Nine billion ways to be snowed

Emanuel Derman separates real tools from passing trends in the risk management vocabulary. This article is adapted from his talk on Future Innovations in Risk Management, presented at the April Risk 2002 Conference in Paris

There is an attractive theory in linguistics known as the Whorf hypothesis, or sometimes, more accurately, as the Sapir-Whorf hypothesis. Loosely speaking, it claims that a culture's language determines the perceptions, thoughts and even behaviour of its native speakers. Simply put, you can't think about things you don't yet have words for, and you can't have words for things you haven't yet thought of.

Whorf's most famous example concerns the Eskimos, who, he claimed, have many more words for snow than we do. Because the qualities of snow are so important to their survival, the argument goes, the Eskimos have learned to perceive (and hence talk about) finer variations in snow quality. It's a captivating story, but not necessarily true. Some studies have claimed to show that other languages transmit the same degree of snow discrimination by using phrases rather than single words, and further studies have contradicted those.

Nevertheless, the notion that language development and the development of perception are culturally linked carries a charm and plausibility that ensures its persistence, if not as a theory, at least as an urban legend. Some psychologists have gone further, claiming that people whose language is less suited to describing subtle colour differences are worse at perceiving them. At the far end of the spectrum, there are those who claim that the concept of colour itself was a human invention, created or discovered and then passed down to us, like the theory of perspective in art, or like other scientific and cultural advances.

I used to think this was totally implausible until I observed my children when they learned to talk, and noticed that it took them much longer to grasp the correct usage of words for colours than words for objects. Colour as a category is certainly a great abstraction; how strange to describe both an oak leaf and the background on my computer's display as 'green', when they have almost nothing else in common.

The right concept and the right word, at the right time, if they make thinking easier, can stick and take over the world. So too with financial models. Creating successful financial models is not just a battle for finding the truth, but also a battle for the hearts and minds of the people that use them. Look for example at option-adjusted spread, an intuitive way to extend spread-over-Treasuries to the world of uncertain payouts. Despite its theoretical problems, it has become the euro of the mortgage and bond markets.

Central challenge

The central challenge of financial valuation is categorising risk and then putting a price on it. In financial modelling, as in any science, ideas come first and their quantitative elaboration follows. Useful theories of value and risk management enumerate and specify the types of risk and the rewards they should generate. The late Owen Barfield, in his History in English Words (1926), traced the development of human consciousness by examining the appearance of new words in our language. Here I want to trace the past and guess at the future of recent ideas about risk by looking at the history of its vocabulary and seeing which new words have survived and prospered.

So, let's start with the most time-honoured word and concepts (Beckers, 1996). Before Markowitz, risk was simply loss, but post-Markowitz, risk involves the **variance** and **correlation** of returns. Risk is a relative quantity, dependent on **portfolio** weights and susceptible to **diversification**.

Two steps forward, one back. By its nature, the **correlation matrix** for a large portfolio requires a long time series, which will then cross market regimes. Giant correlation matrixes can be unintuitive and even nonsensical. Along came the capital asset pricing model and the view that the driver of expected return in equilibrium must be **non-diversifiable risk**. What counts is the **beta** of each stock, its relevant relation to the market. Arbitrage pricing theory introduced **multiple risk factors** for real returns, a framework that now lies at the basis of most risk models.

Since 1973, our vocabulary has grown to encompass **convexity** and its concomitants, **delta**, **gamma** and **dynamic replication**. **Implied volatility** is the market's consensus, in one effective variable, of the future cost of replication under convexity. **Arrow-Debreu state-prices**, **calibration**, **risk-neutral valuation** and its high-falutin nephew, the **martingale measure**, all represent the crystallisation of additional insights.

Options theorists have had a great ride with the replication of hedgeable risk. Nevertheless, most movements in the world aren't hedgeable. Are we nearing the era of diminishing returns?

Here to stay?

What about our present vocabulary? What current fashionable words are likely to stick?

