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Calculated risks

If it's risky, quantify it. If it's uncertain, avoid it. **Louise Simpson** explores the extraordinary world of financial mathematics

Do you know your fixed-income derivatives from your collateralised debt obligations, your options from your futures? Or are you more knowledgeable about Indiana Jones than Dow Jones? Whether you have stocks or a pension or are merely trying to get the best price for your car insurance, the invisible hand of the market makes the world go round, as Adam Smith taught us.

For generations universities taught *The Wealth of Nations* but showed little interest in analysing real-world market movements, assuming no theory worthy of the name could be wrung from such a maelstrom of numbers. Even though Cambridge was founded at just the time Magna Carta was formalising the right of foreign merchants to trade in England, it took nearly 800 years for the university to decide it needed a business school – and even then it proved a hard sell. The first American business school – Wharton, in Philadelphia – was founded in 1881, the Cambridge economics tripos in 1903, the Judge Business School not until 1990.

Yet Cambridge has always loved numbers. For centuries the curriculum was dominated by mathematics, which had such cachet that until the 1820s it was the only route to an honours degree. Robert Malthus (Jesus 1784) invented modern demography; Charles Babbage (Trinity 1811) developed the earliest calculating machine; Alfred Marshall (St John's 1862) pioneered the economic analysis of markets and industries; John Maynard Keynes (King's 1902) laid the foundations for macro-economic theory; and Alan Turing (King's 1931) founded the subject we now call computer science. All started out as mathematicians.

Finance was central to *The General Theory of Employment, Interest and Money* (1936), and two of Keynes's successors – James Meade (Trinity 1930) and Richard Stone (Caius 1931) – were awarded Nobel Prizes for Economics for their work developing modern national accounting. Yet for putting Cambridge belatedly on the international financial map we have to thank an American: the venture capitalist and philanthropist Bill Janeway (Pembroke 1965).

Attracted by the legacy of Keynes, Janeway originally came to Cambridge as a Marshall Scholar to write a PhD on the Wall Street Crash and American depression. 'Cambridge was extraordinary after Princeton, where I had spent my life shuttling from class after class. Suddenly I was given a lot of research time, which I used to deeply immerse myself in Keynes. I loved his sense of the world as a place of radical uncertainty in which we nonetheless have to make decisions, the consequences of which we have to live with forever. You get exactly the same issues in Dickens' *Little Dorrit*!'

Leading universities did not treat capital markets finance as part of economics because 'economists found it difficult to model the dynamic behaviour of booms and busts'. As a result, as business schools developed, enclaves of academics interested in finance coalesced only slowly. The first serious attempt to explain the behaviour of capital markets came in the 1950s from American mathematicians who used models drawn from physics to develop 'modern portfolio theory', but the evolution of more suitable models, based on economic principles and probabilistic ideas, required new mathematical methodologies and took rather longer.

Cambridge began to take finance seriously in 1996 when it appointed Canadian Michael Dempster to the Judge Business School as its first professor of finance, but the real turning point came five years later when Bill Janeway – wealthy from a thirty-year career providing private equity for high-tech start-ups – decided, with his wife Weslie, to give Cambridge $20m to set up a Cambridge Endowment for Research in Finance (CERF). The idea, he says, was 'to look at how financial mathematics had evolved in the previous thirty or forty years – from historical, economic and institutional perspectives.'

CERF works with Cambridge Finance, a university-wide research initiative started in 2003 by Dempster, mathematician Chris Rogers, and the economists Hashem Pesaran and John Eatwell. Today it embraces not just those founding disciplines but lawyers and land economists too. The risk and uncertainty surrounding financial markets are the common denominators. 'If market volatility were only a function of external events like floods and earthquakes, risk models would be a lot simpler,' says Janeway. 'It's the behaviour of human beings that makes them so complicated. What is rational for me depends on what you do, and so on.' Using game theory, for instance, mathematicians can now construct sophisticated models to simulate a rich repertoire of human reactions.

For mathematician Chris Rogers every working day involves probing randomness and risk. The day we meet he has just cycled in across the fields from Harston, past autumnal hedgerows and fiery ash trees to the university's iconic new mathematics centre

on Clarkson Road. 'Finance is not a science,' he assures me. 'You can't replicate 1963! It's one thing looking at molecules of water – we know they will always behave in the same way. But you can't apply physical laws to a million people. They won't obey identical rules even if they are subject to the same inputs.'

Professor Rogers heads a lab of around fifteen researchers, all studying financial mathematics with an eye to becoming academics or bankers. In recent years the subject has acquired cult status, he says. 'In the twenty-first century maths is the language of the educated classes. It's central to everything. Take a train or turn on an electrical appliance and mathematics is part of it.' Every year Rogers' group takes about four top PhD students from the 20–30 enquiries he receives. 'You have to do this face to face,' he says, indicating a chalkboard covered with impenetrable equations behind him. 'You can't base selection on paper qualifications and testimonials. We ask potential students to work through some basic maths modelling before progressing to harder stuff. If they can't do that, I just wait for the interview to be over!'

