

# SHORT-TERM INTEREST RATE FUTURES

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Not long ago futures trading was limited to contracts for agricultural and other commodities. Trading in futures contracts for financial instruments began in the early 1970s, after almost a decade of accelerating inflation exposed market participants to unprecedented levels of exchange rate and interest rate risk. Foreign currency futures, introduced in 1972 by the Chicago Mercantile Exchange, were the first financial futures contracts to be traded. The first interest rate futures contract, a contract for the future delivery of mortgage certificates issued by the Government National Mortgage Association, began trading on the floor of the Chicago Board of Trade in 1975. Today financial futures are among the most actively traded of all futures contracts.

At present there are active futures markets for two different money market instruments: three-month Treasury bills and three-month Eurodollar time deposits. Treasury bill futures were introduced by the Chicago Mercantile Exchange in 1976, while trading in Eurodollar futures began late in 1981. Domestic certificate of deposit futures were also actively traded for a time but that market, while technically still active, became dormant for all practical purposes in 1986.

## AN INTRODUCTION TO FUTURES MARKETS

A futures contract is a standardized, transferable agreement to buy or sell a given commodity or financial instrument on a specified future date at a set price. In a futures transaction the buyer (sometimes called the **long**) agrees to purchase and the seller (or **short**) to deliver a specified item according to the terms of the contract. For example, the buyer of a Treasury bill contract commits himself to purchase at some specified future date a thirteen-week Treasury bill paying a rate of interest negotiated at the time the contract is purchased. In contrast, a cash or spot market transaction simultaneously prices and transfers physical ownership of the item being sold. A cash **commodity** (cash security) refers to the actual physical commodity (security) as distinguished from the futures commodity.

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Futures contracts are traded on organized exchanges. The basic function of a futures exchange **is** to set and enforce trading rules. There are thirteen futures exchanges in the United States at present. The principal exchanges are found in Chicago and New York. Short-term interest rate futures trade on a number of exchanges; however, the most active trading in these contracts takes place at the International Monetary Market (IMM) division of the Chicago Mercantile Exchange (CME).

## Market Participants

Futures market participants are typically divided into two categories : hedgers and speculators. **Hedging** refers to a futures market transaction made as a temporary substitute for a spot market transaction to be made at a later date. The purpose of hedging is to take advantage of current prices in future transactions. In the money market, hedgers use interest rate futures to fix future borrowing and lending rates.

Futures market speculation involves assuming either a short or long futures position solely to profit from price changes, and not in connection with ordinary commercial pursuits. A dentist who buys wheat futures after hearing of a nuclear disaster in the Soviet Union is speculating that wheat prices will rise, while a grain dealer undertaking the same transaction would be hedging unless the futures position is out of proportion with anticipated future wheat purchases.

## Characteristics of Futures Contracts

Three distinguishing characteristics are common to all futures contracts. First, a futures contract introduces the element of time into a transaction. Second, futures contracts are standardized agreements. Each futures exchange determines the specifications of the contracts traded on the exchange so that all contracts for a given item specify the same delivery location and a uniform deliverable grade. Traded contracts must also specify one of a limited number of designated delivery dates (also called **contract** maturity or **settlement** dates). The only item negotiated at the time of a futures transaction is price. Third, the exchange clearinghouse interposes itself as a counter-

party to each contract. Once a futures transaction is concluded, a buyer and seller need never deal with one another again; their contractual obligations are with the clearinghouse. The clearinghouse, in turn, guarantees contract performance for both parties.

The first of these characteristics is not unique to futures contracts. A forward contract, like a futures contract, is a formal commitment between two parties specifying the terms of a transaction to be undertaken at a future date. Unlike futures contracts, however, forward contracts are not standardized; rather, they are custom-tailored agreements. As a general rule forward contracts are not transferable and so cannot be traded to a third party.

Trading in futures contracts is facilitated by contract standardization and the clearinghouse guarantee. Contract standardization reduces transaction costs. The clearinghouse guarantee removes credit risk, or risk that a party to the contract will fail to honor contractual commitments. These two characteristics make all contracts for the same item and maturity date perfect substitutes for one another so that a party to a futures contract can always liquidate a futures commitment (or **open position**) before maturity by making an offsetting transaction. For example, a trader with a long position in Treasury bill futures maturing in March of 1987 can liquidate his position any time before the last day of trading by selling an equal number of March Treasury bill futures. **In** practice, most futures contracts are liquidated in this way before they mature. By one estimate two percent of all futures contracts are held to maturity on average, although delivery is more common in some markets.<sup>1</sup>

### Margin Requirements

A contract for the future delivery of an item gains value to one of the parties to the contract and imposes a liability on the other when futures prices change. A rise in Treasury bill futures prices, for example, gives all traders who are long in bill futures the right to buy Treasury bills at a price below the currently prevailing futures price; equivalently, they have the right to invest money at an interest rate higher than the current market rate. Traders with short positions, on the other hand, are committed to sell bills at a price lower than that which they would be required to pay if they wished to buy the contract back at the new futures price.

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<sup>1</sup>See Little [1984, p. 43].

In the early days of trading in time contracts, as they were called in the nineteenth century, traders adversely affected by price movements often disappeared as the delivery date drew near. In response, futures exchanges adopted the practice of requiring a performance bond, called a margin **requirement**, of all buyers and sellers. They also began requiring all traders to recognize any gains or losses on their outstanding futures positions at the end of each trading session, a practice called **marking to market**.

All futures exchanges now require members to maintain margin accounts. Brokers who execute orders on behalf of customers are required to collect margin deposits from them before undertaking any trades. Minimum margin requirements are set by the exchanges. Brokers can, and most do, require their customers to maintain margins higher than the minimum levels set by the exchange. Any gains or losses realized when the contracts are marked to market at the end of a trading session are added to or subtracted from a trader's margin account. If the margin account balance falls below a specified minimum, called the **maintenance margin**, the trader faces a **margin call** requiring the deposit of additional margin money, called variation **margin**, to his account.

### Futures Exchanges

The right to conduct transactions on the floor of a futures exchange is typically limited to exchange members, although trading privileges can be leased to another party. Members also have voting rights, which give them a voice in management decisions. Membership privileges can be bought and sold; the exchanges make public the most recent selling and current offer price for a membership.

Exchange members can be grouped into two categories. **Commission brokers** (also known as **floor brokers**) execute orders for nonmembers and other customers. Some floor brokers are employees of commission firms while others are independent operators who execute trades for other firms. The second type of exchange member is the **floor trader**, or local. Locals are independent operators who trade for their own account.<sup>2</sup>

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<sup>2</sup>Different types of floor traders can be distinguished based on the trading strategies they use most often: see Rothstein and Little [1984] for a description. Silber [1984] presents a comprehensive analysis of marketmaker behavior in futures markets.

