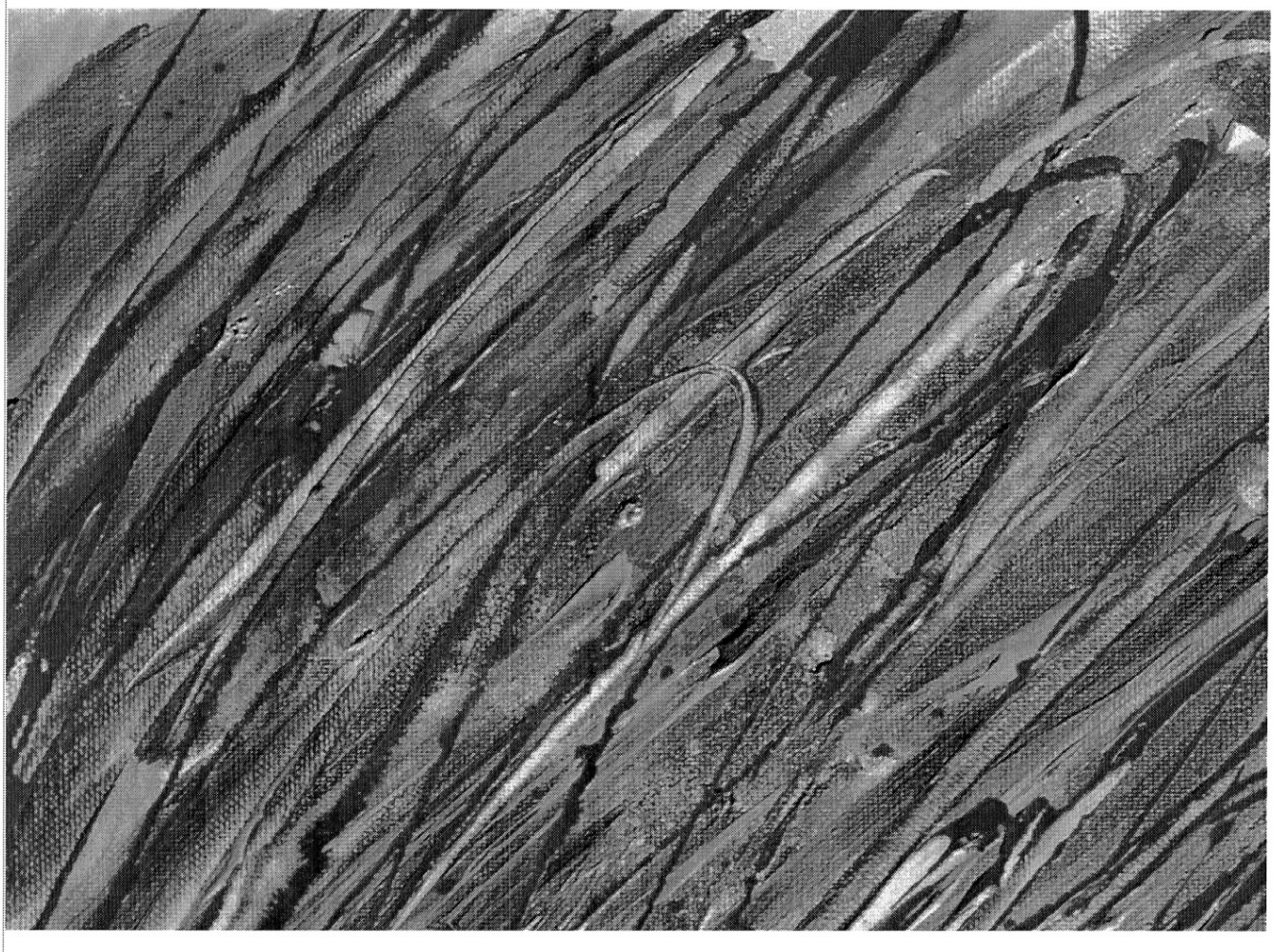
FINANCIAL DERIVATIVES

Pricing and Risk Management



Robert W. Kolb, James A. Overdahl, Editors

KOLB SERIES IN FINANCE

Essential Perspectives

CHAPTER 4

The Social Functions of Financial Derivatives

CHRISTOPHER L. CULP
Senior Advisor, Compass Lexecon, and Adjunct Professor of Finance,
The University of Chicago Booth School of Business

Despite the long-standing concerns about their social costs, derivatives are among the oldest and most prevalent financial instruments in the global capital markets, having been used successfully by financial institutions, nonfinancial corporations, asset managers, and government-sponsored enterprises in their commercial, financial, and risk management activities. Many of the later chapters in this book review in more detail the various ways that firms can use derivatives constructively. Subsequent chapters also address some of the controversies surrounding derivatives, including the role they have played (if any) in recent financial crises and corporate scandals.

In this chapter, however, we explore a higher-level and more general topic than how derivatives have (or have not) impacted the fortunes of particular enterprises. Specifically, we consider here how the use of derivatives by some firms can benefit individuals and firms *apart from those directly participating in derivatives activity.*[1] These "social functions" of derivatives include:[2]

- Facilitating risk transfer.
- Serving as arenas for price discovery.
- Promoting the efficient allocation of resources to their most highly valued uses over time.
- Enhancing opportunities for investors to access alternative asset classes.
- Mitigating "underinvestment problems" by creating opportunities for asset-based financing.

This chapter discusses each of these social functions of derivatives in more detail, using historical and current examples where appropriate.[3]

The usual disclaimer applies: The opinions expressed herein do not necessarily reflect those of any organization with which the author is affiliated or their clients. Please address correspondence to the author to christopher.culp@chicagobooth.edu.

