

# Quants' golden age

*Quants received a lot of flak for the crisis, but the profession is on the cusp of a golden age, according to Myron Scholes, co-inventor of the Black-Scholes pricing model. In an interview with **Laurie Carver**, he also criticises post-crisis regulation, discusses the value of intermediation – and the lessons he learned from the collapse of Long-Term Capital Management*

The birth of quantitative finance is often dated back to the work of Louis Bachelier in 1900, but for the subsequent seven decades it won few converts – notable exceptions such as Benoit Mandelbrot aside – until the arrival of Fischer Black, Myron Scholes and Robert Merton.

In a series of seminal papers in the early 1970s, these three figures revolutionised trading through the now-famous Black-Scholes option pricing formula, which largely replaced the intuitive approaches used up to that point. Their work also changed the nature of trading as a business – by demonstrating that a partial differential equation could be used to solve pricing problems, the Black-Scholes formula opened the doors of the world's banks to an influx of physicists and mathematicians.

The subsequent celebrity led to Merton and Scholes embarking on their own career in the financial world, joining the board of hedge fund Long-Term Capital Management (LTCM) before it started trading in 1994. The fund used the Black-Scholes formula, along with giant levels of leverage, to pull near-40% returns year-on-year from perceived arbitrages. At least, it did until 1998 – a year after Merton and Scholes had shared the Nobel memorial prize for economics – when the Russian debt default and the Asian financial crisis meant a takeover deal with the banks had to be brokered by the Federal Reserve. The total losses reached \$4.6 billion.

Scholes has continued his academic work at Stanford University, championing the concept of 'omega' – the additional returns generated by intermediation, and an adjunct to the more familiar concepts of alpha and beta, which respectively represent excess returns above the risk-free rate, and sensitivity to market returns. More recently, he has called attention to the inherent difficulties in risk factor modelling that arise from their computational complexity and hidden assumptions. Until the beginning of this year, he also served on the board of another hedge fund – Platinum Grove Asset Management – that came through the 2008 crisis intact but not unscarred.

Despite widespread attacks on quantitative techniques following the crisis, Scholes argues the coming years should be a golden age for risk modelling and management, because of the array of complex problems highlighted since markets froze up in 2007 – from helping capture omega through mean reversion modelling, to modelling liquidity, and constructing better risk measures.

He is also worried about the impact of post-crisis regulation. Having warned in June that overly onerous capital requirements will make markets more volatile ([www.risk.net/2080786](http://www.risk.net/2080786)) by pricing out the corrective effect of market-makers, he uses the Lehman Brothers bankruptcy to raise concerns about the role envisaged for central counterparties (CCPs). If the industry does not learn from its mistakes, he argues, it risks replacing one lottery with another.

**Risk:** What is the biggest lesson for the industry from the crisis?

**Myron Scholes:** The biggest lesson from the recent crisis is that you should not over-weight recent risk data when forecasting future values, nor assume the structure of relations we see today will remain constant. If individuals only observe these cross-sectional associations, it pushes them in certain ways as they allocate assets, and creates more risk in the system. If volatility appears to be low and people believe it, they are going to take on more risk.

When you misunderstand risk, the convexity costs are higher, and you must adjust quickly.

In particular, the government should not take steps that imply to everyone the level of volatility is low, that we all understand risks and it's all OK. When we think we understand risk, we take more risk.

The problem in the crisis was that risk managers were thought of as being about regulatory compliance, and were not part of the optimisation process, deciding on required returns for risks taken. They should be thought of as important in their own right. Boards of directors of financial institutions – and corporations in general – should have people who understand risk and can ask questions about risk, and augment the information that determines the business decisions.

**Risk:** Many – including Adair Turner, chairman of the UK's Financial Services Authority – laid some of the blame for the crisis on quants. Is that fair?

**MS:** Everyone tries to blame someone else. But yes, models were part of it. A model is a description of reality, so if it doesn't reflect reality then it's not going to work. If you think the model error is basically second-order and it's not, then the terms you neglected are going to come to the fore and the model will fail. That doesn't mean you're going to do any better with intuition – presumably you used your intuition in picking the model, and intuition can fail, too.

