Pygmalion held such high standards for women that none could meet them. Driven crazy with loneliness, he sculpted what he thought was an ideal woman of ivory. He clothed it, wedded it, and took it to bed. Aphrodite, taking pity on him, substituted a real woman for the sculpture and blinded him to her imperfections.

Unfortunately, Pygmalion’s blessing made him insufferable. Bragging of his intolerance for flaw, he encouraged wave after wave of idolatry. People clung to their narrow images of perfection and begged the gods to make them real. They forgot that reality transcends imagination.

For those of us in finance, it is high time to remember.

As we return to work or studies, as we review our investments or speak out as citizens, I hope we find both new respect and new skepticism for financial markets. Winston Churchill once described democracy as the worst form of government except for everything else. We can say the same about financial markets as predictors of future returns. They disgrace with error, and dazzle with error correction.

Fair value can never be more than what we’re learning it to be. Learning adds risk. Moreover, we can never completely get a handle on learning risk; it’s too complex and unpredictable. The best we can do is track its
evolution, project it forward with broad confidence intervals, and correct the mistakes we see.

When it comes to specific conclusions, each of us is entitled to draw her own. Here are mine. Mostly they recapitulate comments made earlier.

Risk-astrophe

Financial catastrophe in 2008 blindsided the world. It destroyed trillions of dollars of nominal wealth in a few months. It shattered confidence. It shuttered production.

It wasn’t supposed to happen. Yes, the theoretical possibility was recognized. Any system founded on beliefs risks their rejection. Markets can have bubbles. Bubbles will pop. But there weren’t supposed to be so many bubbles, much less so many popping at once. What happened to our risk controls?

The answer is that they did control risk, only not in the way we wanted. They redirected risk toward safe sectors, only to make them unsafe from the concentration. They kept small risks under control, only to induce even riskier leverage. They deterred uncoordinated blowups, only to make a coordinated blowup more devastating.

But the answer still begs why. Did we measure risk wrong? Did we measure the wrong risks? Did we use the measures wrongly? Did we wrongly expect too much from risk measures?

Yes. Yes. Yes. Yes.

We stumbled because we forgot an eternal trade-off. People can seize opportunity only by taking on uncertain risk. Metaphorically I ascribe this to an ancient bargain between Zeus and Pandora. Having emerged from the box of treasure and woe, risk can never be compartmentalized again. Mankind can aspire to mastery of the universe but never achieve it. To err big is human.

Finance continually pushes us to the edge of this bargain. Its willingness to price uncertain risks and trade them encourages innovation. But that doesn’t mean asset markets know the true risks. Market-clearing prices are just consensus beliefs, weighted by the money attached to convictions. Truth enters only in dribs and drabs, via observations that give noisy evidence on the current path and foggy glimpses into the future.

Consequently, whether we focus on objective risks or beliefs, we will never completely tame financial markets. They are bound to evolve in sur-
prising ways and make us scramble to control them. If we try to regulate them tightly, the way some think is right, we will quench the fires of discovery and innovation that make our world so special.

Risk-pertise

One thing the financial world sorely needs is more risk-analysis expertise. Current standards are grossly lopsided. Most risk managers have detailed knowledge of individual trade exposures, largely redundant with that of the traders they’re checking on. However, when it comes to aggregating those exposures into portfolio risks as whole, they often know barely more than outside regulators.

In my experience, less than a quarter of risk managers understand the precision of the estimators they use, much less the trade-offs between estimators. Most measure their reports by the number of pages they contain, not the insights they provide. Spurious information obscures the connection between portfolio tail risks and common risk drivers.

The further one gets away from trading, the worse it gets. Consider the Madoff scandal, the biggest private-sector Ponzi scheme of all time. Nearly as disgusting as the fraud itself was the lapsed oversight of regulators and feeder funds. Already by 2000, Madoff’s performance record was, from a statistical perspective, too smooth to be true. Yet when investigator Harry Markopolos reported this to the SEC along with other circumstantial evidence, he met with incomprehension (Markopolos 2010).

This is pathetic. Centuries ago, before people understood the germ theory of disease, barbers doubled as surgeons because they knew how to use knives. How much longer will people oblivious to statistics be allowed to judge reasonable financial doubt?

Risk managers and regulators who’ve worked their way up without deep risk-pertise are unlikely to think they need it now. Let us focus instead on training future cohorts. At least three professional associations already sponsor certification programs for financial risk analysts. These kinds of programs need to be expanded and deepened.