## The Role of the Exchange Clearinghouse

Each futures exchange operates a clearing organization, or clearinghouse, that records all transactions and insures all buy and sell trades match. The clearinghouse also assures the financial integrity of the contracts traded on the exchange by guaranteeing contract performance and supervising the process of delivery for contracts held to maturity.

Clearing **member firms** act as intermediaries between traders on the floor of the exchange and the clearinghouse, assisting in recording transactions and collecting required margin deposits. Clearing member firms are all members of the exchange, but not all exchange members are clearing members. All transactions taking place on the exchange floor must be cleared through a clearing member firm. Traders who are not directly affiliated with a clearing member must make arrangements with one to act as a designated clearing agent.

Clearing member firms are responsible for collecting margin deposits from their customers and depositing required margins with the clearinghouse. The clearinghouse holds clearing members responsible for losses incurred by their customers. Any time a trader fails to meet a margin call his position is immediately liquidated, with the resulting losses taken from his margin account. If losses exceed funds available in a customer's margin account the clearing member firm is required to make up the difference to the clearinghouse.

## Futures Commission Merchants

A Futures Commission Merchant (FCM) is an intermediary that handles orders for the sale or purchase of a futures contract from the general public. An FCM can be a person or a firm. Some FCMs are exchange members employing their own floor brokers; others rely on independent brokers to handle trades ordered by their customers. An FCM is responsible for collecting the required margin deposit from customers before acting to execute a trade. The FCM must in turn deposit the required margin with its clearing agent. All FCMs must be licensed by the Commodity Futures Trading Commission (CFTC), which is the government agency responsible for regulating futures markets.

## TREASURY BILL FUTURES

Treasury bills are short-term securities issued by the U. S. Treasury to help finance the federal govern-

ment. Bills with maturities of thirteen, twenty-six, and fifty-two weeks are issued by the Treasury on a regular basis. The secondary market for these securities is active and well-organized, making Treasury bills (often referred to as T-bills) among the most liquid of money market instruments,

Treasury bill futures contracts are traded in the United States on two Chicago exchanges: the International Monetary Market (IMM) and the Mid-America Commodity Exchange. Both contracts specify delivery of thirteen-week (91-day) bills. The IMM T-bill contract, which is the most actively traded of the two by a large margin, is described below.

## Contract Specifications

Upon maturity the IMM contract requires the seller to deliver a U. S. Treasury bill with a \$1 million face value and thirteen weeks left to maturity. Contracts for delivery during the months of March, June, September, and December are traded on the exchange. At any one time contracts for eight different delivery dates are traded. A new contract begins trading after each delivery date, making the furthest delivery date for a new contract twenty-four months away.

**Price Quotation** Treasury bills do not pay explicit interest. Instead, they are sold at a discount relative to their redemption or face value. The difference between the purchase price of a Treasury bill and its face value determines the interest earned by a buyer. Treasury bill yields are typically quoted on a discount basis, that is, as a percentage of face value rather than of actual funds invested.<sup>3</sup>

Price quotations for T-bill futures contracts are based on an index devised by the IMM. The index is calculated by subtracting the Treasury bill discount yield from 100. For example, if the discount yield on a traded T-bill futures contract is 9.75 percent, then the index value is  $100 - 9.75 = 90.25$ . Index values move in the same direction as the future purchase price of the deliverable bill; a rise in the index value, for example, means that the price a buyer must agree to pay to take future delivery of a T-bill has risen.

<sup>3</sup>The formula for calculating the discount yield is

$$\text{Discount Yield} = \frac{\text{Face Value} - \text{Purchase Price}}{\text{Face Value}} \times \frac{360}{\text{Days to Maturity}}$$

The minimum price fluctuation permitted on the trading floor is one basis point (.01 percent), which comes to \$25 on a contract specifying the delivery of a 90-day Treasury bill with a \$1 million face value. Thus, the price of a T-bill futures contract may be quoted as 94.25, or 94.26, but not 94.255. The IMM eliminated maximum daily price limits for all its interest rate futures contracts in December of 1985.

A sample of a newspaper clipping reporting Treasury bill futures prices is reproduced in Box 1.

**Delivery Requirements** The Treasury auctions thirteen- and twenty-six-week bills each Monday (except for holidays and special situations) and

issues them on the following Thursday. Fifty-two-week bills are auctioned every four weeks. These auctions are held on a Thursday and the bills are issued on the following Thursday. To insure an adequate supply of deliverable bills, the IMM schedules T-bill futures delivery dates for the three successive business days beginning with the first day of the contract month on which a thirteen-week bill is issued and a one-year bill has thirteen weeks to maturity. This schedule permits delivery requirements for the T-bill futures contract to be satisfied with either a newly issued thirteen-week bill or an original-issue twenty-six- or fifty-two-week bill with thirteen weeks

**Box 1**

**FOLLOWING DAILY FUTURES MARKET ACTIVITY**

Many newspapers report information on daily trading activity in futures markets. The clipping for IMM Treasury bill futures reproduced below is taken from the October 3, 1986, edition of the Wall *Street Journal*.

Each row gives price and trading volume data for a different contract delivery month. Delivery months for currently traded contracts are listed in the first column.

The next four columns show the opening price, high and low prices, and the closing or settlement price for the previous day's trading.

Column six gives the change in the contract settlement price over the last two trading sessions.

The seventh column reports the interest rate implied by the most recent settlement price, calculated by subtracting the settlement price from 100.

Column eight reports the change in the interest rates implied by the two most recent settlement prices. Note that the figures in this column are equal in magnitude but opposite in sign to the change in settlement price displayed in the sixth column.

The last column lists open *interest* for each contract delivery month. Open interest refers to the number of outstanding contracts. Each unit represents both a buyer and a seller with an outstanding futures commitment, or open position. Notice that open interest is greatest

for the nearest delivery month and declines steadily for successively distant delivery months. This pattern is typical, except when delivery for the nearby contract is impending and market participants begin to close out their positions.

Total trading volume and open interest for all contract delivery months are given in the last line. Trading volume refers to the total number of contracts for all contract delivery months traded on a particular day. Each transaction included in the count reflects both a purchase and sale of a futures contract. Note that the clipping includes data on total trading volume for each of the previous two trading sessions.

Total open interest, reported in the last line, is simply the sum of the open interest for each contract month listed in the rightmost column. The final entry on the bottom line reports the change in open interest over the previous two trading sessions.

