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To Conclude: Keep In ation Low and, in Principle, Eliminate It

Thomas C. Melzer

The U.S. economy is doing exceptionally well this year, with low inflation and an average unemployment rate of only 5 percent. Economic growth continues to be robust in this seventh year of the current expansion, which started in April 1991. Since that time, the economy has created 14 million new jobs, and inflation has been comparatively low and stable. In the first nine months of 1997, inflation in the Consumer Price Index was running at an annual rate of only 1.8 percent, which is as close to a stable price environment as we have seen in decades. Private-sector forecasts, however, indicate that inflation, as measured by the CPI, is expected to return to its trend level of roughly 3 percent in the next year.

High employment today means that many workers are acquiring skills and experience that will yield benefits for the rest of their careers. But the best thing about the current economic good news is that it has not been created by artificial demands stemming from excessive money creation. On the contrary, the low money growth and low inflation of the current expansion mean that long-term prospects are not being jeopardized for the sake of today's prosperity.

In response to such good news, some observers—especially those prone to hyperbole—have proclaimed a "new economic paradigm" in which the U.S. economy has become both recession-proof and inflation-proof. In this view, policymakers need not worry about demand or inflation because markets will keep growth strong and inflation in check. However, history suggests caution with respect to such Panglossian notions that "all is for the best in this best of all possible worlds."

We must not ignore the lessons of the past by adopting inflationary policies that have consistently culminated in slowed growth and higher unemployment. The fact is that, throughout history, efforts to use expansionary monetary policy to squeeze more real growth out of the economy than can be sustained have always led to increases in the misery index. What is the misery index? It is the sum of the inflation, unemployment, and long-term interest rates. This index was at an all-time high in the early 1980s, when each of these three rates soared into the double digits. By comparison, the index is very low today, registering less than half the "misery" of the early 1980s.

The purpose of this article is to address the following issues: why low and stable inflation has been good for economic growth, how inflation uncertainty hurts our economy, and what steps the Fed can take to make its price stability policies credible. The appropriate monetary policy response to today's environment of comparatively low inflation, low unemployment, and low interest rates is to nurture it with a credible commitment to price stability—an inflation rate so close to zero that it ceases to be a significant factor in long-term planning. Only in this way can the Fed reconcile its potentially conflicting statutory objectives of "maximum employment, stable prices, and moderate long-term interest rates" and realize its ultimate goal of a rising U.S. standard of living. Let me begin by considering the first issue I posed earlier.

WHY HAS LOW INFLATION BEEN GOOD FOR THE ECONOMY?

Under the successful disinflation policies of the past 15 years, the U.S. economy has enjoyed its most cyclically stable period ever. Since 1982, the economy has had positive growth in all but three quarters out of 59. By comparison, between 1969 and 1982, when inflation was trending upward, there were 20 recessionary quarters out of 56. The current stable growth experience is the best evidence that the Fed's choice to fight the double-digit inflation of the late 1970s and early 1980s has been good for the economy. Even though we have not yet achieved price stability as I've defined it, the current 3 percent inflation trend is the best record we've had since the early 1960s.

Let me briefly review the basic arguments as to why low inflation is good for the economy. First, a stable price backdrop enables the price system to work more efficiently than it would with high and variable inflation. By "working efficiently," I mean that the economy is not wasting resources. When the general level of prices is comparatively stable, decision makers can interpret changes in dollar prices as accurate signals on which to base decisions. In free economies, clear, reliable signals from prices help people make the choices that are best for them. Interest rates, for example, represent one of the most fundamental prices in the economy—the rental price of capital—and the real interest rate is a central factor in savings and investment decisions. But market interest rates transmit fuzzier signals about the required real rate of interest in an inflationary climate, because observed nominal interest rates also respond to shifts in inflation expectations.[1] Accordingly, the decisions of savers and investors are distorted in an inflationary monetary regime.

Thus, the best way to keep price signals clear is to keep inflation low and, in principle, eliminate it.

Second, inflation distorts decisions because it is a hidden tax on the private sector borne by holders of money and government securities. Even at today's 3 percent inflation trend, the real value of a dollar is cut in half in less than 25 years. Although the government admittedly has to collect taxes, the inflation tax generates incentives for wasteful efforts to reduce money holdings, like currency, which depreciate through inflation. Inflation also distorts decisions to save and invest, since inflation-compensating interest payments and inflation-induced capital gains are counted as taxable income. The tax on the portion of interest payments that is intended to adjust for inflation inadvertently enlarges the wedge between the value of the interest paid by the borrower and the after-tax value of interest received by the lender.[2] In the case of capital gains, significant tax burdens can fall on transactions that have not generated any real income—for example, when an asset is sold at a price that has increased only at the rate of inflation. These inflation-induced tax distortions decrease planned savings and interfere with capital formation.

The best way to attenuate the inflation tax is to keep inflation low and, in principle, eliminate it.

Third, recent business-cycle research suggests that a stable, non-inflationary environment, rather than one in which monetary policy is directed at fine-tuning real growth, may be the best contribution monetary policy can make toward sustaining real growth. Behind the premise of fine-tuning lies the notion of a trade-off between inflation variability and output variability—the idea that higher inflation can buy more real growth in the short run. Contemporary thinking, however, says that inflationary variability *threatens*, rather than prolongs, economic expansions. Recessions are often the product of particular inflationary imbalances, instead of expansions that have simply "run out of steam."[3] An example of an inflationary imbalance from the mid-1980s is the excessive investment in commercial real estate that eventually depressed the market, taking years to unwind.

[1] The U.S. Treasury's issuance of inflation-indexed bonds, which began in January 1997, is intended in part to help distinguish changes in real interest rates from changes in expected inflation, but substantial imprecision persists. Campbell and Shiller (1996) provide an international appraisal of indexed bonds in practice.

[2] See Dewald (1986) and Feldstein (1996) for discussion of how inflation distorts saving and investment.

[3] Diebold, Rudebusch, and Sichel (1993) evaluate evidence that the age of an expansion does not significantly influence the probability of the onset of recession.

Because inflation has been shown to be more volatile at higher levels, the best way to reduce its variability is to keep inflation low and, in principle, eliminate it.

In general, U.S. monetary policy has succeeded in capturing many of these benefits of low inflation during the past 15 years. I would further argue that this success has not been an accident but, instead, a deliberate policy choice. The policy shift since the early 1980s to a low-inflation regime has required a commensurate reduction in the rate of monetary expansion. Growth in the M2 aggregate averaged more than 9 percent from 1968 to 1983, but less than half as much—4.4 percent—from 1984 to 1997. This experience demonstrates that the Federal Reserve can restrain excessive money growth and bring down the inflation rate. Inflation control is undeniably the Fed's responsibility because it alone has the tools to determine the long-run rate of monetary expansion needed to keep inflation low. Even though the inflation rate so far this year is running at less than a 2 percent rate, there remains a good deal of uncertainty as to whether inflation is down for the count. Until price stability becomes the explicit, publicly recognized, and sole objective of monetary policy, a degree of inflation uncertainty is bound to persist. Let me now turn to the second of my three questions.

WHY IS INFLATION UNCERTAINTY BAD FOR THE ECONOMY?

In addition to expected inflation, inflation *uncertainty* increases nominal interest rates because lenders demand compensation for the risk they take that inflation might end up higher than expected.[4] The inflation-risk premium, which effectively raises real borrowing costs, arises in policy regimes where credibility is imperfect. What happens is that lenders judge that future inflation will almost certainly not be much less than expected, but could quite possibly be considerably *more* than expected. This asymmetry often results when inflation has fallen to a low level at which lenders and borrowers agree that inflation has a greater likelihood of a substantial increase than decrease. In such an environment, market interest rates adjust to compensate lenders for facing these asymmetric risks. As a market response to uncertainty, the inflation-risk premium resembles other risk premiums that help people hedge against risk. Whereas other risk premiums respond to risks that are intrinsic to the nature of the investment, the inflation-risk premium hedges against an unnecessary risk uncertainty surrounding the value of the money that will be used to repay the debt. Only a non-inflationary monetary regime can eradicate this unnecessary inflation risk and thereby deliver the lowest sustainable real borrowing costs to stimulate capital formation and foster future growth.

International evidence suggests that investors often require substantial inflation-risk premiums. After they have been burned by inflation once, investors typically need to see years of consistently low inflation to convince them that the risk of inflation has subsided. For the past several years, almost all major industrial countries have had inflation rates well below 5 percent. Yet the real borrowing costs on government securities differ widely across countries because of the substantial inflation-risk premiums in countries that have a long history of inflation. Indeed, the prospect of reducing the inflation-risk premium in their interest rates strongly motivates Italy, Portugal, and Spain, for example, to join the European Monetary Union.

Much of the inflation-risk premium in interest rates stems from the experience that once inflation is unleashed, the process of bringing it back down is long and painful. As a consequence, it is even more important for the Fed to convince the public of its intentions to contain inflation. Reductions in the inflation-risk premium are possible if the Fed follows a disciplined and credible policy to move inflation lower and keep it that way. This brings me to the last of my three questions.

[4] Kandel, Ofer, and Sarig (1996) and Chan (1994) find evidence of an inflation-risk premium in interest rates.

HOW CAN THE FED MAKE PRICE STABILITY POLICIES CREDIBLE?

The persistence of inflation-risk premiums in nominal interest rates—even with inflation as low as it has been in recent years—is an indication of imperfect inflation credibility. A policy is credible when it can be counted on. And a credible non-inflationary monetary policy is one that can be counted on to keep inflation low. Credibility is an essential element of a price stability policy for the simple reason that only when people have faith in price stability can the full range of benefits begin to accrue. Otherwise, interest rates will remain elevated by an inflation-risk premium.

New Zealand is one country that had a history of high inflation in which the central bank appears to have rapidly acquired credibility for its new, low-inflation policies.[5] There, a legislative mandate calling for price stability through inflation targets has convinced investors that the country's imperfect past inflation record is not likely to recur. Without this newly created credibility—even with low current inflation—long-term interest rates in New Zealand could easily be 3 or 4 percentage points higher than they are. By achieving a degree of credibility through inflation targets and a legislative mandate that makes price stability the monetary policy objective, New Zealand has been able to reduce real borrowing costs substantially.

I am concerned, however, that in the United States, 3 percent inflation has become too entrenched in people's expectations. One argument against a move to lower inflation is that, because of these entrenched expectations, the transition would be too disruptive. Indeed, a surprise attack on inflation could well lead to a regrettable loss in output. A sound way to change these entrenched expectations would be to adopt an approach similar to that of New Zealand and several other countries. This approach involves setting a precise inflation goal and a timetable for achieving it. At the semiannual congressional hearings on monetary policy, the Fed could announce a set of multiyear inflation targets, which would then define a course by which inflation could gradually be reduced. Correspondingly, policy actions would be geared both to place inflation within that year's target range and to set the stage for the following year's target. In short, when inflation is too high—and I think even 3 percent is too high—a specific inflation target and stated timetable would make it easy to see if policymakers were in fact carrying out their responsibilities.

I would argue that announced policy objectives in the form of inflation targets would enhance the Fed's credibility, because its policy actions would be easier to interpret. In such an environment, preemptive policy actions against inflationary pressures could be readily understood for what they are. If, on the one hand, people believed that the Fed were merely acting at an early stage to head off inflationary imbalances, they would understand that the economy was not in immediate danger of either a recession or a burst of inflation. If, on the other hand, the Fed had poor credibility and poorly understood reasons for acting, the public might believe that the Fed acts only when panicked, and they might therefore interpret any Fed action as cause for alarm.

CONCLUSION

I have emphasized that "price stability" is a state that must be sustained, and considered sustainable, over time. Although CPI inflation has been running at just 1.8 percent so far this year, longer-term expectations are for roughly 3 percent a year, and there is always a risk that inflation could run higher. What really matters is not merely the absence of inflation at any given point in time, but the widespread presence of public expectations that prices will remain stable in the *future*. I believe the best way for the Fed to achieve price stability is to announce multiyear inflation targets, paving the way for private plans, contracts, and Fed policies to reinforce each other. In this way, price stability represents a compact with the American

[5] Walsh (1996) discusses recent monetary policy practice in New Zealand.

people that, if upheld, could achieve lower interest rates, eliminate the deadweight costs of inflation, and remove inflationary imbalances as a cause of economic downturns. For its part, the Federal Reserve can best contribute to this compact by confirming that it is following a price stability policy by announcing specific inflation targets and a timetable for meeting them. A legislative mandate along these lines would further strengthen the compact.

I do not think the excellent performance of the U.S. economy during the current economic expansion is just a chance occurrence. The low-inflation environment has been an important contributing factor, and the public should give monetary policies that have restrained excessive money growth their due credit for contributing to current economic good times. The public should also recognize that the Fed's single-minded pursuit of price stability is the best way it can contribute to an economic environment of sustained growth and a rising standard of living.

Indeed, my conclusion is that the best policy for economic growth is to keep inflation low and, in principle, eliminate **it.**

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The New Risk Management: The Good, the Bad, and the Ugly

Philip H. Dybvig and William J. Marshall

At one time, risk management meant buying corporate insurance, implementing procedures to avoid lawsuits and accidents, and installing safety equipment. The new risk management uses financial markets to hedge different sources of risk within the firm. Trading in financial markets can hedge companies against the risk of changes in interest rates, input prices, or currency fluctuations. While hedging per se is not new, the scale and diversity of hedging are far greater than they used to be. When executed properly, the new risk management can be good and even essential for competition. Unfortunately, the new risk management can also be bad, wasting resources without reducing risk and perhaps even increasing it. The new risk management can be ugly, generating large losses such as those in widely publicized cases at Barings, Metallgesellschaft, Procter and Gamble, and other firms. In these and many other firms, employees relatively far from the top of the hierarchy of control had the authority to take financial positions large enough to generate losses that could bankrupt the firm. Thus, policies for risk management should be put in place at the highest level of a firm, and they should provide for monitoring and control. The purpose of this article is to provide an introduction to the new risk management and some policy choices firms should be considering.

We start with a discussion of the option-pricing tools that make the new risk management possible, and we follow with a stylized example of how the new risk management ought to work. Then we consider implementation issues, including some general policy questions as well as some accounting issues.

TOOLS FOR THE NEW RISK MANAGEMENT

Starting with the famous work of Black and Scholes (see shaded insert, next page), option-pricing theory has been very successful in pricing various financial claims. The Black-Scholes model was designed to price standard call and put options, and it has been extended to price all sorts of financial claims. The Black-Scholes model and its extensions form the theoretical foundation for the new risk management.

There were option-pricing models prior to the work of Black and Scholes, including some models with formulas similar to Black-Scholes. What makes the Black-Scholes model different is that it provides a *hedging strategy* that is an investment policy with an investment equal to the model's option price and a terminal value equal to the terminal value of the option. Knowing the trading strategy means that the model is not only someone's best guess; it is also possible to profit if the model is wrong. If the model price is lower than the price in the economy, we can sell the option, pocket the excess over the model price, and invest in the hedging strategy to cover the terminal value of the option we have sold. If the model price is higher than the price in the economy, we follow the hedging strategy in reverse, taking a short position instead of a long position and lending instead of borrowing. In the model, the

THE BLACK-SCHOLES OPTION-PRICING MODEL

The precursor of all modern option-pricing models was developed by Fischer Black and Myron Scholes.† The main result is an option-pricing formula based on simple and reasonable assumptions in a continuous-time model. The remarkable thing about the result is that it relies on the absence of arbitrage, and part of the proof is a formula that specifies a trading strategy in the underlying stock and the riskless bond that will replicate the payoff of the option at the end.†† If the option is priced differently in the economy, buying or selling the option and following either the trading strategy or the reverse of the trading strategy will make money! Using the same sort of analysis, one can derive a trading strategy that will hedge the financial risk in a firm's cash flows.

Now we present the Black-Scholes formula for the price of a call option. Recall that a call option gives the owner the right (at the owner's option) but not the obligation to buy one share of the underlying stock at the strike (or exercise) price *X* specified in the option contract on or before the maturity date of the option. If the stock price is *S* and the price of the bond promising to pay the amount of the strike price at the maturity date of the option is *B*, the Black-Scholes price, *C*, of the call option is

$$C = S\,N(x1) - B\,N(x2),$$

where

$$x1 = \log(S/B)/s + s/2,$$

$$x2 = \log(S/B)/s - s/2, \text{ and}$$

s is the standard deviation (or square root of the variance) of the stock price at maturity, given the stock price today, and the function *N* () is the cumulative normal

hedge replicates the option value perfectly; in practice, the hedge is not perfect, but it works remarkably well. This is why the Black-Scholes model and its progeny are widely used in business.

The introduction of these option-pricing models and the parallel development and maturation of liquid financial markets have made it easier and easier to hedge financial risks using options, futures, futures options, swaps, caps, collars, floors, and a variety of other financial instruments.

