Cash U.S. Treasury Market Fundamentals and Basics of Eurodollar/Treasury Spreading

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This document is intended to provide an overview of the fundamentals of trading cash Treasury securities and how they can be spread against the CME's Eurodollar futures. We assume that readers have only a cursory knowledge of coupon-bearing Treasury securities.

1. Coupon-Bearing Treasury Securities

U.S. Treasury bonds and notes represent a loan to the U.S. government. Bondholders are creditors rather than equity- or share-holders. The U.S. government agrees to repay the face or principal or par amount of the security at maturity, plus coupon interest at semi-annual intervals. Treasury securities are often considered "riskless" investments given that the "full faith and credit" of the U.S. government backs these securities.

The security buyer can either hold the bond until maturity, at which time the face value becomes due; or, the bond may be sold in the secondary markets prior to maturity. In the latter case, the investor recovers the market value of the bond, which may be more or less than its face value, depending upon prevailing yields. In the meantime, the investor receives semi-annual coupon payments every six months.

Suppose, for example, you purchase $5 million face value of the 5-3/8% note maturing in June 2000. This security pays half its stated coupon or 2.6875% of par on each six-month anniversary of its issue. Thus, you receive $134,375 semi-annually. Upon maturity in June 2000, the $5 million face value is re-paid and the note expires.

Price/Yield Relationship - A key factor governing the performance of bonds in the market is the relationship of yield and price movement. In general, as yields increase, bond prices will decline; as yields decline, prices rise. In a rising rate environment, bondholders will witness their principal value erode; in a declining rate environment, the market value of their bonds will increase.

IF Yields Rise ↑ THEN Prices Fall ↓

IF Yields Fall ↓ THEN Prices Rise ↑

This inverse relationship may be understood when one looks at the marketplace as a true auction. Assume you purchase a 10-year note with a 6% coupon when yields are at 6%. Thus, you pay 100% of the face or par value of the security. Subsequently, rates rise to 7%.

You decide to sell the original bond with the 6% yield, but no one will pay par as notes are now quoted at 7%. Now you must sell the bond at a discount to par in order to move the bond; i.e., rising rates are accompanied by declining prices.

Falling rates produce the reverse situation. If rates fall to 5%, our investment yields more than market rates. Now the seller can offer it at a premium to par. Thus, declining rates are accompanied by rising prices.

Should you hold the note until maturity, you would receive the par or face value. In the meantime, of course, you receive semi-annual coupon payments.

Quotation Practices - Unlike money market instruments (including bills and Eurodollars) that are quoted on a yield basis in the cash market, coupon-bearing securities are typically quoted in percent of par to the nearest 1/32nd of 1% of par. For example, one may quote a note at 99-27. This equates to a value of 99% of par plus 27/32^{nds}. The decimal equivalent of this value is 99.84375. Thus, a one million-dollar face value security might be priced at $998,437.50. If the price moves by 1/32nd from 97-27 to 97-28, this equates to a movement of $312.50 (per million-dollar face value).

But often, these securities - particularly those of shorter maturities - are quoted in finer increments than 1/32nd. For example, one may quote the security to the nearest 1/64th. If the value of our note in the example above were to rally from 99-27/32^{nds} by 1/64th, it may be quoted at 99-27+. The trailing "+" may be read as +1/64th.

Quotation Practices

Quote	Means	Decimal Equivalent
99-27	99-27/32^{nds}	99.84375% of par
99-272	99-27/32^{nds} + 1/128th	99.8515625% of par
99-27+	99-27/32^{nds} + 1/64th	99.859375% of par
99-276	99-27/32^{nds} + 3/128^{ths}	99.8671875% of par

Or, you may quote to the nearest 1/128th. If, for example, our bond were to rally from 99-27/32^{nds} by 1/128th, it might be quoted on a cash screen as 99-272. The trailing "2" may be read as +2/8^{ths} of 1/32nd; or, 1/128th. If the security rallies from 99-27/32^{nds} by 3/128^{ths}, it may be quoted as 99-276. The trailing "6" may be read as +6/8^{ths} of 1/32nd or 3/128^{ths}.

The normal commercial "round-lot" in the cash markets is $1 million face value. Anything less is considered an "odd-lot." However, you can purchase Treasuries in units as small as $1,000 face value. Of course, a dealer's inclination to quote competitive prices may dissipate as size diminishes.

Accrued Interest and Settlement Practices - In addition to paying the (negotiated) price of the coupon-bearing security, the buyer also typically compensates the seller for any interest accrued between the last semi-annual coupon payment date and the settlement date of the security.