The problems started when agencies started building models to rate credit derivatives and using historical data to calibrate them. They thought the number of clusters was more definite than it actually was, and that a default in cluster one doesn't affect cluster 27. So, for instance, New Orleans mortgages were uncorrelated to mortgages in Miami, which were uncorrelated to Phoenix, which was uncorrelated with Las Vegas and so on.

When they used short-term historical data to determine the number of clusters, they were finding that number to be much greater than it actually was, and they didn't realise the structure would change over time. It turns out the number of clusters was much smaller and the relations much stronger.

**Risk:** Some said at the time that the job of a credit quant was basically to ensure a security got the highest-quality rating with the poorest-quality underlying assets. Do you agree?

**MS:** The rating agencies' model became an inventory transition mechanism. They

didn't realise people would figure out how to achieve the AAA grade and game the agencies. Once they could do that, they started doing collateralised debt obligations (CDOs) that were comprised of other CDOs – the so-called CDO-squared structures – and then CDO-cubed, credit default swaps (CDSs) on CDOs, and so on.

The accounting incentivised this, incidentally – as soon as the investment banks bought the insurance on their product, they could immediately book a profit. I never thought of buying insurance as a profit-making activity. In the future, if Goldman Sachs books a \$200 million profit on a trade with American International Group (AIG), then AIG has to book a \$200 million loss on the trade.

**Risk:** You have first-hand experience of the collapse of a financial institution – at the hedge fund LTCM, which was a stimulus for quants to consider the impact of low-probability events.

**MS:** Actually, LTCM was a much higher-probability event than people thought at the time, because it told people they were going to make 40% a year at 20% volatility – a high risk level. The problem comes because as a hedge fund you don't really have deep pockets, so it's hard to run at a high risk for a long time. LTCM ran leveraged positions at too high risk levels. It was not a sustainable business in the longer run if you have to reduce leverage and seek extra capital at a time when risk transfer costs are high.

**Risk:** Did LTCM affect the way you view models and your intuition for them?

**MS:** Sure. The interesting point is that if you are running an interconnected leveraged business then you have to run it very differently from running an unleveraged business. Tail risk, and what happens in terms of the outlier, is more important. I believe capital models should not rely on portfolio theory, because the correlation structure is just not constant – in a crisis you have intermediaries reducing risk simultaneously, so things that appeared to be independent clusters in the past become correlated, and diversification against those clusters doesn't provide staying power. Capital models should give levels that are required to sustain the business at times of shock, and this is different for hedge funds because they can't call for additional capital from investors.

I would have done many things differently. The people who experienced



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this crisis will learn a heck of a lot because they experienced it. But people who didn't experience it can't understand because they weren't there.

**Risk:** You have been promoting your concept of 'omega' in recent years, roughly meaning the extra returns earned due to intermediation in the market. What is the role for quants here?

**MS:** The effect of intermediation is to correct prices, so it brings mean reversion into the processes – which one can attempt to capture with models. The idea is that you have a belief in where prices are going to revert to, and how fast they will do so, and this determines strategy. For example, if you have a lot of volatility you may want to go into your position sooner because mean reversion might occur more quickly. You're also thinking about how much capital is necessary to sustain one's positions over any extreme movements in the interim. The question is whether you can build a model that can systematise the scaling of how far prices can move before mean reversion kicks in, and whether this is superior to just using intuition.

**Risk:** Another issue you have been talking about recently is the inherent numerical complexity in portfolio management. In particular, you have claimed that determining risk factors is 'NP-complete'. What does this mean, and what are its implications for trading?

**MS:** Basically, it's too computationally difficult a problem to be handled by brute-force computation. When you try to determine risk factors you are taking return

data and trying to put them into a certain number of groups with similar characteristics. In computer science, this is known as a 'k-means clustering' problem, and it has this property that the number of calculations needed to solve it is of the order two to the power of the size of the data set. So if you have 10,000 stocks, then it takes two to the 10,000th power calculations to organise their returns into some number of buckets. There are two problems here – first, that number of calculations is going to bring a computer to its knees. Second, the number of clusters – risk factors – has to be determined in advance.

**Risk:** So there's an implicit assumption you know the number of significant factors?

**MS:** Yes. And even if we could define the clusters, the number of clusters is not constant. When you get a shift in the

would then buy shares in hedge funds instead. Regulators find it is easier to regulate institutions rather than services.