Personally I’d like to see a three-year program, with each year offering Master’s-level training in a different field: economic history, statistics, and finance. Toss in some cross-disciplinary seminars, case studies, and internships on trading floors. Perhaps China or India, with fewer vested interests in the status quo, will seize the opportunity to lead in training.
Having skilled cohorts at hand won’t force risk takers to take heed. Finance should learn from Ulysses. When he wanted to hear the Sirens lure him to ruin, he had his crew tie him to the mast, stopper their ears with wax, and row past regardless of his orders. Since few higher-ups will voluntarily abridge their powers the way Ulysses did, and since the potential social damage from mishandling risk is so high, let’s try to embed more responsibility into the decision-making process.

That’s a tall order. No regulations can measure up. Indeed, they might divert more effort to checking boxes than to thinking outside them.

However, let’s consider the starting point. We can’t legally run a trucking company without hiring licensed drivers, providing them with safety equipment, and ensuring our trucks don’t spill toxic waste on the roads. We can legally run a huge investment firm trafficking in tens of billions of dollars in potentially toxic derivatives without being required to hire any licensed risk professionals, defer to expert judgment, or avoid behavior we know is unsound.

On balance I think the problems are best addressed through extending the “actuary approach” long used in the insurance industry. Like doctors and lawyers, actuaries have to pass rigorous exams administered by a professional board. They also pledge a fiduciary responsibility to the public.

Needs for actuary approval discourage misrepresentation of risks or intentional underfunding of reserves. Actuaries carry enough prestige and professional backing that employers are wary of twisting their arms. However, actuaries do work for their companies and have incentives to take thoughtful risks.

This is not a call to manage the rest of finance like insurance. Market risk is wilder and woollier than ordinary life-and-casualty risk; it needs room to roam. I am simply recommending that we raise qualification standards, hold risk managers accountable for substance as well as form, and provide external backing.

Perpetual Debt Deferral

The biggest single systemic risk in finance is domestic sovereign default. It strikes not only at sovereign debt holders but also at confidence in the rules of the economic game. However, paying off debt is burdensome. As an alternative, suppose a sovereign resolves to service all principal and interest by issuing new debt. No lender gets defaulted on; no generation ever
feels the burden of repayment. It’s like issuing a perpetually deferred perpetuity.

Perpetual deferral is a game of musical chairs in which most of the chairs and players are concealed from view. By allocating a bit more GDP toward repaying debt or growing a bit faster, perhaps the sovereign will start supplying chairs faster than new players arrive. Until then, the knowledge that some players bring their own chairs and don’t need to sit in them right away gives us confidence in finding a seat.

Most developed countries are currently playing the biggest perpetual deferral game of all time. Judging from history, they will most likely fail. Previous debt spirals have nearly always culminated in default.

The United Kingdom and the United States were the most prominent exceptions to this rule. They undertook huge debts in wartime and worked them down relative to GDP in peace, with the support of prospering citizenry grateful for victory. The context today is very different. The debts pay for leisure and health care, the structural balance between net benefit takers and net taxpayers is worsening, and every generation insists that it not be a net payer.

Yet they don’t have to fail. World productivity is growing at record rates. Debt stocks can expand in proportion without raising the percentage burden on GDP. The expansion amounts to a kind of seigniorage that governments can tap. More importantly, by raising retirement ages and private copayments for health care, it is relatively easy to get public finances back on track.

Hopeful uncertainty helps explain developed governments’ ability to raise enormous sums at low rates, even as fiscal imbalances worsen. Other factors enter, too: the Chinese government’s willingness to lend, fear about the business climate for private investment, and search for safe havens from debt blowups elsewhere. Still, uncertainty lies at the core.

The implication for good policy is clear. Don’t take this benevolent uncertainty for granted. It can turn quickly, as it has for the PIIGS. Perhaps it should. When I said it was relatively easy to get public finances back on track, I meant relative to the effort needed to fight a war or holocaust. When it comes to gathering motivation it’s extraordinarily difficult. The greatest single demotivator is the ease of rolling over debt.

More transparent accounting of the costs and risks can help. Stop exempting public agencies from private sector standards for estimating the NPV of future obligations. To put teeth in this, let’s make accomplices liable for knowingly abetting concealment. For example, some investment
banks have reaped billions of dollars from helping governments and public agencies cook their books. This ought to be a crime.

**Bank Regulation**

A lot of bank regulation pretends that a steady stream of future revenues can substitute in crisis for cash on hand. Hundreds of years of banking experience tell us otherwise. Yes, developments in financial markets make more assets more liquid most of the time. But they can’t prevent emergencies where cash is king. Banks that can’t tide themselves through emergencies aren’t worth banking on.

Ensuring the smooth functioning of the payments system should be a top priority. To that end, let’s reduce duration mismatch. Make banks that depend heavily on demand deposits shorten their lending profile. To secure extra buffers they’ll have to offer new savings products or seek longer-term capital.

Few banks want to do that. They profit from offering liquidity on the back of illiquidity. Many economists applaud. They feel that borrowing short to lend long encourages productive investment. Conventional wisdom accepts high duration mismatch and just seeks to make lending safer.

