

CORNERSTONE RESEARCH

Demystifying  
Financial  
Derivatives

*René M. Stulz*





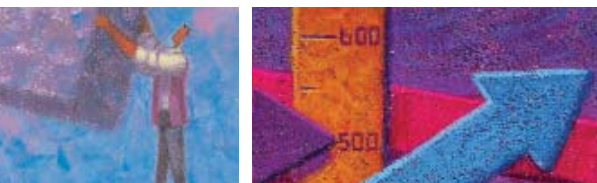
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Versions of this article appeared previously in the *Milken Institute Review* and the *Journal of Economic Perspectives*.



DEMYSTIFYING FINANCIAL DERIVATIVES

"The derivatives genie is now well out of the bottle, and these instruments will almost certainly multiply in variety and number until some event makes their toxicity clear. ... [D]erivatives are financial weapons of mass destruction, carrying dangers that, while now latent, are potentially lethal."

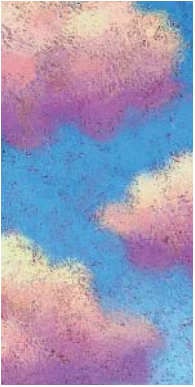
*Warren Buffett*

Chairman's Letter to the Shareholders of Berkshire Hathaway, February 21, 2003

**I**n the litigation context, the matter of derivatives represents a distinct and increasingly important area of interest. Consider the sheer scale of the market alone. By 2005, the notional size of the derivatives market had grown to over five times the total capitalization of all exchange-traded equity and debt in the world. Litigation involving trading activity by hedge funds, employee stock options, executive compensation, distressed debt valuation, and so-called “real options” (such as oil and gas exploration or pharmaceutical research and development) are all intimately tied to the theory and application of derivatives.

When derivative contracts lead to large financial losses, they can make headlines. In recent years, derivatives have been associated with the collapses of Barings Bank (the Queen of England’s primary bank) and Long-Term Capital Management. Derivatives have been alleged to have a role in the fall of Enron. But there are two sides to this coin. Although some serious dangers are associated with derivatives, handled with care they have proved to be immensely valuable to modern economies, and will surely remain so.

This monograph aims to shed light on the derivatives market more broadly: what derivatives are, how they are typically used, and what risks they can present.



## THE NUTS AND BOLTS

Derivatives are financial instruments promising payoffs that are derived from the value of something else, which is called the “underlying.” The underlying is often a financial asset or rate, but it does not have to be. For example, derivatives exist with payments linked to the S&P 500 stock index, the temperature at Kennedy Airport, and the number of bankruptcies among a group of selected companies. These instruments come in a variety of forms:

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### **Forward and Futures Contracts**

A forward contract obligates one party to buy the underlying at a fixed price at a certain future date (called the maturity) from a counterparty, who is obligated to sell the underlying at that fixed price. Futures contracts are similar to forward contracts, but they are standardized contracts that trade on exchanges. Consider a U.S. exporter who expects to receive a 100 million euro payment for goods in six months. Suppose that the price of the euro is \$1.20 today. If the euro were to fall by 10 percent over the next six months, the exporter would lose \$12 million. But by selling euros forward, the exporter locks in the current forward exchange rate. If the forward rate is \$1.18 (less than \$1.20 because the market apparently expects the euro to depreciate a bit), the exporter is guaranteed to receive \$118 million at maturity.

Hedging consists of taking a financial position to reduce exposure to a risk. In this example, the financial position is a forward contract, the risk is depreciation of the euro, and the exposure is 100 million euros in six months, which is perfectly hedged with the forward contract. Since no money changes hands when the exporter buys euros forward, the market value of the contract must be zero when it is initiated. Otherwise the exporter would get something for nothing.

### **Options**

Although options can be written on any underlying, let’s use options on common stock as an example. A call option on a stock gives its holder the right to buy a fixed number of shares at a given price by some future date, while a put option gives its holder the right to sell a fixed number of shares on the same terms. The specified price is called the exercise price. When the holder of an option takes advantage of her right, she is said to exercise the option. The purchase price of an option (the money that changes hands on day one) is called the option premium.