**TREASURY BILLS (IMM)—\$1 mil.; pts. of 100%**

	Open	High	Low	Settle	Chg	Settle	Chg	Interest	Open
							Discount		
Dec	94.83	94.84	94.78	94.81	-.02	5.19	+	.02	26,133
Mr87	94.77	94.78	94.73	94.75	-.02	5.25	+	.02	6,510
June	94.59	94.59	94.55	94.56	-.02	5.44	+	.02	1,626
Sept	94.28	94.28	94.24	94.26	-.01	5.74	+	.01	668
Dec	93.89	93.90	93.87	93.89	-.02	6.11	+	.02	313
Mr88	93.53	93.54	93.51	93.53	-.02	6.47	+	.02	312
	Est vol 3,554; vol Wed 7,750; open int 35,624, +632.								

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left to maturity. The method used to determine the final delivery price is described in Box 2.

### Market History

The IMM introduced the three-month Treasury bill futures contract in January of 1976. At the time the contract was introduced, trading in interest rate futures was still a relatively new development. Trading in the first interest rate futures contract, the Board of Trade's Government National Mortgage Association (GNMA) certificate contract, had begun only a few months earlier. The Treasury bill contract was the first futures contract for a money market instrument.

Dealers in U. S. government securities were among the first market participants to actively use Treasury bill futures. Other money market participants entered into futures trading more slowly. By the time the IMM contract was two years old, however, trading activity had begun to accelerate rapidly.

This trend can be seen in Charts 1 and 2, which plot two different measures of market activity for the IMM contract from the inception of trading in 1976 through the end of 1984. The first measure, plotted in Chart 1, is total monthly trading volume, which is a count of the total number of contracts (not the dollar value) traded for all contract delivery months. Each recorded trade reflects one buyer and one seller.

Chart 2 plots total month-end open interest for all contract delivery months. Month-end open interest is a count of the number of unsettled contracts as of the end of the last trading day of a given month. Each contract included in the open interest count reflects both a buyer and a seller with an outstanding futures commitment.

### EURODOLLAR FUTURES

Eurodollars are U. S. dollar-denominated deposits held with banks or bank branches located outside of the United States, or with International Banking Facilities (IBFs) inside the United States.<sup>4</sup> There are two types of Eurodollar deposits: nontransferable time deposits and CDs. Time deposits make up the

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<sup>4</sup>An International Banking Facility, or IBF, is an office of a U. S. bank, U. S. branch of a foreign bank, or Edge Act corporation, which is domiciled in the United States but operates under rules and regulations similar to those applied to foreign branches of U. S. banks. restricted to doing business with foreign residents, foreign banks and foreign branches of U. S. banks, and foreign operations of multinational firms. See Key [1982] for further details.

bulk of the Eurodollar market. These deposits have fixed maturities ranging from one day to five years; most are very short-term, three months being a common maturity. Eurodollar CDs are also most commonly issued with maturities under a year.

Eurodollar futures contracts are actively traded on two exchanges. In the United States, a three-month Eurodollar time deposit contract is traded at the IMM. A similar contract is also traded at the London International Financial Futures Exchange (LIFFE). The IMM contract is described below.

### Contract Specifications

Technically, the buyer of a Eurodollar contract is required to place \$1,000,000 in a three-month Eurodollar time deposit paying the contracted rate of interest on the contract maturity date. This requirement exists only in principle, however, because the Eurodollar contract is **cash settled**. Cash settlement means that actual physical delivery never takes place; instead, any net changes in the value of the contract at maturity are settled in cash on the basis of spot market Eurodollar rates. Thus, cash settlement can be viewed as a final marking to market of the contract with the settlement amount based on the difference between the previous day's closing price and the final settlement price.

**Price Quotation** Price quotations for Eurodollar futures are based on a price index similar to that used for Treasury bill futures. Unlike Treasury bills, Eurodollar time deposits (as well as domestic and Eurodollar CDs) pay explicit interest. The rate of interest paid on the face amount of such a deposit is termed an **add-on yield** because the depositor receives the face amount of the deposit plus an explicit interest payment when the deposit matures. In the case of Eurodollar time deposits, the add-on yield is commonly called the London Interbank Offered Rate (LIBOR), which is the interest rate at which major international banks offer to place Eurodollar deposits with one another. Like other money market rates, LIBOR is an annualized rate based on a 360-day year. The IMM Eurodollar futures price index is 100 minus the LIBOR for Eurodollar futures.

**Determination of Settlement Price** When a futures contract contains provisions for physical delivery, market forces cause the futures price to converge to the spot market price as the delivery date draws near. This phenomenon is called convergence. In the case of a cash-settled contract, the futures exchange forces the process of convergence to take place

**Box 2**

**EXAMPLE OF A TREASURY BILL FUTURES TRANSACTION**

Suppose that on October 2, 1986, a trader buys one December 1986 Treasury bill futures contract at the opening price of 94.83. Once the transaction is complete the trader is contractually obligated to buy a \$1 million dollar (face value) thirteen-week Treasury bill yielding  $100 - 94.83 = 5.17$  percent on a discount basis on the contract delivery date, which is December 18, 1986. At the time of the initial transaction, however, the trader pays only a commission and deposits the required margin with his broker.

**Effects of Price Changes** The *Wall Street Journal* entry in Box 1 shows that futures prices fell two basis points during that day's trading session, meaning that the discount rate on bills for future delivery rose after the contract was purchased. Since each one basis point change in the T-bill index is worth \$25 the trader would lose \$50 if he were to sell the contract at the closing price.

The practice of marking futures contracts to market at the end of each trading session means that the trader is forced to realize this loss even though he does not sell the bill; thus, he has \$50 subtracted from his margin account. That money is then transferred to a seller's margin account. After the contract is marked to market, the trader is still obliged to buy a Treasury bill on December 18, but now at a discount yield of 5.19 percent (the implied futures discount yield as of the close of trading).

**Final Settlement** If the trader chooses to hold his contract to maturity the contract is marked to market one last time at the close of the last day of trading. All longs with open positions at that time must be prepared to buy the deliverable bill at a purchase price determined by the closing futures index price.

The final settlement or purchase price implied by the IMM index value is determined as follows. First, calculate the total discount from the face value of the bill using the formula

$$\text{Discount} = \frac{\text{Days to Maturity} \times ((100 - \text{Index}) \times .01) \times \$1,000,000}{360},$$

where  $((100 - \text{Index}) \times .01)$  is the futures discount yield expressed as a fraction. Second, calculate the purchase price by subtracting the total discount from the face value of the deliverable bill. Note that this is essentially the same procedure used to calculate the purchase price of a bill from the quoted discount yield in the spot market, the only difference being the use of the futures discount rate implied by the index value in place of the spot market rate.