I demur. Given the importance of stable liquidity, we should be wary of pumping it up on false pretenses. Besides, the world isn’t short of aggregate saving, except where tax and benefit policies discourage it.

What the world is short of, and will always be short of, is lending under both high risk and high uncertainty. That’s where banks can help. In the course of handling payments, they learn about real businesses and their customers. They learn about real homeowners and their jobs. The more idiosyncratic the risk and the harder it is for third parties to neatly categorize, the more banks ought to excel relative to alternatives.

Hence we should welcome banks making lots of relatively risky loans, provided the risks aren’t too common and the spreads cover costs. Securitization should enhance this comparative advantage, by allowing banks to resell the most standardized exposures of their lending books. Better-matched duration will reduce vulnerability to panic. Add another layer of protection by tightening leverage caps.

Regrettably, the global banking reforms summarized in Basel I and Basel II moved in the opposite direction. They excused nearly any duration mismatch or leverage, provided it was “safe.” The safest categories, in Basel’s
view, were developed country debt and home mortgages. Not surprisingly, that’s where the investable money went.

It made people feel richer, as low bond rates buoyed equities and low mortgage rates buoyed housing. The flip side was less investment in manufacturing and private-sector services, even as foreign imports soared. It exacerbated the hollowing out of productive capacity in the developed countries, a trend Landes (1999) had decried even before.

The worst part was aggravation of the credit cycle. Trillions of dollars funneled toward the same low-risk loans initially vindicated their safety. As valuations soared, loans came to be backed more by prospects for favorable rollover and further appreciation than by real earning power. Basel helped a mountain of debt disguise itself as a mountain of real wealth.

Credit Rating

The main problem with credit ratings is how we use them. We need to stop idolizing assurances of safety. Even experts can’t know. They are extrapolating from too little data into environments than can easily change. The estimates don’t deserve the reserves-not-needed pass that current regulations give them.

That doesn’t mean we should cripple rating agencies. Credit rating is a valuable service. It summarizes information relevant to servicing and makes it easier to compare credits. Sharing information economizes on investigation and helps build a consensus.

I don’t even mind that regulators delegate some of their powers to rating agencies. On balance, that breeds more competence and less corruption than an in-house monopoly. While it tempts credit rating agencies to shade their ratings, concern about reputation usually provides a reasonable offset.

Clearly that offset failed in the last bubble. Rating agencies deserved to be shamed. Their defective modeling of portfolio risk contributed heavily to securitization.

Still, I blame banking regulations at least as much for providing such skewed incentives. The leverage gradient for credit ratings is way too steep. The extra uncertainty at high credit grades calls for extra buffers. My ballpark estimate is that gradients should be no more than half as steep as they are now.
To make rankings more useful, credit rating agencies should be obliged to indicate their uncertainty. Mathematically this corresponds to reporting the variance of default risk estimators as well as the means. As rating agencies and users are accustomed to non-numeric credit grades, the most palatable way to inform of uncertainty would be to report a credit grade range.

Rating agencies already hint of uncertainty through credit watches, warnings, and outlooks. Issuing upper and lower credit grades would make this routine. It would encourage timelier adjustments and discourage outcry, since no single grade would look quite so bold.

Upper and lower credit grades will be particularly useful for rating issuers with implicit guarantees. The PIIGS in Europe, overstretched U.S. states and municipalities, and the Fannie/Freddie mortgage giants are unlikely to service their debts on their own. No higher authority explicitly guarantees their debts. However, they can surely tap external assistance, and possibly enough assistance to avoid default. High and low credit grades should therefore reflect the default risks with and without assistance.

Ratings of credit portfolios need a more fundamental makeover. The dominant methodologies are wrong. They ignore common drivers—e.g., a credit bubble’s impact on mortgages.

With common drivers, defaults tend to cluster. This makes portfolio tail risks decay much slower than for the standard binomial and normal benchmarks: indeed, more log-linearly than log-quadratically. A mixed gamma-Poisson distribution, also known as negative binomial, provides a much better benchmark.

Value at Risk

Value at Risk is the most beautiful name ever invented for a bad financial concept. It suggests certainty where there is none. It portrays a floor on crisis exposure as a ceiling. It pretends to a precision and robustness it doesn't have.

The rational essence of VaR is a percentile calculation: a threshold loss expected to be exceeded some fraction of the time. Reserve concerns favor setting the fraction at 0.1% or lower, so as not to threaten a crisis every year. Direct estimation tends to be so unreliable that the fraction is usually set at 5%. However, a 5-percentile is significantly less precise than an ordinary standard deviation, without providing any more insight into tail risk.
An even worse problem is the typical one-to-two-year sampling horizon for VaR. That’s far too long to provide useful warning of market storms. Forecasters of market risk need to learn from the experience of weather forecasters. Medium-term projections don’t work; too many things can go awry. Focus instead on up-to-date tracking, short-term projection, and error correction.