Some fads die fast: **expert systems**, **AI**, **chaos theory** and **neural nets** have so far proved less than useful, and are now so-last-century. But **value-at-risk** is still a 900-pound gorilla, uncaged and here to stay. Don't mistake it for a theory; it's a measure, a monitoring device. The key to risk management is still understanding where your risk comes from, and VAR doesn't automatically provide that insight. It is not enough to know that your VAR is $50 million; you should want to know under what **scenario** your portfolio will suffer that loss.

The **volatility smile** is also here to stay, propagating from options market to options market as participants get better at reflecting their experience and fears through options prices. We still lack a standard model for these effects. There may not be a standard – each market seems to suffer a skew for a different reason. Perhaps the theories of local and stochastic volatility and jump diffusion will give way to more realistic models of **regime switching**, no easy task.

The near-term future of **exotic options** seems to lie more with **hybrid products** than with ever-more arcane single-underlier payouts. Hybrids, like basket **credit derivatives**, demand the valuation and hedging of correlation, volatility's unstable and difficult step-sister.

Expect to see more realistic pricing of illiquid derivatives contracts. For this purpose, **profit and loss simulation** has a growing future. What matters for a trading desk is not a simple model price, but what actually happens to a hedged portfolio, given the movements of real markets and the way traders adjust their hedges. The distribution of simulated P&L provides the appropriate information to calculate capital charges and uncertainty reserves, especially for illiquid products. Also, expect to see the prices of derivatives contracts better reflect the difference in credit qualities of party and counterparty.

The future

As for the future, I would like to see more ambitious **theories**. You can't understand data without a theoretical framework. "When I read an empirical paper, I usually seek out the theory section and ignore the tables," wrote Fischer Black (1993). I'd like to see a little less of regression models and a little more in the way of models with **dynamics** and **causality**. Regression merely describes the degree to which things move together; dynamics tells you who's the mover, and why. You need dynamics if you want to make Theories Of More Than One Thing, to unify different kinds of risk under one umbrella – bonds, stocks, credit spreads and default probabilities, for example.

It would also be satisfying to narrow the gap between the invisible microstrucure of markets and the observable macroscopic regularities of prices. In physics and chemistry, thermodynamics deals with the macroscopic behaviour of materials, while statistical mechanics provides the microscopic justification. There, macro and micro work in tandem, complementing each other. In financial theory, the gap between macro and micro is disturbingly large. We need a better macroscopic description of the properties of **return distributions** and their relation to **liquidity**, **trading volume** and **market impact**, and we need a microscopic model of how these properties come into existence. What is the analogue of the ideal gas law for markets?

None of this is easy, which is why it's almost 30 years since Black-Scholes. Financial modelling is so hard because of the implicit interaction between past and future. Physics, chemistry, engineering and even biology use differential equations to project you from the past or present into the future. Time runs forward. Financial models also project you into the future, but the data they begin with (yields, volatilities, default probabilities, etc) are sentiments about markets' future behaviour. Time runs from the future into the present and then back into the future again. That's because we're dealing with behaviour. The capital asset pricing model is about expected return. Options value is determined by implied volatility. 'Return' and 'volatility' lie in the realm of quantitative finance, but 'expected' and 'implied' lie in the domain of behaviour. A future theory that married the quantitative to the behavioural would be a worthy goal.

In his vaguely Borgesian story, The Nine Billion Names of God, Arthur C Clarke describes a monastery of Tibetan monks who believe that God's work for the world will be complete only when all his 9 billion names have been enumerated. The monks order a mainframe, programmed to work its methodical way through the enumeration of the names. Having delivered the computer, written the program and started its execution, the engineers enter their airplane and leave Tibet. A short while into their flight they notice all the stars in the firmament beginning to dim. The universe is complete.

We will never see the end of risk management. Every year brings new instruments and more subtle ways of courting catastrophe. But our job is to understand and enumerate the types of risk, to develop new theories, and ultimately, to be able to name and price the 9 billion ways markets can snow you. ■

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