

AN Expensive EDUCATION

How last year's financial crisis taught us everything we needed to know about risk management.

BY ROBERT A. JARROW

The recent credit crisis offers an opportunity to reflect upon the success and failure of existing risk management tools, putting the spotlight on two in particular: traded derivatives to hedge credit risk and risk management models to quantify credit risk. Did these risk management tools fail?

The financial press has blamed these new fangled derivatives—especially those on subprime mortgages—and the risk management models as the cause of the crisis. Warren Buffett admonished models and quantitative researchers in a *Wall Street Journal* report, warning, “All I can say is, beware of geeks... bearing formulas.” (*WSJ* November 3, 2008.) And in testimony to Congress days before, Alan Greenspan stated, “Had instead the models been fitted more appropriately to historic periods of stress, capital requirements would have been much higher and the financial world would be in far better shape today, in my judgment.” Perhaps. But before we can form a judgment, we need to dispel three myths that appear repeatedly in the financial press, claiming that: (1) derivatives are new; (2) derivatives are bad, and (3) using risk models is bad.

Contrary to common belief, the first myth is false. Derivatives are not new. Derivatives have been trading for thousands of years. Forward contracts existed in cuneiform script on clay tablets in Mesopotamia, 2000 B.C. Forward trading in commodities such as grain, salt, wool and herring appeared in ancient medieval fairs

between the 5th and 15th centuries, with Venice the centre of such trading in the 1400s.

The “modern” era of derivatives really began in 1600s Amsterdam with the trading of options and futures. Even then, derivatives were blamed for high commodity prices and enabling manipulation. Regulatory bans on short sales were occasionally imposed and removed, with defaults on financial contracts commonly litigated. Does this sound familiar?

But, if derivatives are not new, why have they existed for so long? The answer to this question brings us to our second myth—that derivatives are bad.

DEFENDING DERIVATIVES

Derivatives are not bad. The reason derivatives have existed for so long and why they are so pervasive today is that they improve individual welfare by enabling the hedging of financial risks. To understand why this is true, one just needs to recognize that financial derivatives are really types of insurance contracts.

To understand this perspective, consider the simplest derivative security, a put option on a stock. For discussion, let the stock be currently trading for \$120.

A put option on this stock gives its owner the right to sell the stock, at a fixed price (say \$100), at some future date (say 1 year). If the stock is trading below \$100 in a year's time (say \$80), the owner of the put exercises the option, and sells the stock for \$100. In essence, the put insures the

Robert A. Jarrow is professor of finance and economics at Cornell University in Ithaca, NY.

stock's price for a value of \$100. In this case, the insurance pays off. If instead the stock is trading above \$100 in a year's time, then the put is not exercised and it expires worthless. The insurance contract is not used. The price of a put option is the premium (the cost) of purchasing the insurance on the stock.

Similar to a put option, all derivatives have characteristics of insurance contracts. For example, the credit derivatives—credit default swaps (CDS—that were so visible during the crisis are precisely insurance contracts written to insure the value of bonds issued by various corporations and financial trusts (Collateralized Default Obligations (CDOs) on subprime mortgages)). As insurance contracts, these derivatives enable the insured to hedge financial risks. And everyone understands the benefits of obtaining insurance.

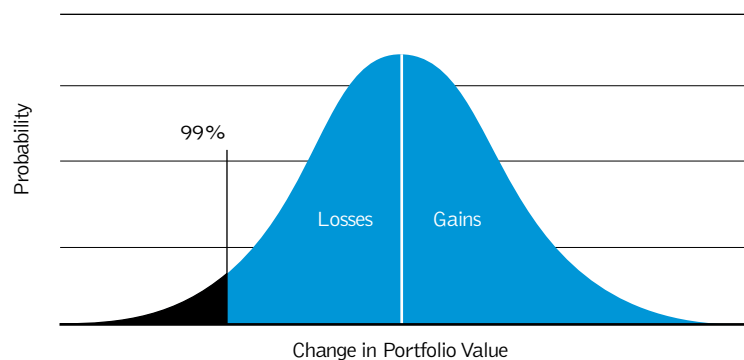
The provider of the insurance, the insurer, is willing to sell the insurance and bear the risk of a loss because they receive a risk premium for this activity. Insurance contracts are good, and they increase society's welfare as long as the insurer can fulfill the terms of the contract if the insured event occurs. This occurs, of course, if the insurer is well capitalized and has sufficient funds set aside to cover any losses incurred by the insured. If not, then insurance doesn't reduce risk, but it magnifies it. When the loss event occurs, both the insured and the insurer suffer losses. In this later case, insurance although good in concept, fails in practice.