- It is Friday, July 24, 1998. You purchase $1 million face value of the 5-3/8% security of June 2000 (a two-year note) for a price of 99-27 to yield 5.46% - for settlement on Monday July 27th. In addition to the price of the security, you must further compensate the seller for interest accrued between June 30, 1998 (the issue date) and the settlement date of July 27th. The total purchase price is $1,002,381.

Price of Note	$998,438
Accrued Interest	$3,944
Total	$1,002,382

Typically, securities are transferred through the Fed wire system from the bank account of the seller to that of the buyer vs. cash payment. That transaction is concluded on the settlement date - which may be different from the transaction date.

It is typical to settle a transaction on the business day subsequent to the actual transaction. Thus, if you purchase the security on a Thursday, you typically settle it on Friday. If purchased on a Friday, settlement generally occurs on the following Monday.

Sometimes, however, a "skip date" settlement is specified. For example, one may purchase a security on Monday for skip date settlement on Wednesday. Or, "skip-skip date" settlement on Thursday; "skip-skip-skip date" settlement on the Friday, etc. Theoretically, there is no effective limitation on the number of days over which one may defer settlement - thus, these cash securities may effectively be traded as a forward.

Treasury Auction Cycle - Treasury bonds, notes and bills are auctioned on a regular schedule by the U.S. Treasury which accepts bids - quoted in yield terms - from securities dealers. A certain amount of each auction is set aside, to be placed on a non-competitive basis at the average yield filled.

Prior to the actual issuance of specific Treasuries, they may be bought or sold on a "WI" or "When Issued" basis. Prior to the actual auction, WI's - bids and offers - are quoted as a yield. Once the security is auctioned and the results are announced, the Treasury will affix a particular coupon to the issue - near prevailing yields. At that time, the security may be quoted on a price rather than a yield basis. Trades previously concluded on a yield basis are settled against a price on the actual issue date of the security, calculated per standard price-yield formulae.

Security dealers purchase these securities and subsequently market them to their customers including pension funds, insurance companies, banks, corporations and retail investors.

The most recently issued securities of a particular maturity are referred to as "on-the-run" securities. On-the-runs are typically the most liquid and most actively traded of Treasury securities and, therefore, are often referenced as pricing benchmarks. Less recently issued securities are known as "off-the-run" securities and tend to be less liquid.

The Treasury currently issues 3-month, 6-month and 1-year bills; 2-year, 5-year and 10-year notes; and, 30-year bonds on a regular schedule. In the past, the Treasury had also issued securities with a 3-year, 4-year, 7-year and 20-year maturity.

U.S. Treasury Auction Schedule

	Maturity	Auctioned
Treasury Bills	3 Month & 6 Month	Weekly
	1 Year	Every Fourth Week
Treasury Notes	2 Year	Monthly
	3 Year	Feb / May / Aug / Nov *
	5 Year	Feb / May / Aug / Nov
	10 Year	Feb / May / Aug / Nov
Treasury Bonds	30 Year	Feb / Aug / Nov

* The Treasury discontinued issuing 3-year notes altogether in May 1998.

"The Run" - If you were to ask a cash dealer for a quotation of "the run," he would quote yields associated with the on-the-run securities from the current on-the-run 3-month bill to the 30-year bond. The most recently issued 30-year bond is sometimes referred to as the "long-bond" because it is the longest maturity Treasury available.

Quoting "the Run"

(As of Friday, July 24, 1998)

	Coupon	Maturity	Bid	Ask	Chg	Ask Yield
3-Mo. Bill	Na	10/29/98	5.01%	5.00%	+0.08%	5.14%
6-Mo. Bill	Na	1/28/99	5.02%	5.01%	-0.01%	5.21%
1-Yr. Bill	Na	7/22/99	5.07%	5.06%	-	5.33%
2-Yr. Note	5-3/8%	6/00	99-26	99-27	-1	5.46%
3-Yr. Note	5-5/8%	5/01	100-13	100-14	-1	5.45%
5-Yr. Note	5-3/8%	6/03	99-19	99-20	-2	5.46%
10-Yr. Note	5-5/8%	5/08	101-10	101-11	-3	5.45%
30-Yr. Bond	6-1/8%	11/27	106-08	106-09	-11	5.68%

Source: Telerate/Cantor Fitzgerald

The long bond is also referred to as the "new bond." Thus, the second most recently issued bond is referred to as the "old bond," the third most recently issued bond is the "old-old bond," the fourth most recently issued bond is the "old-old-old bond." As of this writing, the long bond may be identified as the 6-1/8% bond maturing in November 2027; the old bond is the 6-3/8% bond of August 2027; the old-old bond is the 6-5/8% of February 2027; the old-old-old bond is the 6-1/2% of November 2026.