Options enable their holders to leverage their resources, while at the same time limiting their risk. Suppose Smith believes that the current price of \$50 for Upside, Inc. stock is too low. Let's assume that the premium on a call option that confers the right to buy shares at \$50 each for six months is \$10 per share. Smith can buy call options to purchase 100 shares for \$1,000. She will gain from stock price increases as if she had invested in 100 shares, even though she invested an amount equal to the value of 20 shares.

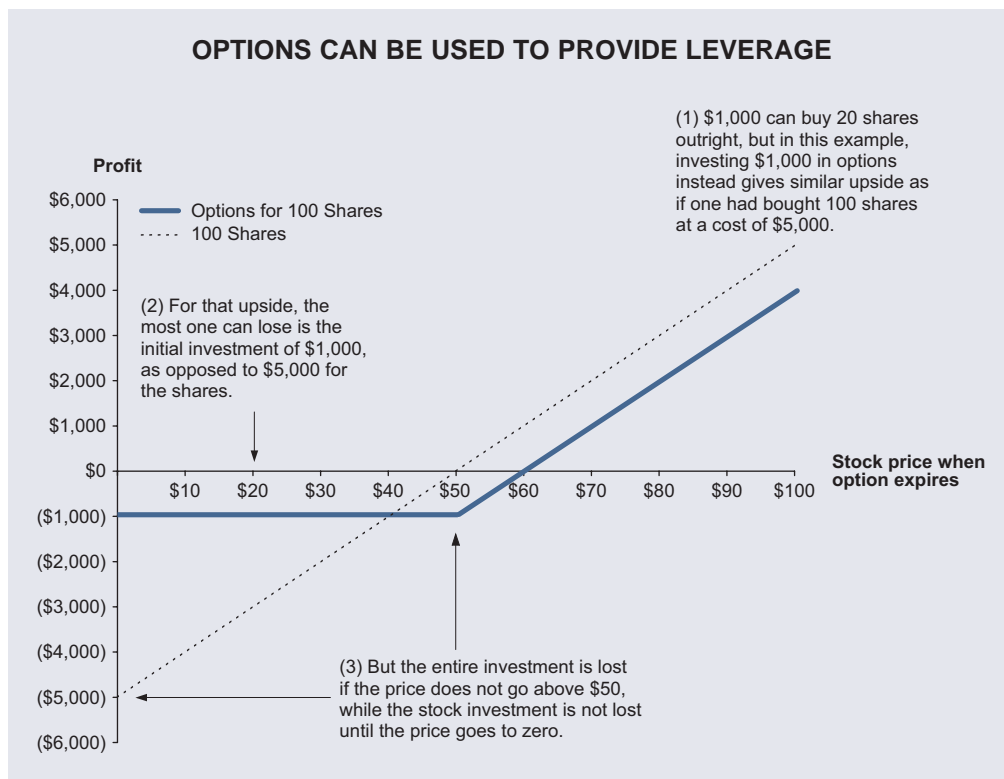


Figure 1

With only \$1,000 to invest, Smith could have borrowed \$4,000 to buy 100 shares. At maturity, she would then have to repay the loan. The gain made upon exercising the option is therefore similar to the gain from a levered position in the stock—a position consisting of purchasing shares with one's own money plus money that's borrowed. However, if Smith borrowed \$4,000, she could lose up to \$5,000 (excluding interest) if the stock price fell to zero. With the call option, the most she can lose is \$1,000. But there's no free lunch here; she'll lose the entire \$1,000 if the stock price does not rise above \$50.

## Swaps

A swap is a contract to exchange cash flows over a specific period. The principal used to compute the flows is the “notional amount.”

Suppose you have an adjustable-rate mortgage with principal of \$200,000 and current payments of \$11,000 per year. If interest rates doubled, your payments would increase dramatically. You could eliminate this risk by refinancing with a fixed-rate mortgage, but the transaction could be expensive. A swap contract, by contrast, would not entail renegotiating the mortgage. You would agree to make payments to a counterparty—say a bank—equal to a fixed interest rate applied to \$200,000. In exchange, the bank would pay you a floating rate applied to \$200,000. With this interest-rate swap, you would use the floating-rate payments received from the bank to make your mortgage payments. The only payments you would make out of your own pocket would be the fixed interest payments to the bank, as if you had a fixed-rate mortgage. Therefore, a doubling of interest rates would no longer affect your out-of-pocket costs. Nor, for that matter, would a halving of interest rates.