HEDGING AND RISK TRANSFER

Perhaps the archetypical social function provided by derivatives is risk transfer. Risk transfer is the process by which the adverse impacts of a risk are shifted from the shareholders of one firm to shareholders of one or more other firms (or individuals). The social benefits of risk transfer are thought to include reduced business failure rates, wider availability of consumer products in high-risk markets, increased opportunities for firms to invest in innovative but risky production technologies, and the redistribution of risks to those parties most willing and able to bear and manage them.

Firms routinely engage in risk transfer without using derivatives. A corporation that issues common stock, for example, is transferring the risks of its business to its stockholders. Similarly, vertical integration is a substitute for risk transfer—for example, a grain elevator can hedge against price increases and a farmer can hedge against price declines, or the grain elevator can acquire the farm (Carlton 1984). Buying and selling assets is also a form of risk transfer. A German chemical company concerned about the currency exposure on a factory it owns in Pakistan, for example, can sell the factory.

If a firm desires to transfer *specific* financial risks, however, the preceding methods of risk transfer may be overkill. The German chemical company that sells the Pakistani factory to eliminate currency risk also eliminates the revenues, costs, and strategic business role of the factory. Similarly, the grain elevator that buys the farm does solve its grain price risk management problem, but it also ends up having to own and operate a farm.

Derivatives can help firms selectively transfer risks, often at a relatively low cost and on flexible terms. Because they allow firms to select the particular risks being shifted, derivatives enable firms to manage risk surgically, freeing up managers to concentrate on those risks in which they have a perceived comparative informational advantage and to focus on running their businesses.

Consider, for example, lending and commercial banking. For many years, banks perceived themselves as having relatively better information about the credit risk of their borrowers than about the direction of future interest rates. Interest rate swaps and Eurodollar futures enabled banks to manage the interest rate risk of their banking books without changing their lending decisions. Credit derivatives and derivatives-based structured credit products, moreover, can also help banks fine-tune their risk management decisions.[4]

PRICE DISCOVERY

Price discovery describes the process by which trading in a market incorporates new information and market participants' expectations into asset prices. In a world without derivatives, the prices of traded securities and other assets presumably still would reflect market expectations. But thanks to the relatively low transaction costs and high liquidity of many derivatives markets, new information about assets is often reflected in derivatives prices first.

Reliable, public prices that reflect current information are essential in guiding the invisible hand for which the free price system is held in such high regard. Apart from promoting efficient resource allocation (as we discuss later), price discovery

also assists firms in other ways. The term structure of futures prices, for example, is regarded for some assets as a good estimate of expected future spot prices. By looking at the term structure, firms can forecast their revenues and costs using market-wide information. Indeed, Roll (1984) observed that orange juice futures prices actually provide better information about weather forecasts than weather forecasts themselves.

Numerous commercial contracts, moreover, are negotiated by reference to corresponding derivatives markets. This is sometimes implicit—for example, a grain elevator that consults current futures prices before entering into a physical delivery contract. But often the relation between cash market prices and derivatives prices is explicit. An interesting example of this interdependence was documented by Kuserk and Locke (1994). In 1991, a tunnel system underneath the Chicago Loop flooded, leading to the temporary closure of the Chicago Board of Trade. During this time, grain elevators actually pulled down price quotes to farmers and did not repost those quotes until the futures markets reopened.

Options markets are also aggregators and providers of information. Market expectations of future price movements, for example, can be extracted from observed traded option prices and the volatility surface.[5] Banz and Miller (1978) show, for example, how this information can be used to guide investment and capital budgeting decisions by nonfinancial firms.

Price Discovery, Commoditization, and Market Structure

Commoditization is the process by which bilaterally negotiated, customized contracts evolve toward organized financial markets. Historically, price discovery has been associated mainly with commoditized derivatives such as futures. Indeed, futures exchanges generate significant revenues from sales of their price feeds to data vendors (Mulherin, Netter, and Overdahl 1991).

Not all customized contracts, however, evolve into standardized financial instruments traded in transparent markets. And those that do often spawn further evolutionary changes in custom, off-exchange contracts. Innovation that begins with customization thus evolves into standardization, which in turn begets further off-exchange innovation (Merton 1992).

Although organized futures exchanges remain arenas for price discovery in many markets, the concept and function of exchanges have changed significantly in recent years. Distinctions between exchange-traded and off-exchange derivatives have blurred, and the convergence of these markets has made it harder to draw clean lines among price discovery, transparency, and market structure.

Consider, for example, the market for Eurodollar derivatives (based on the 90-day London Interbank Offered Rate, or LIBOR). In the late 1980s and early 1990s, Eurodollar futures provided price discovery for short-term interbank funding markets. Fixed-for-floating interest rate swaps—also based on LIBOR—were growing rapidly at that time but were still mainly customized, opaque transactions. Over the next decade, however, interest rate swaps commoditized (while still remaining off-exchange). Bid-ask spreads on plain vanilla swaps tightened, and plain vanilla swap rates became more readily available from data vendors. Today, whether Eurodollar futures or swaps provide price discovery for interbank markets is no longer clear.

INTERTEMPORAL RESOURCE ALLOCATION

A significant social benefit of derivatives—forward and futures contracts, in particular[6]—is the role they play in rationing scarcity over time in the underlying assets on which they are based.