OPTION PRICING AND RISK MANAGEMENT

Hedging an option is an example of risk management. Its purpose is to remove the risk and capture the pure economic profit of the transaction. Fundamentally, this strategy is the same as insurance. For the insured, the insurance policy makes money in bad times (when the insurable event occurs) and loses money in good times (when no insurable event occurs but the premium is paid), which reduces risk by softening the impact of bad outcomes. The same is true of a hedging strategy; losing money on the hedge in good times and making money in bad times offsets the original cash flows, making the total cash flow less volatile. In either strategy, payment for the insurance can be "up-front" or "pay-as-you-go": For hedging, as for insurance, the arrangement of cash flows[1] accommodates the preference of the insured. There are important differences in taxation and regulation between hedging using insurance and hedging using financial markets, but those are beyond the scope of this paper.

[1] Cash-flow is the accounting notion of actual cash coming in or out from operations. Unlike profits, cash flow does not include depreciation or amortization, but it does include (as an offset) investment in capital. In our examples later, we will treat the two the same, although this is not appropriate except in the case of very simple businesses that rent any required capital.

distribution function. If there is a constant, continuously-compounded interest rate, r, and T is the time-to-maturity of the option, then B is the discounted exercise price

$$B = X exp(-rT).$$

And, if the stock has a variance, v, per unit time, we have that

$$s^2 = vT$$

is the variance of the final stock price.

In the expression for C, the first term is the stock holding in the hedge strategy, and the second term is the bond holding (which is negative, which is a short sale or borrowing). The main assumptions of the model are absence of arbitrage, a constant riskless rate, continuous stock prices, and a constant variance of returns per unit of time for the underlying stock. The intuition is that we can replicate the risk of holding the option by holding just the right portfolio of riskless bonds and the underlying stock. For example, if at a point in time the option moves fifty cents for each one-dollar movement in the underlying stock price, then the replicating strategy would hold one share of stock for each two options we are replicating. To hedge the value of the option, we would short (borrow) a share of stock for each of two options. In that case, the stock's value change would neutralize the effect on our wealth of the option's price change. The hedge's holdings in the stock and bond will change over time and in response to stock price changes, since the sensitivity of the option value is different when the option is in the money than when it is out.

† Black, F. and M. Scholes, "The Pricing of Options and Corporate Liabilities" *Journal of Political Economy* 81, 1973, 637-54.

†† For more discussion of why this makes sense, see Rubinstein, M. and H. Leland, "Replicating Options with Positions in Stock and Cash," *Financial Analysts Journal*, (Jan-Feb 1995), pp. 113-21.

Using dynamic trading strategies to hedge financial options may seem significantly different from hedging price risk in a firm. However, the concept is exactly the same. A hedger is taking the other side of the risky investment in futures or whatever would be used to replicate the cash flows that are being hedged. Normally, these cash flows cannot be hedged precisely, but the hedge can still reduce risk significantly. For example, one policy is to hedge the expected cash flow conditional on the price of inputs that can be hedged in futures markets while leaving the remainder unhedged, which means that the remaining risk is borne by the stock and bond holders of the firm.

Before turning to the general policy issues in risk management, we will consider a typical example.

RISK MANAGEMENT IN MANUFACTURING

Our example considers the hedging problem of a manufacturer that uses significant amounts of copper as an input. (With little change in the discussion, this input could be zinc, silver, oil, or wheat. With a slightly greater change, the "production" could be servicing of core deposits in a bank, and the analysis would provide the optimal hedging of interest rates.) We will examine the optimal hedging of copper price movements in the cash flows before turning to a general discussion of policy and oversight.

In the example, expected output is 1,000 units, which will sell for $100 per unit. The price has been committed to in advance because of long-term contracts,

Table 1

A Manufacturer's Copper Price Hedge

Each section of this table shows the cash flows one year from now for the simple example of a manufacturer that is facing copper price risk. In the example, copper prices are higher when demand for output is higher. Each section of the table illustrates a different hedging strategy and profit (= cash flow) in three copper price scenarios. The example abstracts from taxes and sources of risk that are not related to the price of copper. In each case, the expected profit is 1,500. The point of hedging is reducing uncertainty, not increasing average cash flow (except indirectly, because it allows you more freedom in choosing projects).

Table 1A

Unhedged Cash Flows

Probability	Copper Price	Units Sold	Output Price	Total Sales	Copper Expense	Other Expenses	Profit (Loss)
1/4	25	1,200	100	120,000	30,000	82,000	8,000
1/2	20	1,000	100	100,000	20,000	78,000	2,000
1/4	15	800	100	80,000	12,000	74,000	(6,000)

Table 1B

Naive Hedge of the Expected Quantity Required

This hedge might be put in place as part of the procurement process, since it looks only at expenses. This is at best an incomplete hedge of copper costs, since the true quantity changes with copper prices. In our example, this naive hedge actually increases risk, since increased sales mean profits are high when copper prices are high.

Probability	Unhedged	Hedge	Net
1/4	8,000	5,000	13,000
1/2	2,000	0	2,000
1/4	(6,000)	(5,000)	(11,000)

Table 1C

Fully Hedged Cash Flows

A complete hedge of all the cash flows requires something more than a simple purchase of futures, since the sensitivity to copper prices of the unhedged profit or loss is higher when copper prices are low than when copper prices are high.

Probability	Unhedged	Hedge	Net
1/4	8,000	(6,500)	1,500
1/2	2,000	(500)	1,500
1/4	(6,000)	7,500	1,500

but the quantity may vary around this expectation because the contracts give customers the option to choose how much to buy within a range. Each unit will use an amount of copper that would cost $20 purchased forward (in a firm commitment to buy one year from now). If purchased in the spot market, the copper in the unit might cost $25 (with probability 1/4), $20 (with probability 1/2), or $15 (with probability 1/4).

One obvious (and common) approach to hedging in this context would be to forecast demand for copper and then hedge that amount, either by entering a fixed-price contract with the supplier or by buying that amount of copper futures—at a shorter maturity, if necessary, because one-year futures are not traded or have a very large spread. This might be a natural outcome if hedging were performed by buyers who were responsible for copper procurement and whose evaluations were based on the cost of a forecast quantity of copper. However, choosing a useful hedge of the entire cash flow is more subtle than that.

Table 1 contains an elaboration of the example. When the economy is doing well, copper prices are high (since this firm and other manufacturers are demanding more copper) and so is demand for the firm's output. Table 1A shows the cash flows in the absence of any special risk management to hedge copper price risk. Table 1B shows the result of hedging by buying forward the expected quantity. Ironically, this naive approach to hedging increases risk exposure, since the firm is already more than hedged by increased sales when the industry is doing well and copper prices rise. The full hedge, the result of which is shown in Table 1C, cannot be implemented by simply buying or selling copper forward one year. However, the full hedge can be implemented either by buying options or by dynamic trading in forward or futures contracts. Since this type of strategy is typical of hedging problems, it is worthwhile deriving the dynamic hedge and discussing its operation.

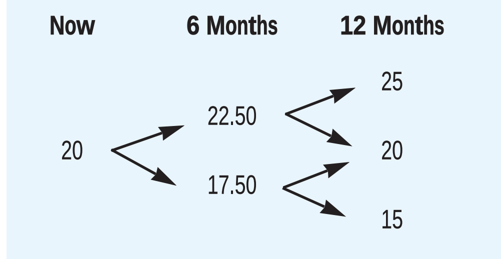
THE DYNAMIC HEDGE

To study the dynamic hedge, we need to understand the trading opportunities and information between now and realization of the cash flows a year from now. The sensitivity of the firm's value to copper prices varies in response to the interim information, and this changing sensitivity should be reflected in our trades.

In the current example, we assume that the firm is using copper futures contracts to hedge changes in copper prices. Futures serve the same economic purpose as forward purchases, but they are somewhat different logistically, since for futures the money changes hands immediately when the prospective value of copper rises and falls. If we buy one futures contract, then at the end of each day we are given (more literally, our margin account is credited with) the change in futures price over the day. If we sell (or *short*) one futures contract, then we must pay the change. If the futures price increases from $50 to $55, then the owner of two futures contracts will collect $10, and someone who has sold two futures contracts will have to pay $10. If the futures price instead decreases from $50 to $45, the person short two contracts collects $10, and the person long two contracts has to pay $10. In general, the futures price need not be exactly equal to the price we would pay for forward purchase, but for most purposes we can think of the two as being the same.[2]

In the actual economy, information arrives minute-by-minute, and a firm can trade on copper prices almost continuously in time. For our simple example, information arrival and trading occur now, six months in, and again in a year. (This is not an essential simplification; while the analysis for a practical model requires more computations, it is conceptually no more difficult.) At the beginning of the year, the futures price of copper delivered a year from now is $20. Six months from now, the futures price will be either $22.50, with probability 1/2, or $17.50, also with probability 1/2. The overall price dynamic is given in Figure 1. The price at a node in the tree is the price paid in a firm commitment to buy copper one year from now. From a given node, an up or down move is equally likely, with probability 1/2, so any given price path has probability 1/4 = 1/2 × 1/2. Consistent with Table 1, the ending node of $20 is twice as likely as the other ending nodes because it can be reached by either an up move followed by a down move (probability 1/4) or a down move followed by an up move (probability 1/4). A final price of $25 comes only from two up moves (probability 1/4), and a final price of $15 comes only from two down moves (probability 1/4).

Figure 1



To derive the full dynamic hedge, the firm requires one more piece of information, which is the rate at which futures gains or losses will be reinvested, which we will take to be 5 percent simple interest over six months. (Actually, the rate we choose will not affect the hedged cash flows in Table 1C, since increasing this rate will result in a completely offsetting decrease in the number of contracts we hold over the first six months.) Holding one futures contract at one node implies a gain of $2.50 (given an up move) or a loss of $2.50 (given a down move), which

[2] In fact, if interest rates are nonrandom (so re-investment rates are known in advance), absence of arbitrage implies that the forward price must equal the futures price, although one futures contract has more impact, since the change in value is received up front, while in a forward contract the change in value occurs at maturity.

A SMALL GLOSSARY OF RISK-MANAGEMENT TERMS

Binomial model. The binomial option-pricing model, developed by Cox, Ross, and Rubinstein [1979], assumes that the stock return over a short time interval has one of two values. The binomial model is a popular alternative to the Black-Scholes model because it is flexible and easy to implement on a computer.

Black-Scholes model. This is the original modern option-pricing model (see shaded insert on pp. 10-11).

Call option. A call option is a contract that gives the owner the right to purchase a share of the underlying asset in exchange for the contractually specified strike price (or exercise price). An *American* call option can be exercised at any time before maturity, while a *European* call option can be exercised only on the maturity date.

Cap. An interest-rate cap is a promise to pay the excess of an interest rate above some level in each of a number of periods. Caps are useful for containing the risk of rising borrowing costs.

Collar. A collar combines the cash flows of buying a cap and selling a floor. It is useful for containing the risk of rising interest rates (like a cap); including the floor gives up some profit potential when rates fall to help to pay for the cap.

Floor. An interest-rate floor is a promise to pay the shortfall of an interest rate below some level in each of a number of periods. Floors are useful for locking in a minimum return.

Forward contract. A forward contract gives the owner the right and the obligation to buy a specified amount of a commodity at a specified price at some specified date in the future.

Futures contract. A futures contract is similar to a forward contract except that there is daily settlement, i.e., each day the parties to the contract exchange money representing the market-determined change in value of the contract. Daily settlement minimizes the need for credit checks and large margin accounts (which are held as collateral), since only one day's price variation is at risk.

Hedge. Hedging a position (or entering a hedge) is undertaking another activity with offsetting risk. Some common hedging instruments include insurance, futures contracts, and options.

Long position. To take a long position (or to "be long") is to purchase an asset or futures.

Put option. A put option is a contract that gives the owner the right to sell a share of the underlying asset in exchange for the contractually specified strike price (or exercise price). An *American* put option can be exercised at any time before maturity, while a *European* put option can be exercised only on the maturity date.

Short position. To take a short position (or to "sell short") is to assume the opposite of a long position. In the case of futures, they are simply sold in the market. Shares and other securities are borrowed (for a nominal fee) then sold in the market, with the promise of buying some shares later to return the borrowed shares. In the meantime, the short must pay any dividends or coupons that are due the person from whom the shares were borrowed. The cash flows for a short position are the negative of the cash flows for a long position.

Value at risk. Value at risk (VAR) is a measure and methodology for assessing risk exposure by looking at total exposure to various market-level risks. This is a useful tool, but it does not account for residual risk that is specific to the project and not related to the market-level risks.

Table 2

Cash Flows from the Dynamic Hedge

Futures Price Path	Cash Now	# Contract Now	Cash in 6 months	# Contracts in 6 months	Cash in 1 yr	Pre-hedge Cash Flow	Hedged Cash Flow
20-22.50-25	0	(1,333)	(3,333)	(1,200)	(6,500)	8,000	1,500
20-22.50-20	0	(1,333)	(3,333)	(1,200)	(500)	2,000	1,500
20-17.50-20	0	(1,333)	3,333	(1,600)	(500)	2,000	1,500
20-17.50-15	0	(1,333	3,333	(1,600)	7,500	(6,000)	1,500

is reinvested until the end at the interest rate. From this we can use simple algebra to derive the solution. In the example, the full hedge is implemented by the following strategy: At the start, the firm sells 1400/1.05 ~ 1,333 futures at the futures price of \$20. If futures go down to \$17.50, the firm increases the short position to 1,600 contracts, while if futures go up to \$22.50, the firm reduces the short position to 1,200 contracts.

The terminal cash flow generated by the hedge (including reinvestment) is analyzed in Table 2. For example, the second row shows the effects of the hedge when prices go up and then down (from \$20 to \$22.50 and back to \$20). The hedge starts with no initial cash. It shorts 1,333 contracts, and when in six months the futures price goes up by \$2.50, \$2.50 × 1,333 = \$3,333 is borrowed, and the short futures position is reduced to 1,200 contracts. When the futures price falls by \$2.50, \$2.5 × 1,200 = \$3,000 in profits are collected, and after payment of \$3,333 × 1.05 = \$3,500 on the loan, net cash from the hedge is \$3,000 – \$3,500 for a loss of \$500. Added to the unhedged cash flow in that state of \$2,000 (from Table 1A), the hedged cash flow is \$1,500. The calculations in the other states work the same way.

We can see now that the dynamic hedge was chosen so that the re-invested proceeds of the hedge plus the original cash flows are made to be the same in every contingency. The necessary hedge can be computed by working backward from the end. The first two rows differ only in the price performance over the last period. Since the difference in pre-hedge cash flow for these two scenarios is \$8,000 – \$2,000 = \$6,000 and the difference in futures prices for the two scenarios is \$25 – \$20, we require \$6,000 / \$5 = 1,200 contracts to replicate the cash flows or short 1,200 contracts (the offsetting position) to hedge the cash flows. Given the calculated hedge at the last date, the calculation at the next earlier date proceeds in the same way, and so forth back to the start. The entire strategy can be computed by looking at the linear equations implicit in Table 2, or by standard techniques described in option pricing textbooks.

While the model underlying the hedge for the simple example probably seems too simple, it is in fact similar (except for the number of intermediate trading dates) to the binomial models used successfully in practice. Adding the additional subperiods is straightforward, given modern computing resources.

SOME FUNDAMENTAL QUESTIONS

In the example in the previous sections, we assumed that hedging is desirable. However, this assumption is far from obvious, and it is useful to examine potential motives for hedging.

Why Should We Hedge?

The reason for hedging should link back to the overall objective of the firm, which is to create or enhance economic value. There is a general issue of whether the firm should maximize narrowly the value to shareholders, the total value to all financial claimants, or some more general social value to a variety of stakeholders. This distinction will not be so important to us; most importantly, we will assume that taxes (governments' claims) are not part of what we are optimizing, and for concreteness we will speak of maximizing value to shareholders in the firm.

The first and most obvious effect of hedging is that it reduces the volatility of the value received by shareholders. Unfortunately, this does not have any value for most shareholders in a large publicly-traded firm, who hold the shares in a well-diversified portfolio and for whom the additional risk is unimportant. Indeed, a conflict of interest may exist between the majority of shareholders and large shareholders (for example, members of the founding family who hold 30 percent of the shares and where holdings are undiversified): expending resources to reduce risk may benefit the large shareholders at the expense of the rest of the shareholders. Management may have a similar conflict, since risk threatens their jobs and they may have a significant proportion of their wealth tied up in the firm's shares. Since most shareholders in a publicly traded firm would not care about the additional risk attributable to copper price exposure, this is not a good reason for hedging. (On the other side of the equation, the cost of hedging may be very small; we will consider this consideration further in a later section on cost issues.)

A more subtle argument for managing copper price risk is that failure to do so may cause ancillary damage within the firm. As an extreme case, adverse copper price movements may push the firm into bankruptcy, which has a number of deadweight costs to the firm, such as payments to lawyers and accountants and the loss of profitable future projects. More normally, unhedged risk exposure may tend to increase taxes, on average: While the government receives additional tax payments when the copper price move is favorable, an unfavorable move will not create a compensating tax reduction, given that tax offsets may only be deferred (and may even be lost). A related tax reason for managing copper prices is that the reduction of risk makes it possible to maintain more leverage to reduce corporate taxes and avoid "double taxation." "Double taxation" is the payment of both corporate and personal taxes on cash flows going to equity, compared with payment of only personal taxes on cash flows going to debt, since interest expense is an offset to income in the computation of corporate income tax. While there are no personal taxes for institutional investors—and therefore no *double* taxation—the parallel argument—single taxation versus no taxation—is valid and even more powerful for institutions. For individuals there is at least a possibility that the corporate tax on equity will be offset by lower taxes at the individual level through deferred realization of gains or by a lower capital gains rate. For tax-exempt or tax-deferred investors, the extra tax is unmitigated.