Suppose that the final index price is 94.81; then, the settlement price for the first delivery day is

$$\$986,880.83 = \$1,000,000 - \frac{91 \times .0519 \times \$1,000,000}{360}.$$

This calculation assumes that the deliverable bill will have exactly 91 days to maturity, which will always be the case on the first contract delivery day except in special cases when a bill would otherwise mature on a national holiday.

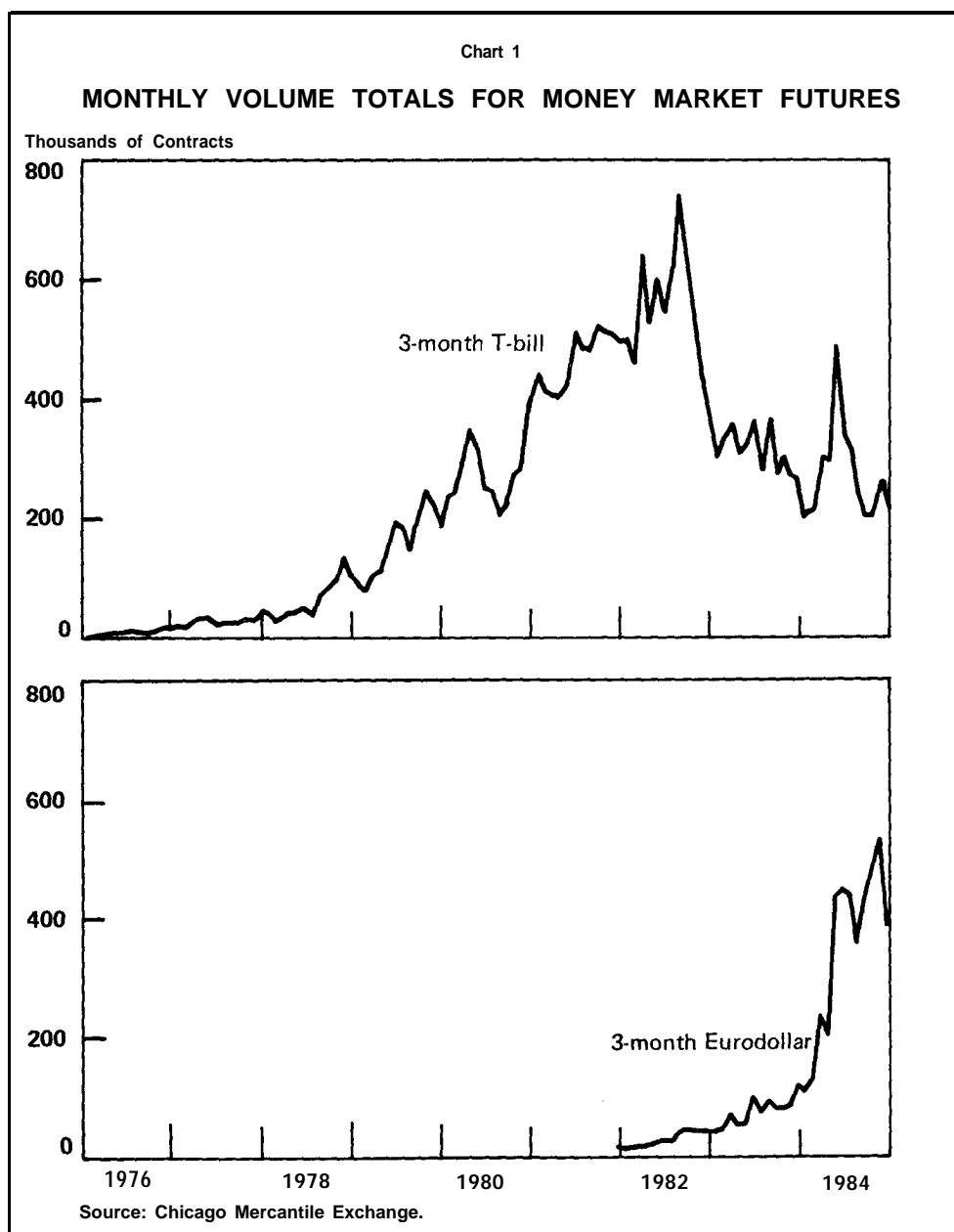
Because buying a futures contract during the last trading session is essentially equivalent to buying a Treasury bill in the spot market, futures prices tend to converge to the spot market price of the deliverable security on the final day of trading in a futures contract. Thus, the final futures discount yield should differ little, if at all, from the spot market discount yield at the end of the final trading day.

by setting the price of outstanding futures contracts equal to the spot market price at the end of the last day of trading.

To determine the final settlement price for its Eurodollar futures contract, the Mercantile Exchange clearinghouse randomly polls twelve banks actively participating in the London Eurodollar market at two different times during the last day of trading: once at a randomly selected time during the last 90 minutes of trading and once at the close of trading. The two highest and lowest price quotes from each polling

are dropped and the remaining quotes are averaged to arrive at the LIBOR rate used for final settlement. The final settlement price is 100 minus the average of the LIBOR rates for the two sample times.

As with Treasury bill futures, every change of one basis point in the Eurodollar futures index price is worth twenty-five dollars. Thus, if the IMM price index rises 10 basis points during the last trading session all shorts have \$250 per contract subtracted from their margin accounts while the longs each receive \$250 per contract. Once the contracts are



marked to market for the last time, buyers and sellers are relieved of the responsibility of actually placing or taking the deposits specified by the contract.