Forward Contracts as Synthetic Storage

Entering into a forward purchase agreement is known as synthetic storage because it is economically equivalent to the purchase and storage of the underlying asset. The forward purchase price is determined in equilibrium to ensure this is so. To see how this works, consider a firm that wants to own one unit of an asset (e.g., a bushel of wheat, a share of stock, a bond, a gold bullion bar) in three months. The firm can, of course, just wait and buy the asset in three months at its then-current spot price. Or the firm could buy the asset now and hold it for three months. Specifically, the firm borrows enough cash to buy the asset now and then holds it for three months. Over the intervening three months, the firm receives any cash distributions paid to asset owners (as well as any intangible benefits of having the asset on hand) but also bears any storage costs. And, of course, the firm must repay principal and interest on the cash loan at the end of the three months.

Alternatively, the firm might have entered into a forward purchase agreement to buy the asset three months later at a fixed price negotiated today. In the absence of arbitrage, the forward price of the asset to be delivered in three months should be equal to the current spot price plus the net cost of carrying the asset over three months (i.e., interest plus physical storage costs less the benefits of holding the asset).

If this "cost of carry" relation between forward and spot prices does not hold, at least some firms may be able to earn riskless profits by exploiting the deviation. Suppose the current price of an asset is $100 and the three-month cost of carry is $2 but the actual quoted three-month forward price is $105. A firm could buy the asset and store it for three months for a total cost of $102 and simultaneously sell the asset for delivery in three months for $105, thus generating a riskless profit of $3. This puts downward pressure on the forward price and upward pressure on the spot price. The process continues until the difference between the forward price, and its fair value is no greater than the transaction costs of the arbitrage.[7]

The cost of carry relation is an equilibrium condition that presumes a perfect capital market. Institutional frictions (e.g., transaction costs, liquidity constraints, restrictions on short sales, etc.) can drive a wedge between true prices and their fair values to the extent they inhibit arbitrage. During the stock market crash of October 1987, for example, operational problems (e.g., slow printers and systems) at the New York Stock Exchange made stock index arbitrage impossible for a time, causing the cash and futures markets to disconnect.[8] But setting aside such exceptions, the cost of carry relation between forward and spot prices tends to be reliable.[9]

Commodity Interest Rates

The relation between the price of an asset for immediate delivery and the price of that asset for future delivery characterizes an implicit commodity interest rate

that guides the allocation of resources to their most highly valued uses over time (Keynes 1930; Sraffa 1932). On any date t, we can express the commodity interest rate prevailing through date T in this way:

$$\text{Commodity Interest Rate} = \frac{S(t) - F(t, T)}{S(t)}$$

where $F(t,T)$ = time t forward price of the asset for delivery on date T
$S(t)$ = current spot price

This commodity interest rate is equal to the marginal benefit less the marginal cost (both interest and storage) of holding the asset from t to T.[10]

The benefit of owning financial assets over time includes cash distributions such as stock dividends or bond coupons. But for commodities, the benefit of holding the asset is a "convenience yield" that reflects the implicit benefit of physical storage for firms that need access to the actual commodity in order to avoid costly production disruptions.[11] When inventories are high, plenty of the asset is available to assure producers and intermediaries that a stock-out will not occur. The convenience yield is small, and the price of the asset for future delivery is above the spot price by just enough to compensate asset holders for interest and storage costs. When the term structure of futures prices is positively sloped—called a carry or contango market—commodity interest rates are negative; a borrower of the commodity would pay more in storage and financing costs than it would receive in benefits from actual asset ownership. Firms thus have no particular economic incentive to take assets out of storage and sell them or loan them out today.

As inventories shrink, however, the marginal benefit of owning a unit of the underlying asset rises. The spot price thus goes up relative to prices for future delivery, resulting in a negatively sloped term structure of forward prices known as an inverted market or a market in backwardation. In an inverted market, current supply is low relative to demand, and firms will be willing to pay a positive commodity interest rate to get their hands on the physical asset today. Positive commodity interest rates in effect penalize firms that leave physical assets in storage for future delivery instead of bringing them out of inventory into the current, tight market.

Exhibit 4.1 illustrates this intertemporal supply rationing feature of derivatives using crude oil data from 1985 to 2007. The graph shows year-over-year percentage changes in total U.S. crude inventories (excluding the Special Petroleum Reserve) versus the three-month commodity interest rate based on Nymex futures prices. For most of the period, when commodity interest rates rise, oil inventories are drawn down.[12]

ASSET FINANCE

Firms that face rising deadweight external borrowing costs as a result of information asymmetries, credit constraints, and other market frictions sometimes must forgo positive net present value investments because of their limited access to affordable external financing (Froot, Scharfstein, and Stein 1993). Such so-called underinvestment problems can reduce capital formation and artificially depress

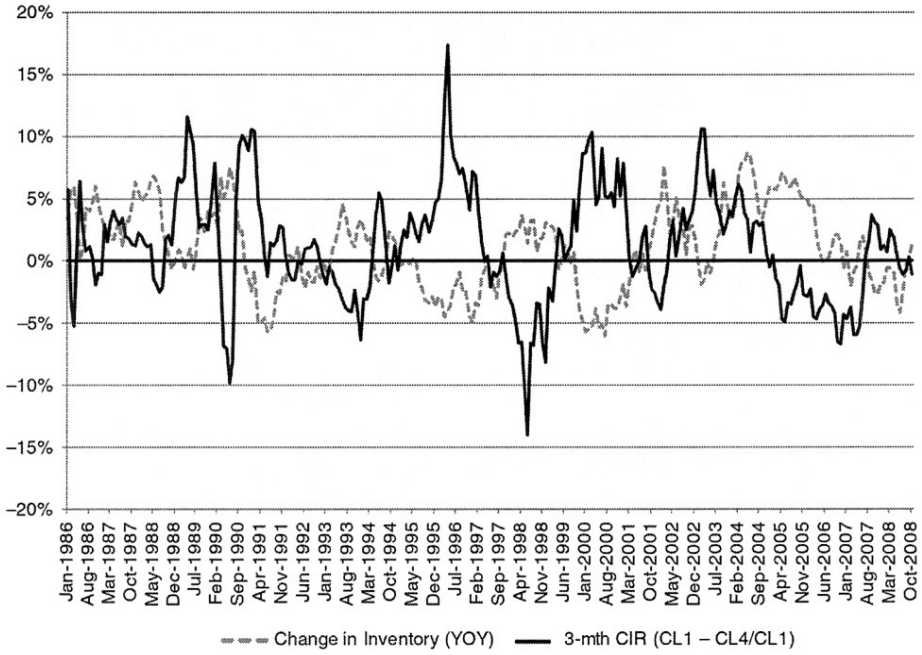


Exhibit 4.1 West Texas Intermediate Crude Inventories versus Commodity Interest Rates, 1986–2008