A third argument for managing copper price risk is that many firms have a policy of smoothing earnings, and hedging can reduce volatility in earnings. Although this is common practice, it is hard to endorse, since it seems to be an expenditure of the owner's resources to minimize the amount of information getting out to the owners. (In principle, smoothing earnings might be used to eliminate temporary variations and provide a clearer picture of long-term value, but it seems more typical that smoothing is intended to avoid bad-looking quarters without necessarily distinguishing short- and long-term shocks.) This use of hedging may make management more comfortable and minimize criticism, but this is not obviously in the interest of shareholders. In some cases, hedging could be justified by the argument that it avoids restrictive debt covenants, but such covenants are far from binding in all but a small proportion of firms that smooth earnings. More common is the opposite extreme case, in which the internal objective of the firm is to ensure that earnings do not fall. Hedging for this purpose may make management comfortable—indeed too comfortable—but it discourages profitable innovation. A related strategy for keeping volatility of earnings small is to maintain a low level of financial leverage, which implies a large voluntary tax contribution that is not in the interest of shareholders.

A fourth argument for managing copper price risk is to make it easier to give managers incentives to produce profits: By hedging risk, we can make (for example) a division manager's compensation depend closely on value-added that the manager can influence rather than what the manager can't influence (the actual realization of copper prices). This argument for managing copper price risk implies that it may be optimal to manage copper price risk at the division level even if copper prices do not represent a significant contribution to the firm's cash flow. Of course, this strategy begs the question of why it can't be done more cheaply (for compensation purposes only) using a paper portfolio.

What Risks Should We Hedge?

The question of what risks to hedge must be subordinate to the question of why we should hedge. If there is not a compelling reason to hedge a particular source of risk, then we probably should not be hedging it. One important issue is the sense in which we would hedge a certain type of risk. For example, suppose we are hedging a bank's exposure to interest-rate risk. Should we hedge the direct interest mismatch of existing assets and liabilities, or should we hedge the full economic value, which would include the value of future business? For example, a bank may find that, as interest rates rise, core deposits tend to be lost. Current accounting methods make it hard to hedge this sort of risk without penalty (and the risk-based capital requirements from the Basle Accord penalize almost all hedging because one has to increase capital once for the underlying cash flow and once again for the hedge). There is a related question of whether to hedge cash flows or value. In principle, the two are the same (if we were to hedge cash flows far enough out), but, in practice, hedging cash flows out a year is much different from hedging the firm's entire value. If the purpose of hedging is to eliminate sources of noise that are beyond the manager's control, it may even be appropriate to hedge particular accounting numbers used in computing compensation rather than hedging cash flow or economic value.

With What Instruments Should We Hedge?

For most commonly hedged risks (such as exposure to interest rates, foreign exchange rates, or commodity prices), many instruments can be used for hedging. For example, to hedge U.S. interest rates we can use bonds, repurchase agreements, Treasury bond futures, swaps, caps, or collars. The choice among this set would be determined by pricing and transaction costs, match to hedging needs, and accounting implications.

Support Your Investment Banker

A common approach of managers planning to hedge is to turn the whole problem over to an investment banker who, after all, has the expertise and the traders who can put the hedge in place and is happy to provide "free" advice on what to do. As in all markets, the "free" advice is priced out in what you pay for the hedge, and then some. To avoid paying too much, it is best to understand how the hedge works and how much it should cost. Ideally, such expertise should be located in-shop; otherwise, it is worth the expense of hiring an expert to monitor the prices being paid to the investment banker. In general, competition among investment bankers may be useful in reducing the cost, but competition will not necessarily produce any incentive to report when hedging is unnecessary.

ACCOUNTANT: FRIEND OR FOE?

Suppose we put in place the optimal hedge computed above, using the model for demand and option-pricing theory to determine the correct holding in futures to offset the risk in the cash flows. What will this do to our accounting statements?

In general, accounting looks at the present and the past: Accountants favor methods whose results are easily replicable, especially since standard mechanical rules, even if inaccurate, are easy to defend if the firm has followed Generally Accepted Accounting Principles (GAAP). Hedge accounting is a relatively new and technical area, and the accounting profession is only starting to address the important issues involved.

First of all, the hedge in question does not seem to meet the requirements for a hedge as stated in the GAAP. According to FAS 80, a futures contract must be marked to market at the end of the accounting period unless it qualifies as a hedge. To qualify as a hedge, (1) the futures must be designated by the firm as a hedge, (2) there must be underlying risk to hedge, (3) while the assessment of risk can be done on a centralized basis (if it is impractical to do otherwise), the risk management must be assessed on a decentralized basis for specific assets, liabilities, and firm commitments, and (4) there must be a clear economic relationship between the price of an underlying asset, liability, or firm commitment, and a high degree of price "correlation" must be *probable*. (The reference to correlation bears no relation to the usual statistical definition of correlation: FAS 80 makes it clear that the statistical definition is not intended and may not be relevant in assessing compliance. Unfortunately, FAS 80 does not make clear how correlation should be defined.) Under these rules, our hedge of sales certainly does not qualify, since future sales corresponding to use of copper in production are off balance sheet and are not firm commitments. Even if the sales were on the balance sheet, it is not clear whether they would meet the vague and mysterious requirement that correlation be probable.

Failure to qualify as a hedge often penalizes hedging. An unqualified hedge will typically reduce volatility of future cash flows but increase volatility of reported earnings. This volatility is especially damaging when it causes violation of debt covenants or capital requirements imposed by regulators. Volatility of earnings may also subject management to criticism; given the current hysteria over derivatives, we may want to pardon a manager who forgoes an economically useful hedge to avoid the appearance of "risky exposure to derivatives." Part of the problem is that there seems to be no simple test, given the current state of hedge accounting, that the lay public can apply to distinguish risky speculation from good hedging.

One interesting feature of the accounting rules is that hedges that are economically equivalent may have very different accounting treatments. Suppose in the example above that demand does not depend on copper prices (putting the same number in all of the "Units Sold" column in Table 1A) and that we are simply interested in hedging the input cost at expected demand. Then it might seem equivalent to hedge through a long-term contract with a supplier, by buying copper futures, or by buying shares in a company whose share price tracks copper closely. However, the contract with a supplier has no impact on earnings before the actual sale, buying copper futures is covered by FAS 80 as discussed above, and shares in the copper company are accounted at fair value, but unrealized gains and losses are unlikely to appear in earnings (FAS 115). In each of these cases, there are various rules, ranging from somewhat specific (FAS 105 and 107) to incredibly vague (FAS 119), that require a company to report its risk exposure. FAS 119 is especially vague; basically, it calls on companies and accounting firms to come up with reports that can be used as a basis for later standards. This approach comes from a general recognition that current reporting practice is often misleading, and from a paucity of good ideas on how to patch things up. It seems that hedging tends to magnify the problems inherent in the accounting profession's tension between historical cost and mark-to-market cost.

It should be mentioned here that some people have proposed universal adoption of mark-to-market (or intrinsic value) accounting, which is "obviously" the correct thing to do because that is a good estimate of what the firm is actually worth, and any hedge would be seen for what it is. Unfortunately, it is not at all clear what this means. For example, do we include future sales in our valuation, and if so, how far in the future do we go, and how do we forecast and value the future flows? Anyone who has been involved in capital budgeting knows that estimates of future cash flows are often inaccurate and may reflect the forecaster's optimism more than the prospects for the firm. Even without these conceptual problems, introducing a whole new system of accounting is not a trivial matter. While we note that current accounting standards are deficient for measuring risk, we do not claim that it is easy to do better.

The differences in accounting treatments of economically equivalent hedges may allow firms to hedge in spite of the deficiencies in the accounting standards. Whether or not a firm that is hedging properly can avoid looking bad, it is clear that a firm that is not hedging at all, or even increasing risk, can look fine.

COST ISSUES

What is the cost of hedging? It is tempting to think that the cost of the hedge is the cost of any securities purchased in the hedge program. In fact, the hedge is often bundled with an investment. It is a fair investment to buy a call option for its intrinsic value, and absent market imperfections there is no cost in doing so. In practice, the cost includes transaction costs such as commissions, bid-ask spread, and any internal costs of trading (e.g., hiring a trader and setting up accounting oversight). For publicly traded contracts in liquid markets, the costs are probably small and easy to measure. When hedging uses custom contracts provided by investment bankers, the costs are hard to assess (because they are built into pricing) and may be much larger. On a more esoteric point, we may also want to include in the cost of hedging the alternative use of any capital tied up in the investment or in margin or variation accounts. On another subtle point, a hedge may be more costly than it appears if its pricing and tax treatment make it inappropriate for the firm.

What is the marginal cost that should be used as an input for decisions about pricing the output? It is probably common to use the hedged price, but in fact the marginal cost of the commodity at the time of use is the spot market price (assuming an active market that was probably necessary to implement the hedge in the first place). It is irrelevant that the price has been locked in for a fixed quantity, since that is sunk, and the profit will be collected or the loss borne on the hedged quantity however much or little is actually used. If more is needed, the shortfall will be purchased at the spot price. If less is needed, the excess will be sold at the spot price. In either case, the marginal cost is the spot price. If the marginal cost is taken to be the hedge price (or some average price), value may be discarded. For example, suppose the spot price is higher than the hedge price. Then a computation assuming that marginal cost equals average price or the hedged price would understate the true cost of buying more of the input, and additional units could be sold when it is more profitable to sell what can be produced from the hedged quantity of inputs.

What is the transfer price that should be used when the commodity is procured by one unit in the firm and used by another? For accounting purposes, the organization should decide up front how profits and losses in the hedging program will be shared. It is probably best to plan to do so in a way that hedges cash flows in each unit, since that will tie compensation in each unit more directly to performance within the manager's influence. If sharing of hedge profit and loss is not decided in advance, an inherent unfairness may result. For example, suppose the transfer price is ambiguous or renegotiable. If the transfer price is the market price when the market price is low but a hedged price when the market is high, the purchasing unit gets a "free option," and the procuring unit loses—whether or not it is hedged. The free option allows the unit to buy at the hedged price or the market price, whichever is less. The procuring unit always loses money.

RISK-MANAGEMENT POLICY

Given that standard accounting procedures do not provide a particularly useful picture of the quality of a firm's hedging program, it is especially important for management to adopt and implement an understandable and effective risk-management policy. Such a policy should specify the goal and scope of any hedging activity, and it should dictate the degree of centralization and the control systems. Furthermore, the policy should provide for oversight and evaluation of the effectiveness of hedging.

A common feature of the large publicized trading losses is a failure of control systems. Financial firms face a particular temptation to have inadequate controls. Because firms want to keep successful traders around, they may tend to be sympathetic to traders' insistence that the bureaucracy should not interfere with their work. A failure to separate the operations and accounting functions from trading was an essential common thread in the recent losses of over a billion dollars each at Barings, Daiwa Bank, and Sumitumo. In each case, the loss was attributable to a single trader. It is important to devote serious talent to the job of monitoring traders, even though the monitoring job is less glamorous, somewhat unpleasant, and, when things are going well, seemingly unproductive.

Besides the scenario of speculation under the guise of risk management, risk management can be counterproductive if it is too localized. To illustrate, the example we discussed earlier showed how a procurement department that is hedging material costs may actually make overall cash flows more variable if input prices tend to be high when the industry does well. Less damaging, but probably still wasteful, is the practice in which companies use different parts of the firm to offset hedging or they hedge economically irrelevant risks (such as risks that represent an insignificant part of a firm's cash flow volatility). For most firms, the benefits of centralization (better control, economies of scale, and cost saving due to internal netting) will outweigh the costs (mostly the difficulty of communicating and aggregating needs). Of course, it is a good idea to have a formal policy in either case, whether risk management is centralized or dispersed.

A good risk management policy should state the goals of the hedging program. Is it the firm's policy to hedge the value of the firm or, alternatively, earnings or dividends paid to shareholders, and if so, what risks should be hedged and what risks should be borne by the shareholders? Should hedging be implemented on a divisional or departmental level (to improve planning and incentive compensation) when that hedging does not reduce the overall variability of the firm's value? Should the hedging program focus on cash flows, earnings, tax avoidance, or something else? We do not yet have definitive answers to these questions, but at least a consistent policy will minimize offsetting efforts.

One important (but probably often neglected) aspect of a risk-management program is the need for ex post evaluation. Especially because these programs are relatively new, it is entirely possible to design a program that is ineffective or that even increases risk (like the naive hedging strategy in our copper price hedging example). Only retrospective analysis of the results can verify that the program is actually reducing risk. The retrospective analysis should also look at any side effects of the hedging, for example variation or margin account payments required to maintain the hedge.

CONCLUSION

Risk management is an important and difficult area of corporate policy. We have seen news accounts of disastrous failures in risk management. Less spectacular, but perhaps more important, is the widespread use of futures contracts and swaps to hedge foreign exchange, interest rate, and commodity risks, since, without this ability to hedge, many profitable businesses would be too risky.

The next few years should be especially interesting, as companies work on implementing vague new accounting standards that require them to describe their risk exposure. Now is also an exciting time for the development of internal controls and policies as companies work on developing effective hedges while avoiding catastrophic losses.

SOME FURTHER READINGS

For general information on risk management, some banks have issued guides that may be useful. For example, the *J. P. Morgan/Arthur Anderson Guide to Corporate Risk Management* is a primer on risk management, while *The Chase Guide to Risk Management* is an extended glossary published by Chase Manhattan in association with *Risk* magazine. Another good general resource is "A Survey of Corporate Risk Management," which was a separately numbered insert to *The Economist*, February 10, 1996, pp. 1-22.

Some observers have debated the advisability of hedging with options. One criticism is that hedging with derivatives often amounts to gambling with firm money at the encouragement of banks ("Betting Your Hedges," J. Ralfe, *Risk*, July 1994, pp. 22-23). One good point is that customized option positions are unlikely to be a good value, especially if it might be necessary to unwind the position before maturity ("Caveat Emptor," D. Westby, *Risk*, June 1995, pp. 24-25). A different argument is that poorly constructed strategies with poor disclosure can lead to legal troubles for managers and directors ("Courting Trouble," W. Falloon, *Risk*, August 1994, pp. 32-33). On the other side of the debate is the suggestion that hedging with options is a good idea and that most criticisms are unjustified ("Keep Those Options Open," M. Schewitz, *Risk*, October 1995, pp. 35-36).

There are, of course, many articles in the popular press citing specific hedging programs gone bad. The case of Metallgesellschaft has sparked a debate among academics, since it may be a case of miscalculation of the hedge. In particular, for commodities subject to temporary shortages, there is no reason to believe that price uncertainty over longer horizons can be hedged effectively by available traded options at short horizons, although this is often assumed to be the case. Several scholars have studied this question using theoretical tools (S. Ross, "Hedging Long Run Commitments: Exercises in Incomplete Market Pricing," 1995 mimeo, Yale University), empirical tools (F. Edwards and M. Cantor, "The Collapse of Metallgesellschaft: Unhedgeable Risks, Poor Hedging Strategy, or Just Bad Luck," *Journal of Applied Corporate Finance*, Spring 1995, pp. 86-105, or G. Bakshi, C. Cao, and Z. Chen, "Pricing and Hedging Long-Term Options," mimeo, University of Maryland), or both theoretical and empirical (S. Pirrong, "Metallgesellschaft: A Prudent Hedger Ruined, or A Wildcatter on NYMEX," mimeo, Washington University in Saint Louis). The defense of Metallgesellschaft's hedging program is that it was a textbook hedge that would have done fine if not interrupted (C. Culp and M. Miller, "Hedging a Flow of Commodity Deliveries with Futures: Lesson from Metallgesellschaft," *Derivatives Quarterly*, Fall 1994).

Value at risk ("An Overview of Value at Risk," D. Duffie and J. Pan, *Journal of Derivatives*, Spring 1997, pp. 7-49) is one methodology that is widely used in practice to quantify various common sources of financial risk. This methodology has its critics, both because an objective measure is difficult to agree upon ("VAR: Seductive but Dangerous," T. Beder, *Financial Analysts Journal*, September-October 1995, pp. 12-24), and because value at risk neglects idiosyncratic risk and some market sources of risk.

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Recent Developments in Wholesale Payments Systems

William R. Emmons

Payments systems can be divided conceptually into two components: retail and wholesale. The retail payments system, used primarily by nonbanks for making and receiving payments, involves relatively small transfers of monetary value. In contrast, the wholesale system, which banks use to make payments to each other, involves relatively large transfers.[1]

The Bank for International Settlements (BIS) in Basle, Switzerland (a consultative forum for major central banks) has recently published a series of reports covering various aspects of the wholesale payments system,[2] the purposes of which are, first, to inform central bankers and payments-system participants about current practices in wholesale payments systems, and second, to provide a central-bank perspective on how various changes to these practices could enhance the safety and efficiency of wholesale payments systems. This article summarizes the reforms to G-10 wholesale payments systems documented in and spurred by this series of BIS reports.

