Paradigm Lost

What can 19th-century epidemiology teach us about 21st-century investment models?

BY AARON LAI, CFA

Light after light well used they shall attain,
And to the end persisting, safe arrive.
This my long sufferance and my day of grace
They who neglect and scorn, shall never taste;
But hard be hardened, blind be blinded more,
That they may stumble on, and deeper fall. …
—from Book III of *Paradise Lost* by John Milton

Since the global financial crisis, the defects and dangers of financial models have come under severe scrutiny. Niall Ferguson, a foremost financial historian at Harvard, argued that the Nobel Prize winners behind Long-Term Capital Management knew "plenty of mathematics, but not enough history. They had understood the beautiful theory of Planet Finance but overlooked the messy past of Planet Earth"—with disastrous results.[1] The financial crisis was a larger version of the same problem. Is it really true that every financial analyst, especially the "quants," have committed nothing but a fatal conceit? What about the investment professionals who rely on them? Investment professionals routinely use quantitative models to make decisions. In some cases, the models "make decisions" on behalf of the professionals (e.g., algorithmic trading); in other cases, the investors make decisions using insights based on models (e.g., credit exposure).

Since Eugene Fama of the University of Chicago published his seminal paper on the efficient market hypothesis (EMH) in 1970, many financial models, including such Nobel Prize-winning works as Black–Scholes–Merton option-pricing models, the capital asset pricing model, and the Modigliani–Miller theorem, have depended on the assumption of an efficient market. Unfortunately, we might have built our castles on sand. Empirical studies might support or cast doubt on EMH but can never be conclusive. If EMH were *in*correct, we would lose decades of progress because most mathematical financial models would no longer be usable. Moreover, what about the failure of conventional models during the recent global financial crisis? An example from 19th century epidemiology offers a helpful analogy.

In 1853–54, a cholera epidemic erupted in Europe. The disease caused more than 20,000 deaths in England and Wales. The dominant epidemiological theory of the time—the miasma theory (sanitary statistics)—suggested that the disease was caused by poisoned soil, air, and water. A rival theory, called the germ theory, postulated that infectious agents were the cause, but the germ theory was hampered by a lack of supporting evidence. Inconsistent data were considered as outliers or the result of incorrect applications. Even then, leading epidemiologists and government officials subscribed to the conventional miasma theory because of its apparent explanatory power. Like EMH, it could explain some of the cases some of the time but not all cases at all times.

The puzzle was finally solved by John Snow of England. He initially took a statistical approach to the cholera problem. Unfortunately, he could not find an obvious relationship among the various attributes evaluated (age, gender, occupation, and so forth). But when he plotted the deaths on a map of London, he found a remarkably interesting area of high mortality—700 deaths within a 250-yard radius around a water pump on Broad Street.

Data visualization was only part of the solution. Snow personally visited and checked those cases that did not fit his theory. For example, why did some houses close to the pump have no deaths? He eventually discovered that those houses, which were breweries, did not use the Broad Street pump at all. He solved the cholera puzzle not with fancy statistical techniques but by meticulously checking his dataset. Checking those inconsistent observations was a particularly important step. Rather than dismissing them as outliers, he sought to find explanations. The implications for financial models are more than merely notional. As reported in the *Financial Times*, PIMCO dispatched troops of analysts to talk to realtors while pretending to be buyers and got the real temperature of the market as early as 2005. The firm took this approach to avoid relying solely on investment models. PIMCO management did what Snow had done and thus weathered the crisis well.

Good results will come only from good data. An example involving a leading empirical researcher, Yin-Wong Cheung, professor of finance at the University of California–Santa Cruz, illustrates the importance of prudence. In an empirical study on the relationship between exchange rate and Hong Kong export performance (subsequently published as "An Analysis of Hong Kong Export Performance" in the October 2005 issue of the *Pacific Economic Review*), Cheung initially found a negative relationship between real exchange rate and export price. His first reaction was to go through the whole estimation methodology and computer codes he had adopted. After two weeks of searching for "bugs," he finally found the culprit—the CPI (consumer price index) data provided by the data vendor. Analysts receive countless data from various sources. Our job as analysts is to check ››

1 Niall Ferguson, *The Ascent of Money* (2008).

and validate every piece of input fed into a model. As the old saying goes, garbage in, garbage out.