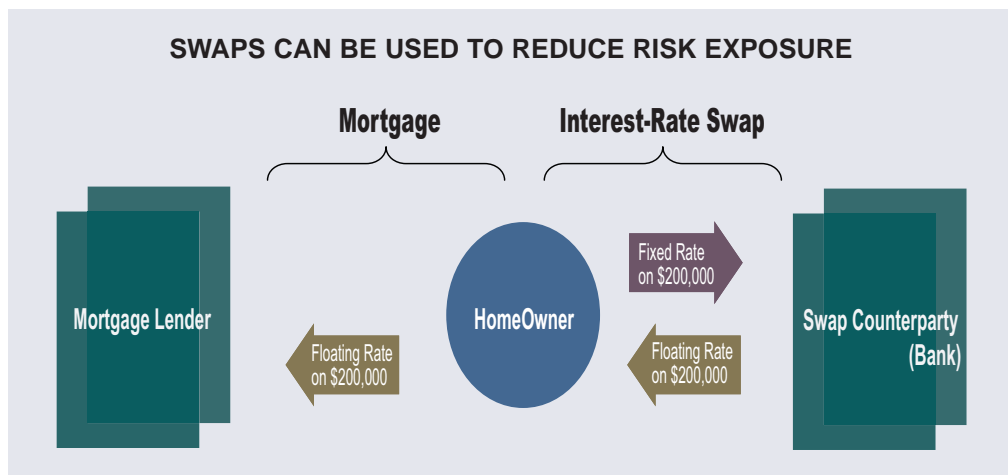


Figure 2

## Exotics

An exotic derivative is one that cannot be created by mixing and matching option and forward contracts. Instead, the payoff is a complicated function of one or many underlyings. When Procter & Gamble lost \$160 million on derivatives in 1994, the main culprit was an exotic swap. The amount it had to pay on the swap depended on the five-year Treasury note yield and the price of the 30-year Treasury bond. Another example of an exotic derivative is a binary option, which pays a fixed amount if some condition is met. For instance, a binary option might pay \$10 million if, before a specified date, one of the three largest banks in Indonesia has defaulted on its debt.

## THE GROWTH OF DERIVATIVES MARKETS

Derivatives markets were small until the 1970s, when economic conditions, along with advances in the pricing of derivatives, led to spectacular growth. In that decade, the volatility of interest rates and currency-exchange rates increased sharply, making it imperative to find efficient ways to hedge related risks. Meanwhile, deregulation in a variety of industries, along with soaring international trade and capital flows, added to the demand for financial products to manage risk.

Until the 1970s, derivatives mostly took the form of option, forward, and futures contracts. Except for futures contracts on commodities, the trading of derivatives had been done “over the counter” (OTC), meaning without intermediation by an organized exchange. But in 1972, the Chicago Mercantile Exchange started trading futures contracts on currencies. The Chicago Board Options Exchange, where stock options are traded, was founded in 1973. In the late 1970s and early 1980s, the swaps market took off. Exotic derivatives trading exploded a few years later.

The OTC derivatives markets are decentralized and unregulated (except by contract law), and the parties are not required to report transactions. However, since an OTC derivative trade typically involves a bank or a regulated broker, the quasi-governmental Bank for International Settlements has been able to estimate the size of the OTC market for derivatives by surveying financial firms.

In December 2005, the total notional amount of derivatives traded over the counter was \$285 trillion (excluding credit default swaps). This figure is a proxy for the value of the underlyings against which claims are traded in the derivatives markets. The euro forward contract example discussed earlier had a notional value of \$118 million, while the interest-rate swap had a notional amount of \$200,000. Interest-rate swaps represent approximately 60 percent of the derivatives market.