How much capital does the insurer need? It depends on the risks involved. For standard insurance risks that are familiar to households (auto, home, life), little capital is needed because the loss events are well understood. Long histories of losses are available to analyze in great detail. In addition, the losses are usually independent (and identically distributed) across the insured, so the law of large numbers applies. The insurer can calculate their expected losses very accurately, and determine the appropriate amount of capital to hold. Furthermore, the actual losses will be close to their expected values and therefore the capital will be sufficient due to the law of large numbers. In this case, insurance works.

A SHORT HISTORY OF LOSS EVENTS

For credit derivatives (insuring default), however, the situation is quite different. There is not a long history of loss events, because the current financial system (including corporations and CDO bonds on subprime mortgages) is different from the past. The loss events

FIG. 1: Probability Distribution of Portfolio Value



Source: Barclays as of 5/29/09

are not independent (nor identically distributed); in fact, there is significant correlation in defaults—this is called systemic risk. Firm defaults are correlated with the business cycle and therefore correlated to each other. For the insurer, it is therefore very difficult to determine the expected losses and the amount of capital to hold to pay claims against default.

Furthermore, since defaults are not independent events, the law of large numbers does not hold. Capital is needed not just to cover the expected losses, but losses at a higher 95 or 99% level. And, if not enough capital is held, then the insurance does not work. The insurers will not be able to pay claims against the insurance policies and the risk in the financial system is magnified. Unfortunately, this is what happened with credit derivatives during the credit crisis.

Why did this happen? Well, this brings us to the third myth—risk models are bad. The truth is that risk management models are good, but the uneducated use of poor risk models is what's bad.

Using risk models is analogous to using prescription medical drugs. If used correctly, prescription drugs are of immense benefit to the user. If used wrongly, they can be dangerous, even deadly. Proper use requires extensive testing, proper education in their use, and care. The same is true of risk management models.

INADEQUATE MODELS, UNEDUCATED USE

Unfortunately, the uneducated use of poor risk management models did help to cause the financial crisis. Two inadequate models were relied upon: value-at-risk (VAR) and the Gaussian copula. Since these models were so crucial to the crisis, we explain both of these in more detail below.

VAR is a model for computing economic capital (the need for which was discussed above). To obtain a firm's

VAR, one fixes a confidence level, say 99%, and a time horizon, say 10 days. The VAR of a given portfolio is that loss in value that is exceeded with probability 1% over 10 days (it is the value on the x-axis underneath the 99% line in Figure 1).

In computing VAR, one needs to include all risks faced by the portfolio—market, credit, liquidity, and operational risk. Of these four risks, market, credit and liquidity risk are self-explanatory. Operational risk is that risk generated from the operations of managing the portfolio. These are the four risks identified in the determination of economic capital by the Basel II Accord.

Unfortunately, it is—and was before the crisis—well known that VAR is not a good risk measure. It has many problems. One, it ignores the magnitude of the loss beyond the VAR level. Two, it only considers a single time horizon (10 days above). What happens if the loss occurs over 20 days instead? Third, it penalizes diversification. It can be

shown that a diversified bond portfolio can have a higher VAR—and thus require more capital—than a single bond portfolio (all else equal). Last, it is very difficult to compute. This is due to the fact that one is estimating a “rare event,” i.e. an event that almost never occurs. As such, these are hard to estimate because there is little historical data, as with credit risk. Consequently, as a flawed risk measure, VAR does not provide good estimates of the economic capital needed to insure the risk of default.

A Gaussian copula is a model used for computing the level of systemic risk in defaults across a portfolio of bonds for use in VAR. It uses as inputs the probabilities that any single bond will default. These are observable using CDS prices. To access joint default across bonds, it assumes a normal distribution to characterize the correlation in defaults across firms. Furthermore, standard practice is to assume a very simple correlation structure. That is that the correlation between any two bonds defaulting is identical across all bonds in the portfolio, regardless of the firms’ industries. Of course, these assumptions are not true.

The Gaussian copula models were, unfortunately, also used to value the CDO bonds on subprime mortgages. For the reasons cited, the Gaussian copula model did not perform well. Default risks were understated, and the Gaussian copula significantly overvalued CDO subprime mortgage bonds. As a result, these subprime

The Failure of Credit Ratings

	Distress Date	Rating One Month Earlier		
		Moody's	S&P	Fitch
Bear Stearns	3/16/2008	A2	A	A+
Fannie Mae	9/7/2008	Aaa/B-	--	AAA
Freddie Mac	9/7/2008	Aaa/B-	--	AAA
Lehman	9/15/2008	A2	A	A+
AIG	9/15/2008	Aa3	AA-	AA-
Merill Lynch	9/15/2008	A2	A	A+
WaMu	9/25/2008	Baa3/D+	BBB-	BBB-
Wachovia Bank	9/29/2008	Aa2/B	AA-	AA-
Fortis Finance	9/29/2008	A1	A	AA-
Dexia	9/30/2008	Aa2	AA	AA
Citigroup	11/23/2008	Aa3	AA-	A+

Source: Barclays as of 5/29/09

THE TRUTH IS THAT RISK MANAGEMENT MODELS ARE GOOD, BUT THE UNEDUCATED USE OF POOR RISK MODELS IS WHAT'S BAD.

mortgage-backed bonds looked very attractive to market participants paying high yields for what appeared to be low risks. They looked “too good to be true” and they were, in fact, “too good to be true.”