One general approach has been to strengthen (or "secure") existing payments system arrangements based on net settlement.[3] Net settlement systems accumulate a record of financial obligations among participants over a prespecified period of time, such as a business day, at the end of which the net amount of funds, securities, or other financial obligations owed by or to each participant is transferred. The primary shortcoming of traditional "unsecured" net settlement systems is that not only do they expose their own members to the risk of default by other members, they also expose financial institutions and other creditors outside the netting system. The danger is that liquidity or solvency problems will thus be transmitted quickly and unpredictably throughout the global financial system.

"Secured" net settlement systems, on the other hand, are designed so that any disruptions caused by a single member (even if this happens to be the institution with the largest net obligations to other members) can be absorbed by the system and its members with no risk of further propagation. To achieve this goal, such systems require that members undertake extensive and perhaps costly risk-management measures. These measures typically include real-time monitoring of counterparties within the system, net debit caps, collateralization, and additional open-ended financial guarantees in case all other safeguards prove inadequate.

Another approach to strengthening wholesale payments systems involves greater private-sector use of gross settlement. Gross settlement systems include real-time gross settlement payments systems (RTGS), delivery-versus-payment (DVP) systems, and payment-versus-payment (PVP) systems. Recently, many central banks have created new RTGS systems or improved their existing ones to strengthen their wholesale payments systems. In contrast to unsecured net settlement systems, gross settlement systems can eliminate virtually all repercussions to other private-sector members when one institution encounters difficulty. There is a cost, however. Depending on its structure, a gross settlement system may impose significant liquidity demands on participants, or it

[1] See Emmons (1996) for an overview of the retail payments system in the United States. See Humphrey, Pulley, and Vesala (1996) for a comparison of G-10 countries' retail payments systems or Bank for International Settlements (1993b) for details on both retail and wholesale components of payments systems in the G-10 countries.

[2] Bank for International Settlements, 1989, 1990, 1992, 1993a, 1993b, 1995a, 1996, 1997a, 1997b.

[3] "Secured" net settlement systems (discussed later in this article) are those that can withstand the failure of the member financial institution with the largest amount due to other members of the system.

may require that the central bank incur substantial supervisory and risk-management costs in the process of alleviating liquidity burdens.

Most G-10 central bankers believe that, despite their costs, gross settlement systems will be important components of wholesale payments systems in the future. Why, then, have private-sector financial institutions very often chosen to upgrade and secure existing net settlement systems instead of moving more rapidly to gross settlement systems? Could (and should) central banks do more to facilitate a more widespread and rapid transition to gross settlement systems?

This article does not provide definitive answers to these questions. Instead, I offer an overview of recent developments in large-value gross and net settlement systems in the G-10 countries. In the first section, I discuss gross settlement systems, including RTGS systems, for large-value funds transfers; DVP systems, for securities; and PVP systems, for foreign-exchange settlement. The second section discusses net settlement systems and explores several related issues, including the risk that netting agreements may not be legally binding in all jurisdictions and the possibility that liquidity or solvency problems could spill over from one financial institution to another and, in turn, to the financial system as a whole, creating a situation termed systemic risk. The third section concludes with a few tentative hypotheses regarding the relatively slow movement to date of wholesale payments and settlement activity to gross settlement systems.

GROSS SETTLEMENT SYSTEMS

"Federal Reserve Updates Payments-System Risk Policy, Implements Pricing on Fedwire."

"European Central Banks Reach Outline Agreement on TARGET."

"Bank of Japan to Convert BOJ-Net to Real-Time Gross Settlement Exclusively."[4]

The common theme in these fictional but representative headlines is a desire on the part of G-10 central banks to influence private-sector behavior in wholesale (large-value) payments systems. In particular, central banks have encouraged the use of real-time gross settlement payments systems and trade-by-trade securities and foreign-exchange settlement systems. This situation has occurred because there is virtual agreement among major central banks that gross settlement systems make wholesale payments systems more immune to widespread financial disruption, a key determinant of economic stability and efficiency.

Key Design Issues in Real-Time Gross Settlement Systems

Real-time gross settlement systems are large-value funds transfer services that operate continuously during the business day to provide irrevocable settlement of payments obligations in central-bank money. Irrevocable funds transfers on RTGS systems occur when a central bank debits the reserve account of the payor and credits the account of the payee. This transfer of value from payor to payee is simultaneous and final (i.e., not subject to reversal for any reason). If the funds transfer occurs (at least in principle) at the time the instructions of the payor are transmitted to the central bank, then it is said to occur continuously, or in "real time."

Central banks provide RTGS systems to commercial banks and other selected institutions such as government agencies and, in some countries, clearing houses for securities and derivatives exchanges (Bank for International Settlements, 1997a, pp. 33-7; Bank for International Settlements, 1997b, p. 14). Funds transfers over RTGS systems may be for millions of dollars or the local-currency equivalent, although these systems also handle smaller payments.

The design and operation of RTGS systems differ considerably from one country to another. Two important dimensions along which currently operating or

[4] Fedwire (the Federal Reserve's Fedwire Funds Transfer Service), TARGET (the Trans-European Automated Real-time Gross Settlement Express Transfer System), and BOJ-Net (the Bank of Japan's large-value funds transfer service) are all real-time gross settlement (RTGS) systems.

Table 1

Intraday Credit Policies and Centrally Located Queues in G-10 RTGS Systems

Countries Whose RTGS Systems Provide:	Centrally Located Queue	No Centrally Located Queue
Central bank intraday credit	Belgium France Germany Italy Netherlands Sweden	United Kingdom United States
No central bank intraday credit	Switzerland	Japan

No RTGS system: Canada.

SOURCE: Bank for International Settlements (1997a, Table 3, p. 18).

proposed RTGS systems differ are (1) policies toward the granting of central bank intraday credit and (2) the existence and management of queues (see Table 1). Intraday credit is valuable in an RTGS system because it can reduce payment blockages that may arise as one bank's outgoing payment awaits an incoming payment from another bank, which may, in turn, be waiting on a payment from a third bank. Payments may become blocked in RTGS systems because of the "cover principle" in gross settlement systems: An outgoing payment order is executed if and only if the sending bank currently has sufficient reserves, or cover, in its reserve account at the central bank.

The worst case of uncoordinated payment demands is gridlock, in which no bank can make a payment through an RTGS system because all reserve balances are held by banks due to receive payments from others. Although unlimited central bank intraday credit would eliminate gridlock, it is not offered in any RTGS systems because such a policy would create moral hazard, in that banks might tend to manage their intraday liquidity less intensively. Such a situation could give rise to an acute liquidity crisis, into which central banks would need to intervene in their role as lender of last resort. Ample availability of central bank intraday credit could also hamper the emergence of intraday money markets, which are, in principle, a necessary component of a complete and efficient set of financial markets.

Despite the fact that all RTGS systems are capable of operating continuously, some payment orders in some RTGS systems are not carried out immediately. For example, when a sending bank has insufficient funds in its reserve account and central bank intraday credit is not available, either temporarily for that bank or as a matter of system design, a payment order will not be executed. A pending payment order is subject to two different responses by central banks.

The payment order may be rejected outright, in which case the sender may enter it into an "internal queue" that assigns priority to outgoing payments. Selected payment orders are then resubmitted to the RTGS system when sufficient covering funds in the bank's reserve account become available, either from payments received or via borrowing from another bank.

Alternatively, a payment order that cannot be executed because of insufficient reserve funds may enter a "centralized queue" maintained by the central bank. That is, rather than returning the payment order unexecuted to the sending institution,

Table 2

Real-Time Gross Settlement (RTGS) Systems in G-10 Countries

Country	Name of RTGS System	Year of Implementation
Belgium	ELLIPS	1996
Canada	—	—
France	TBF	1997
Germany	EIL-ZV	1988
Italy	BI-REL*	1997
Japan	BOJ-NET	1988
Netherlands	TOP*	1997
Sweden	RIX	1986
Switzerland	SIC	1987
United Kingdom	CHAPS	1984
	Euro version of CHAPS	1999
United States	Fedwire	1918

*BI-REL and TOP replace previously existing RTGS systems BISS (implemented in 1989) and FA (implemented in 1985), respectively (Bank for International Settlements, 1993b, pp. 218-19, 302-5).

SOURCE: Bank for International Settlements (1997a), Annex 1.

the central bank may retain all payment orders that require incoming cover in a centrally located computer file. When adequate reserves become available to execute any of the queued requests, the central bank then reenters the payment order into the system.

A centrally located and managed queue can facilitate an orderly flow of payments because the system operator can identify payment requests that will offset each other to some extent. That is, one payment provides cover for the next, which provides cover for the next, and so forth. This type of oversight and queue management is termed "optimization" (Bank for International Settlements, 1997a, pp. 24-7).

The existence of a centralized queue and optimization routines may discourage intensive management of intraday liquidity by banks. These factors may also encourage banks to anticipate payments (i.e., credit the accounts of depositors to whom queued payments are directed before final settlement actually occurs). Unfortunately, the practice of systematically anticipating payments that are being held in queues tends to increase systemic interdependence and settlement risk—precisely the problems that RTGS systems are designed to eliminate.

Overview of RTGS Systems in G-10 Countries

Table 2 lists the RTGS systems currently in operation or in preparation in the G-10 countries. The Federal Reserve's Fedwire funds-transfer service is the oldest RTGS system in the world. Since 1984, RTGS systems have been introduced by all other members of the G-10 group of countries except Canada. Other European Union countries (i.e., those not in the G-10) that hope to participate in the initial launch of the European single currency in 1999, including Greece, Spain, Ireland, Luxembourg, Austria, Portugal, and Finland, are also developing RTGS systems (European Monetary Institute, 1996). Other countries that have recently introduced RTGS systems or plan to do so include the Czech Republic, Hong Kong, Korea, Thailand, Australia, China, New

Zealand, and Saudi Arabia (Bank for International Settlements, 1997a, p. 1).

The Federal Reserve System's Fedwire Funds Transfer Service (commonly known as "Fedwire") began operations in 1918 and was converted to a fully computerized, high-speed electronic telecommunications and processing network in 1970 (Bank for International Settlements, 1997a, p. 12). In addition to upgrading Fedwire technical and communications capabilities, the Federal Reserve has also implemented a series of measures to improve Fedwire risk management in recent years (Richards, 1995; Hancock and Wilcox, 1996). One focus of these efforts has been to reduce banks' daylight overdrafts (short-term credit extensions by the central bank) on Fedwire (see shaded insert: "Federal Reserve Attempts to Limit Daylight Overdrafts on Fedwire").

RTGS systems in European G-10 countries differ among themselves but generally fall into two categories according to whether or not the country expects to participate in the initial phase of European Economic and Monetary Union (EMU) beginning in 1999. Those countries that plan to participate (Belgium, France, Germany, Italy, and the Netherlands) have conformed their RTGS systems to a common set of standards to facilitate their interlinking in the TARGET system. In particular, fairly liberal policies toward central bank intraday credit and centralized queuing facilities are envisioned for participating RTGS systems. Both of these features enhance the liquidity of RTGS systems. In contrast to Fedwire, the EMU systems will not assess charges for daylight overdrafts, although such borrowings must be fully collateralized in order to protect the fledgling European System of Central Banks against credit risk posed by individual banks (Bank for International Settlements, 1997a, pp. 12-3). European G-10 members that do not plan to participate in EMU at the outset include the U.K. and Switzerland (not a member of the European Union). Liquidity-enhancing measures in these countries' RTGS systems (particularly in Switzerland) are not as liberal as those of the other European countries mentioned above, as the discussion below will make clear.

The Bank of Japan is prepared to go further than any other G-10 central bank in forcing the pace of change toward RTGS systems. Currently, banks may submit payments to BOJ-Net to be settled at 9:00 a.m., 1:00 p.m., 3:00 p.m., or 5:00 p.m. on a net basis; or payment orders may be submitted for immediate execution via the RTGS mode of BOJ-Net. The BOJ announced at the end of 1996 that it will phase out the net settlement capability of BOJ-Net by the year 2000 (Matsushita, 1997). Thereafter, real-time gross settlement will be the only mode of settlement available via BOJ accounts. This is a significant policy decision, because designated-time net settlements accounted for 98.8 percent of volume and 99.9 percent of value on BOJ-Net in 1995, while RTGS accounted for the remainder (Bank for International Settlements, 1997a, Annex 1).

In sum, there appears to be no international consensus regarding the optimal design of an RTGS system. This conclusion is not surprising when one takes into account significant cross-country differences in central-bank preferences, locally prevailing cash-management technologies, availability of collateral, and securities market liquidity (Furfine and Stehm, 1996). All existing systems appear to be a compromise between objectives that sometimes conflict among banks and institutional constraints that may be evaluated differently by different central banks.

The Role of Intraday Credit in RTGS Systems

Some RTGS systems allow participating banks to send payments with finality for amounts greater than their reserve balances immediately prior to the time of the request. In carrying out such a payment request, the central bank extends a short-term loan to fund the reserve account of the sending bank. Since all central banks that grant such credit extensions require repayment by the end of the business day, these loans are termed daylight overdrafts.[5]

[5] All G-10 central banks provide overnight lending facilities, some of which can be accessed during the business day (Bank for International Settlements, 1997a, Annex 1, Part II). Without exception, banks find them relatively unattractive sources of intraday funds to meet payments obligations.

FEDERAL RESERVE ATTEMPTS TO LIMIT DAYLIGHT OVERDRAFTS ON FEDWIRE

For more than 10 years, the Federal Reserve has undertaken a campaign to induce banks to control the amount of their daylight overdrafts on Fedwire. While Fed policymakers have long believed that relatively liberal provision of central bank intraday credit on Fedwire was appropriate (Board of Governors of the Federal Reserve System, 1988, p. 50), they also felt that some form of market discipline or regulatory restraint on daylight overdrafts could improve the allocative efficiency of such credit without sacrificing its overall benefits in terms of enhancing the system's liquidity. The impetus for Federal Reserve action to limit Fedwire daylight overdrafts stemmed from three considerations (Richards, 1995, pp. 1066-67):

First, large daylight overdrafts create the potential for large demands for overnight borrowing, thereby complicating the conduct of monetary policy. Since daylight overdrafts are unsecured, but overnight discount-window loans must be secured, a large overhang of daylight overdrafts that cannot be repaid by day's end could create disorderly conditions in the Federal funds and securities markets as reserves and collateral are sought to eliminate or secure Federal Reserve lending. Alternatively, such an overhang could force the Fed to allow some uncollateralized overnight overdrafts, thus violating its own risk-management policies.

Second, the Fed became increasingly aware in the 1980s of the substantial credit risk associated with unsecured daylight overdrafts. The Fed guarantees all payments made on Fedwire, so unlimited, unpriced, unsecured overdrafts allowed sending banks to appropriate the Federal Reserve's unsurpassed credit rating at no cost to themselves.

Finally, the Fed began to recognize more clearly that substantial daylight overdrafting on private large-value transfer systems put the payments system as a whole at risk. In order to control the risk in parts of the wholesale payments system over which the Fed had only indirect influence—such as CHIPS[†]—it was necessary to accumulate experience and demonstrate progress in managing risk where the Fed *did* maintain control, namely, on Fedwire. Controlling daylight overdrafts on Fedwire was a step toward implementing sound intraday credit policies throughout the wholesale payments system.

The Federal Reserve imposed net debit caps on daylight overdrafts in March 1986 and began charging explicit fees for daylight overdrafts in accounts at Federal Reserve Banks in April 1994 (Hancock and Wilcox, 1996, pp. 873-76). The Fed also uses real-time monitoring for "problem" institutions and requires these and selected other Fedwire participants to post collateral for daylight overdrafts. Net debit caps were tightened and adjusted several times subsequent to their introduction, while overdraft fees were increased in April 1995. Empirical evidence indicates that these measures—especially overdraft fees—have been effective in curtailing certain banks' use of daylight overdrafts on Fedwire (Hancock and Wilcox, 1996, pp. 906-7).

† CHIPS (Clearing House Interbank Payments System) is a net settlement system operated by the New York Clearing House Association. See section on net settlement systems for details.