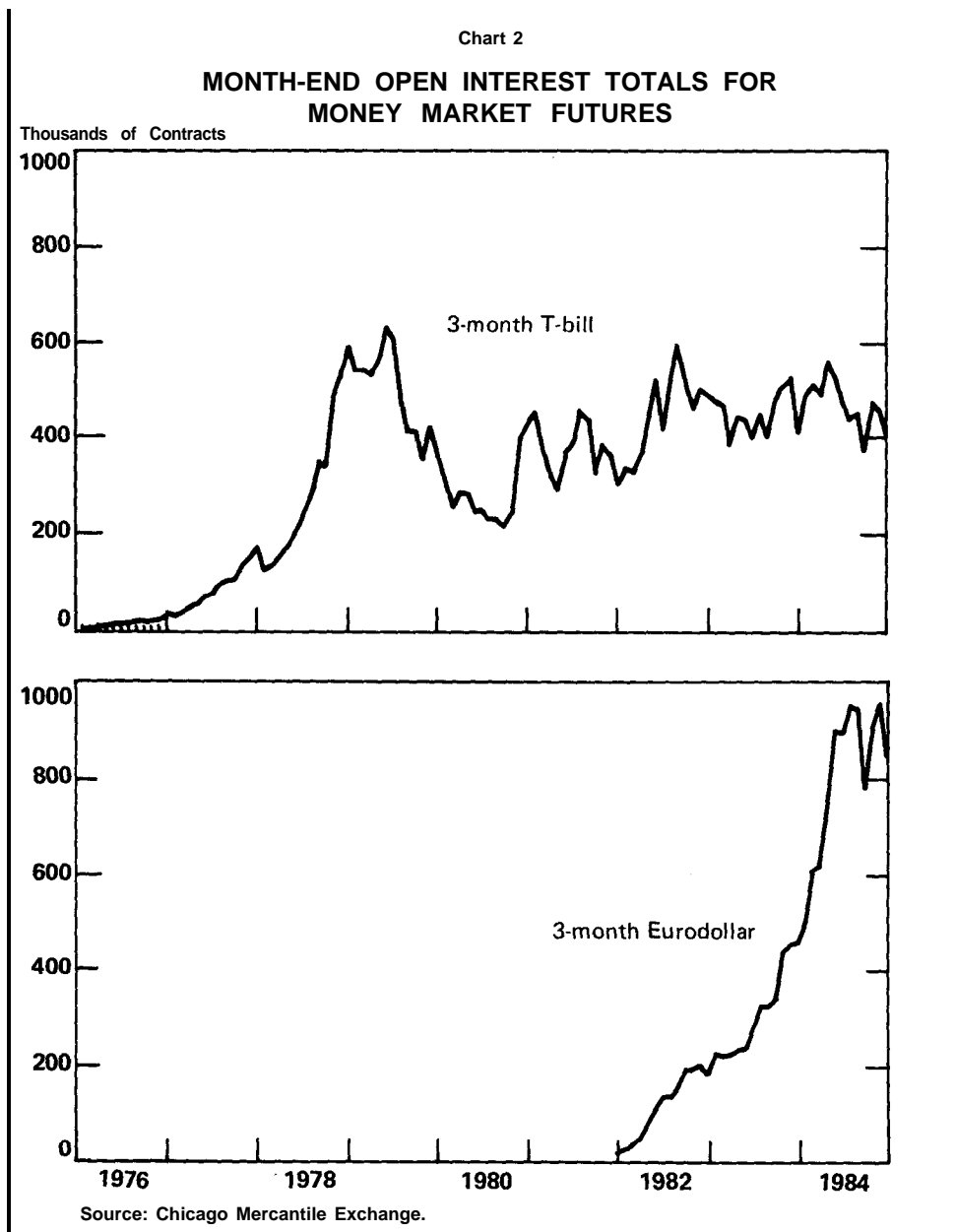
The IMM Eurodollar contract is the first futures contract traded in the United States to rely exclusively on a cash settlement procedure. The LIFFE Eurodollar contract also relies principally on cash settlement, although it does have provisions for physical delivery.<sup>5</sup>

<sup>5</sup>Tompkins and Youngren [1983] contains a detailed comparison of the IMM and LIFFE contracts.

### Market History

Trading in the IMM Eurodollar contract began in December 1981. The LIFFE introduced its Eurodollar contract a few months later in September of 1982. Both markets are currently active. Trading activity in the IMM contract is much heavier than in the LIFFE contract, however.<sup>6</sup> Charts 1 and 2

<sup>6</sup>As of the end of trading on October 2, 1986, for example, total volume and open interest for the IMM contract were 44,378 and 217,542 contracts, while trading volume for the LIFFE contract was 3,454 and open interest was 23,541.





**THREE-MONTH TREASURY BILL AND EURODOLLAR TIME DEPOSIT FUTURES:  
IMM CONTRACT SPECIFICATIONS**

	<u>Treasury Bill</u>	<u>Eurodollar Time Deposit</u>
Contract Size	\$1,000,000	\$1,000,000
Deliverable Grade	U. S. Treasury bills with thirteen weeks to maturity	Cash settlement with clearing corporation
Delivery Months	March, June, September, December	March, June, September, December
Price Quotation	Index: 100 minus discount yield	Index: 100 minus add-on yield
Minimum Price Fluctuation	.01 percent (1 basis point=\$25)	.01 percent (1 basis point = \$25)
Trading Hours (Chicago Time)	7:30 a.m. - 2:00 p.m. (last day - 10:00 a.m.)	7:30 a.m. - 2:00 p.m. (last day - 9:30 a.m.)
Last Day of Trading	The day before the first delivery date	Second London business day before the third Wednesday of delivery month
Delivery Days	Three successive business days beginning with the first day of the contract month on which a thirteen-week T-bill is issued and a one-year bill has thirteen weeks to maturity	Last day of trading

Source: Chicago Mercantile Exchange

display monthly time series of total trading volume and open interest for the IMM Eurodollar contract through the end of 1984.

Three factors have contributed to the popularity of Eurodollar futures. First, most major international banks rely heavily on Eurodollar market for short-term funds. To maintain ready access to this market, many of these banks have become active market-makers in Eurodollar deposits. Eurodollar futures provide a means of hedging interest rate risk arising from these activities.

Second, major international corporations have come to rely increasingly on Eurodollar markets for borrowed funds. Borrowing rates for these corporations are typically based on the three- or six-month LIBOR. When loans are priced this way, Eurodollar futures offer a means of hedging borrowing costs.

Finally, Eurodollar and domestic CD futures display almost identical price characteristics, which means that the two contracts are virtually perfect substitutes as hedging instruments.<sup>7</sup> The physical delivery requirements for CD futures proved to be awkward in comparison with the cash-settled Eurodollar contract, however, causing U. S. banks, once among the heaviest users of CD futures, to rely

<sup>7</sup>Faux [1984] found the correlation between Eurodollar and CD futures prices to be .993.

instead on Eurodollar futures to hedge domestic borrowing costs. In fact, the steep rise in trading volume in the Eurodollar contract during 1984 evident in Chart 1 coincides with a decline in CD futures trading volume beginning at about the same time. Thus, it appears that the success of the Eurodollar contract has contributed to the demise of trading in CD futures.

