Maths and the markets: making money using quantitative analysis

With the credit crunch underway and the threat of an economic recession on the horizon, the subject of finance has become a concern for many of us. For **Iain Clark**, a financial mathematician, or "quant", the fluctuations of the world economy are familiar territory. Here he explains how maths can be used to develop investments that are independent of market changes and discusses the pros and cons of working in the financial sector.

Did you always enjoy maths? What did you want to be when you were a child?

I didn't always enjoy homework or exams, but I always liked mathematics! At various points when younger I wanted to be an astronomer, a lawyer, a computer programmer, an engineer, a mathematician and a physicist. I later settled on mathematics, completing an undergraduate double major in mathematics and physics, followed by a PhD in applied mathematics. I lived in Western Australia as a child, and I studied for my undergraduate degree at the University of Queensland in Brisbane.

How did you end up working in financial mathematics?

When I had finished my PhD I didn't like the look of the job market in academia and I wanted to see something of mathematics in the real world. My PhD had been in mathematical physics and involved the analysis of partial differential equations (PDEs), so when I found out that PDEs are used in option pricing I was rather intrigued. I bought a few books on the subject, worked through some exercises, and eventually decided to enrol on an MSc course to learn more. I relocated to the UK where I studied for the Edinburgh/Heriot-Watt MSc in financial mathematics. I was then fortunate enough to start as a front office quant in JP Morgan in 1998.

What is a "quant"? What does your job actually entail?

"Quant" is short for quantitative analyst. There are actually a few different types of quant. Some use statistical methods to try to predict short-term market moves or identify opportunities to lock in profits, but what my group does is somewhat different. We develop and

implement various pricing models for a trading desk which are *specifically designed* to be indifferent as to whether markets go up or down.

We work in foreign currency (FX). Though everyone is familiar with the concept of buying currencies (e.g. holiday money) and how exchange rates vary, the risks involved with currency fluctuations are greater for funds and corporations than for individuals. So there is a market for financial contracts that can be used either for hedging against or speculating on currency risk. Some are more complex than others.

How is mathematics involved in the world of finance?
In my job, mathematics is involved through a process known as dynamic replication. What we're trying to do is to relate the prices of complex financial derivatives to simpler tradable assets.

However, even the more complex trades can generally be replicated by dynamic replication – this means knowing at all times exactly how much you need to buy or sell various simpler contracts (we call these the hedge instruments) so that the end result, no matter what the markets do, is the same as the complex trade.

This completely hedged portfolio of the complex trade and the correct amount of the hedge instruments (if it really *is* completely hedged) shouldn't be any riskier than just holding cash in a risk-free bank account, which means that we can match the expected returns and end up with a partial differential equation that relates the price of the complex trade to factors such as time, the instantaneous value of the hedge instruments, and possibly other untradeable risk factors.

How do you go about creating an economic model?
To create a pricing model, what we tend to do is consider possible risk factors and write the equations governing the asset price processes in terms of these risk factors. Then we either need to run a simulation or derive the differential equation for the price of contracts. Choosing the risk factors is the interesting part. For example, long-dated FX contracts have more risk attached to uncertainty in future interest rates, whereas shorter term FX contracts derive more risk from whether the exchange rate volatility is itself volatile.

interview

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How useful are mathematical models for predicting the future of the economy?
My colleagues in econometrics would probably say very useful indeed. But I would be doing my job very badly if I tried to predict the future. Our models need to be indifferent to it, even if we personally aren't.

What inspires your work as a financial mathematician?
The mathematics of option pricing in low dimensions is basically the same as the heat or the diffusion equation. So, and maybe because I was trained as a physicist, I tend to see economic value as a physical quantity like heat or chemical concentration. Solving these equations is very much like taking an initial distribution of ink in a tank and watching how it diffuses.

Are we heading for an economic recession? What can mathematicians such as yourself do to help prevent it?
There certainly seem to be indications that a recession is likely; there was a tremendous amount of cheap credit available earlier this decade that lenders are definitely less keen to extend now. If that leads to consumers reining in their spending, then a recession is definitely possible. What can mathematicians do? At this stage, I suspect not much. It's in the hands of the central banks now.

What are you working on now?
As always, I'm involved in a combination of projects. I'm trying to make sure our reference library has the right balance between specific and generic structures, which is good for cross-checking results. At the same time I'm trying to provide some guidance for my juniors on a problem of calibrating a mathematical model to market data, as well as working on the problem of coupling together a network of PDEs to price a particular class of security.

"The mathematics of option pricing is basically the same as the heat or the diffusion equation"

Describe your typical working day.
I don't believe in a culture of long regular working hours,

Financial terms: some definitions

Quantitative analyst ('quant'): A person who applies numerical or quantitative techniques to tackle issues in the investment industry. This may involve using either mathematical or statistical models to study financial markets.