Granted, short-term forecasts can be myopic. Financial risk analysts need to stay aware of economic history, sovereign debt pressures, and other macro factors. It’s analogous to a weather forecaster staying aware of seasonal changes and climate.

The trouble with standard VaR is that it tells us neither weather nor climate but some jumble in between. Standard VaR reports are like weather reports updating us on the twelfth worst weather experienced over the past year. They won’t help us plan our day. They won’t help us plan for disaster.

Decades ago, regulators banned advertisement of cigarette filters as protection against tobacco carcinogens. Let them now ban the advertisement of VaR as protection against financial carcinogens. Let’s advertise, instead, our evolving uncertainty and forecasters’ best efforts to understand it.

We can improve dramatically on VaR by tracking slanted trading ranges or “price channels.” Good traders have done this for generations. With modern technology it’s easy to evaluate a host of different methods, mix them dynamically for better tracking, and make this information widely available. Simple calculations with trading range data put VaR to shame.

Publishing volatility-adjusted indices would be a practical way to alert investors to market risk. Over time, these could become investible instruments themselves. Such instruments could help level the playing field for smaller investors.

21st Century Finance

In the late nineteenth century, Rayleigh’s Law in physics predicted that looking into a hot black box should blind the viewer with X-rays. When this didn’t happen, no one complained that radiation was foolish. Physicists humbly recognized that if practice consistently defies existing theory, existing theory must be wrong.

Eventually someone came along who thought outside the box about the box. He found a single way to explain the evidence: nature must restrict
energy discharge to discrete pulses. Max Planck’s discovery marked the birth of quantum theory.

Fast-forward a hundred years. Finance researchers have discovered numerous puzzles where practice defies existing theory. However, finance theory has not reinvented itself the way physics did. Instead it has split into rival camps. In a sense, orthodox finance studies optimal “economically rational” rules of conduct while behavioral finance studies the violations. Synthesis is reduced to estimating the empirical mixture.

I believe that uncertainty and learning can account for most apparent violations of economic rationality. Pandora’s Equation, which shows that each update of a cumulant of beliefs depends on the cumulant one order higher, provides a key to understanding. Demonstration of its full power falls outside the scope of this book. However, we did see how easy it is to—

• Account for excess volatility, using the updating equation for mean beliefs.
• Account for GARCH-type behavior, using the updating equation for the variance of beliefs.
• Account for the high volume and frequency of trading, using the turbulence of cumulant updating.
• Account for the appeal of charting, again using the turbulence of cumulant updating.

Pandora’s Equation can help resolve even more puzzles when coupled with two more findings. One is Martin’s (2010) demonstration that higher cumulants of beliefs are crucial to the determination of discount rates. The other, developed in Chapter 8 using an Ising-type model, is that a miniscule deference to others can congeal a robust consensus on risk.

These findings are interconnected. If all beliefs were Gaussian normal, the paradoxes wouldn’t exist. If cumulant updating were self-contained, we couldn’t explain why markets are so turbulent. If we never deferred to consensus, we couldn’t build viable financial markets to tide us through the turbulence.

Uncertainty and learning point to a finance theory worthy of the twenty-first century. Such a theory can in turn offer new insights on learning. We have seen that markets can function like composite brains and that their turbulence is more rational than it appears. We have seen hints that brains themselves can function like markets. Someday, finance theory will help guide the construction of learning machines beyond current imagination.
This may seem far-fetched. Remember, though, that quantum theory in its early stages gave few hints of the treasures in store. Embracing Pandora’s risk opens a gateway to better understanding and practical mastery.

“He finished the book,” said Pandora. “What do you think?”

“It was better than I expected. Maybe we taught him something after all. I still think he didn’t write enough about your equation,” said Prometheus.

“Some will say he wrote too much. At least he motivated it. It’s more important to ask the right questions than to answer the wrong ones.”

“He doesn’t always. No man does.”

“It’s a start. I’m more worried about who will read it, and whether they take it to heart and head. We’ve got to get finance theory out of its rut.”

“It’s easy. Theorists just need to emphasize the contradiction between the aim of finance and the arrow of time. Finance wants to discount future returns. Time forces reliance on past and present returns. Beliefs mark a synthesis. Your equation describes the inherently unstable dynamics.”

“That’s a great explanation,” said Pandora, “if you’re a Hegelian Marxist. There aren’t many of them in finance.”

“They like equations. He should have focused on your equation. I think it would have better conveyed the key theme of the book, in one simple line.”

“Of that we can’t be certain.”