real investment activity. Derivatives can help mitigate underinvestment problems by enabling at least some firms to engage in asset-based financings.

Commodities Lending

As we saw in the previous section, forwards and futures facilitate intertemporal supply rationing by defining implicit commodity interest rates. In some markets, however, the borrowing and lending of assets is explicit, and the commodity interest rate is an observable market price.

Gold mines, for example, can borrow physical bullion from central banks and sell the gold spot to obtain immediate financing, repaying these gold loans later with gold from their own mines. The "gold lease rate" is the interest rate paid on a gold loan—for example, an annual gold lease rate of 5 percent on a 100-ounce gold loan means that 105 ounces of gold must be repaid to the gold lender in a year. The gold forward offered rate (i.e., GOFO) is generally above the spot price, which means LIBOR is at a premium to gold lease rates most of the time.[13] Exhibit 4.2 illustrates this. So, for mines facing high external financing costs, gold loans can provide a relatively cheap source of funds to finance capital investments.[14]

Commodity loans such as those we see in the gold market are hardly a recent innovation. On the contrary, they date back at least to Babylonia in 1900 B.C. to 1600 B.C. Like many other activities of the Mesopotamian era, banking in ancient Babylon was predominantly a religious practice centered around sanctuaries and temples (Jastrow 1911). The Temple of Šamaš (Ebabbara or Bit-Uri) at Sippar—a

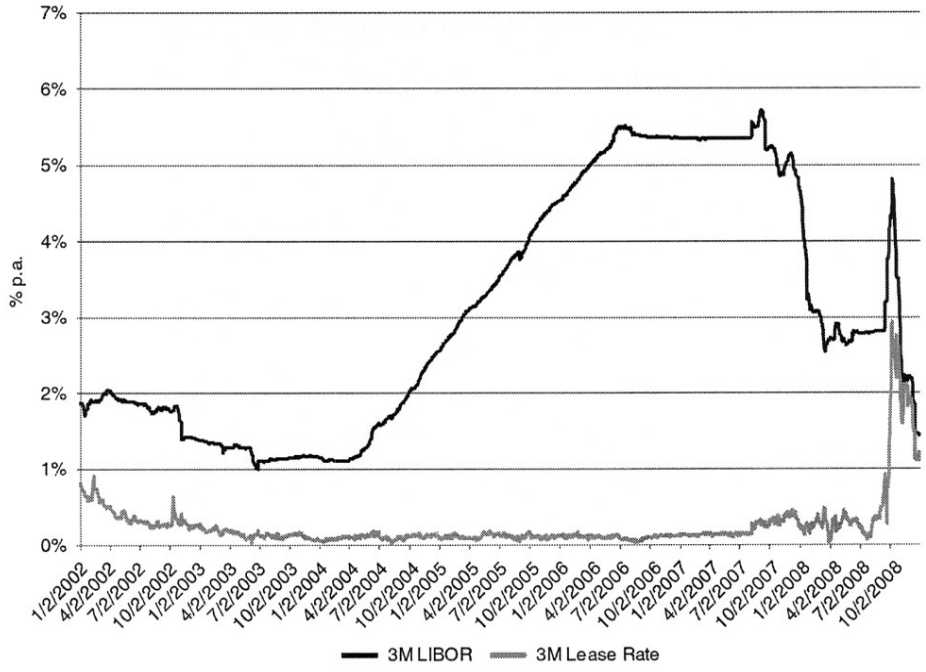


Exhibit 4.2 Three-Month Gold Lease Rates versus LIBOR, 2002–2008

shrine to Šamaš, the sun god and lord of justice and righteousness—was the dominant banking institution for much of the period (Bromberg 1942).

When the grain and livestock received by the Temple of Šamaš from tithes and offerings began to exceed storage capacity, the temple began lending grain to farmers who needed it to feed their families and workers and to sell for cash on the spot market to finance their operating cash flows. For example, the next quotation is translated from a loan tablet documenting a grain loan from the Temple of Šamaš to Minutum around the time of Sin-muballit, the father of Hammurabi:

> *10* gur *of grain—at the rate of 1/5th* gur *per* gur*—Minutum has borrowed from Šamaš. At harvest time he shall return it. (Bromberg 1942, p. 80)*

In other words, Minutum was obliged to return whatever grain he borrowed plus 20 percent to the Temple of Šamaš. Notice that this grain lending rate was quoted in quantity terms just as gold lease rates are today.[15]

Project Finance

A prepaid forward contract is a forward contract in which the seller agrees to deliver an asset in the future in return for receiving a payment from the buyer up front. Especially for firms with hard assets but limited access to unsecured credit, prepaid forwards can be an efficient method of monetizing those assets for financing purposes.[16]

Consider, for example, a developing country with below-investment-grade credit but a large supply of proven oil reserves. The country can sell its oil for future delivery using prepaid forwards, thereby generating cash up front that it may need to bring its oil fields into operation. Examples of such structures abound in modern structured project finance and are especially popular with credit-constrained borrowers.[17]