Both of these models (VAR and the Gaussian copula) were inadequate and both of these models were too simple for the complexity of the credit risks involved. These failings were well known at the time, and better models existed, but better models were not used by the industry. Is this the models’ fault, or the fault of the users? I would argue, the fault of the users. Just as the poor use of prescription drugs is the fault of the user, and not the prescription drugs.

CREDIT RATING AGENCIES: UNDERESTIMATING RISK

The most visible poor users of these inadequate models were the credit rating agencies where these models resulted in the underestimation of default risk for individual firms as well as structured products (the subprime mortgage-backed CDOs). This is particularly egregious because the investment community looked to the credit rating agencies for their counsel to access the risks of default correctly. The credit agencies failed in this regard.

The extent of the errors of the credit rating agencies can be illustrated by examining the table above. This table records the ratings of various well-known companies one month before financial distress. Surprisingly, all of

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the three major credit rating agencies were rating all of these financial institutions as

very unlikely to default. For example, in this table, Lehman Brothers was rated A2 by Moody's, A by S&P, and A+ by Fitch. These are serious misratings.

So, what caused the crisis? I would say that it was partly caused by the uneducated use of poor risk management models. Why did this happen? It happened because the players in the financial system had the wrong set of incentives. The players were the money managers, the credit rating agencies, the mortgage originators of subprime loans, the creators of the subprime CDO trusts, and the financial regulators.

Money managers investing in subprime-backed securities had the wrong incentives. They were compensated mostly via short-term bonuses. As long as they were making money, money managers didn't need to worry about a possible financial crisis. In addition, there was an over-reliance on the credit rating agencies' ratings by these money managers. The subprime-backed securities that they invested in were quite complex, so they delegated responsibility to the credit rating agencies. Consequently, the money managers did not perform independent due diligence of the risks involved.

The credit rating agencies had the wrong incentives as well. They had an incentive to provide high ratings for these subprime CDO bonds because they were paid by the entities that they rated. High ratings were needed by their clients to create the CDO trusts. And, the creation of the CDO trusts generated a guarantee of receiving significant future revenues. The CDO asset trust pools had to be continuously monitored by the rating agencies, and they were paid for these services.

The CDO equity holders in the search of profits created the CDO trusts. In the process, the CDO equity holders played the “rating arbitrage” game, turning “junk” into “gold.” They succeeded where alchemists for centuries could not. By paying the credit agencies for their rating services, the CDO equity holders could guarantee that they received the ratings they needed to issue the CDO bonds—the desired AAA stamp—based on pools of junk bonds issued against subprime mortgages.

The entities originating the subprime mortgage loans underlying the CDO bonds, the mortgage originators, found their incentives were also skewed. By selling the loans to the CDO trust pools, they removed the risks of the mortgages' defaulting from their bottom lines. Their

profits increased in the volume of loans issued, not on the performance of the mortgage loans with respect to whether or not the borrowers could make the loan payments. Of course, as is now well known, most mortgage borrowers were not well qualified, and this created much of the subsequent difficulties in the economy.

And, where were the regulatory agencies in all of this? Well, there was fragmented coverage, split between the SEC, the CFTC, and the Federal Reserve. Most of this subprime mortgage activity fell between the cracks. And if the financial system is not broke, the standard response in government due to entrenched interests is: why fix it?

It was the “perfect storm” where all the failings of the system converged at one point in time to create a financial crisis.

BETTER EDUCATION

So what did we learn from all of this? We can safely say that if the correct models had been used, and the financial risk had been correctly quantified, then adequate capital would have been in the system, and the credit crisis would have been avoided.

This is particularly true of the credit rating agencies. If the credit rating agencies had quantified the risks correctly, then the money managers would not have taken such large risky positions, and the losses would have been dramatically reduced. Furthermore, rating arbitrage would not have existed. And the CDOs would not have been created, and mortgage loans to unqualified borrowers would not have been issued.

So, how can we prevent future crises? To prevent future crises, we need to be better educated in the use of risk management models, so that we can use them correctly. Furthermore, we need to fix the perverse incentives in the system. One, we need to change the money managers' payment scheme so that it depends on long-term performance, and not short-term profits. Two, we need to change the way that credit agencies are compensated. They should not receive their revenues directly from the entities that they rate. In addition, the use of credit ratings should not be mandated by government regulations. And three, we need the regulatory agencies to set proper capital standards. All of these changes are possible, but only with the educated use of risk management models and traded derivatives. ■