**USES OF INTEREST RATE FUTURES:  
HEDGING AND SPECULATION**

**Hedging Theory**

In the most general terms hedging refers to the act of matching one risk with a counterbalancing risk so as to reduce the overall risk of loss. Futures hedging was traditionally viewed narrowly as the use of futures contracts to offset the risk of loss resulting from price changes. To illustrate, consider the example of an investor with holdings of interest-bearing securities. If market interest rates rise, the value of those securities will fall. Since futures prices tend to move in sympathy with spot market prices, taking on a short position in interest rate futures produces an opposing risk. Traders with short positions in interest rate futures profit when interest rates rise because the contracts give them the right to sell the

underlying security at the old, higher price, meaning that they can buy back the contracts at a profit.

This traditional view emphasized risk avoidance—futures hedging was seen solely as providing a form of insurance against price risk. The contemporary view of hedging, on the other hand, emphasizes the relative efficiency of futures markets. Buying or selling futures contracts is a good temporary substitute for planned spot market transactions because futures contracts are more liquid than cash securities and transaction costs are generally lower in futures markets. From this perspective, the hedging transaction described above can be viewed as a temporary substitute for selling existing holdings of interest-bearing securities and buying shorter-term securities whose value would be less affected by interest rate changes. Either transaction would reduce the risk faced by the investor, but the futures hedge does so at a lower cost.

**Hedging as Profit-Maximizing Behavior** The principal shortcoming of the traditional concept of hedging is that it does not explain the hedging behavior of profit-maximizing firms. Although all firms must bear some risk inherent to the normal conduct of business, it is widely recognized that firms seek to maximize profits, and not to minimize risk. While risk minimization is not generally consistent with profit-maximizing behavior, cost minimization is. This is not to deny that hedging transactions are undertaken to reduce risk; hedging is one tool used in implementing a broader policy of risk management. The hedging behavior of profit-maximizing firms is best understood, however, when hedging is viewed as a temporary, low-cost alternative to planned spot market transactions rather than as a form of price insurance.<sup>8</sup>

The emphasis that modern hedging theory places on transaction costs is especially useful in understanding the hedging behavior of money market participants. In the money market, investors interested only in minimizing risk need not hedge; they can simply hold a portfolio composed solely of T-bills that are close to maturity. Arbitrage pricing theory holds that two securities that can serve as perfect substitutes should earn identical rates of return, so that a perfectly hedged, and therefore riskless, port-

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<sup>8</sup>The concept of hedging as profit-maximizing behavior was developed by Working [1962]. Telser [1981, 1986] takes a similar view, arguing that futures markets exist primarily because they minimize transaction costs, and not because futures contracts can be used to insure against price risk.

folio would be expected to earn only the riskless rate of return. Most investors, however, are willing to bear some additional risk in exchange for a higher expected rate of return. Hedgers in the money market selectively buy and sell interest rate futures to fix future borrowing and lending rates when they perceive it to be to their advantage to do so, and not to minimize risk per se.<sup>9</sup>

**Portfolio hedging theory** views futures contracts in the context of a hedger's entire portfolio of cash holdings. With this approach, cash holdings are treated as fixed and the expected returns of the unhedged portfolio are compared with those of a hedged portfolio. To the extent that futures prices are correlated with the value of the unhedged portfolio, a hedge can reduce portfolio risk. Final hedging positions are determined by the desired risk-return trade-off, which may not be the risk-minimizing combination.<sup>10</sup>

### **Basis Risk**

**Basis** refers to the difference between the spot market price of the security being hedged and the futures price. In portfolio hedging applications, basis can also refer to the relationship between the value of the portfolio and the price of a futures contract. **Basis** risk refers to the risk hedgers face as a result of unexpected changes in basis.

In a **perfect hedge** any gains or losses resulting from a change in the price of the item being hedged is offset by an equal and opposite change in futures prices. Perfect futures hedges are rarely attainable in practice because futures contracts are not custom-tailored agreements. Contract standardization, while contributing to the liquidity of the futures markets, practically insures that those contracts will not be perfectly suited to the needs of any one hedger. As a result, hedgers are exposed to basis risk.

At least two sources of basis risk can be identified. First, because standardized delivery dates for futures

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<sup>9</sup>Although these hedging concepts have gained widespread acceptance among market participants and regulatory agencies such as the CFTC, bank regulatory agencies define permissible hedges in terms of risk reduction. Federally insured banks and savings and loan associations are permitted to buy and sell futures for their own accounts only when the transactions can be shown to reduce overall risk; see Koppenhaver [1984] for more details.

<sup>10</sup>Powers and Vogel [1981, chapter [4] contains an introductory discussion of portfolio hedging theory. Figlewski [1986] contains a formal development of the portfolio approach to hedging, including methods for determining a risk-minimizing hedge.

contracts rarely coincide with planned transaction dates, most hedgers must unwind their futures positions before the contract delivery date. Futures prices do not always move in perfect conformity with spot prices before the contract maturity date, however, most often for fundamental economic reasons but sometimes for reasons that are not fully understood. Thus, any changes in the value of the futures contracts held as a hedge may not fully reflect changes in the spot price of the item being hedged at the time the hedge is lifted. If the date of a planned spot market transaction coincided exactly with the corresponding futures contract delivery date, delivery of the underlying cash instrument would permit a hedger to avoid this source of basis risk.

Second, in most cases the grade of the commodity being hedged differs from the deliverable grade specified by the futures contract. Price differentials between different commodity grades can vary, exposing hedgers to basis risk. This problem is not limited to commodity futures, moreover. Interest rate differentials on bank deposits, reflecting different risk premiums, can vary even among major money-center banks.

As long as changes in futures prices are highly correlated with changes in underlying cash prices a futures hedge can reduce overall risk. Hedging cannot eliminate basis risk, however. For this reason, it is often said that hedging replaces price risk with basis risk.

### **Cross Hedging**

Futures markets do not exist for all financial instruments. **Cross hedging** refers to the use of a futures contract for the delivery of one security to hedge an anticipated future transaction in a different security. An example of a popular cross hedge in the money market is the use of Eurodollar futures to hedge transactions in domestic CDs.

Futures prices tend to be more highly correlated with the price of the deliverable security than with other securities; as a result, a cross hedge will carry more basis risk than a regular hedge. When choosing a futures contract for a cross-hedging application, hedgers try to pick the futures contract for which price changes are most highly correlated with price changes of the security being hedged.

### **Examples of Interest Rate Hedging Strategies**

A wide variety of interest rate hedging strategies have been devised in the few years since interest rate

futures were first introduced. Interest rate futures can be used to establish interest rates on anticipated future investments and borrowing rates on future loans. Financial intermediaries, such as banks, use interest rate futures to protect their balance sheets from adverse effects of changes in market rates. Examples of different hedging strategies are briefly described below.