Front office (or desk) quant: This type of quant implements pricing models that are directly used by traders. Other types of quant include *model validating quants*, whose job it is to check that front office models are correct; and *research quants*, who work on developing new pricing approaches.

Financial derivative: A financial instrument whose value is derived from a risk factor such as a rate of interest or the price of a commodity, currency or share. Derivatives are used to reduce the risk of owning things that are subject to unexpected price fluctuations. The two main types of derivatives are *futures* (contracts for future delivery at a specified price) and *options* (which give one party the ability to buy from or sell to the other party at a prearranged price).

Asset: Any item of economic value owned by a business or a corporation.

Trading desk: A desk where transactions for buying and selling financial securities (such as bonds or shares in corporate stock) can be executed instantaneously.

Hedging: A strategy designed to minimise the risk of loss when investing in the stock market. A *hedge* usually consists of taking an offsetting position in a related security.

Speculation: Engagement in high-risk business transactions (such as the trading of commodities and stocks) on the chance of obtaining large profits from fluctuations in market price. Speculation is distinct from hedging, in which the aim is to minimise risk.

Volatility: A statistical measure of the tendency of a security's value to change over a period of time. A higher volatility means that a security's value can potentially be spread out over a larger range of values and therefore the price of the security can change dramatically over a short time.

for myself or my team. I believe in taking advantage of laptops and Blackberries, and saving one's energy reserves to work long hours when they're genuinely needed. So I generally work 9am–6pm and maybe a little extra in the evening from home. I'm usually either developing code in C++ (which we typically access from Excel spreadsheets), integrating it into our systems, or writing technical documents.

What do you do if you get really stuck on a problem?
You have to get the right balance between tenacity, determination, and distancing yourself from the problem. Sometimes the best thing to do is to explain it to a friend or colleague, since the act of just talking about it can sometimes help. The other thing that I think helps is to reduce it to the simplest case that still shows the problematic behaviour.

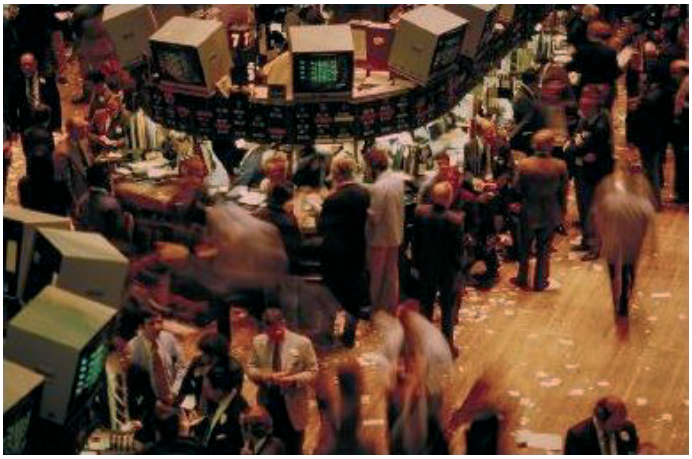
How much travelling do you get to in your job?
Not so much – I've had a couple of trips to Frankfurt for meetings and giving presentations, and I travelled up to Manchester for a careers fair last year. But London really is where it's at, especially for FX.

What do you like most about your job?
I am really enjoying designing and building a quant library that takes mathematical concepts and abstractions (such as random number generators, PDE engines, boundary conditions, least squares optimisers, etc.) and brings them to life in a real world context. I'm very lucky to get paid to do fun things like this.

…and what do you least like?
Trading floors can be pretty loud sometimes…

Profile

Iain Clark was born in London in 1970, but spent his childhood in Western Australia. He studied for a PhD at the University of Queensland in Brisbane, before relocating to Edinburgh, where he completed an MSc in financial mathematics. His first job was at the financial services firm J P Morgan in London. Now the head of FX Quantitative Analysis at the London-based investment bank Dresdner Kleinwort, he specialises in the application of differential equations to short-dated and long-dated FX (foreign exchange) derivative pricing.



Busy and noisy: a stock exchange trading floor

"If the current lack of cheap credit leads to consumers reining in their spending, then a recession is definitely likely"

How do you relax?
This line of work is rather desk-based, so to compensate I like to get outdoors – walking, hiking, running, that kind of thing. I also like playing the guitar but can't claim to be much of a musician.

If you could change one thing about the world, what would it be?
I think humankind should colonise another planet before we ruin this one or an asteroid slams into it. And we should probably do it while we still have relatively good reserves of fossil fuels to use, i.e. within this century.

What's on your to-do list for the future?
In addition to my FX responsibilities, I'm trying to learn more about other asset classes such as interest rate, equity and credit derivatives.

What is your greatest achievement?
I'm hoping I've yet to find out. So far it's getting my PhD and then finding a career in which I certainly feel I'm still utilising and continually developing the skills from my education. ●

Interview by Sarah Shepherd