The models Rogers' team use to predict financial behaviour are more sophisticated than most of those in use commercially. 'Banks rely on quite basic models, some dating back a hundred years. They aren't very interested in new models when they can make so much money from unsophisticated ones!' At present, he's analysing this summer's economic crash and developing insurance pricing models for huge but remote risks such as hurricanes and earthquakes. 'For mathematicians modelling insurance is very interesting because the premiums depend on how recent the last natural disaster was. Companies compete against one another, and if there hasn't been a disaster for a while they relax and sell cover for less. Then a big disaster like Hurricane Katrina comes along, the claims come in, and people realise they're vulnerable and raise their premiums.' Financial mathematicians create models that bring together all these variables to predict what may or may not happen in the future: rather like the Jeff Goldblum character in *Independence Day* who calculates the real risk of the alien invasion and uses maths to save the planet. Handy stuff in a crisis!

Michael Dempster, the university's foundation professor of finance, collaborates with Chris Rogers but in general approaches risk and uncertainty from a more commercial angle, applying theory to the markets. Educated at Toronto, Carnegie Mellon and Oxford (where he was also a professor), he has just moved to an emeritus position at the Centre for Mathematical Sciences where his office is awash with boxes.

Cut through the technicalities and financial mathematics isn't necessarily conceptually complex, says Dempster. 'Futures, for instance, come out of our agricultural roots. They're just contracts for the physical delivery of something in the future for a price determined by the market at delivery time. If a farmer has a contract for next year's hogs, that stops the hog cycle where prices are low so no one grows hogs. If the price goes up, everyone grows hogs and so the price of hogs falls again. With futures contracts, the farmer is assured that next year he can sell his hogs, so this sort of cyclical pattern is erased.'

One of the biggest boosts to understanding financial markets came with the Sputnik programme launched by the Soviet Union in 1957 to demonstrate the viability of space satellites. This really pushed out the boundaries of stochastic mathematics, says Dempster. 'Scientists were dealing with the random effects of the white noise of the universe, and the likelihood of this beach-ball-sized satellite being hit, driven off course, exploding, or whatever. And when the space-race was over, those same risk analysts morphed into financial mathematicians, working with problems that were pretty much parallel.'

Dempster enjoys creating models for uncertainty as well as risk, but draws a strict distinction between the two. 'Having a heart attack is risky, but life after death is uncertain. In other words, if you can apply probabilistic laws to something, you're dealing with risk (as you are with insurance pricing). If you're dealing with uncertainty, you can't apply any laws because you don't have a clue what risk is entailed. Bayesian statisticians don't accept this view, but that's because – like many probabilists working in higher mathematics – they believe probability, even subjective probability, will describe everything.'

Ten years on, the future of financial mathematics in Cambridge seems assured, thanks to the Janeways' generosity and the academic leadership of Dempster and his colleagues in Cambridge Finance. Only last month the university received a generous gift from Sir Evelyn de Rothschild (Trinity 1952) to fund a new professorship of finance that would focus on venture capital. New student courses are also coming on stream. The Judge Business School next year launches a one-year Master of Finance degree to add to its existing MPhils in finance and financial research.

Business degrees attract outstanding students from China, Korea, Japan and America, with as many women as men progressing from them to work in the world's top banks. With luck, some will one day be able to give back to society as generously as Bill Janeway, for whom economic progress is all about how we compute and confront risk. 'Social progress is highly dependent on investments in innovative technology,' he says. 'We would be nowhere without the risk takers of capital markets.'

Academics take pleasure in the success of their students, so it's no surprise to find Michael Dempster delighted that one of his recent graduates is already running the Options desk at the Union Bank of Switzerland in Hong Kong. What's perplexing is to discover that neither he nor Chris Rogers much fancies their chances speculating on the stockmarket. They say it's too risky. ■

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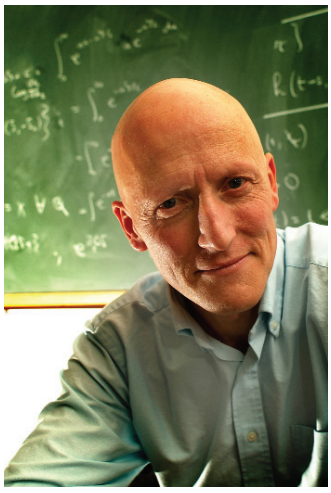
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Number crunchers. From left: Chris Rogers, Michael Dempster and Bill Janeway