**Risk:** So higher capital for banks means more shadow banking. Are proposed capital levels high enough to produce that effect?

**MS:** It's very evolutionary and seems to be changing all the time. It doesn't seem that onerous to me, even though the banks claim so. We'll see in the coming years.

**Risk:** Could the Volcker rule also have an effect here – specifically on the ability of banks to act as market-makers?

**MS:** Taking customer business requires you to take positions. Traders take positions in anticipation of the supply and demand in the market, where prices are heading. Does somebody call and ask for some product and you tell them:

to think about providing time for unwinding in a way that doesn't cause the whole system to cascade. If there is a way to default under an option or swap Isda-type contract while having a period of time to unwind, we lessen the chances of a panic. The idea of allowing 2 million contracts to just collapse over a weekend – it's kind of rough to expect markets to deal with that.

**Risk:** Where is the quantitative approach headed in the future? What great questions does it need to answer?

**MS:** The most important thing in the coming years will be intermediation – and modelling is a big part of that. How much capital do we want against a given strategy? What kind of capital structure should we have? How can we risk-manage dynamically, taking account of changes in the risk factors, changes in the risk appetite, the cost of adjusting the portfolio?

Feedback in the system is another growth area in the application of quantitative techniques to risk management – we need to realise what we're doing is not independent of what others are doing in the system. There's the role of the government – the fact that you have intervention in the market – how do you account for that, and how much should the government interfere? At times of shock, how does the response affect our ability to adjust our portfolio or our risks?

Liquidity is also a fascinating area for quants. It's an institutional problem and the idea is to work out ways in which we can transfer risk efficiently. It's easy for me to transfer government bonds because there's less uncertainty. If I had a long-term bond that had some default risk I could swap that fixed-rate payment for floating if I could find a counterparty to do that, and buy a CDS on that bond, so I've converted it into a safe asset. Then I can go to my bank and get 100%, or whatever I can borrow against that, and I have 100% liquidity on a risky product. This was only possible because the risk transfer market was functioning.

It's not the holding of the asset – it's the transfer, the omega, that creates the cost. At times of shock the institutional arrangements are insufficient to allow for risk transfer at low cost.

I'm very bullish on the future for quants. One thing about a crisis is that it shakes old opinions and you start learning new things. I hope we do – it should be a golden age for risk modelling and management. ■

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number of factors, the question becomes whether it's a regime shift or an evolution. Once new clusters are formed there's nothing in economics to suggest things necessarily should go back to where they were before. If you create a set of clusters and diversify with respect to it, that can give you a false sense of security because the clusters are arbitrary and can change over time as a function of the outlook of people in the system. In general, we think of risk as exogenous – we observe returns and factors and base our models on them, but this ignores the endogenous behaviour that comes from the capital flows from individuals investing and managing their own particular risks. By looking at historic data there's the risk you're looking at a subset of the whole process, and are zeroing in on something irrelevant.

**Risk:** Is there a danger that post-crisis regulation could backfire by making financial markets more unstable?

**MS:** The issue driving behaviour is what services the market needs and requires, not the institutions that provide these services, so if you regulate one set of institutions and make it costly for them to provide it, then another set of institutions will rise to provide those services at a lower cost. Bankers will leave their firms to start hedge funds. You bypass the banking systems, and investors who buy shares in banks

“OK, just wait an hour while I figure out the hedge”? No, of course not. So they need to anticipate, and take positions, which under Volcker would be considered prop trading. Again, that makes it difficult for market-makers – and this leads to more volatility.

**Risk:** One of the pillars of the regulatory agenda is the move to centrally clear over-the-counter derivatives. But does concentrating exposures sow the seeds of the next crisis?

**MS:** Yes. We ran a huge experiment when we allowed Lehman Brothers to fail. During the crisis, most of the difficulty arose because the banks did not post initial margin and when it was called for the crisis accelerated. Hedge funds and others moved their prime brokerage accounts to JP Morgan, which ended up being the *de facto* clearing house. The market selected the best counterparty for that role, and JP Morgan had the skills to evaluate the contracts in Lehman's place. But those skills would not exist at a clearing corporation. It's not clear to me that we've learned all the lessons of that experience, and there's a risk we jump straight into a new set-up unsure of the new risks we are taking. We're moving from one lottery to another.

With Lehman we needed time to understand what was happening. We have

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