Sophisticated **vulgarity**

Financial models may be mathematically consistent, but nevertheless wrong. So, what's the point of modelling? ***Emanuel Derman*** *of Columbia University discusses some of the issues*

People who haven't lived and died by financial models often have difficulty understanding how they are used. In physics or engineering, a theory predicts future values. In finance, you're lucky if your model can predict the future sign correctly. So, what's the point?

Let's look at a simple financial problem: estimate the price of a seven-room Park Avenue duplex from the known price of a two-room Battery Park City apartment. Here's a simple model: figure out the implied price per square foot of the Battery Park apartment, multiply by the square footage of the Park Avenue duplex, then make some rule-of-thumb corrections for location, views and amenities.

The implied price per square foot is the calibration parameter. It is implied, because it subsumes other variables – location, appliances and so on – that have nothing to do with the square footage itself. This simple model extrapolates from known apartment prices to unknown ones.

Black-Scholes is similar: you use implied volatility to interpolate from known stock and bond prices to an unknown call price. The volatility is implied, because it subsumes trading costs, hedging errors, salaries and so on.

Models in finance, unlike those in physics, don't predict the future; mostly they relate the present value of one security to another.

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In science, when you say a theory is 'right', you mean that it's mathematically consistent and 'true' – that is, it explains and predicts its corner of the universe. In finance, 'right' is used to mean merely consistent: many models are 'right' but usually none of them are 'true'. (They can still be useful, though.)

The capital asset pricing model is right but it isn't true; Black-Scholes is right and a little closer to true. Adding stochastic volatility and jump diffusion to Black-Scholes makes it more complex, but doesn't necessarily make it truer. It may even make it less true. Models must be calibrated to be useful, and that's very difficult for extended models.

Options pricing is unarguably the most successful theory. But it's not very accurate. If you replicate the hedging of an actual three-month index option over its lifetime, the deviations from the Black-Scholes value are surprisingly large. You cannot consistently make money by hedging a single option unless you charge a giant premium. Your best bet is to assemble a very large portfolio with a vega close to zero and hedge only the small residual gamma risk.

There is no 'true' model for the volatility smile. Stochastic volatility, local volatility, jump-diffusion and variance gamma, each of them 'right', lead to different deltas for vanilla options and different values for exotics. Each market needs its own model, and each model is imperfect.

Some of the most practical models for valuing exotic options move along the geodesic line between input (Black-Scholes implied volatilities of vanilla options) and output (exotic option values). You use static vanilla hedges to approximately replicate an exotic in a Black-Scholes world, then turn on the smile to see what happens to the vanillas. You haven't eliminated model dependence – you're extending Black-Scholes somewhat inconsistently – but the method is more direct.

What I like about this approach is its sophisticated vulgarity, in the sense that it employs only the patois of markets – Black-Scholes volatilities. And what are markets if not vulgar? In physics, it pays to drop down deep, several levels below observation, formulate an elegant principle, then rise to the surface again to work out the observable consequences. In finance, the most usable models are wisely vulgar – they use variables the crowd uses.

Options theory works like this: 1) pick a plausible stochastic process; 2) calibrate the parameters to match the prices of liquid securities; and 3) use the model to calculate the values and hedge ratios of other securities. This method began with Black-Scholes. Every few years, we've moved to a new asset class. Eventually, we unleash the calibration parameters themselves and let them become stochastic too.

The paradigm's difficulties are well known: first, a financial model isn't a law of nature – it's a limited starting point based on naive assumptions whose every possible violation should be considered.

Second, our understanding of underliers is poor. Eugene Stanley of Boston University and his collaborators have discovered remarkable power-law universalities in the distributions of stock returns. Their discovery, and its consequences for options prices, deserves disproof or elaboration. Large-scale understanding of underlier behaviour will probably come before small-scale understanding, just as pressure, temperature, volume and thermodynamics preceded atomic theory and statistical mechanics.

Finally, how do we develop a better theory of absolute pricing when markets are incomplete and hedging is impossible? ■

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