

## **Financial Models Must Be Clean and Simple**

The complex financial models that got us into this mess too often mask human nature behind false limitations of risk

By Emanuel Derman and Paul Wilmott

Whirring away at the center of the mortgage meltdown that prompted the current crisis were those theoretical constructs known as financial models. As bankers sliced and securitized mortgages, traders and investors relied on the models to calculate the bundled loans' values and risks—risks they failed to predict.

What went wrong? As modelers, we see the fantasy of perfection as the fatal flaw seducing both developers and users. The invisible worm of financial modeling is a dark love of theoretical elegance and excessive precision.

Whenever we make a mathematical model of something involving human beings, we are forcing the ugly stepsister's foot into Cinderella's pretty glass slipper. It won't fit without sawing off some essential parts. Trimmed for simplicity or beauty, models inevitably mask risk rather than expose it.

At bottom, financial models are tools for approximate thinking, a way to help transform one's intuition about the future into a price for a security today. The key word here is approximate. The most important questions about any model are: "What does it ignore, and how wrong is it likely to be?"

Financial modeling hit Wall Street big-time back in the 1970s when listed equity options markets opened in Chicago and interest rates soared after the U.S. dollar went off the gold standard. The growing options market created demand on Wall Street for "rocket scientists," as we quants were then called (in the mistaken assumption that rocketry was the cutting edge of physics). Our mission was to manage and hedge risks with models and the computer programs that used them.

Physics, because of its astonishing success at predicting the future behavior of material objects from their present state, has inspired most financial modeling.

Physicists study the world by repeating experiments again and again to discover natural forces and their almost magical mathematical laws. Galileo dropped weights from Pisa's leaning tower. Giant teams in Geneva study what happens when protons repeatedly collide. If a law is proposed but experiments contradict its predictions, it's back to the drawing board.

The method works. The discovered laws of atomic physics are accurate to more than 10 decimal places.

Financial theory has tried hard to emulate physics and discover its own elegant, universal laws. But finance and economics are concerned with the human world of monetary value. Markets are made of people who are influenced by events, by their feelings about events, and by their expectations of other people's feelings about events.

There are no fundamental laws in finance. And even if there were, there is no way to run repeatable experiments to verify them. Financial theories written in mathematical notation—aka models—imply a false sense of precision. Good modelers know that.

You can hardly find a better example of this problem than in models for the bundled mortgage securities known as collateralized debt obligations. (The issues are complex, so bear with us as we get a little technical.)

To estimate values for these CDOs, CDO modelers apply abstract probability theory to the price co-movements and default probabilities of thousands of mortgages.

This reliance on probability and statistics is a severe limitation of CDO models. Statistics are merely shallow description, quite unlike the deeper cause and effect of physics. Yet the causes of defaults can be complex. One homeowner's default is likely to be followed by another if interest rates have increased and housing prices fallen, for instance. But such a second default will be less likely if the government has taken action to lower rates or prop up housing prices after a first wave of defaults.

Statistics can't easily capture such subtle causal sequences. Nor can the soundness of the variety of mortgages in the pool be accurately represented by a single, average number.

Still, CDO modelers need to make their abstract theories usable. So they resort to sweeping under the model's rug all the unknown behavior of mortgage holders considering default and the dynamics of their interaction with the larger economy.

All that's left at the end is a single model variable: "the default correlation," which represents the probability that, on average, any one future loan default will be accompanied by another.

Other than the future growth in housing prices (which was almost always overestimated), it is the value of this variable alone that determines the CDO price. Worse, the simplistic model gives no indication of the CDO's risk.

What makes a good model, then? We think the best ones use only a few variables and are explicit about their assumptions. In this regard, we believe that the Black-Scholes model for options valuation—now often maligned—is a model for models. It is clear and robust. Clear because it is based on true engineering: It gives you a method for manufacturing an option out of stocks and bonds, and it tells you what, under ideal circumstances, the option should be worth. (To picture how the model works, imagine Del Monte figuring out the offering price of a can of its tropical fruit salad from the cost of the individual fruits, labor, and transportation.) The world of markets doesn't exactly fulfill the ideal conditions Black-Scholes requires. But the model allows an intelligent trader to see what real-world dirt has been swept under the rug—and to adjust his or her risk estimates accordingly.

Financial markets are alive. A model, however beautiful, is an artifice. To confuse the model with the world is to embrace a future disaster in the belief that humans obey mathematical principles.

How can we get our fellow modelers to give up their fantasy of perfection? We propose, not entirely in jest, a model makers' Hippocratic Oath:

- I will remember that I didn't make the world and that it doesn't satisfy my equations.
- Though I will use models boldly to estimate value, I will not be overly impressed by mathematics.

- I will never sacrifice reality for elegance without explaining why I have done so. Nor will I give the people who use my model false comfort about its accuracy. Instead, I will make explicit its assumptions and oversights.

- I understand that my work may have enormous effects on society and the economy, many of them beyond my comprehension.

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Business Week Online, December 31, 2008, 5:00PM EST