The use of prepaid forwards in commodity finance was prevalent as early as the sixth century in Islamic countries. Two principles of *shariah* are its prohibitions against usury and entering into transactions involving *gharar*, or risk. An important exception is called *salam*, defined as a sale in which specific goods are promised to a buyer for future delivery in exchange for a price paid in full up front. If a farmer needed cash (e.g., to pay his workers) before his crop came in, *salam* permitted the farmer to sell some or all of the crop before the harvest in return for a commitment to deliver grain in the future.[18]

Trade Finance

Derivatives also play an important role of trade finance. A Brazilian farmer selling coffee to Nestlé in Switzerland, for example, might go to a bank and obtain trade credit to finance his coffee exports. The bank likely will require the coffee to be pledged as collateral for the loan, along with a requirement that the farmer use derivatives or other means to lock in the value of the coffee collateral. Alternatively, the farmer might obtain pre-export financing and lock in his coffee sale price using a prepaid forward sale agreement with Nestlé.

One of the earliest examples of the use of derivatives in trade finance comes from medieval Europe, where the Medici Bank was operating very much like swap dealers today.[19] International trade in Europe up to the mid-1300s was conducted mainly at periodic regional fairs where merchants from various places came together in one location and exchanged their wares. This was problematic for merchants in two respects.

1. They had to finance their initial purchase of goods in their home currency.
2. Because correspondent and foreign bank branches did not maintain funds outside their home locations until the 15th century, merchants had little choice but to convert their foreign currency revenues back into their home currency. A Florentine merchant wishing to sell goods in Champagne, for example, thus needed to raise florins to finance his initial purchase of goods and would then later receive Provins money from the sale of those goods at the Fair of Champagne. (Face 1958)

In the fourteenth century, however, the church defined usurious lending as charging interest on a money loan in which the only risk to the lender was credit risk. Trade credit facilities like the bank loan to the Brazilian farmer in our earlier example thus were prohibited. But if the transaction was also subject to exchange rate risk, church usury prohibitions did not apply.

So the Medici Bank began offering a contract called a cambium that combined foreign exchange and commercial lending in a single transaction. An ordinary cambium involved a loan to the merchant in his local currency in exchange for the subsequent repayment of funds in a different currency and location at a

prespecified price—that is, a currency forward. Because both the merchant and bank were exposed to exchange rate risk, the church did not view cambiums as usurious and thus permitted them.

In the late fourteenth century, the Fair of Champagne declined in popularity and trade migrated to fairs in larger cities, such as London and Bruges, where countinghouses arose at which merchants maintained foreign currency balances. In response to competition from those countinghouses, the banking community replaced ordinary cambiums (which were custom, bilateral transactions) with standardized bearer certificates called *lettera di pagamento* or *lettera di cambio* (bills of exchange), which were prepaid currency forwards by another name. Organized markets for trading bills of exchange eventually emerged, with the Medici Bank as the dominant market maker. As the number of correspondents, branches, and agents of the Medici Bank grew in the fourteenth and fifteenth centuries, published quotes by the Medici Bank became *the* central source of information about foreign exchange rates (De Roover 1963, p. 122).

Financial Asset Inventory Management

Derivatives also can be used for asset finance by financial intermediaries. Although perhaps not an example of how credit-constrained firms can use derivatives and asset finance to mitigate underinvestment problems, derivatives do enable securities dealers to liquefy their securities portfolios and finance their securities inventories at a lower cost than if they had to borrow unsecured. This can reduce their costs of liquidity provision and market making, thereby promoting more efficient and liquid underlying securities markets.

A government bond dealer, for example, can finance a bond position by selling the bond and agreeing to repurchase it later at a higher price. The difference between the two prices—the repo rate—represents the interest rate the dealer pays to its counterparty for a cash loan collateralized with the underlying bond. This interest rate is generally below commercial borrowing rates such as LIBOR and is the closest a private corporation can get to the Treasury borrowing rate. A repo is, of course, just a forward contract combined with a sale of the security in the spot market—that is, a synthetic loan of the security.

In a stock loan, the stock borrower (e.g., a short seller who needs to borrow the stock to honor a security sale commitment) enters into an agreement with a stock lender to acquire shares in return for an obligation to return those shares whenever the stock lender wants. The borrower posts collateral at the time the shares are borrowed. When the shares are returned, the borrower receives back the collateral plus a rebate of some or all of the interest. Shares in higher demand command lower rebates, and hot issues may have negative rebates, in which case the stock borrower must make an additional payment to the lender above and beyond the forgone interest on the collateral.[20] Stock loans thus are also types of repos (albeit undated) in which the stock lender sells shares for cash and later repurchases them for a total net cost based on the rebate rate.

SYNTHETIC ASSET ALLOCATION

Investors often find derivatives appealing because they provide low-cost alternatives for investing in asset classes that, absent derivatives, are prohibitively costly

or operationally difficult to hold otherwise. If these new asset classes have low or negative correlations with existing major asset classes, adding them to the investment opportunity set enables investors to achieve their target expected returns with less risk. Investors can access these opportunities by using derivatives directly (possibly on a fully collateralized basis) or by investing in funds that use derivatives, such as managed futures funds, certain hedge funds and structured investment vehicles, and collateralized commodity obligations.

Gorton and Rouwenhorst (2006) show, for example, that commodities have similar Sharpe ratios (i.e., average return per unit of risk) to equities but returns that are negatively correlated with stocks and bonds. Not surprisingly, the growth in managed commodities funds seeking to engage in synthetic asset allocation into commodities has been significant over the past decade.