In 1987, the notional amount outstanding of currency swaps, interest-rate swaps, and interest-rate options was approximately \$865 billion; 18 years later, it was almost \$213 trillion, implying growth at an average annual rate of 36 percent (see Figure 3). The notional amount of exchange-traded derivatives (futures and options) grew from \$616 billion in December 1986 to \$57.8 trillion in December 2005, for an average annual growth rate of 27 percent.



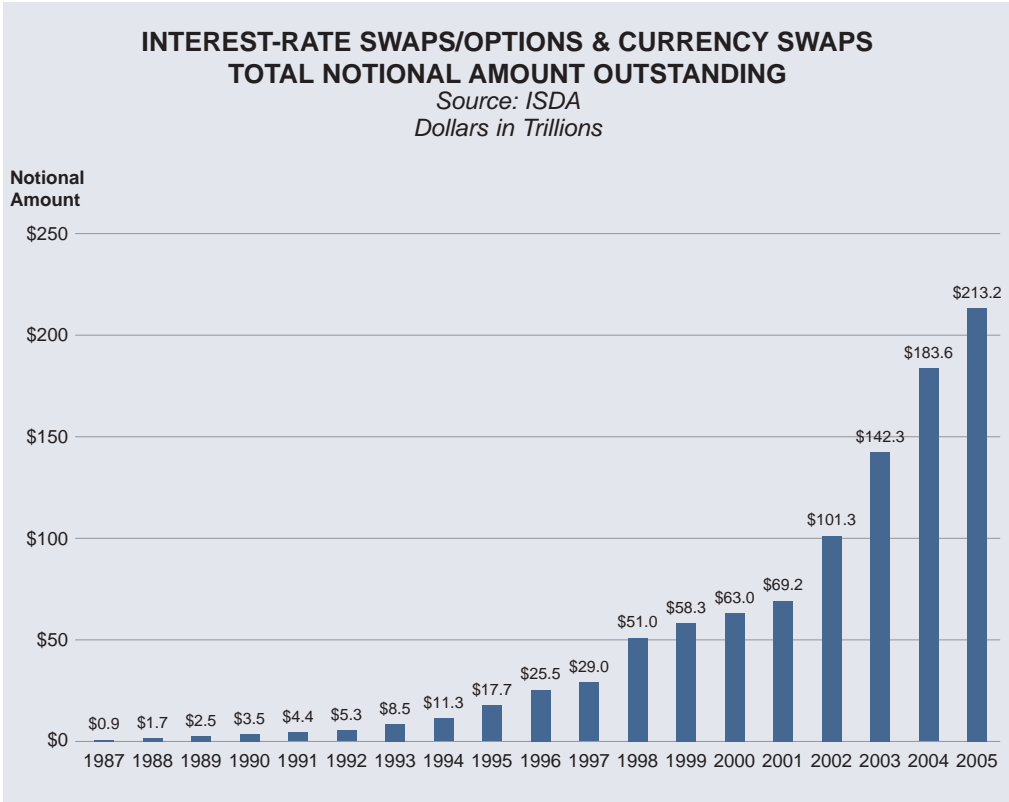


Figure 3

Adding up the OTC market and the exchanges, the notional amount of derivatives was over \$340 trillion at the end of December 2005. To put this number in perspective, the total capitalization of exchange-traded debt and equity in the world was \$67 trillion at the end of 2005.

A second way to look at the size of the derivatives market is as follows: Suppose that every party and counterparty had to write off all derivatives contracts. For each swap contract, one party would write off an asset, the positive value of the contract at that time, and the counterparty would write off a liability. Now, just add up the positive value of all contracts at that time. By this net measure, the aggregate value of OTC derivatives outstanding in December 2005 was \$9.1 trillion (a big number but nothing compared to the notional amount of contracts outstanding).

## THE BENEFITS OF DERIVATIVES

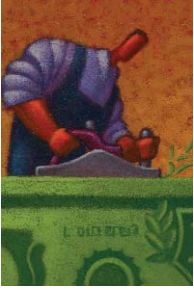
The main benefit of derivatives is to permit individuals and firms to achieve payoffs that they would not otherwise be able to realize or could only realize at greater cost. Derivatives make it possible to hedge risks that otherwise would not be possible to hedge. And when economic actors can manage risk better, risks are borne by those who are in the best position to bear them, and firms can take on riskier but more profitable projects by hedging.