There are several basic models for daylight overdraft privileges on RTGS systems (Bank for International Settlements, 1997a, pp. 14-21 and Annex 1, Part II). Among G-10 RTGS systems, daylight overdrafts on Fedwire within a bank's net debit cap are unusual in that they do not generally require specific collateral backing.[6] This feature is advantageous to banks, which typically do not need to hold or

[6] Each bank's net debit cap is set as a multiple of its regulatory capital. Branches or agencies of foreign banks, domestic financial institutions that have been identified by the Federal Reserve as troubled, and non-bank financial institutions that provide overdraft funding of securities activities for affiliates must provide collateral for overdrafts. Collateral is also required for frequent and material overdrafters. In total, more than 50 percent of all intraday credit extended by the Fed is collateralized.

manage significant amounts of reserves or collateral for payments purposes. Another unusual aspect of daylight overdrafts on Fedwire is explicit volume-based pricing. The Federal Reserve charges an annualized rate of 15 basis points on the daily average overdraft in excess of the bank's deductible amount, which is 10 percent of its regulatory capital. Only about 90 financial institutions typically incurred overdraft fees of more than $100 in any two-week period in 1995 (Richards, 1995, p. 1072), so Fedwire overdraft fees do not constitute a large explicit cost for intraday credit.[7] Given the existence of some amount of unpriced, uncollateralized daylight credit (up to the amount of a bank's net debit cap) and low explicit costs for overdrafts in excess of an institution's deductible, the Federal Reserve's intraday credit policy could be termed relatively liberal, overall.

Another model for central-bank extensions of intraday credit requires a borrowing bank to fully collateralize the overdraft.[8] This approach is typical of existing or planned European RTGS systems that permit daylight overdrafts. Quantitative limits on overdrafts apply in Belgium and Italy but not in Germany, the Netherlands, or Sweden (Bank for International Settlements, 1997a, Annex 1, Part II).

Intraday credit in the U.K. and France is available not through daylight overdrafts per se but rather through intraday sale and repurchase transactions with the central bank. This facility was chosen in order to solidify the central bank's legal claim to the securities involved, rather than for any substantive economic reason (Bank for International Settlements, 1997a, p. 13). Similarly, daylight credit for the RTGS component of Japan's BOJ-Net is available exclusively through sale and repurchase transactions. Given adequate supplies of collateral securities in the market, a central bank intraday credit policy involving unpriced but collateralized overdrafts (or sale and repurchase transactions) with no quantity limits or relatively high ones could also be termed fairly liberal, as is the case in the United States on Fedwire.

Finally, Switzerland alone among the G-10 countries with RTGS systems operates a very restrictive policy toward central bank intraday credit. The Swiss SIC system does not allow daylight overdrafts on any basis (collateralized or not), nor does the Swiss National Bank (SNB) provide facilities for intraday sale and repurchase agreements. The only direct liquidity assistance provided by the SNB is collateralized overnight borrowing, which, if it arises from a failure by a bank to produce reserve funds to cover its queued payments, incurs a penalty rate of interest (Bank for International Settlements, 1993b, p. 365).

Delivery-Versus-Payment (DVP) and Payment-Versus-Payment (PVP) Systems

As part of their overall function of providing bank-to-bank large-value funds transfers, RTGS payments systems frequently constitute one element in a delivery-versus-payment (DVP) settlement system for securities or of a payment-versus-payment (PVP) system for settling foreign-exchange trading obligations (Bank for International Settlements, 1992, p. 15; Bank for International Settlements, 1993a, p. 4). Many new DVP and PVP systems are being planned or discussed (Bank for International Settlements, 1997a, pp. 33-7). The three main models for structuring DVP systems are outlined below (Bank for International Settlements, 1992, pp. 17-24):

Model 1 DVP Systems. So-called "Model 1" DVP systems consist of linked gross, simultaneous settlement of a securities transfer (delivery) and the corresponding funds transfer (payment). The Federal Reserve's Securities Transfer Service for U.S. Treasury and agency securities (commonly called the "Fedwire book-entry system") operates on the same principle as RTGS systems for funds transfers. That is, the seller of a security (comparable to the payor of funds above) must post the securities with the system operator before the buyer of the security (comparable to the funds payee above) takes final, irrevocable

[7] Richards reports that a much larger group of banks—about 700—appear to keep their overdrafts within their net debit caps by managing intraday liquidity, thereby avoiding overdraft fees, as well (Richards, 1995, p. 1072).

[8] To be fully effective as a central bank risk-management tool in a real-time payments system, a full-collateralization policy requires a "Model 1" DVP system covering collateral-eligible securities. The point is that collateral securities must be available for real-time pledges, as well.

delivery. The Fed's book-entry and funds transfer services are linked and together constitute a "Model 1" DVP system (Bank for International Settlements, 1992, pp. A322-24).

A few other central banks have developed already or are in the process of developing similar systems. In particular, "Model 1" DVP systems will be critical in providing the future European System of Central Banks (ESCB) with the protection against individual banks' credit risk envisioned in the policy of collateralized intraday overdrafts. Although the ESCB has no plans to establish a Europe-wide gross settlement system for securities, individual national securities settlement systems will be linked with TARGET to establish "Model 1" DVP systems.

Model 2 DVP Systems. A "Model 2" DVP system consists of gross settlements of securities transfers, followed at the end of the day by net settlement of funds transfers. The U.K. gilt-edged (Treasury) securities market operated according to this model as of 1992 (Bank for International Settlements, 1992, pp. A319-21). In this type of system, all securities transfers are final when executed during the day. However, the corresponding funds transfers remain provisional until the end of the day, when final settlement occurs on a multilateral net basis. Failure of a bank in a net-debit position on funds transfers (i.e., owing funds after calculation of net funds positions) does not affect the finality of securities transfers that have already taken place.

Model 3 DVP Systems. Finally, "Model 3" DVP systems consist of parallel multilateral net settlement of securities and funds transfers. The Bank of Japan's "DVP-NET" is an example of this type of system (Bank for International Settlements, 1992, pp. A37-9). Private DVP systems that follow this model include the Government Securities Clearing Corporation, the National Securities Clearing Corporation, the Depository Trust Company, and the Participants Trust Company in the United States, and Euroclear and Cedel Bank in Europe (Federal Reserve System, 1997). As noted above, final settlement of the net obligations on one or both legs (securities and/or funds) that arise in these systems is typically accomplished via a gross settlement system. This points out an important complementarity that often exists between the various types of DVP systems. "Model 3" DVP systems in the U.S. may use the Federal Reserve's "Model 1" DVP system to provide final settlement of the *net* obligations of participants resulting from multilateral clearing of securities or funds transfers.

PVP Systems. PVP systems are analogous to "Model 1" DVP systems because they allow a pair of financial transfers to be settled on a gross basis simultaneously and with finality. The difference is that each leg of a PVP transaction consists of a funds transfer on a different national RTGS funds-transfer system. That is, instead of providing simultaneous transfers of securities and funds in a single currency, PVP systems allow foreign-exchange transactions to be settled with finality in real time. PVP systems could be helpful in reducing foreign-exchange settlement risk, the single largest remaining source of risk in G-10 payments and settlement systems (Bank for International Settlements, 1996, pp. 4-5).

No PVP systems linking national RTGS systems are currently operating or being planned. Although it may appear to be such a system, the TARGET system in Europe will link national RTGS systems operating in the *same* currency, the euro. Therefore, TARGET's interlinking of national RTGS systems will constitute a communications and clearing system only (similar to the financial links between the twelve Federal Reserve Banks in the United States).

Private foreign-exchange netting arrangements provide PVP elements without central-bank involvement in a manner analogous to a "Model 3" DVP system. For example, in a multilateral foreign-exchange netting arrangement that involved ten banks and four currencies, each of the ten banks would be informed at the end of the day of its net position (debit or credit), in each of the four currencies, vis-a-vis the other members. Settlement of each bank's obligation in each currency would then proceed in separate national large-value payments systems (such as CHIPS or Fedwire in the United States) and therefore would not be linked or simultaneous.

A multilateral foreign-exchange netting agreement that nets currency-by-currency reduces overall settlement risk by lowering the amount of each currency owed to or by any given bank. That is, all of a bank's trades involving U.S. dollars covered by the agreement are reduced to a smaller net U.S. dollar amount due or receivable, all of the bank's trades involving deutsche marks are netted to a smaller net deutsche mark amount due or receivable, etc. As in the "Model 3" DVP systems for securities settlement, one could think of this foreign-exchange netting approach as parallel provisional settlement rather than linked final settlement ("Model 1"). Final settlement of the net positions in each currency must still be carried out separately.

Both multilateral and bilateral foreign-exchange netting arrangements currently exist in the United States and Europe. The Multinet International Bank and ECHO (Exchange Clearing House) are multilateral foreign-exchange netting services, while FXNET, S.W.I.F.T. (Society for Worldwide Interbank Financial Telecommunication), and VALUNET provide bilateral netting services for banks engaged in foreign-exchange trading (Bank for International Settlements, 1996, p. 15-16).

A newly formed venture, CLS Services, Ltd., is an important private-sector initiative that will attempt to implement a PVP system that is analogous in some respects to a "Model 1" DVP system but is closer to traditional correspondent banking in other respects. CLS Services, Ltd., which is jointly owned by a group of banks active in foreign-exchange trading, plans to create a subsidiary bank to function as a multi-currency financial institution that can perform simultaneous, matched, "on-us" transfers of various currencies. Formed by the so-called G-20 group of major international banks, this "continuous linked settlement" bank (hence CLS Services) would eliminate the time delay between settlement of the two legs of a foreign-exchange transaction, which is the source of the most serious risk exposures in this market (Bank for International Settlements, 1996, p. 22; "Global Banks," 1997). In addition to being available for direct use by individual trading banks, the CLS bank could also assist netting arrangements such as FXNET and Multinet in discharging the net obligations that remained among participants after netting in individual currencies had occurred.

As in a "Model 1" PVP system, the CLS bank could provide virtually instantaneous confirmations to trading banks in each currency on a gross basis. Settlement would be final, although withdrawals of individual currencies might be delayed by the failure of counterparty banks to fund their CLS accounts with the appropriate mix of currencies. Thus, the CLS bank could not provide unconditional protection against foreign-exchange liquidity risk—as with a true "Model 1" PVP system—because some trades that are settled may not allow counterparties to withdraw specific currencies immediately (Bank for International Settlements, 1996, p. 22).

For example, suppose a Japanese bank and an American bank use the CLS bank for a single foreign exchange trade during one day. The Japanese bank promises to send an American bank yen, and the American bank promises to pay dollars to the Japanese bank. If a sufficient amount of yen is not in its CLS account by the end of the day, the Japanese bank must fund that account with an RTGS transfer to the CLS bank over BOJ-Net. If the Japanese bank is declared insolvent before funding its yen account, the CLS bank might cancel this trade.[9] In any case, if the American bank has been counting on the trade for fulfilling other time-critical obligations, the failure of

[9] This would occur if the CLS bank operated according to the "guaranteed refund system" (Bank for International Settlements, 1996, p. 22). Alternatively, if the CLS bank operated under the "guaranteed receipt system," a member bank could receive yen if and only if it delivered dollars to the CLS bank. The latter system would involve a performance guarantee from the CLS bank requiring capital or loss-sharing commitments by owner banks. At present, it appears likely that the CLS bank will take the latter approach.

its counterparty could create disruptions or delay.

Hence, although the CLS bank could eliminate the settlement and liquidity risks inherent in a large number of foreign-exchange trades, it would not be operating as a true "Model 1" PVP system. Instead, the CLS bank would be acting as a correspondent bank for each of its account holders. Thus, it could not unconditionally guarantee that all foreign-exchange trades would be perfectly liquid. Only central banks with the ability to create unlimited amounts of their own currency can jointly operate a "Model 1" PVP system.

NET SETTLEMENT SYSTEMS

The principal alternatives to RTGS systems for large-value funds transfers are bilateral correspondent-banking relationships and multilateral deferred net settlement (DNS) systems.[10] Both correspondent banking and multilateral netting systems offset gross payments obligations in order to arrive at a much smaller net settlement obligation.[11] Similarly, the principal alternative to trade-by-trade gross settlement of trades in securities and other financial obligations is a net securities or financial obligation settlement system.

The primary benefit to financial institutions of netting is a reduced need for immediate liquidity or ownership of securities, since final settlement is deferred until the end of the clearing cycle (usually the end of the business day). Because deferral of settlement implicitly requires a financial institution to extend credit to another institution from which it expects to receive funds or securities, longer elapsed periods between settlements also imply greater exposure of individual payee banks to the credit risks posed by their payments counterparties, the payors (Shen, 1997, pp. 48-50). Thus, it is clear that both the primary benefits and the principal costs of netting derive from the use of private credit in settlement activity (see shaded insert: "Private Credit Extensions in Net Settlement Systems").

In addition to creating risky private intraday credit, however, netting arrangements also reduce the absolute amount of settlement activity that must ultimately occur. In general, the longer the period between successive settlements, the greater the reduction in settlement obligations. Consequently, the direct credit exposures that build up over an extended clearing cycle in a netting system are, at the same time, reduced by the process of netting (Board of Governors of the Federal Reserve System, 1988, p. 4). The greater is the amount of two-way trading among a set of counterparties during a clearing cycle (i.e., buying and selling of the same financial instrument), the more likely it is that the risk-reducing aspect of netting will outweigh the risk-increasing nature of deferred settlement. Thus, when bilateral and multilateral netting arrangements are soundly structured in appropriate circumstances, regulators generally welcome them. This conclusion is particularly true today after the decade-long efforts by the Committee on Payments and Settlement Systems of the Bank for International Settlements, and by individual central banks, to upgrade the soundness of existing and proposed multilateral net settlement systems in the G-10 countries.

Deferred Net Settlement (DNS) Large-Value Funds Transfer Systems

Table 3 lists the major DNS large-value funds transfer systems in the G-10 countries. The largest private DNS payments system in the world is the Clearing House Interbank Payments System (CHIPS) in the United States (see Tables 4 and 5). CHIPS is operated by the New York Clearing House Association and includes over 100 domestic and foreign banks as its members. Fedwire, by way of contrast, connects roughly 10,000 financial institutions in the United States to the Federal Reserve and thereby to each other.

Private-sector large-value payments clearing houses like CHIPS are not a prominent feature of the Japanese or most European payments systems, for largely

[10] It is important to note that RTGS and DNS systems are not direct competitors in all respects. DNS systems typically rely on the national RTGS system for final daily settlement of the multilateral net (or "Net Net") obligations incurred by participants in the netting system.

[11] In correspondent banking, one bank holds deposit balances at another (or they hold balances with each other) that can be debited or credited for funds transfers, foreign exchange, securities, derivatives, or other transactions. Accumulated net credits or debits may be settled periodically through transfers of central bank reserves. These relationships are very important in foreign-exchange trading because they form the only link between different national RTGS or DNS systems. For an overview of payments and settlement in the foreign exchange market, see Gilbert (1992). For detailed discussions of market practices and risks in the foreign-exchange market, see Bank for International Settlements (1989, 1990, 1993a, 1996).

PRIVATE CREDIT EXTENSIONS IN NET SETTLEMENT SYSTEMS

Deferring final settlement requires an implicit extension of credit from payee to payor in net settlement systems. Intraday loans are economically important even though there is no explicit private intraday credit market in most countries. That is, the time value of an intraday loan may be zero (more precisely, no market price exists), but net settlement systems require them in order to function, and lenders in such systems bear the sometimes substantial credit risks imposed by borrowers.

Consider an example in which three banks, called Banks A, B, and C, are the members of a DNS system. They enter payment orders at different times during the business day, which extends from 9:00 a.m. to 5:00 p.m. (the time of each payment request is listed in parentheses in the table below). Final settlement occurs at 5:00 on a multilateral net basis. All three banks know the amount and timing of upcoming payment flows at the beginning of the business day:

	Receiving Bank (Lender)		
Paying Bank (Borrower)	Bank A	Bank B	Bank C
Bank A		$100 (9:05 a.m.)	
Bank B			$100 (4:59 p.m.)
Bank C	$100 (9:10 a.m.)		

Final settlement occurs at 5:00 p.m., so Bank B is effectively lending Bank A $100 during the period from 9:05 a.m. to 5:00 p.m. Typically there is no explicit cost for this intraday credit, although collateral requirements may impose some opportunity cost on the payor. Similarly, Bank C receives an intraday loan of $100 from Bank A between 9:10 a.m. and 5:00 p.m., while Bank B receives an intraday loan of $100 from Bank C between 4:59 p.m. and 5:00 p.m. Viewed at the end of the day, all banks are in an identical position with zero net debits or credits vis-à-vis the system. In other words, no actual payments are required to settle the day's transactions if the netting agreement has legal standing (see the section on the legal status of netting agreements below) or if all banks are solvent at the end of the day.

This end-of-day symmetry masks the fact that Bank B was a net lender to Bank C for most of the business day, whereas it received a promise for $100 from Bank A early in the day. If Bank B had not entered its payment order to Bank C before 5:00 p.m., and had Bank C been unable to settle its resulting net debit of $100, Bank B would be forced to recover its $100 claim against the netting system. Bank C would have a net debit position in the system of $100, so Bank B would have a claim against Bank C and any other resources already committed to support the netting system, such as collateral, capital, or back-up lines of credit underwritten by surviving members. Thus, relatively modest end-of-day net settlement amounts in a multilateral netting system (zero in this example) may disguise substantial intraday credit exposures faced by individual banks.

historical reasons. There are a few exceptions, however. The United Kingdom's Clearing House Automated Payment System (CHAPS) settled large-value funds transfers in pounds sterling on a multilateral net basis between 1984 and 1996. Subsequently, the system became a real-time gross settlement interface between private banks and the Bank of England (European Monetary Institute, 1996, p. 627).