Because mathematical models must be internally consistent, developing practical models sometimes requires unrealistic assumptions. A famous example from the history of physics highlights this pitfall. To resolve inconsistencies of planetary motion, 19th century physicists (limited by their reliance on the Newtonian framework) developed the hypothesis of an "ether." A famous experiment disproved the hypothesis and set the stage for Albert Einstein's development of relativity theory, which rendered the mysterious ether unnecessary. Ronald Coase, a University of Chicago economist and Nobel laureate, once predicted that "utility" would become as obsolete as ether in physics. Decades later, this view remains only a prediction.

Investors face problems analogous to those confronted by Victorian epidemiologists and physicists. We have some "nice" models that can explain most cases most of the time, but they have failed miserably in some cases, especially the critical ones. What should an investor do? As a starting point, we should have curious minds and intellectual integrity. As in the case of Snow, we need to pay serious attention to minute details in data. We need to constantly ask ourselves what could break the models we are using or what could make a theory incorrect.

Although the axiomatic approach was good for mathematics, it might not be practical for real-world subjects, such as finance, according to Emanuel Derman of Columbia University, an inventor of the famous Black–Derman–Toy interest rate model.[2] "Theories deal with the world on its own terms, absolutely," Derman has written. "Models are metaphors, relative descriptions of the object of their attention that compare it to something similar already better understood via theories. Models are reductions in dimensionality that always simplify and sweep dirt under the rug. Theories tell you what something is. Models tell you merely what something is partially like." As a former Goldman Sachs quant, Derman is well qualified to fire the warning shot—models are not the truth, and we should not treat them as such.

Investors should explore alternative theories/assumptions for the phenomena their models explain; our eyes should be wide open to alternative theories or explanations. A notable pioneer in "alternative" theory, Andrew Lo of MIT, has proposed an "adaptive markets hypothesis" that assumes market participants are adapters rather than perfectly rational players.[3] The adaptive market hypothesis, which can help us think beyond the usual "optimal solution" and "rational investors" paradigm, consists of five elements: (1) individuals act in their own self-interest, (2) individuals make mistakes, (3) individuals learn and adapt, (4) competition drives adaptation and innovation, and (5) evolution determines market dynamics.

Another route to "alternative" theories comes from evolutionary biology. In a 2010 paper published in the journal *Nature*, Andrew Haldane, the executive director of the financial stability board at the Bank of England, and Lord Robert May, an evolutionary biologist from Oxford, explained what bank regulators could learn about the stability of financial systems by drawing on the insights of epidemiologists.[4] They emphasize systemwide stability and the role of the interconnections among banks with similar strategies and asset classes because interconnectedness is particularly prominent in liquidity shocks. The key to stop the spread of a disease is to stop the "super spreaders," and the key to stopping a financial market contagion is containing the effects of a handful of critical firms or junctions (e.g., Lehman Brothers). Haldane and May argue that regulators should focus on a financial institution's impact on the wider financial system and not simply the institution's own ability to survive a crisis. "Excessive homogeneity," they write, "can minimize risk for each individual bank but maximize the probability of the entire system collapsing." Unfortunately, after the financial crisis, the "survival of the fittest" becomes "survival of the fattest"! If the regulators had had less faith in the almighty free market as implied by the EMH and had paid more attention to the concentration of power and the fallibility of risk management models, we might have been able to avoid the near-death experience of global financial meltdown. We investment professionals could have used this "alternative" theory to better understand our counterparty exposure. Consider that Lehman Brothers, as a stand-alone company, had a strong regulatory capital ratio the day before it collapsed.

To borrow from an old saying, we analysts know the prices of everything but the "value" of nothing. Keynes famously said that when evidence changed, his view would also change. Snow found that his germ theory could explain the situation better than the conventional miasma theory because his theory fit the data not only in the analytical sense but also in the clinical sense. (People with cholera suffered gastrointestinal symptoms, not the respiratory symptoms predicted by miasma theory.) It is important to know when to use a model; it is even more important to know when *not* to use one.

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2 Emanuel Derman, "Metaphors, Models & Theories," (December 2010). (www.edge.org)
Emanuel Derman, "Models," *Financial Analysts Journal* (Jan/Feb 2009). (www.cfapubs.org)

3 Andrew W. Lo, "Alpha and Beta in the New Financial Order," (2009). (www.cfawebcasts.org)

4 Andrew G. Haldane and Robert M. May, "Systematic risk in banking ecosystems," *Nature* (20 January 2011).