Beyond that, one is expected to identify the security of interest by coupon and maturity. For example, the "6-3/4s of '26" refers to the bond with a coupon of 6-3/4% maturing on August 15, 2026.

Most Recently Issued Thirty-Year Bonds
(As of Friday, July 24, 1998)

	Coupon	Maturity	Bid	Ask	Chg	Ask Yield
	6-7/8%	8/25	114-27	114-31	-11	5.77%
	6%	2/26	103-05	103-07	-10	5.77%
	6-3/4%	8/26	113-15	113-19	-11	5.77%
Old-Old-Old Bond	6-1/2%	11/26	110-05	110-09	-11	5.76
Old-Old Bond	6-5/8%	2/27	112-01	112-05	-11	5.75%
Old Bond	6-3/8%	8/27	108-31	109-00	-16	5.73%
Long Bond	6-1/8%	11/27	106-08	106-09	-11	5.68%

Source: Telerate/Cantor Fitzgerald

One important provision is whether or not the bond is subject to call. A "callable" bond is one where the issuer has the option of redeeming the bond at a stated price - usually 100% of par - prior to maturity. If a bond is callable, it may be identified by its coupon, call and maturity date; i.e., the 11-3/4% of November 2009-14 is callable beginning in November 2009 and matures in 2014.

Prior to the February 1986 auction, the U.S. Treasury typically issued 30-year bonds with a 25-year call feature. That practice was discontinued, however, as the Treasury instituted its "Separate Trading of Registered Interest and Principal on Securities" or STRIPS program with respect to all newly issued 10-year notes and 30-year bonds.[1]

Quoting "the Roll" and the Importance of Liquidity - Clearly, traders who frequently buy and sell are interested in maintaining positions in the most liquid securities possible. As such, they tend to prefer on-the-run as opposed to off-the-run securities.

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1 The STRIPS program was created to facilitate the trade of zero-coupon Treasury securities. Prior to 1986, a variety of broker dealers including Merrill Lynch and Salomon Bros. issued zero-coupon securities collateralized by Treasuries under acronyms such as TIGeRs and CATS. For example, if you buy a 10-year Treasury, you can create zero coupon securities of a variety of maturities by marketing the component cash flows. By selling a zero collateralized by a coupon payment due in five years, one creates a five-year zero; or, one may create a ten-year zero by selling a zero collateralized by the principal payment. They engaged in this practice because the market valued the components of the security more dearly than the coupon payments and principal payment bundled together. Today, one might notice that the yield on a Treasury STRIPis usually less than a comparable maturity coupon-bearing Treasury. Beginning with 10s and 30s issued in February 1986, the Treasury began assigning separate CUSIPnumbers to the principal value and to tranches of coupon payments associated with these securities. A CUSIPnumber is a code unique to each security and is necessary to wire-transfer and, therefore, market a security. Thus, the Treasury STRIPS market was created. These securities are most popular when rates are high and, therefore, the price of the zero may be quite low.

It is intuitive that on-the-runs will offer superior liquidity when one considers the “life-cycle” of Treasury securities. Treasuries are auctioned - largely to broker-dealers - who subsequently attempt to place the securities with their customers. Often these securities are purchased by investors who may hold the security until maturity. At some point, securities are “put-away” in an investment portfolio until their maturity. Or, they may become the subject of a strip transaction per the STRIPS program.

In any event, as these securities find a home, supplies may become rare - bid/offer spreads inflate and the security becomes somewhat illiquid.

Liquidity is a valuable commodity to many. Thus, you may notice that the price of on-the-runs tends to be bid up - resulting in reduced yields - relative to other similar maturity securities. This tends to be most noticeable with respect to the 30-year bond.

Traders will frequently quote a “roll” transaction where one sells the old security in favor of the new security. The “old bond” in our table above was quoted at a yield of 5.73% while the “new bond” was seen at 5.68%. Clearly, someone is willing to give up 5 basis points (0.05%) in yield for the privilege of holding the new bond. In other words, liquidity is worth about 5 basis points.

Dealers may quote a bid/offer spread in this transaction, offering the opportunity to sell the old bond/buy the new bond; or, buy the old bond/sell the new bond, in a single transaction.

Repo Financing - Leverage is a familiar concept to futures traders. Just as one may margin a futures position and thereby effectively extend one’s capital, the Treasury markets likewise permit traders to utilize “repo” financing agreements to leverage Treasury holdings.