Another private DNS payments system in Europe is the ECU Clearing and

Table 3

Deferred Net Settlement (DNS) Systems in G-10 Countries

Country	Name of DNS System	Year of Implementation
Belgium	CH (Clearing House of Belgium)	NA
Canada	LVTS (Large Value Transfer System)	1998
France	SNP (Système Net Protégé)	1997
Germany	EAF2 (Elektronische Abwicklung Frankfurt)	1996
Italy	ME (Electronic memoranda); SIPS	1989, 1989
Japan	Zengin (Zengin Data Telecommunications System); FEYCS (Foreign Exchange Yen Clearing System); BOJ-Net	1973, 1989, 1988
Netherlands	8007-SWIFT (Society for Worldwide Interbank Financial Transfers); FA	1982, 1985
Sweden	—	—
Switzerland	—	—
United Kingdom	CHAPS (Clearing House Automated Payment System)	1984
United States	CHIPS (Clearing House Interbank Payments System)	1970
Cross-border	ECU Clearing System	1983

SOURCES: Bank for International Settlements (1997a), p. 4 and Annex 2; Bank for International Settlements (1995b), Table 10a; Bank for International Settlements (1993b), pp. 305-06; pp. 498-501.

Settlement System operated by the ECU Banking Association (EBA) since 1983 (European Monetary Institute, 1996, pp. 692-96). After clearing interbank payment obligations denominated in ECU (the European Currency Unit, a fixed basket of European currencies) on a multilateral net basis, final settlement takes place in accounts at the Bank for International Settlements (BIS) in Basle, Switzerland. The BIS acts as a correspondent bank for all the clearing banks in the arrangement, who agree to maintain clearing accounts without overdraft features. The private ECU clearing system does not currently meet the Lamfalussy minimum standards for netting schemes.[12] However, reforms including sender caps, liquidity-sharing, and loss-sharing agreements are being implemented to increase the safety of settlement procedures (European Monetary Institute, 1996, p. 695). The EBA plans to convert the ECU clearing system to one that will settle interbank euro payments on a multilateral net basis beginning in 1999, or whenever the single currency is introduced. The new system will be called EURO 1 and is expected to play a role in Europe analogous to that of CHIPS in the United States, providing large-value multilateral net settlement services alongside TARGET, the RTGS system for euro.

Finally, the major banking groups in many European countries (for example, private commercial banks, state-owned savings banks, or co-operative banks) either clear interbank payments through the national central bank or operate their own centralized correspondent (or bankers' banks) that provide clearing and other services to the sector's members (see Bank for International Settlements, 1993b, pp. 166-78, for a discussion of the German case). These private-sector arrangements handle primarily small-value transactions, however.

In Japan, the Foreign Exchange Yen Clearing System (FEYCS) was established in 1980 by the Tokyo Bankers Association (TBA) to handle yen settlement of cross-border transactions, comparable to the role of CHIPS in the United States. However, the TBA transferred the operation of FEYCS

[12] The Lamfalussy standards specify the minimum criteria any private net settlement system must meet to be acceptable to a G-10 central bank (Bank for International Settlement, 1990). See the discussion and Table 6 for an overview of these standards.

Table 4

Milestones in the Development of CHIPS (Clearing House Interbank Payments System)

Event	Date
Computerization of message transfers for participants	April 1970
Paper Exchange Payment System (PEPS) implemented for non-members	March 1972
Larger computer installed; all PEPS-using banks become CHIPS participants	October 1974
Same-day settlement implemented through special reserve account at the Federal Reserve Bank of New York	October 1981
Bilateral credit mechanism implemented	October 1984
Sender net debit caps installed	March 1986
Loss-sharing arrangement among all participants implemented; collateral requirements to support each participant's contingent liability	October 1990
New criteria for settling participants adopted	March 1992
New message format adopted	August 1992
Settlement-finality improvements announced, including reduced net debit caps, increased collateral requirements, and modified loss-sharing procedures	July 1995

SOURCES: Hook (1994); Richards (1995).

to the Bank of Japan in 1989 (Bank for International Settlements, 1993b, pp. 261-68).

Monitoring and Risk Management in Deferred Net Settlement Systems

The BIS and individual central banks have strongly encouraged the members of many DNS systems to intensify their risk-management efforts in recent years, hence increasing the private-sector costs of using them. In Europe, the central banks of the (then) European Economic Community set down recommendations regarding the minimum common features of domestic payments systems in 1993 (Bank for International Settlements, 1997a, p. 40). In the United States, the Federal Reserve updated its payments-system risk policy for the design and operation of privately operated large-value multilateral netting schemes in 1994 and again in 1997 (Bank for International Settlements, 1997a, p. 40; McConnell, 1997, p. 2).

Many G-10 central banks now distinguish between "secured" DNS systems — essentially, those that meet the Lamfalussy standards — and all other DNS systems (see Table 6). A secured DNS system is one that is capable of settling all net obligations at the end of a clearing cycle, even when the member with the largest net-debit position is unable to settle (Standard 4). Banks may establish a "failsafe" settlement guarantee by posting collateral in advance, lodging capital funds at the clearing house, forming a joint back-up settlement agreement with the members, obtaining a government guarantee, or some combination of these elements (Bank for International Settlements, 1997a, pp. 39-42).

In principle, direct monitoring by banks of other banks is a potentially significant benefit associated with private multilateral net settlement systems. This is because private financial institutions may obtain finer levels of detail, in a more timely fashion, about other market participants than is possible for central banks or other banking supervisors. The financial exposure one bank creates for another in such a system provides a strong incentive for the creditor bank to monitor the debtor bank.

Table 5

Participants, Number, and Value of Transfers on CHIPS

Year	Year-End Number of Participants	Annual Number of Transfers (millions)	Annual Dollar Value of Transfers (trillions)
1971	15	0.8	1
1975	63	6.0	11
1980	100	13.2	37
1985	142	24.9	78
1990	131	37.3	222
1991	126	37.6	217
1992	122	39.1	238
1993	121	42.2	266
1994	115	45.6	295
1995	111	51.0	**310**
1996	104	53.4	332

SOURCE: CHIPS (1997).

Reliance on direct bilateral monitoring by banks in multilateral payments and settlement systems is subject to at least two shortcomings, however. Most importantly, decentralized monitoring in multilateral DNS systems suffers from a fundamental "free-rider problem." Each participating bank realizes that any losses created by a member in excess of its own resources will be shared among all the remaining members in some fashion. Any individual bank's financial exposure to a counterparty in the system is therefore attenuated by the co-insurance feature of the multilateral system; consequently, that bank's incentive to monitor is reduced. Some elements of shared financial responsibility remain even in systems that attempt to allocate residual risks to members in proportion to their dealings with the defaulting participant. Therefore, diffused financial risks in a multilateral payments and settlement system necessarily imply a reduced intensity and quality of monitoring relative to purely bilateral relationships.

An additional shortcoming is that the monitoring efficiency of a net settlement system is likely to be sensitive to the size of the membership. Increasing the number of participating banks increases the monitoring burden on each bank, a situation that may lead to a decreased quality of monitoring. This problem exists independently of the free-rider problem identified above; in fact, it becomes more acute the less the system shares risk among all participants. To see this, consider a multilateral DNS system that provides no risk sharing at all among its surviving members and which "unwinds" (cancels) all transactions involving a defaulting bank. Each member is fully exposed to the losses created by each of its transactions with a failed counterparty, so it must monitor all of them as if no multilateral system existed at all. If the increased monitoring burden results in a lower quality of monitoring, the end result is a greater risk of unanticipated disruption (Bank for International Settlements, 1997a, pp. 39-43). Restricting the membership of any payments or settlement system to encourage better monitoring incentives is likely to run afoul of antitrust regulations, however. This conflict between restricting access in order to preserve monitoring incentives and the need to remain open to new members to promote competition is likely to become more serious as financial markets become more global and interconnected.

Centralized monitoring (i.e., delegation of monitoring responsibilities to a central authority, such as a clearing house) may be a viable option in some cases, but centralization entails difficult issues in its own right. These include the need to "monitor the monitor" and to decide on a formula

Table 6

The Lamfalussy Standards

Area of Concern	Proposed Standard
1. Legal basis of netting schemes	Netting schemes should have a well-founded legal basis under all relevant jurisdictions.
2. Participants' understanding of financial risks	Netting scheme participants should have a clear understanding of the impact of the particular scheme on each of the financial risks affected by the netting process.
3. Credit- and liquidity-risk management procedures	Multilateral netting systems should have clearly defined procedures for the management of credit risks and liquidity risks that specify the respective responsibilities of the netting provider and the participants. These procedures should also ensure that all parties have both the incentives and the capabilities to manage and contain each of the risks they bear and that limits are placed on the maximum level of credit exposure that can be produced by each participant.
4. Settlement capability	Multilateral netting systems should, at a minimum, be capable of ensuring the timely completion of daily settlements in the event of an inability to settle by the participant with the largest single net-debit position.
5. Admission criteria	Multilateral netting systems should have objective and publicly disclosed criteria for admission that permit fair and open access.
6. Operational reliability	All netting schemes should ensure the operational reliability of technical systems and the availability of back-up facilities capable of completing daily processing requirements.

SOURCE: Bank for International Settlements (1990, p. 5).

for allocating any losses that cannot be covered by the pool of resources (collateral or equity capital) held at the central institution. The centralized monitor must also guard against exposing members to moral hazard: When freed from the direct scrutiny of other members, they might be more tempted to act in ways that would increase the system's overall risk. In sum, private-sector risk management in net settlement systems is promising but problematic. Participating banks possess some natural advantages over regulators in providing monitoring services, but private monitoring is likely to be costly and imperfect, regardless of how it is done.

Financial-Obligation Netting Systems

Table 7 lists some important netting systems and agreements for securities, derivatives, and foreign exchange. These arrangements are collectively known as financial-obligation netting arrangements (in contrast to payments netting arrangements). The basic mechanics of netting are similar for multilateral payments and obligation netting systems. In particular, each member of the netting arrangement enters trades with counterparties, which are recorded in real time. It then settles its final obligation to the system—either a net credit or a net debit—only at the end of the clearing cycle. Settlement occurs either several times during the day or once at the end of the day.

In addition to providing periodic net settlement of financial obligations, organized derivatives exchanges also require firms to post and maintain margins. That is, members must make available to the clearing house cash or other liquid assets sufficient to cover likely changes in the net value of the firm's positions implied by movements in financial markets (Bank for International Settlements, 1997b, pp. 21-4). Margin management is an important risk-control tool of derivatives exchanges that requires efficient banking operations (so-called "money settlement") to function effectively. In this sense, financial-obligation netting systems can be compared to DVP systems for securities settlement.

Table 7

Private-Sector Financial-Obligation Netting Arrangements

Netting System or Agreement	Organizers	n Descriptio
Futures and options exchanges (Chicago Board of Trade, Chicago Mercantile Exchange, Chicago Board Options Exchange, London International Financial Futures Exchange, Deutsche Terminboerse, Marché à Terme International de France, etc.)	Member firms	Clearing Corporations are central counterparties for all transactions with end-of-day mark-to-market and daily settlement through a single settlement account across all exchange-traded contracts.
Government Securities Clearing Corporation (GSCC)	Member firms	Government securities clearing agency offering automated trade comparison, netting, and risk-management services
National Securities Clearing Corporation (NSCC)	Member firms	Clearing agency for U.S. equities, long- and medium-term corporate and municipal bonds, guarantees settlement
Model Interbank Foreign Exchange Netting Agreement (IFEMA)	Foreign Exchange Committee (FEC) and the British Bankers Association (BBA)	Master agreement for bilateral close-out netting, netting by novation, or payment netting of foreign-exchange obligations in an over-the-counter (off-exchange) setting
International Securities Dealers Association (ISDA) obligation-netting agreements	ISDA	Framework agreements for implementing obligation netting in an over-the-counter setting
Foreign Exchange and Options Master Agreement (FEOMA)	FEC and BBA	Master agreement for bilateral close-out netting of over-the-counter options

SOURCES: Richards (1995, p. 1075); Labrecque (1996, p. 21); Foreign Exchange Committee (1995); Federal Reserve System (1997).

Organized derivatives exchanges use two primary models for carrying out trading activities and settling margins: the central bank model and the private settlement bank model (Bank for International Settlements, 1997b, pp. 12-15). In the central bank model, the derivatives exchange and/or its members hold reserve accounts directly at the central bank; these accounts can be debited and credited in real time to effect cash transfers in support of trading and margining activities. Most continental European G-10 derivatives exchanges follow this model (Bank for International Settlements, 1997b, Annex 2). This money-settlement model for derivatives exchanges is similar to the "Model 2" DVP securities settlement system noted above (gross securities settlement followed by deferred net settlement of payments), except that the roles of the two financial instruments are reversed. That is, in the central bank model of money settlement for derivatives exchanges, the traded financial obligations are settled on a deferred net basis, while cash payments—including margins—are carried out in the national RTGS system. Of course, cash payments to effect margin and open-position adjustments are not carried out in real time on any derivatives exchange; the point is that the central bank model of money settlement can provide continuous marking-to-market in the cash account.

The second type of money-settlement model for derivatives exchanges involves private settlement banks. This approach—which is used in the United States, the United Kingdom, the Netherlands, and Japan (Bank for International Settlements, 1997b, Annex 2)—is comparable to a "Model 3" DVP system in which both financial obligations and funds transfers are settled on a net basis some time after the trades (or margin calls) are issued. Continuous marking-to-market in central bank funds is not feasible in this model unless private settlement banks are prepared to give derivatives exchange members essentially direct access to RTGS systems via deposit accounts. This approach would approximate the indirect access to Fedwire that non-bank securities dealers obtain in the United States via their clearing banks.

Systemic Risk in Gross and Net Settlement Systems

If settlement lag is the "building block" of risk in the DNS systems, then systemic risk represents the collapse of the edifice. Systemic risk in its narrowest sense refers to the possibility of a chain reaction of settlement failures in an interlinked payments or settlement system. In more general terms, systemic risk encompasses situations in which the credit or liquidity problems for one or more market participants create substantial credit or liquidity problems for participants elsewhere in the financial system (Berger, Hancock, and Marquardt, 1996, p. 706). It is largely the specter of systemic risk that has preoccupied payments-systems experts at G-10 central banks for the last decade or so, generating the veritable cascade of BIS reports mentioned earlier. The most noteworthy of these reports may have been the Lamfalussy Report of 1990. Under these standards, so-called secured DNS systems are characterized by specific risk-management provisions their members must have implemented to reduce systemic risk (Table 6).

Gross settlement systems seek to eliminate systemic risk by inserting "circuit breakers" into payments and settlement chains. The key is that an institution attempting to make a payment or effect a settlement over a gross settlement system is required to post "cash in advance" (or collateral or securities, depending on the type of payments or settlement system).[13] Gross settlement systems do not allow the insolvency of one financial institution to be transmitted to others through the payments system, because settlements are never conditional on a paying institution's solvency.[14]

By way of contrast, DNS systems merely accumulate records of "IOUs"—that is, credit extensions—issued by banks to each other during the business day. These IOUs are netted against each other and settled in cash or by delivery of the relevant securities or foreign currency at the end of the clearing cycle—as long as none of the participants in a net debit position defaults. In case of such a default, the entire set of transactions may be unwound and re-entered after all of the defaulting institution's transactions have been deleted.

Another factor that makes settlement lag a source of risk is that a party due to receive a payment may prematurely consider the payment final. Since the payee may receive some information about the pending payment during the settlement lag, either from the payor directly or from the DNS system, there may be a temptation, or indeed an established local business practice, to take the payment for granted. Clearly, decoupling the payment information from the final settlement increases DNS flexibility and the flexibility of financial institutions that use it, but it also creates the potential for complex scenarios of disruption.[15]

Legal Status of Netting Arrangements

As noted, the ultimate source of risk in DNS systems is settlement lag, the time that elapses between the inital transmission of a payment request from the sending bank to the DNS system and the final receipt of good funds or securities by the receiving bank (Bank for International Settlements, 1997a, pp. 7-9; Shen, 1997, pp. 48-53). In addition, legal uncertainty surrounding netting agreements in many jurisdictions makes the risk of settlement failure costly. Rather than being exposed to the smaller risk that a valid netting agreement implies, some banks could lose the larger gross amount due from a coun-

[13] Fedwire allows payors to overdraw their reserve accounts without posting specific collateral; for this reason, some have compared it to a DNS system (Kahn and Roberds, 1996, p. 3). From the payee's (and the systemic-risk) perspective, however, Fedwire functions as an RTGS system, since every payment is final when received.

[14] Unfortunately, in a gross settlement system a distressed financial institution's illiquidity can be transmitted to other participants, resulting in a systemic liquidity crisis or gridlock.

[15] Some RTGS systems are also vulnerable to this problem, as noted above. In particular, those that place outgoing but unexecuted payment orders in a queue and allow receiving banks to "look into the queue" may encourage banks to anticipate payments before they become final.

terparty if the netting agreement did not stand up under legal challenge.