Some have also characterized volatility as an asset class. In equities, for example, volatility is negatively correlated with stock index returns.[21] Option spread trades, such as straddles and strangles, allow traders to take directionless positions on volatility. More recently, volatility derivatives, such as variance swaps, have become a popular tool for investing in volatility as an asset class.

Apart from these examples of synthetic asset allocation, numerous hedge funds and structured product vehicles make use of a wide range of active strategies involving derivatives for the purpose of enhancing returns. Whether such strategies actually expand the efficient portfolio opportunity set (as opposed to simply repackaging existing opportunities or adding leverage) is an empirical question.

Derivatives and Public Policy

Empirical financial economics and econometrics cannot tell us definitively if derivatives have been a net benefit to society in the nearly 4,000 years they have been around. Nevertheless, the reasons to believe that derivatives have done more good for society than harm are compelling.

As financial entrepreneurs continue to develop new derivatives, some surely will come under scrutiny, especially if such products are associated with headline-making losses—as some inevitably will be. The temptation of derivatives critics in such situations will be to respond with political proposals to restrict or deter some of these ostensibly dangerous new derivatives products. In the wake of the credit crisis, for example, criticisms of derivatives (especially credit derivatives) and demands for new regulations have been as numerous as they have been vigorous. But that does not necessarily mean those criticisms are well founded or that the proposed regulations are the appropriate response.[22]

Public policy decisions concerning the risks of innovative financial structures should be made with prudent deliberation and based on the empirical evidence. The risks to society of restricting unproven but controversial financial innovations, after all, may well exceed any risks of the innovations themselves. Smith (2003) makes this point compellingly:

> *Civilization can be seen as the gradual evolution of ever more creative risk management—from the family and private property to derivatives and structured financing arrangements. The goal is to permit an ever greater scope for the prudent assumption of risk. Because knowledge is dispersed, only that expanded scope offers any hope of fully using the varied skills of all the peoples of this planet. Civilization is the story of the advances and retreats of such prudent risk management expansions.*

> *Civilization makes it possible to better manage risks in the financial, technological, and social fields. Indeed, a reasonable metric for assessing the level of civilization is mankind's success in evolving institutions that permit an ever-larger scope of prudent risk taking. Prudence is best defined as a careful calculation of the risks of change versus the risks of stagnation—and the development of institutions that encourage that careful balancing. (p. 266–267)*

An appropriate metric of civilization is our ability to manage the risk of innovation—business, financial, technological, and social innovation alike. Indeed, a reasonable metric for assessing the level of civilization *is* mankind's success in evolving institutions that permit an ever larger scope of prudent risk taking. History is the story of mankind's slow stride from tribal collectivism to modern individualism, from poverty to affluence. Prudence is best defined as a careful calculation of the risks of change versus the risks of stagnation—and the development of institutions that encourage that careful balancing.

ENDNOTES

1. Despite the theoretical and empirical problems with estimating "social welfare" (see, e.g., Demsetz 1969), a lot of empirical work has been done on derivatives, much of which aims to address more specific and tractable questions than whether derivatives are "socially good" or "socially bad." Nevertheless, this chapter makes no claim to be a literature survey. Certain references to the literature are provided when appropriate, but these references are not intended to be and are not exhaustive.
2. Not all derivatives perform all of these functions all of the time.
3. For a comprehensive review of the historical evolution of derivatives, see Swan (2000).
4. Some contend that by facilitating risk transfer, credit derivatives were in part to blame for the subprime crisis. An article in *Fortune* magazine, for example, claimed that "by ostensibly providing 'insurance' on risky mortgage bonds, [credit derivatives] encouraged and enabled reckless behavior during the housing bubble" (Varchaver and Benner 2008). It remains to be seen whether the empirical evidence supports these (and numerous other recent) criticisms of credit derivatives. Addressing these criticisms, moreover, is beyond the scope of this chapter.
5. See, e.g., Jackwerth and Rubinstein (1996).
6. Despite some important institutional differences, we treat futures and forwards as economically equivalent in this discussion for expositional simplicity.
7. Not all firms face the same interest and storage costs or derive the same benefit from asset ownership. The cost of carry reflected in forward prices in equilibrium is the marginal cost of carry of the marginal market participant. In other words, not all firms will be able to exploit this arbitrage opportunity. But some will, and that is enough for the adjustment process to work as described.
8. See, e.g., Furbush (1989), Gammill and Marsh (1989), Harris (1989), Kleidon (1992), and Kleidon and Whaley (1992).
9. See, e.g., Fama and French (1987, 1988), Ng and Pirrong (1992) Ng, V. K., and C. Pirrong. "Fundamentals and Volatility: Storage, Spreads, and the Dynamics of Metals Prices." Journal of Business 67(2) (April 1994), 203–230. Stoll and Whaley (1990), Telser (1958), and Working (1948, 1949).
10. In this formulation, the benefits of asset ownership and the costs of physical storage would be expressed as a percentage of the spot price.
11. See, e.g., Williams (1986) and Working (1948, 1949).