**The Long Hedge** A long hedge involves buying futures contracts, or assuming a long futures position. Investors use long hedges to protect against falling interest rates by fixing interest rates on future investments. One way to think of a long hedge is as a transaction that lengthens the effective maturity of holdings of interest-bearing securities. This is illustrated by the following example.

Suppose a corporate cash manager is instructed to invest \$10 million in Treasury bills until the firm anticipates needing the funds again in six months. The manager can fix the rate of return earned over this period in advance either by buying six-month bills or by simultaneously buying three-month bills and bill futures. The latter strategy of putting on a long futures hedge creates a **synthetic** six-month Treasury bill.

To take a simplified example suppose the date is September 18, 1986, exactly 91 days before the first delivery date for December Treasury bill futures. Six-month bills can be purchased at a discount yield of 5.42 percent. Creating a synthetic six-month bill would require the simultaneous purchase of a three-month Treasury bill and a futures contract for the delivery of a three-month bill on December 18. Three-month bills sell at a 5.23 percent discount yield and the discount yield for December bill futures is 5.36 percent. Buying an actual six-month bill turns out to be the more profitable alternative in this example (all numbers used in this example, incidentally, reflect actual closing prices for September 18, 1986); however, putting together a synthetic Treasury bill can sometimes produce a higher yield than buying a longer-term bill in the spot market.<sup>11</sup> Another potential advantage to the futures hedge is that it can easily be lifted if market rates begin to rise.

A drawback to using the futures strategy comes from exposure to basis risk. In the above example the date of the initial transaction was chosen so as to fall exactly 91 days before the maturity date of December Treasury bill futures contracts. This does not always occur in practice.

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<sup>11</sup> See Werderits [1983], for example.

**The Short Hedge** The money manager in the above example could have used another method to create a synthetic six-month bill. Instead of buying three-month bills and a futures contract for delivery in three months he could buy nine-month Treasury bills and simultaneously sell March 1987 bill contracts. Selling the futures contracts effectively shortens the maturity of the nine-month bills to six months. This last strategy is an example of a short hedge. A short hedge involves selling interest rate futures to protect the value of cash holdings of interest-bearing securities or to fix borrowing costs. The following example shows how a corporation might use Eurodollar futures to fix a borrowing rate on a future loan.

Overseas affiliates of multinational firms frequently take out loans with borrowing costs tied to LIBOR. Consider a firm that expects to need such a loan in a month. The firm faces the risk that borrowing rates may rise before the loan is taken out. The corporate treasurer can hedge this risk by shorting Eurodollar futures. Since taking out a loan amounts to selling an interest-bearing security, selling interest rate futures contracts serves as a temporary substitute for taking out the loan now and investing the proceeds until the funds are needed. If interest rates rise, the cost of satisfying delivery requirements for the futures contract falls while the contracted delivery price remains the same. The gain from the futures position offsets increased borrowing costs.

**Hedging Interest Rate Risk** Financial intermediaries, such as banks and securities dealers, fund their holdings of earning assets largely through debt. Traditionally, financial intermediaries have used short-term sources of funds to finance holdings of longer-term assets. This condition is described as a **positive** gap. When an institution has a positive gap, changes in interest rates affect funding costs faster than asset returns. This means that any rise in interest rates will hurt future earnings, while a fall in rates produces windfall profits. The risk to net earnings caused by changes in interest rates is termed interest rate risk.

Financial intermediaries have begun to use interest rate futures to hedge interest rate risk. A positive gap can be hedged by either shortening the effective maturity of asset holdings or by fixing future borrowing rates. Readers interested in learning more about gap hedging strategies are referred to Brewer [1985], Kaufman [1984], and Kawaller [1983].

## Risks Associated with Hedging

**Risk of Margin Calls** Hedgers, like all traders who take on futures positions, face the risk of margin calls. In the case of a hedging transaction, any decline in the value of a futures position is normally offset by gains from a cash position. Gains on the cash position are typically not realized immediately, however, while futures contracts are marked to market at the end of each trading session. The practice of marking futures contracts to market every day, while helping to insure the financial integrity of futures contracts, can place strains on a hedger's cash flow.

**Liquidity Risk** Although futures contracts are more liquid than the underlying security as a general rule, liquidity can be a problem in some markets. CD futures provide a good example. As of September 4, 1986, trading volume in CD futures was zero while total open interest was twenty-eight contracts. In such a market, it can at times be literally impossible to execute market orders for the purchase or sale of a contract. Hedgers who venture into such markets should be prepared to satisfy delivery requirements.

Liquidity can also be a problem for futures contracts with delivery dates more than a year away. Trading activity in futures contracts is heaviest in contracts for the nearby delivery month. Trading in the most distant contracts is typically very thin, indicating that those markets are less liquid. Liquidity can also be a problem for contracts a few days away from settlement. Unless a hedger plans delivery, it is best to either lift the hedge or roll it over (close out the existing futures position and buy or sell another futures contract) into the next contract delivery month before the last week of trading in a contract.<sup>12</sup>

## The Role of Speculators

Speculators have been active participants in futures markets since the earliest days of futures trading. Futures markets have proven attractive to speculators for at least two reasons. First, fractional margin requirements permit speculators to effectively leverage their positions to a greater degree than might otherwise be possible. Second, lower transaction costs and greater liquidity make futures contracts an attractive alternative to cash transactions for speculators as well as hedgers.

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<sup>12</sup> Ronalds [1986] discusses contract life cycles for a number of financial futures.

The early history of futures trading is filled with accounts of market squeezes-attempts at price manipulation effected by dumping or withholding commodity supplies on futures delivery dates-and traders who defaulted on their obligations when price changes created losses. Most often, speculators were blamed for these abuses. In addition, commodity producers often held speculators responsible for declines in commodity prices. These perceived speculative abuses produced several attempts to ban futures trading entirely.<sup>13</sup>

In response to these events, the futures exchanges devised ways to insure the orderly functioning of futures markets. Delivery requirements were designed so as to minimize the danger of market squeezes.<sup>14</sup> Margin requirements and the daily marking to market of contracts were adopted to eliminate credit risk from futures contracts. Speculators in futures markets are still sometimes blamed for large price fluctuations; for the most part, however, they have come to be viewed as playing a useful role in futures markets through their willingness to assume price risk, thereby making the markets more liquid for hedgers.

#### PRICE RELATIONSHIPS BETWEEN FUTURES AND CASH MARKETS

As a general rule futures prices tend to be highly correlated with the spot price of the deliverable security. All futures hedging strategies rely on this price relationship: it is because futures and spot prices are highly correlated that futures contracts can serve as temporary substitutes for cash transactions.