A second important benefit is that derivatives can make underlying markets more efficient. First, derivatives markets produce information. For example, in a number of countries, the only reliable information about long-term interest rates is obtained from swaps, because the swap market is more liquid and more active than the bond market. Second, derivatives enable investors to trade on information that otherwise might be prohibitively expensive to use. For instance, selling stock short—that is, selling stock you don't own—is often difficult to do, because the shares must be borrowed from someone who does own them. This slows the speed at which adverse information is incorporated in stock prices, thereby making markets less efficient. With put options, a derivative that mimics the dynamics of selling short, investors can more easily take advantage of adverse information about stock prices.

In theory, this cuts both ways; derivatives can also disrupt markets by making it easier to build speculative positions. But there isn't much evidence that derivatives trading has actually increased the volatility of the underlying assets.



## WHO USES DERIVATIVES AND WHY?



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The most comprehensive study of the use of derivatives by non-financial firms was made by Söhnke Bartram (Lancaster University), Gregory Brown (University of North Carolina), and Frank Fehle (Barclays Global Investors), who examined some 7,300 non-financial firms from 48 countries, using corporate reports from 2000 and 2001. They found that 60 percent of these firms used derivatives. The most frequently used were foreign-exchange derivatives (44 percent of firms), followed by interest-rate derivatives (33 percent of firms), and commodity derivatives (10 percent). Swaps and forwards are used more than options.

Wayne Guay (University of Pennsylvania) found that when firms started using derivatives, on average their stock return volatility fell by 5 percent, their interest-rate exposure fell by 22 percent, and their foreign-exchange exposure fell by 11 percent. Clearly, firms do use derivatives for hedging. There is also evidence that firms use derivatives to minimize earnings volatility and reduce their tax liability.

The way managers are paid affects the extent to which firms hedge. In general, firms for which options are a more important component of managerial compensation are less likely to hedge. That makes sense: in many situations, managers who hold options benefit from increased volatility, since their options will be worth more if the stock price rises but the option will never be worth less than zero if the stock price falls. Finally, firms sometimes do use derivatives to speculate.

## THE RISKS OF DERIVATIVES AT THE FIRM LEVEL

Derivatives that trade in liquid markets can always be bought or sold at the market price, so mathematical models are not required to value them. Valuation is much more problematic when trading is illiquid. In these cases, models have to be brought to bear to value derivatives—a procedure called “marking them to market.” And, in the words of a skeptical Warren Buffett, “In extreme cases, mark-to-market degenerates into what I would call mark-to-myth.”

### **Market Liquidity**

If a firm buys a widely traded plain vanilla derivative—say, a put option on the euro with a maturity and exercise price common in the marketplace—it is generally easy to sell. However, it can be harder to get out of long-maturity contracts and complicated derivatives. First, it is much more likely that there is risk involved in the replicating strategy for such derivatives. Second, a complicated derivative only appeals to a small number of counterparties who both want that particular set of risk characteristics and are confident that they understand what they are getting.



### Transparency and Reliability of Accounting

Consider a 30-year swap contract in which Enron delivered gas at regular intervals and received fixed amounts of cash over time. The value of this contract had to be marked to market each quarter for accounting purposes. However, it can be tempting to tweak assumptions—say, about the growth in the storage cost of gas decades down the road—in a way that has a substantial impact on present profits. And, apparently, Enron was not reluctant to make the best of the ambiguous.

Though concerns about disclosures of derivatives positions have increased recently, the information disclosed typically focuses on the stand-alone risks of derivatives rather than the context in which the derivatives are used. If a firm uses derivatives to hedge, it can take on a large amount of seemingly risky derivatives in the name of reducing risk. Although disclosure requirements for derivatives are not much help in seeing how they are used, some firms do report the impact of their hedging activities on various risks.

Another problem is that it can be a major challenge for a firm to describe all the details of its derivatives risks. For example, Enron had complicated derivatives with credit-rating triggers that required it to make payments if its credit rating fell below a specified level. Once Enron's credit cratered and the triggers were activated, it could no longer survive because the required payments were too large.