12. Although positive commodity interest rates do penalize firms for storage, the converse is not usually true; negative commodity interest rates do not necessarily induce firms to store. In a "full carry" market, prices for future delivery exceed current prices by just enough to compensate for the interest and physical costs of storage, thus making firms indifferent between actual and synthetic storage. In recent times, however, the oil market has been in what some call "super-contango" in which prices of crude for future delivery exceed current spot prices by more than interest and storage costs, indicating a negative convenience yield and a positive return to storage. Not surprisingly, the tank farms in Cushing, Oklahoma—the delivery point for many crude derivatives—have been virtually at capacity during much of this period. In principle, we would expect to see upward pressure on storage prices until physical and synthetic storage costs converge.
13. Gold is usually in contango because of its limited industrial applications (hence, a nonexistent convenience yield). Gold briefly moved into backwardation after the adoption of the Washington Agreement on Gold in September 1999, in which European central banks agreed to restrict the sale and lending of gold.
14. Locking in low financing rates with a gold loan is synthetically equivalent to a forward sale of gold. If spot prices later rise, the mine thus cannot realize any gains from sales of its own gold at those higher prices. But mines with external credit problems for which gold loans may be most appealing might be better served by avoiding the risk of gold price fluctuations anyway. Tufano (1996) provides an insightful review of risk management practices in the gold mining industry more generally.
15. Up to the time of Hammurabi, the commodity interest rate on grain seemed to remain at around 20 percent. In the famous legal Code of Hammurabi, a maximum commodity interest rate of 33 1/3 percent per year was stipulated (Bromberg 1942).
16. Prepaid forwards can be a legitimate form of commodity-based finance (see, e.g., Culp and Kavanagh 2003). Unfortunately, Enron gave prepaid forwards a bit of a bad name. The problems with the Enron structures were not with the prepaid forwards per se but with the manner in which Enron used those structures to facilitate seemingly misleading accounting and disclosure practices.
17. See the examples in Culp (2006).
18. One of the conditions of salam is that it may not be based on a specific asset that is subject to destruction or degradation. A farmer thus cannot precontract to sell the specific crop from a specific field but can enter into an agreement to sell a specified amount and quality of comparable grain instead.
19. The use of derivatives in medieval Europe in general and by the Medici Bank in particular is discussed in great detail by De Roover (1948, 1963), from which most of the historical facts presented in this section are drawn.
20. See Culp and Heaton (2007) for a discussion of stock lending in the context of the "naked shorting" controversy.
21. See, e.g., Hafner and Wallmeier (2006).
22. Miller (1996) examines the social costs of the so-called great derivatives disasters of the 1990s. His admonitions and commentary are eerily applicable to the credit crisis, as well. See also Miller (1991).

FURTHER READING

Bakken, H. H. 1953. *Theory of Markets and Marketing*. Madison, WI: Mimir Publishers.

Culp, C. L. 2004. *Risk Transfer: Derivatives in Theory and Practice*. Hoboken, NJ: John Wiley & Sons.

Culp, C. L., and M. H. Miller. 1995. "Metallgesellschaft and the Economics of Synthetic Storage," *Journal of Applied Corporate Finance* 7, no. 4 (Winter): 62–76.

Culp, C. L., and M. H. Miller, eds. 1999. *Corporate Hedging in Theory and Practice: Lessons from Metallgesellschaft*. London: Risk Books.
Culp, C. L., and W. A. Niskanen, eds. 2003. *Corporate Aftershock: The Public Policy Lessons from the Collapse of Enron and Other Major Corporations*. Hoboken, NJ: John Wiley & Sons.
Culp, C. L., S. H. Hanke, and A. M. P. Neves. 1999. "Derivative Diagnosis," *International Economy* (May/June): 36–37, 67.
Figlewski, S. 1994. "How to Lose Money in Derivatives," *Journal of Derivatives* 2, no. 2 (Winter): 75–82.
French, K. R. 1986. "Detecting Spot Price Forecasts in Futures Prices," *Journal of Business* 59, no. 2–2 (April): S39–S54.
Kroszner, R. S. 2008. "Assessing the Potential for Instability in Financial Markets, Speech before the Risk Minds Conference, December 8.Geneva, Switzerland.

REFERENCES

Banz, R. W., and M. H. Miller. 1978. "Prices for State-Contingent Claims: Some Estimates and Applications," *Journal of Business* 51, no. 4 (October): 653–672.
Brav, A., and J. B. Heaton. 2003. "Market Indeterminacy," *Journal of Corporation Law* 28, no. 4 (Summer): 517–539.
Bromberg, B. 1942. "The Origin of Banking: Religious Finance in Babylonia," *Journal of Economic History* 2, no. 1 (May): 77–88.
Carlton, D. W. 1984. "Futures Markets: Their Purpose, Their History, Their Growth, Their Successes and Failures," *Journal of Futures Markets* 4, no. 3 (Fall): 237–271.
Culp, C. L. 2006. *Structured Finance and Insurance*. Hoboken, NJ: John Wiley & Sons.
Culp, C. L., and J. B. Heaton. 2007. "Naked Shorting," SSRN Working Paper (August).
Culp, C. L., and B. T. Kavanagh. 2003. " Structured Commodity Finance after Enron: The Uses and Abuses of Pre-paid Forwards and Swaps," in C. L. Culp and W. A. Niskanen, eds., *Corporate Aftershock: The Public Policy Lessons from the Collapse of Enron and Other Major Corporations*. Hoboken, NJ: John Wiley & Sons.
De Roover, R. 1948. *Money, Banking and Credit in Medieval Bruges*. Cambridge, MA: Medieval Academy of America.
De Roover, R. 1963. *The Rise and Decline of the Medici Bank* (1999 ed.). Washington, D.C.: Beard Books.
Demsetz, H. 1969. "Information and Efficiency: Another Viewpoint," *Journal of Law and Economics* 12, no. 1 (April): 1–22.
Face, R. D. 1958. "Techniques of Business in the Trade between the Fairs of Champagne and the South of Europe in the Twelfth and Thirteenth Centuries," *Economic History Review* 10, no. 3: 427–438.
Fama, E. F., and K. R. French. 1987. "Commodity Futures Prices: Some Evidence on Forecast Power, Premiums, and the Theory of Storage," *Journal of Business* 60, no. 1 (January): 55–73.
Fama, E. F., and K. R. French. 1988. "Business Cycles and Behavior of Metals Prices," *Journal of Finance* 43, no. 5 (December): 1075–1093.
Froot, K. A., D. S. Scharfstein, and J. C. Stein. 1993. "Risk Management: Coordinating Corporate Investment and Financing Policies," *Journal of Finance* 48, no. 5 (December): 1629–1958.
Furbush, D. 1989. "Program Trading and Price Movement: Evidence from the October 1987 Market Crash," *Financial Management* 18, no. 3 (Autumn): 68–83.
Gammill, J. F., and T. A. Marsh. 1989. "Trading Activity and Price Behavior in the Stock and Stock Index Futures Markets in October 1987," *Journal of Economic Perspectives* 2, no. 3 (Summer): 25–44.