Price relationships between futures and underlying spot markets can be explained using arbitrage pricing theory, which is based on the premise that two different securities that can serve as perfect substitutes should sell for the same price. To apply this principle to the pricing of futures contracts, note that buying a futures contract substitutes for buying and holding the underlying security. Arbitrage pricing

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<sup>13</sup>Hieronimus [1971, chapter 4] tells of the arrest of nine prominent members of the Chicago Board of Trade following the enactment of the Illinois Elevator bill in 1867. That bill classified any contract for the sale of grain for future delivery as gambling, except in cases where the seller actually owned physical stocks of the commodity being sold. The sections of the bill classifying futures contracts as gambling were repealed in the next session of the Illinois legislature, however, and the exchange members never came to trial.

<sup>14</sup>Paul [1985] discusses the design of contract settlement provisions.

theory would thus predict that the futures price should just equal the price of the underlying security plus any net carrying costs.

#### The Cost of Carry Pricing Relation

The cost of financing and storing a commodity or security until delivery is called the cost of carry. For agricultural and other commodities cost of carry includes financing costs, storage, and any transaction costs. The convention in financial markets is to apply the term net carrying cost to the difference between any interest earned on the security and the cost of borrowing to finance its purchase.

The cost of carry pricing relation holds that the price of a futures contract should be determined by the spot price plus net carrying costs. Formally, the relation is given by

$$F = S + c ,$$

where  $F$  is the market futures price,  $S$  is the current spot price of the deliverable security, and  $c$  is the cost of carry.

By definition, the difference between the futures and spot price is basis. Thus, basis should theoretically be determined by the cost of carry when the item being hedged is the same as the deliverable security. Understanding the cost of carry model is important in designing hedge strategies because it allows the hedger to anticipate certain changes in basis over the life of a hedge.

#### Convergence

Carrying costs fall as the futures settlement date approaches because the time period a cash position must be held grows shorter. This causes futures prices to converge to underlying spot market prices as the delivery date draws near. On the final day of trading in a futures contract a futures transaction is essentially equivalent to a spot transaction, so futures prices should differ little from spot prices. Changes in carrying costs can thus explain the phenomenon of convergence. Because of convergence, basis tends to decline systematically over the life of a hedge.

#### Cash and Carry Arbitrage

To see why futures prices should conform to the cost of carry model, consider the arbitrage opportunities that would exist if they did not. Suppose, for example, that the price of gold futures exceeded the current spot price of gold plus the cost of carry. Arbitragers could earn riskless profits by buying

gold in the spot market, simultaneously selling gold futures, and subsequently delivering the gold on the futures settlement date. This type of transaction is known as cash and carry arbitrage because it involves buying the cash commodity and carrying it until the futures delivery date.

If the futures price were below the spot price, arbitrageurs would have the incentive to sell any cash holdings of gold (or short gold in the cash market if possible), buy gold futures, and then take delivery to replenish inventories. In either case, arbitrage activity should force futures prices to adjust to the current spot price plus the cost of carry.

Now consider a cash and carry transaction in the Treasury bill market. Applying the cost of carry pricing relation to the pricing of bill futures is a straightforward exercise because T-bills are discount instruments that do not pay explicit interest. The cost of carry (c) for a Treasury bill is therefore just the interest expense associated with funding the purchase of the bill over the period it is held. For the sake of simplicity suppose that the next delivery date for Treasury bill futures is exactly thirteen weeks away. If the current futures price exceeds the cost of buying a twenty-six-week-bill plus the carrying cost for the thirteen-week holding period, arbitrageurs can earn riskless profits by simultaneously buying twenty-six-week bills, selling nearby Treasury bill futures, and then delivering the bills when the contracts mature. In the opposite case a profitable arbitrage would involve selling cash holdings of twenty-six-week bills, buying Treasury bill futures, and accepting delivery in thirteen weeks. A more detailed description of how Treasury bill carrying costs are determined follows.

### The Implied Repo Rate

A repurchase agreement (more commonly called a *repo* or RP) is a transaction involving the sale of a security, usually a Treasury security, with a commitment on the part of the seller to repurchase the security after a stated length of time. Repurchase agreements can be viewed as short-term loans collateralized by securities holdings. The interest rate paid by borrowers in the RP market is called the *repo rate*. Because repurchase agreements are a primary funding source for dealers in government securities, the Treasury bill repo rate is typically used to calculate net carrying costs for Treasury bill futures.

The *implied repo rate* (irr) is a measure of carrying costs implicit in the futures-spot price relation-

ship. It is formally defined as the difference between the invoice or delivery cost F implied by the futures price and the current spot price S, converted to an annualized rate of return. The formula for calculating the implied repo rate is

$$\text{irr} = \frac{F - S}{S} \times \frac{360}{t}$$

The implied repo rate actually measures the rate of return that could be earned by buying a Treasury bill and simultaneously selling a futures contract with a delivery date t days away. It measures implied interest expense in the sense that it reveals the borrowing rate at which the gross return to a cash and carry arbitrage transaction would just equal the cost of financing that transaction.

Comparing implied repo rates with actual rates amounts to comparing theoretical futures prices, as determined by the cost of carry model, with actual futures prices. An implied repo rate above the actual three-month repo rate would indicate that futures contracts are relatively overpriced because implied interest expense would be greater than actual interest expense. An implied repo rate below the actual rate, on the other hand, would indicate that futures contracts are underpriced. Gendreau [1985] presents indirect evidence suggesting that arbitrage keeps actual and implied repo rates for Treasury bills in alignment.

Two final observations are in order. First, the effect that margin calls can have on anticipated financing costs has been ignored in this discussion; Stigum [1983, chapter 14] and Kidder [1984] explain how this affects the calculations. Second, although this discussion has centered on applying implied repo rate calculations to the pricing of Treasury bill futures, the concept can also be applied to the pricing of other types of futures contracts; see Kidder [1984] and Rebell [1984] for more examples.

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**FROM TRADE-OFFS TO POLICY INEFFECTIVENESS:  
A HISTORY OF THE PHILLIPS CURVE**

Thomas M. Humphrey

The Federal Reserve Bank of Richmond is pleased to announce the publication of ***From Trade-offs to Policy Ineffectiveness: A History of the Phillips Curve***. This 36-page monograph traces the evolution, public policy implications, and criticisms of the idea of an inflation-unemployment relationship from David Hume to the modern new classical school. Intended for advanced undergraduate college students, this monograph may be used in courses in macroeconomics, money and banking, and the history of economic thought. Copies may be obtained free of charge by writing to Public Services Department, Federal Reserve Bank of Richmond, P. O. Box 27622, Richmond, Virginia 23261.