The legal status of interbank netting agreements in the United States results from four different bodies of insolvency law: (1) the U.S. bankruptcy code as amended in 1990, (2) the Financial Institutions Reform, Recovery, and Enforcement Act of 1989 (FIRREA), (3) New York State banking legislation (including Article 4A of the Uniform Commercial Code applying to wholesale electronic funds transfers, drafted in 1989), and (4) the Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA).[16]

In general in the United States, netting or set-off arrangements are stayed (i.e., not allowed to proceed) in bankruptcy because netting imposes a *de facto* seniority structure where none exists *de jure* (Rochet and Tirole, 1996, p. 837). Similarly, secured creditors are prevented from repossessing their security after a Chapter 11 bankruptcy filing (Sharpe and Nguyen, 1995, p. 275). From this perspective, netting is inconsistent with the overall intent of formal bankruptcy proceedings, which is to satisfy all creditor demands in an orderly and equitable manner according to strict priority rules. However, certain financial contracts are exempted from this general disallowance of netting in bankruptcy because Congress and many state legislatures have accepted the argument that some netting arrangements should be allowed to proceed to avoid triggering systemic failures in the financial system.

The bankruptcy code, FIRREA, and New York State banking legislation (including Article 4A) are similar with respect to netting agreements, including "safe harbors" for swap agreements, securities contracts, commodities contracts, forward contracts, and repurchase agreements (Russo, 1996, p. 98). In addition, Article 4A and the Federal Reserve's Regulation J (governing large-value electronic funds transfers, including Fed-Wire) explicitly permit net settlement of wholesale electronic funds transfers among banks in order to encourage banks to accept payment orders from financially weak sending banks (Patrikis, Bhala, and Fois, 1994, pp. 36-7).

In contrast to the previous case-by-case legal approach to netting, the FDICIA of 1991 essentially permits all netting agreements among financial institutions (including clearing houses) to proceed notwithstanding bankruptcy or insolvency. In other words, netting agreements now have a firm legal foundation in U.S. law with the implication that the *de facto* seniority created by a netting agreement among financial institutions has become *de jure* and enforceable in transactions for which U.S. law prevails.

In general, the legal status of netting agreements in countries outside the United States is uncertain (Bergsten, 1994, pp. 451-52; Padoa-Schioppa, 1994, pp. 30-5; Bureau of National Affairs, 1997, pp. 721-22). The United Nations Commission on International Trade (UNCITRAL) adopted the UNCITRAL Model Law on International Credit Transfers in May 1992, which could have given an impetus to international efforts to solidify the legal standing of netting. The model law was developed under the influence of the drafters of Article 4A of the U.S. Uniform Commercial Code, which gives explicit legal standing to netting of wholesale electronic funds transfers. In the end, however, the UNCITRAL model law did not include any provisions on the applicability of netting agreements. Consequently, there are still gaps in most countries' insolvency laws concerning the enforceability of netting agreements (Bergsten, 1994, p. 452).

In Switzerland, provisional payment orders issued by a bank that is subsequently declared bankrupt are deemed revoked (the "zero-hour rule")—that is, any netting agreement including such a bank must be unwound. This rule makes netting agreements unreliable for the participants (Hess, 1994, p. 334). Zero-hour rules exist in other countries, as well.

In Japan, settlement of net positions in FEYCS, the Foreign Exchange Yen Clearing System, is not explicitly insured by the Bank of Japan. A loss-sharing

[16] This section follows discussions in Russo (1996, pp. 97-100), Cohen and Wiseman (1994, pp. 53-9), and Patrikis, Bhala, and Fois (1994, pp. 36-7).

arrangement is in place, but beyond this, there is uncertainty about the implications for participants of the default of a member (Saito, 1994, pp. 223-24). The Bank of Japan's implicit guarantee of settlement is widely assumed, however.

In the United Kingdom, finality of payment is determined by common law. In the absence of clear precedents in various kinds of netting arrangements, the legal status of the participants in any given agreement is not entirely clear (Beaves, 1994, p. 364).

In France, the wholesale payments netting system, SAGITTAIRE, is based on S.W.I.F.T. (Society for Worldwide Interbank Financial Telecommunication) messages, which are irrevocable from the point of view of the sender once they have been received. However, the Banque de France may revoke some exchanges. The net positions of members are drawn up after the close of the accounting day, then debited or credited on the books of the Banque de France. Transactions do not become final until 10:00 a.m. the following day. Hence, the legal status of participants in SAGITTAIRE in the face of a default of a participant is unclear (Perdrix, 1994, pp. 148-49). Recently, however, changes have been made in the legal system to assure the legal enforceability of bilateral netting agreements (Padoa-Schioppa, 1994, p. 33).

In the European Union as a whole, only four countries (Belgium, Germany, France, and Italy) currently provide legal assurance for the enforceability of bilateral netting, while multilateral netting agreements have no firm legal standing in any E.U. country.[17] Some progress toward recognition of netting agreements for bank supervisory purposes has been achieved recently at the E.U. level. In particular, the so-called "EC Netting Directive" was issued by the European Parliament and the Council of the European Union in March 1996 (Deutsche Bundesbank, 1996, pp. 146-47). This allows national bank supervisors to adjust banks' capital requirements downward on the basis of close-out netting agreements covering over-the-counter derivative instruments if the concerned banks obtain legal opinions stating that the agreements are likely to be legally binding in all relevant jurisdictions. This is, of course, far short of the solid legal basis for netting agreements available in the United States since 1991 and required by a strict interpretation of the Lamfalussy Standards.

CONCLUSION

The wholesale payments and settlement systems of G-10 countries have undergone significant change in recent years. Recognizing the inherent limitations and vulnerability to disruption of bilateral and multilateral netting arrangements for payments and settlement, private financial institutions and central banks alike have implemented measures to make them safer. Secured net settlement systems pose less threat of systemic disruption to G-10 payments and settlement systems than unsecured systems. Further progress in establishing legal foundations for domestic and cross-border netting arrangements will further solidify their contributions to the global financial system. The largest costs associated with secured net settlement systems today are those of day-to-day risk management incurred by participating banks.

A different approach to strengthening the wholesale payments system is to create and/or improve trade-by-trade (gross) settlement systems for large-value funds transfers and securities settlement. Gross settlement systems can be very effective in reducing and isolating the sources of risk that make netting systems vulnerable. From the point of view of private-sector participants, gross settlement systems virtually eliminate the need to manage counterparty credit risk. However, these systems may impose significant liquidity costs on users, or they may require substantial risk-management measures on the part of central banks, depending on the design of the system.

There are several plausible hypotheses for why the quantitative importance of gross settlement systems remains limited at this

[17] Table 1 in Padoa-Schioppa (1994, p. 32) summarizes the legal standing of various types of netting arrangements in the major European Union nations as of 1994.

point. First, gross settlement systems have become available in most G-10 countries only recently. It takes time for payments and settlement practices to change, although they probably will continue to do so over the next few years, in large part because central banks continue to encourage greater use of gross settlement.

Second, existing net settlement systems are well-established in most countries, and they generally have a disruption-free track record (even if they are or were unsecured). Proponents of gross settlement systems therefore have little actual evidence with which to bolster their claims that net settlement is excessively risky.

Finally, gross settlement systems may have been adopted slowly because of their significant liquidity costs. These costs could be lessened if central banks paid a market rate of interest on reserve balances or pursued monetary policies that ensured price stability and, hence, lower nominal interest rates than would otherwise obtain. Either approach might encourage financial institutions to hold larger clearing balances (i.e., central bank reserves in excess of legal minimums). These balances could serve as the basis for greater participation in RTGS payments systems at little or no opportunity cost. They would also provide ready collateral for intraday securities lending to support gross settlement of securities transactions.

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Using Federal Funds Futures Rates to Predict Federal Reserve Actions

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The Federal Reserve implements monetary policy by making discrete adjustments to its target for the federal funds rate. Such adjustments are believed to have significant implications for other short-term interest rates, so considerable resources are expended on forecasting the timing and magnitude of the Fed's next move. Many analysts, both inside and outside of the Federal Reserve System, look to the federal funds futures market for an indication of whether the market anticipates a change in Fed policy. Because futures market participants make commitments that are contingent on what they believe the federal funds rate will be, they necessarily look to factors they believe will influence its course. The Fed targets the funds rate, and the overnight federal funds rate stays close, on average, to the Fed's target. Hence, the federal funds futures rate naturally embodies the market's expectation of what the Fed will do.

Because of how the federal funds futures market is structured, using the federal funds futures rate as a gauge of the market's expectation for Fed action is trickier than it may at first appear. The purpose of this article is to point out the issues that arise in using the federal funds futures rate to forecast a change in monetary policy. In addition, we present some evidence on the relationships among the federal funds rate, the federal funds futures rate, and the federal funds target rate, and the usefulness of the federal funds futures rate as a predictor of whether the Fed will change its target.

THE FEDERAL FUNDS FUTURES MARKET

The Chicago Board of Trade (CBOT) began offering federal funds futures contracts in October 1988 (CBOT, 1992). Unlike T-bill futures contracts, where the contract is for the T-bill rate on a specific day, the federal funds futures contract is for the simple average of the daily *effective federal funds rate* during the month of the contract. The effective federal funds rate is a weighted average of all federal funds transactions for a group of federal funds brokers who report to the Federal Reserve Bank of New York each day. The CBOT offers contracts ranging from the current month to 24 months out. Contracts have a nominal value of $5 million, and their settlement price is equal to 100 minus the average of the effective federal funds rate for the month of the contract. Hence, a market price of 94.3 for a one-month contract on October 15 means that the current futures rate for November is 5.7 percent (100 – 94.3).

The Futures Rate as a Predictor of the Average Federal Funds Rate

The futures rate is an obvious measure of the market's prediction for the monthly average effective federal funds rate, after allowing for the possibility of a non-zero risk premium. That is,

$$FFF_{t,i} = E_t \overline{FF}_{t+i} + \alpha_i, \qquad (1)$$

where E_t denotes the expectation conditional on all the available information up to t; $FFF_{t,i}$ is the i-month ahead futures rate; $\overline{FF}_{t+i}$ is the average of the daily effective federal funds rate for each day of the month; and α_i is a bias term that varies with the forecast horizon.

Figure 1

Spread between the Fed Funds Futures Rates and the Average Fed Funds Rate $FFF_{t,i} - \overline{FF}_{t+i}$

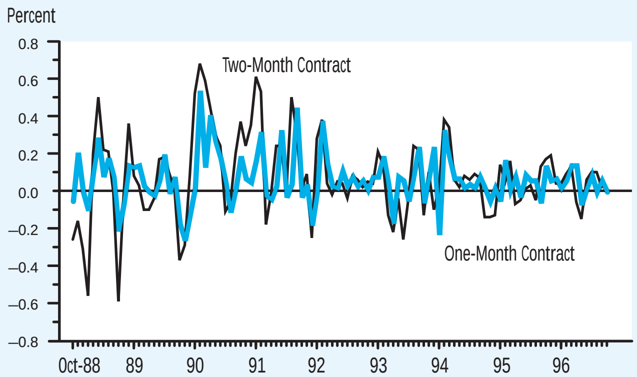


Figure 1 presents the implied forecast error, $FFF_{t,i} - \overline{FF}_{t+i}$, for one- and two-month contracts, where the futures rate is that of the last day of the month for the period October 1988 through August 1997. Because the data are measured on a monthly frequency, the forecast errors follow MA(i-1) processes. Also note that the variability of both series has been somewhat lower since 1995.[1]

The serial correlation-adjusted estimates suggest a significant positive bias in the federal funds futures rate forecast at both horizons, with the bias increasing as the forecast horizon lengthens. These estimates are consistent with the presence of a *hedging premium* in the futures market. For the one-month forecast, the bias estimate is 3.7 basis points, with a standard error of 1.3 basis points. For the two-month forecast, the bias estimate is 7.5 basis points, with a standard error of 3.0 basis points.

One possible explanation for the hedging premium is that large banks, which regularly finance a significant amount of their loan portfolios in the spot market for federal funds, also participate in the federal funds futures market. Such institutions may use the futures market to hedge against increases in the spot funds rate. If institutions that are hedging against a potential increase in the spot rate are dominant, there could be a premium built into the futures rates.

The Futures Rate as a Predictor of Fed Actions

Because the funds rate tends to stay reasonably close to the funds rate target on average, it is not uncommon for analysts to look to the federal funds futures market for an indication of whether a change in Fed policy is expected. However, two interrelated issues make it extremely difficult to infer the market's expectation for Fed action from the behavior of the federal funds futures rate, even after adjusting for the underlying bias. First, the futures rate is a forecast of the average federal funds rate and not a forecast of the average federal funds rate *target*. Second, the effect of a target change on the average federal funds rate depends on the *timing* and *magnitude* of the target change. We now consider the effect of each of these issues on the interpretation of the federal funds futures rate.

The Futures Rate and the Funds Rate Target

The fact that the futures rate is not strictly a forecast of the funds rate target leads to an obvious identification problem. To illustrate the problem, we express the market's forecast of the average funds rate as the sum of the forecast for the average funds rate target and the expected deviation of the average funds rate from the average target. Substituting for the expected average funds rate from Equation 1 then gives

$$(2)\qquad FFF_{t,i} - \alpha_i = E_t\overline{FFT}_{t+i} + E_t\left(\overline{FF}_{t+i} - \overline{FFT}_{t+i}\right),$$

where $\overline{FFT}_{t+i}$ is the average federal funds target rate for month t+i. The bias-adjusted *futures* rate and the market's forecast for the average *target* rate will differ when the market expects the average funds rate to deviate from the average target. Hence, the expected target component of the forecast cannot be deduced from the federal funds futures rate without making additional assumptions.

[1] Krueger and Kuttner (1996) show that generally the federal funds futures market efficiently incorporates publicly available information that is likely to affect the direction of the funds rate. They find, however, that at the one-month horizon, some variables such as inflation, industrial production growth, etc., add significantly to forecasts when they use the federal funds futures rate. The finding of non-exploited profit opportunities appears to stem from the use of monthly average data for the futures rate. When the last day of the month is used to forecast the average funds rate in the next month, no variable adds significantly to federal funds futures forecast (Robertson and Thornton, 1997). Thornton (1997) has also shown that the Fed's practice since 1994 of changing its funds rate target at regularly scheduled FOMC meetings has improved the federal funds futures market's forecasts of the average funds rate.

One common assumption, sufficient to identify the market's expectation for the average funds rate target, is that the market always forecasts the average funds rate to coincide with the average target rate, i.e., $E_t\left(\overline{FF}_{t+i} - \overline{FFT}_{t+i}\right) = 0$. If this were true, the bias-adjusted futures rate would be the market's forecast for the average funds rate target. Since the futures rate rarely coincides with the current target, one would conclude that the market is almost always forecasting a change in the target.[2]

We think it is unlikely that market participants always expect the average funds rate to equal the average of the funds rate target. The expectation for the difference between these rates is likely to be based on estimates of general market conditions, the reserves positions of banks, and whether and by how much the funds rate is permitted to deviate from the funds rate target. For one thing, the average funds rate has tended to be above the average funds rate target by about three basis points over the sample period. That is, the average funds rate is a biased estimate of the average funds rate target. In addition, when the average funds rate is above or below the funds rate target, it tends to remain so for a few months, that is, there is mild positive serial correlation. Market participants likely utilize such information in developing their forecasts.

A Partial Identifying Assumption

Numerous other assumptions could be made to recover the underlying market expectations for the average of the federal funds rate target. However, estimates of the market's expectation will depend on the particular identifying assumption used. Here we consider an example of what might be called a *partial identifying assumption*. It is a partial identifying assumption because it is sufficient only to identify some of the occasions when the market is anticipating a change in the funds rate target. It is insufficient for determining the *magnitude* of the expected target change. Moreover, it is incapable of determining all of the occasions when the market is expecting no change in the target. Specifically, suppose we know that $E_t\left(\overline{FF}_{t+i} - \overline{FFT}_{t+i}\right)$ always falls within a certain interval. If the bias-adjusted i-month spread between the futures rate and the current target rate is *outside* this interval, we can conclude that the market expects a target change. While we can be fairly certain that the market is expecting a change in the target, we will not know the magnitude of the change. If, on the other hand, the bias-adjusted spread is *inside* this interval, we cannot conclude that the market is *not* expecting a target change. It might be that the market is expecting a target change that will have a relatively small effect on the bias-adjusted futures rate.

To illustrate the implications of this assumption, subtract the current level of the funds rate target, FFT_t, from both sides of Equation 2 to give:

(3) $$FFF_{t,i} - FFT_t - \alpha_i = E_t\left(\overline{FF}_{t+i} - \overline{FFT}_{t+i}\right) + E_t\overline{FFT}_{t+i} - FFT_t.$$

Assume for the moment that the market's forecast of how much the average funds rate deviates from the average target is known to always range between –20 and +20 basis points. If the market expects no change in the target, the bias-adjusted spread is simply

(4) $$FFF_{t,i} - FFT_t - \alpha_i = E_t\left(\overline{FF}_{t+i} - \overline{FFT}_{t+i}\right),$$

and this spread will also vary between –20 and +20 basis points. If the bias-adjusted one-month spread is outside this interval, it must be that the market expects a change in the target. If the spread is inside the interval, it may or may not be the case that the market expects a change in the target.