### Derivatives and Incentives

A wise trading firm will typically hedge the derivative that it has sold. But placing a value on the derivative and the corresponding hedge can be difficult in an illiquid market. And executives do not always have strong incentives to side with risk managers who want to value derivatives conservatively. For example, when a conservative valuation would cause a firm to show a loss, top executives may find reasons to side with traders who prefer a more aggressive stance.

Furthermore, derivative trading generates revenue by assuming additional risks. And proper evaluation of the profitability of derivatives requires taking into account the capital required to support those risks. The major banks have developed approaches that allow them to do just that. Other firms, though, are more likely to ignore the cost associated with the increase in risk, which leads them to believe that derivatives trading is more profitable than it actually is.

### Understanding the Risks

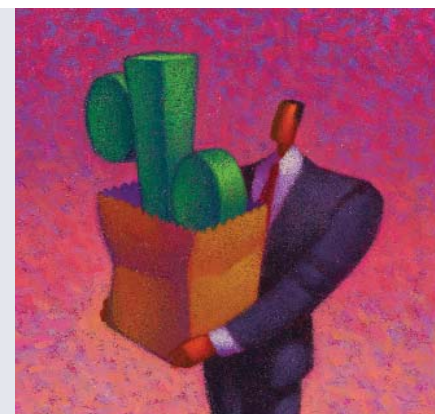
In the past decade, regular users of derivatives have made considerable progress in measuring the risks of derivatives portfolios. One popular measure is called value-at-risk (VaR). For instance, a 5 percent value-at-risk of \$100 million means that there is a 5 percent chance the derivative user will lose \$100 million or more in a specified time period. With another measure, called a stress test, the firm computes the value of its derivatives portfolio using hypothetical scenarios. For example, it might compute the value of its portfolio if the Russian financial crisis of 1998 were repeated.

Many firms with large portfolios of derivatives now report their value-at-risk and may also report the outcomes of various stress tests. But these measurement tools do not always work well. During the Russian crisis, banks exceeded their VaRs more than their risk models suggested they should have.

With a derivative, somebody's loss on the contract is inevitably somebody else's gain. But derivatives losses can lead to financial distress at the firm level and, in exceptional circumstances, can have more pervasive effects on the economy.

### GIBSON GREETINGS

In 1994 a firm in Cincinnati called Gibson Greetings lost its profits for the year, thanks to its operations in derivatives. One of its derivative contracts worked like this: A swap specified that starting on April 5, 1993, and ending October 5, 1997, Gibson would pay Bankers Trust the six-month LIBOR (the London Inter-Bank Offered Rate), a commonly used interest rate, squared, then divided by 6 percent times \$30 million. In return, Bankers Trust paid Gibson 5.50 percent times \$30 million. Such exotic transactions can raise concerns that some parties involved don't fully understand the risks they are taking.



## WHO GETS HURT BY DERIVATIVES LOSSES?

### The Derivatives Risks of Financial Institutions

In the fourth quarter of 2005, insured commercial banks in the United States had derivatives positions with a total notional amount of \$101.5 trillion, with 96 percent of the total held by five banks.

Banks generally report the market risk of their trading positions—the risk associated with possible changes in financial prices and rates. For instance, J.P. Morgan Chase reported a value-at-risk of \$281 million on the last day of 2003, which meant there was a 1 percent chance that it would realize a one-day loss on its trading portfolio in excess of \$281 million. Of course if the bank actually started losing sums of this magnitude, it would take steps to cut its risk. Note, moreover, that stockholders' equity in J.P. Morgan Chase was \$43 billion at the time. Thus, by any standard, the bank's derivatives risks seemed manageable.

A large bank might make significant losses if one or several of its large derivatives counterparties defaulted. However, participants in financial markets have strong incentives to control counterparty risk. Fully 65 percent of plain vanilla interest-rate swaps were collateralized in 2001. Parties also put triggers in derivatives contracts, forcing the counterparty to post more collateral if it becomes less creditworthy. One result is that charge-offs from derivatives losses by commercial banks have been small compared to charge-offs from commercial loans in the United States.

