sell decisions that drive changes in demand and supply on any given day. Since the market clearing price reflects the net balance of these largely independent decisions, it is not surprising that changes in such prices often exhibit a roughly normal distribution. This is, however, not always the case.

Mutual self-awareness

Consider an example totally unrelated to finance. Say you equip the passengers of a single-deck cruise ship with a device that allows you to locate them exactly at any given moment. Then proceed to calculate once every minute the centre of gravity of all these locations with reference to the two dimensional framework of the ship and plot the resulting distribution. At most times passengers will be in a variety of locations based on their personal preferences, their energy levels, their mood of the moment and the available alternatives. The resulting distribution of their centre of gravity over time will be a cloud of points bunched around the centre of the available passenger areas. We would expect it to exhibit something very close to a bi-variate normal distribution.

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Now, however, assume there is an announcement over the ship's loudspeaker that there is a pod of whales breaching off the port bow. The consequences are fairly obvious. We would see a sudden outlier in the distribution as passengers rush to find a good viewing spot among the limited spaces available. In the immediate aftermath of the announcement, a typical passenger knows several things:

- first, there is an opportunity to see something quite unique;
- second, the time to see it is limited;
- third, there is an ideal location for viewing the phenomenon;
- finally, everyone else knows what they know.

It is this final point, this mutual self-awareness, that makes for the sudden mad rush to the port bow. Each passenger reacts to the knowledge that speed is of the essence if a good viewing place is to be secured. If the ship was nearly empty, or if only a few people were aware of the opportunity or were likely to take advantage of it (if, say, most passengers were confined to their cabins with sea sickness), the sense of urgency would be greatly reduced.

Crystallising events

There is a relevant scene in the movie *Rogue Trader* about Nick Leeson and the Barings debacle. He is awakened by a call at home in the early hours from another member of the firm. The voice at the other end of the phone says urgently, "Turn on CNN!!" The TV in the bedroom flickers to life showing scenes of the Kobe earthquake. The voice at the other end of the phone says, "This is going to just kill the market!"

This is much like the announcement on the ship, but on a global basis. Observers around the world are suddenly focused on a common crystallising event with obviously directional implications for the market. In addition, everyone knows that everyone else knows. Suddenly the millions of decisions that drive the market are no longer randomly independent. Rather they are subject to a common shared perception. The core structural assumptions that underpin a normal distribution have temporarily broken down, and we see a sudden extreme observation.

Various statistical methods are used to try to build such behaviour into market value-at-risk distributions. These include regime-switching techniques that produce jump diffusion processes. What these approaches cannot do, however, is predict in advance when such events will occur. Thoughtful consideration of such potential scenarios, especially those that present special threats given the existing open positions in the book, is an essential component of effective market risk management. Such analysis remains in the realm of experience and seasoned judgement that no amount of advanced analytical technique can, or ever will, replace. ■