Gorton, G., and J. G. Rouwenhorst. 2006. "Facts and Fantasies about Commodity Futures," *Financial Analysts Journal* 35, no. 2 (March/April): 47–68.

Hafner, R., and M. Wallmeier. 2006. "Volatility as an Asset Class: European Evidence, SSRN Working Paper (January).

Harris, L. 1989. "The October 1987 S&P500 Stock-Futures Basis," *Journal of Finance* 44, no. 1 (March): 77–99.

Jackwerth, J. C., and M. Rubinstein. 1996. "Recovering Probability Distributions from Option Prices," *Journal of Finance* 51, no. 5 (December): 1611–1631.

Jastrow, M. 1911. *Aspects of Religious Belief and Practice in Babylonia and Assyria*. New York: American Academy of Religion.

Keynes, J. M. 1930. *A Treatise on Money: Volume I, The Pure Theory of Money, and Volume II, The Applied Theory of Money* (1950 ed.). London: Macmillan.

Kleidon, A. W. 1992. "Arbitrage, Nontrading, and Stale Prices: October 1987," *Journal of Business* 65, no. 4 (October): 483–507.

Kleidon, A. W., and R. E. Whaley. 1992. "One Market? Stocks, Futures, and Options during October 1987," *Journal of Finance* 47, no. 3 (July): 851–877.

Kuserk, G. J., and P. R. Locke. 1994. "The Chicago Loop Tunnel Flood: Cash Pricing and Activity," *Review of Futures Markets* 13, no. 1: 115–146.

Merton, R. C. 1992. "Financial Innovation and Economic Performance," *Journal of Applied Corporate Finance* (Winter): 12–22.

Miller, M. H. 1991. "Leverage," *Journal of Finance* 46, no. 2 (June): 479–488.

Miller, M. H. 1996. "The Social Costs of Some Recent Derivatives Disasters," *Pacific Basin Finance Journal* 4 (July): 113–127.

Mulherin, J. H., J. M. Netter, and J. A. Overdahl. 1991. "Prices Are Property: The Organization of Financial Exchanges from a Transaction Cost Perspective," *Journal of Law and Economics* 34, no. 2-2 (October): 591–644.

Roll, R. 1984. "Orange Juice and Weather," *American Economic Review* 74, no. 5 (December): 861–880.

Smith, F. L. Jr. 2003. "Cowboys versus Cattle Thieves: The Role of Innovative Institutions in Managing Risks along the Frontier," in C. L. Culp and W. A. Niskanen, eds., *Corporate Aftershock: The Public Policy Lessons from the Collapse of Enron and Other Major Corporations*. Hoboken, NJ: John Wiley & Sons.

Sraffa, P. 1932. "Dr. Hayek on Money and Capital," *Economic Journal* 42, no. 165 (March): 42–53.

Stoll, H. R., and R. E. Whaley. 1990. "The Dynamics of Stock Index and Stock Index Futures Returns," *Journal of Financial and Quantitative Analysis* 25, no. 4 (December): 441–468.

Swan, E. J. 2000. *Building the Global Market: A 4000 Year History of Derivatives*. London: Kluwer Law.

Telser, L. 1958. "Futures Trading and the Storage of Cotton and Wheat," *Journal of Political Economy* 66, no. 3 (June): 233–255.

Tufano, P. 1996. "Who Manages Risk? An Empirical Examination of Risk Management Practices in the Gold Mining Industry," *Journal of Finance* 51, no. 4 (September): 1097–1137.

Varchaver, N., and K. Benner. 2008. "The $55 Trillion Question," *Fortune*, September 30, 2008.

Williams, J. 1986. *The Economic Function of Futures Markets*. Cambridge, MA: Cambridge University Press.

Working, H. 1948. "Theory of the Inverse Carrying Charge in Futures Markets," *Journal of Farm Economics* 30, no. 1 (February): 1–28.

Working, H. 1949. "The Theory of Price of Storage," *American Economic Review* 39, no. 6 (December): 1254–1262.

ABOUT THE AUTHOR

Christopher L. Culp is senior advisor with Compass Lexecon, an adjunct professor of finance at the University of Chicago Booth School of Business, an adjunct professor at Universität Bern in the Institut für Finanzmanagement, and director of Risk Management Consulting Services, Inc. He teaches graduate degree courses on structured finance, insurance, and derivatives, and provides advisory consulting services and testimonial expertise in these same areas. Dr. Culp is the author of four books—*Structured Finance & Insurance*; *Risk Transfer: Derivatives in Theory & Practice*; *The ART of Risk Management*; and *The Risk Management Process*—and the coeditor of two books—*Corporate Aftershock: The Public Policy Consequences of the Failure of Enron and Other Major Corporations* (with William Niskanen) and *Corporate Hedging in Theory & Practice* (with Merton Miller). He holds a PhD in finance from the University of Chicago Booth School of Business.