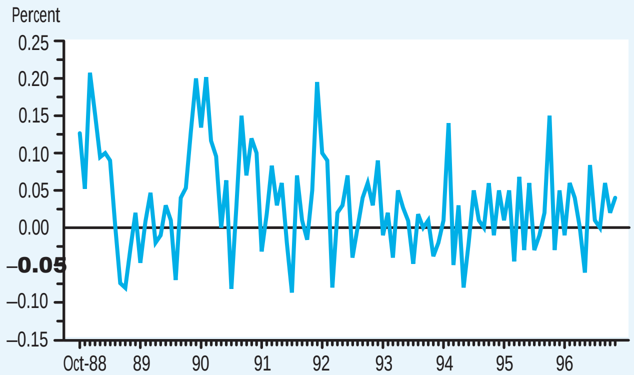
The Expected Timing and Magnitude of Target Changes

Over the period from October 1988 to August 1997, there were 38 months when the Fed changed its target for the federal funds rate. There were 25 decreases in the target and 13 increases. On all but four occasions, the target change was 25, 50, or 75 basis points, with the majority of the changes being 25 basis points.

[2] Implicitly one is assuming that the market is always assigning some probability, P, to a non-zero change in the target. According to this view, $E_t FFT_{t+i} - FFT_t$, is equal to P times the expectation of a non-zero target change. However, this interpretation does not allow us to identify P. For example, suppose that the bias-adjusted spread between the futures rate and the current target rate is 10 basis points. This spread is consistent with a 20 percent probability of an expected 50 basis-point increase, a 40 percent probability of an expected 25 basis-point increase, or an infinite number of alternatives. When the issue of the timing of the change is considered, the identification problem becomes even more severe.

Figure 2

Spread between the Average Fed Funds Rate and the Average Fed Funds Rate Target



Before August 1989, it was not uncommon for the Fed to make two or more adjustments to its federal funds rate target in a month.

The Fed's adjustments to its funds rate target affect the level of the corresponding federal funds rate. However, the federal funds futures market forecasts the monthly average of the funds rate, not the funds rate on any particular day. Consequently, an expected target change's effect on the futures rate depends on when and by how much the target is expected to change. This problem interacts with the previously noted identification problem. To see how, assume that at the end of the month the target rate is 5 percent, the bias-adjusted federal funds futures rate is 5.13 percent, and the average funds rate is expected to lie within ± 20 basis points of the average funds rate target. We might conclude that the market is not anticipating a change in the funds rate target. On the other hand, it might be that the market expects the average funds rate to equal the average funds rate target next month. In this case, the 13-basis-point spread is consistent with an expected rise in the target of 25 basis points about mid-month, an increase of 50 basis points about three-quarters of the way through the month, or even a 75-basis-point rise very late in the month.

The predicament is perhaps most severe when the market is anticipating a policy action late in the upcoming month. For example, assume that futures market participants are anticipating a 50-basis-point change in the funds rate target, from 5 percent to 5.5 percent, on the twenty-seventh day of the next month, and suppose that the bias-adjusted one-month futures rate is 5.05 percent. Such a small spread value could easily be mistaken to indicate that no change in the target is expected. Of course, if the market is predicting no action in the subsequent month, the two-month futures rate should be about 50 basis points higher than the current target rate. Hence, a comparison of the one-month and two-month contracts would help determine whether the market is anticipating a Fed action next month. Even then, it would be easy to infer that the market is anticipating a target change two months from now, rather than next month.

PREDICTING A TARGET CHANGE

We have argued that it is extremely difficult to extract the market's expectation for the Fed's funds rate target from the behavior of the federal funds futures rate. However, this difficulty need not prevent us from exploring the usefulness of the futures rate for forecasting changes in the Fed's target. To illustrate, reconsider the partial identifying assumption described previously. To make this procedure operational, we assume that the bounds of $E_t\left(\overline{FF}_{t+i} - \overline{FFT}_{t+i}\right)$ in any period are the largest and smallest values of $\left(\overline{FF}_t - \overline{FFT}_t\right)$ over the whole sample period. This assumption is arbitrary, but it is perhaps not too unrealistic.

As can be seen in Figure 2, the difference between the average funds rate and the average target is often large, ranging between about –9 and +21 basis points over the sample period. Also, there is no tendency for the two series to drift apart for too long over time; consequently, the serial correlation of the difference is only

Figure 3

1-Month Forecasts from Fed Funds Futures Rate

(Bars represent change in average funds rate target over current target)

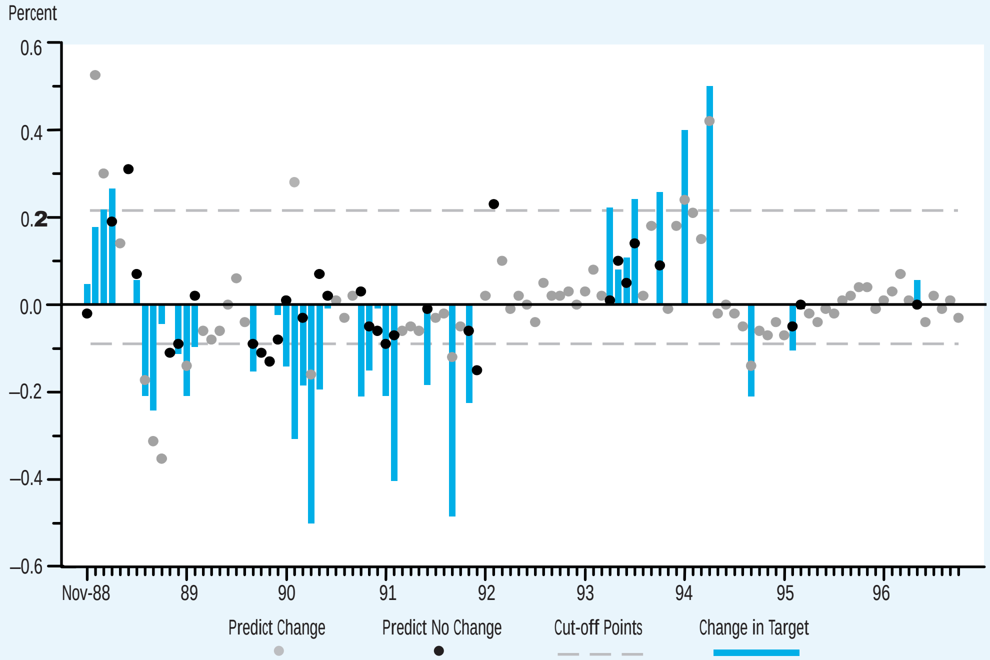


Table 1

Contingency Table for One-Month Spread

	Actual Change	Actual No Change	Predicted Total
Predict Change	12*	6	18
Predict No Change	26	62	88
Actual Total	38	68	106

* One of the predicted changes was in the wrong direction.

mildly positive. That the range is asymmetric about zero stems in part from the fact that the funds rate has tended to be above the target level (see shaded insert for an analysis of the sources of this bias). Our estimate of the forecast bias in the one-month futures rate is about four basis points. Given our assumptions, when the bias-adjusted spread between the one-month futures rate and the current target rate is *outside* the cut-off points, the futures market is forecasting a target change next month. A spread that is *inside* the interval may or may not indicate an expected target change. However, for the purpose of this discussion we treat such outcomes as forecasts of no target change. This potential misclassification of expectations could be a major source of forecast error.

Figure 3 presents the one-month bias-adjusted spread for the period November 1988–August 1997. The sample mean is 1.0 basis point, and the standard deviation is 12.3 basis points. The horizontal lines give the cutoff points, and the vertical bars give the difference between the current target and the average target in the following month. Not surprisingly, the difference between the end-of-month target rate and the average target rate for the following month is almost always less than the actual target change.

Table 2

Contingency Table for Two-Month Spread When Forecast "No Change" from One-Month Spread

	Predicted No Change/Actual Change	Predicted No Change/Actual No Change	Predicted Total
Predict Change	14	16	30
Predict No Change	12	46	58
Total	26	62	88

For example, there has been a 25-basis-point change on 24 occasions since October 1988—19 decreases and 5 increases. A total of five of the decreases and two of the increases resulted in less than a 13-basis-point change in the average target level. The forecast results are summarized in a contingency table, Table 1.

Going down the column of Table 1 headed "Actual Change," we see that our empirical rule correctly predicts a change in the target on only 12 of the 38 occasions that the target was changed and predicts no change on the remaining 26 months. Thus, the accuracy of this forecast is 32 percent (12/38), and on one occasion (December 1990), the prediction was that the Fed would raise the target when, in fact, it was reduced. Going down the column headed "Actual No Change," we see that the rule correctly predicts no change in 62 of the 68 months when the Fed did not change its target. Hence, the accuracy of the no-change forecast is 91 percent (62/68). The overall accuracy is 70 percent (74/106).

While forecast accuracy is important, so is forecast reliability. The rule only predicts that the target will change on a total of 18 occasions. The proportion of these forecasts that is actually correct—the hit rate—is 67 percent (12/18). The forecasts of no change are slightly more reliable. The rule predicts no target change 88 times, so the hit rate is 70 percent (62/88).[3]

Notice that the cutoff points are asymmetric about zero. The basis-adjusted spread was less than –9 basis points on four of the six occasions that the rule incorrectly forecast a change, while on the remaining two occasions it was above 22 basis points. Given our assumptions, these are forecast errors. Conversely, the one-month futures rate was below the current target rate on 13 of the 26 times that the rule incorrectly forecast no target change, above it 11 times, and equal to it on two occasions. Of course, we cannot infer that these were necessarily forecasting mistakes by the market, since the rule cannot distinguish among small spread values.

One reason for the rule's low accuracy in predicting target changes is that the futures market predicts the *average* level of the funds rate. When the rule indicates that the market is not predicting a target change, it may actually be predicting a target change late in the month. Hence, when the one-month rate predicts no change and a change occurs, it is useful to look to the two-month federal funds futures rate to see if the market may have been anticipating a target change late in the month.

Table 2 summarizes the results for the two-month spread for the 88 occasions in Table 1 when the one-month contract predicted no change in the target. The bias is set at eight basis points, and the implied interval is still –9 to 21 basis points. As we can see, of the 26 occasions when the rule predicts no change next month but a change occurs, a target change is predicted at the two-month horizon on 14 occasions. Of the 62 months when the rule correctly predicts no change the next month, the two-month spread predicts a change for the following month on 16 occasions.

Table 3 presents a revised contingency table for the one-month forecast based on the spreads for the one-month and two-month federal funds futures rates. Incorporating the two-month rate spread has little effect on the overall forecast accuracy: It declines slightly to 68 p**ercent**

3 Not surprisingly, the results are sensitive to the cutoff values. Basically, a narrow range increases the proportion of predictions of a change in the target, while a broad range leads to relatively fewer predicted changes. The highest overall accuracy is 73 percent, achieved using cutoff points of –7 and +23 basis points and ignoring the forecasted change in the wrong direction.

WHY IS THE FUNDS RATE A BIASED ESTIMATOR OF THE FUNDS RATE TARGET?

The spread between the monthly average funds rate and the average funds rate target indicates a bias of 3.1 basis points, with a *t*-ratio of 3.7.[†] That is, the monthly average funds rate has tended to average slightly higher than the monthly average for the funds rate target. The standard deviation of the series is 6.2 basis points, and the variability appears to be smaller in the latter part of the sample.

Sources of Bias

	$\overline{FFX_t}-\overline{FFT_t}$ 1988.10-1997.08	$\overline{FF_t}-\overline{FFT_t}$ 1994.02-1997.08	$\overline{FFX_t}-\overline{FFT_t}$ 1994.02-1997.08
mean	1.43	1.53*	0.13
t-statistic	1.84	2.93	0.26

* Indicates statistical significance at the 5 percent level.

One potential source of this bias is the effect of settlement Wednesdays. The funds rate deviates substantially from the targeted level on the final day of the reserve maintenance period, called settlement Wednesday. It is unusually high if reserves are scarce or unusually low if reserves are abundant. If, on average, reserves were a little scarce on reserve settlement days, the monthly funds rate could average a few basis points higher than the target.

It is also possible that the behavior of this series has changed over time, partly in response to the Fed's disclosure policy. Evidence (Thornton, 1996) indicates that, prior to the Fed's policy of immediate disclosure, the market took a few days to figure out that the Fed had changed its funds rate target. If so, the funds rate would trade above the target when the Fed reduced the target and below it when the target was raised. During the period prior to immediate disclosure, the Fed changed its funds rate target 27 times. Of these, 22 were decreases, and only 5 were increases. Hence, it would not be surprising to see a positive bias in the funds rate over the funds rate target for this period, but the bias should disappear with immediate disclosure.

Formerly, the Federal Open Market Committee (FOMC) announced its policy decisions about six weeks after the previous meeting. At its February 1994 meeting, the FOMC broke this long-standing tradition and announced the decision as soon as it was made. While the FOMC made no commitment to continue the practice, the next five changes (all increases) were announced immediately. The new policy was formalized at the February 1995 meeting.

Evidence of the importance of the effect of settlement Wednesdays and immediate disclosure is obtained by re-estimating the average spread. We investigate the possibility of a settlement Wednesday effect by replacing the simple monthly average of the effective federal funds rate with a monthly average rate that excludes settlement Wednesdays. We test the possibility that immediate disclosure could account for the non-zero mean by estimating the average over the period from February1994 to August 1997.

The results, summarized in the table above, suggest that both of these factors have played a role. Using data adjusted for settlement Wednesdays, we find that the average spread of the funds rate over the funds rate target for the period from November 1988 to August 1997 was only 1.43 basis points; however, the mean is statistically significant at the 10 percent level. Hence, while the settlement Wednesday effect plays a role in the bias of the funds rate, it does not appear to account for it all.

The estimated mean over the period since immediate disclosure is 1.53 basis points, and the null hypothesis that the mean is zero is rejected at the 5 percent level of significance. When settlement Wednesdays are excluded, the estimated mean drops to less than one basis point and is not statistically significant.

[†] AR(1) process was used.

Table 3

Revised Contingency Table For the One-Month Horizon Based on the One- and Two-Month Federal Funds Futures Rates

	Actual Change	Actual No Change	Predicted Total
Predict Change	26*	22	48
Predict No Change	12	46	58
Actual Total	38	68	106

* One of the predicted changes was in the wrong **direction.**

(72/106). However, using both the one-month and two-month spreads makes the target change forecasts substantially more accurate, 68 percent (26/38), but at a cost of reduced reliability, 54 percent (26/48). The accuracy for no-change forecasts declines to 68 percent (46/68), while the hit rate increases to 79 percent (46/58). Hence, a more accurate forecast of a target change is also associated with lower accuracy in forecasting no change.

CONCLUSIONS

The federal funds futures market naturally embodies the market's expectation of future Fed policy. However, the federal funds futures rate is a forecast of the average monthly level of the funds rate. The potential for bias and the fact that the federal funds futures rate forecasts the funds *rate* and not the funds rate *target* means that using it for forecasting Fed action is considerably more difficult than it might at first appear.

This article discusses the consequences of these difficulties for interpreting the spread of the one-month-ahead futures rate over the current target rate. In particular, we show that there is a fundamental identification problem that can be overcome only by making some additional and somewhat arbitrary assumptions. Using a particular partial identifying assumption, we investigate the predictive accuracy of the federal funds futures rate over the period October 1988–August 1997. Our empirical forecasting rule correctly predicts a target change in the following month only about one-third of the time. The rule is much better at forecasting no change in the target and has an overall forecast reliability of around 70 percent. When the two-month federal funds futures rate is incorporated into the analysis, the accuracy of the rule in forecasting target changes one month in advance is substantially improved. There is some deterioration in forecast reliability, however.

Because our criterion identifies only expected changes in the target that have a sufficiently large impact on the futures rate, there is considerable uncertainty about the interpretation of small deviations of the futures rate from the current target. Consequently, the forecast errors are not necessarily forecasting mistakes by the market.

Because our forecasts are based on the federal funds futures rate for the last day of the month and the Fed changes its target at various times during the month, the forecast horizon is not held constant. It is likely that the forecast accuracy will vary with the forecast horizon. This fact is of particular interest now because the FOMC has followed the practice of changing its funds rate target at regularly scheduled meetings since it adopted the policy of immediate disclosure. Also, because meeting dates are known in advance, the market should not be expecting a target change in months when there is no meeting. Although they do not account for the inherent randomness of the federal funds futures rate nor its bias, Pakko and Wheelock (1996) find that the futures rate predictions improve a few days prior to FOMC meetings. It would be interesting to see whether there is an optimal horizon for predicting Fed target changes and how well the federal funds futures rate performs relative to other predictors of Fed activity. These subjects are left for other research.[4]

[4] For instance, the time series properties of the funds rate target itself can be utilized to form a forecasting rule. The fed funds futures rate may be a useful predictor in this context (see Robertson and Thornton, 1997).

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