Two issues are still worth considering here. First, even if large losses at the firm level would impose large costs on the financial system, firms have little incentive to take such externalities into account. Second, though existing measures capture most risks, they can't capture risks we do not know about. In 1998, liquidity risk—the risk associated with the cost of selling a position quickly—was crucially important, but it was not included in most models. The bottom line is that while it is impossible to answer the question of whether unknown risks are large, the conventional measures suggest that no large bank is seriously at risk because of its derivatives holdings.

### What Would Happen if a Major Dealer or User Collapsed?

Bankruptcy law contains an automatic-stay provision that prevents creditors from requiring immediate payment, making it possible for their claims to be resolved in an orderly fashion. Interest-rate swaps and some other derivatives, however, are exempted from this automatic stay. Instead, the parties to a swap contract use a master agreement that specifies how termination payments are determined in the event of a default. Without this exemption from the automatic stay, defaults on derivatives contracts would present a considerable problem, since counterparties would in some cases have to wait (sometimes for years) for their claims to be adjudicated, leaving them with mostly unhedgeable risks.

Under normal circumstances, markets are sufficiently liquid that a party can quickly eliminate the risk created by default. But the situation may be more grim if the default occurs in a period of economic turmoil. If all parties are trying to reduce risk, they may all get stuck, because there is only a limited market for the positions they are trying to sell. In such a situation, the Federal Reserve would have to step in to provide liquidity. Given the central role of Treasury securities in dynamic hedging, the Fed might also have to intervene to settle down the Treasury market.



### THE LONG-TERM CAPITAL MANAGEMENT COLLAPSE

The collapse of the hedge fund Long-Term Capital Management (LTCM) is often cited as an example of a crisis linked to derivatives that could have led to a meltdown of the entire financial system. At the end of July 1998, LTCM held assets worth \$125 billion, which were financed with about \$4.1 billion of its own capital along with loans. It also had derivatives with a total notional amount in excess of one trillion dollars.

Many strategies employed by LTCM involved taking long positions in bonds that LTCM perceived to have too high a yield in light of their risk, and then hedging these positions against interest-rate risk with derivatives or short positions in U.S. Treasuries. When Russia defaulted on its sovereign debt in 1998, there was a general flight to safety by investors around the globe. Interest rates on Treasuries fell, but the yields on the bonds held by LTCM did not fall as much; so LTCM had losses on its hedges not matched by gains on the market value of its bonds. LTCM's losses then triggered a vicious circle. As the fund registered losses, it sold some assets, which put pressure on prices. More important, the market perceived that liquidation of its positions became more likely. Traders who knew about LTCM's portfolio could position themselves so that they would not be hurt by a liquidation and might even benefit from it. Their actions put pressure on prices, further reducing the value of LTCM's portfolio—which made liquidation more likely and hence created incentives for a new round of trading.

What's more, as prices moved against LTCM and liquidity in the markets was drying up, counterparties were trying to maximize the collateral that they could obtain from the giant hedge fund on their marked-to-market contracts. This generated further marked-to-market losses for LTCM. Finally, investors and banks that in normal times would have bid for assets in the event of an LTCM liquidation were facing losses of their own. Some were forced to sell assets that LTCM also held, putting yet more pressure on prices. By mid-September, LTCM could only avoid default by closing its positions or receiving an infusion of capital.

Closing LTCM's positions would have been exceptionally difficult, since it was a party to more than 50,000 derivatives contracts and securities positions in markets where liquidity was now low. For creditors, the most efficient solution was to take over the fund, inject some cash, and liquidate the portfolio slowly or find a buyer for it.

A potential buyer did appear: Warren Buffett's Berkshire Hathaway and Goldman Sachs bid four billion dollars for the portfolio. Instead, creditors chose to inject \$3.6 billion into the fund and took control, with the LTCM partners retaining some ownership. There was no default and no public bailout; the creditors eventually took more money out than they put in.

We will never know what would have happened if LTCM had defaulted. But one lesson is clear: when a market participant that is large relative to the markets gets in trouble, its difficulties may affect prices adversely. That makes its situation worse—a fact that does not figure in models treating economic agents as passive price-takers.

If LTCM had been denied easy access to derivatives, it could have manufactured its own. This would have decreased its profits a bit, and might have been too expensive for some strategies. But LTCM would still have been very highly levered, would still have registered extremely large losses in September 1998, and might still have been liquidated. It is difficult to say, then, whether the risk to the economy would have been greater or smaller had LTCM been subject to restrictions on its use of derivatives. Its leverage would have been lower. But in replicating derivatives on its own, it might have needed to trade more in illiquid markets.

## WHAT TO MAKE OF IT ALL

Derivatives allow firms and individuals to hedge risks or to bear risk at minimum cost. They can also create risk at the firm level, especially if a firm is inexperienced in their use. For the economy as a whole, the collapse of a large derivatives user or dealer may create systemic risks. On balance, derivatives plainly make the economy more efficient. However, neither users of derivatives nor their regulators can afford to be complacent.

Firms have to make sure that derivatives are used properly. This means that the risks of derivatives positions must be measured and understood and that firms must have well-defined policies for derivative use. What's more, a firm's board must know how risk is managed within the firm and what role derivatives play.

For their part, regulators need to monitor financial firms with large derivatives positions very carefully. Though regulators seem to be doing a good job in monitoring banks and brokerage houses, the risks taken by insurance companies, hedge funds, and government-sponsored enterprises like Fannie Mae and Freddie Mac are not equally well understood and monitored.

Should we fear derivatives? Most of us choose to fly on airplanes even though they sometimes crash. But we also insist that planes are made as safe as it makes economic sense for them to be. The same logic should apply to derivatives.

## GLOSSARY OF TERMS




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<b>Binary option</b>	a derivative contract that pays a fixed amount if some condition is met.
<b>Call option</b>	a derivative contract that gives the holder the right to buy a fixed number of shares at a given price at (or sometimes before) maturity.
<b>Derivative</b>	a financial instrument promising payoffs derived from the value of another asset or security, or otherwise conditional upon some outcome or event.
<b>Exercise price</b>	the pre-specified price at which the underlying security can be purchased or sold.
<b>Exotic option</b>	a type of option that cannot be created by mixing and matching option and forward contracts.
<b>Forward</b>	a contract that obligates one party to buy the “underlying” at a fixed price at maturity from the counterparty, who is obligated to sell the underlying at that fixed price.
<b>Future</b>	a standardized forward contract that trades on an exchange.
<b>Hedging</b>	taking a financial position to reduce exposure to a risk.
<b>Maturity</b>	the date a derivative expires.
<b>Notional amount</b>	the principal dollar amount on which swap payments are based.
<b>OTC</b>	“Over The Counter” derivative that is traded outside of organized exchanges.
<b>Put option</b>	a derivative contract that gives the holder the right to sell a fixed number of shares at a given price at (or sometimes before) maturity.
<b>Swap</b>	a derivative contract to exchange cash flows over a specified period of time.
<b>Underlying</b>	the asset, security, or rate on which the payoff of the derivative depends.
<b>VaR</b>	the loss not expected to be exceeded with a given probability, so that a Value-at-Risk of \$100 million for a probability of 5 percent means that there is a 5 percent chance of having a loss that exceeds \$100 million.

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Professor Stulz is the Everett D. Reese Chair of Banking and Monetary Economics at the Ohio State University. He also serves as Director of the Dice Center for Research in Financial Economics at the Ohio State University, and as a Research Associate of the National Bureau of Economic Research in Cambridge, Massachusetts. In addition to the Ohio State University, his teaching experience extends to the Massachusetts Institute of Technology, the University of Rochester, the University of Chicago, the University of Lausanne, and the University of Torino. Professor Stulz was also a Bower Fellow at the Harvard Business School.

An expert in financial economics, Professor Stulz has worked closely with Cornerstone Research on a number of litigation matters involving complex financial issues. His expertise is also reflected in an extensive body of work, having published more than 60 articles on issues in financial economics, authored a textbook, and edited several books. Editor of the *Journal of Finance* for 12 years and co-editor of the *Journal of Financial Economics* for five years, he has experience on the editorial boards of more than ten academic and practitioner publications. Professor Stulz is also a former president of the American Finance Association.

Professor Stulz received his Ph.D. in Economics from the Massachusetts Institute of Technology in 1980.

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