A repurchase agreement (repo or simply RP) represents a facile method by which one may borrow funds - typically on a very short-term basis - collateralized by Treasury securities. In a repo agreement, the lender will wire transfer same-day funds to the borrower; the borrower wire transfers the Treasury security to the lender - with the provision that the transactions are reversed at term with the lender wiring back the original principal plus interest.

The borrower is said to have executed a repurchase agreement; the lender is said to have executed a reverse repurchase agreement. Many banks and security dealers will offer this service - once the customer applies and passes a requisite credit check. The key to the transaction, however, is the safety provided the lender by virtue of the receipt of the (highly-marketable) Treasury security.

These repo transactions are typically done on an overnight basis - but may be negotiated for a term of one-week, two-weeks, a month. Overnight repo rates are typically quite low - in the vicinity of Fed Funds.

Any Treasury security may be considered "good" or "general" collateral. Sometimes when particular Treasuries are in short supply, dealers will announce that the security is "on special" and offer below-market financing rates in an effort to attract borrowers.

2. There Are Yields and There Are Yields

Not all yields are created equal. Thus, fixed income traders must be careful to ensure that, when comparing yields, they are comparing similarly constructed figures per similar assumptions.

Discount Yield - If you purchase $1 million face value of a bill, you pay less than $1 million and receive $1 million some days (d) later at term. The difference between the $1 million face value (FV) and the actual price of the bill is referred to as the discount (D). The rate (r) is known as a "discount yield." The price (P) paid to purchase a bill may be calculated as follows.

$$D = FV\,[r \times (d/360)]$$

$$P = FV - D = FV - FV[r \times (d/360)]$$

- Earlier, we quoted a (3-month) T-bill maturing October 29th at a discount yield of 5.00% as of July 24th. There were 94 days to maturity. The price of a $1 million face value unit of this bill may be calculated as follows. This implies a discount of $13,056 and a price of $986,944.

$$\text{Discount} = \$1{,}000{,}000\,[0.05 \times (94/360)] = \$13{,}056$$

$$\text{Price} = \$1{,}000{,}000 - \$1{,}000{,}000\,[0.05 \times (94/360)] = \$986{,}944$$

However, this discount yield of 5.00% applies two incorrect assumptions: (1) there are 360 days in a year when in fact there are 365 days; and (2) the principal value or investment is $1,000,000 when in fact it is less.

Money Market Yields (MMYs) - Money market yields or MMYs should be well understood by traders active in Eurodollar markets. MMYs do not suffer from the mistaken assumption that the investment value is the amount returned upon maturity. This is because Eurodollars are "add-on" instruments where you invest the stated face value and receive the original investment plus interest at term. Repo transactions are likewise quoted on a MMY basis.

$$\text{Interest} = FV\,[r \times (d/360)]$$

• If you were to purchase a $1 million face value unit of 94-day Euros with a 5.00% (MMY), you would receive the original $1 million investment plus $13,056 at the conclusion of 94 days.

Interest = $1,000,000 [0.05 x (94/360)]
= $13,056

Note that the interest of $13,056 is the same as our T-bill example. Clearly, however, you would prefer to invest only $986,944 to earn $13,056 than to invest $1,000,000. To render a discount yield (DY) comparable with a money market yield (MMY), use the following formula.

MMY = [(FV / D) -1] x (360/d)

• In our example, a discount yield of 5.00% equates to a money market yield of 5.07%.

MMY = [($1,000,000/$986,944) -1] x (360/94)
= 5.07%

Bond Equivalent Yields (BEYs) - MMYs may represent a step up from a discount yield. Yet they also still suffer from the mistaken assumption that there are but 360 days in a year (a "money-market" year!).

Accordingly, we must convert those DYs or MMYs in order to render them comparable to a bond or note yield quotation - a bond-equivalent yield (BEY).

BEY = MMY x (365/360)

• We calculated a money market yield of 5.07% in our previous example. Let's convert that figure to a bond-equivalent yield. Note that this figure of 5.14% is quoted in our table as the "ask yield" and is comparable to the yields associated with the coupon-bearing securities.

5.14% = 5.07% x (365/360)

Complicating the calculation is the fact that notes and bonds offer semi-annual coupon payments. Thus, money market instruments that require the investor to wait until maturity for any return do not permit interim compounding. This means that the formula provided above is only valid for instruments with less than 6-months (183-days) to term. If there are 183 or more days until term, use the following formula.

$$BEY = (-d/365) + \sqrt{\frac{([d/365]^2 - [(2d/365) - 1]\,[1 - (1/Price)])}{[(d/365) - 0.5]}}$$

• Above, we had shown a 1-year bill (with 360 days until maturity) quoted at a DDY yield of 5.06%. The price of the bill can be quoted as $949,400:

Price = \$1,000,000 - \$1,000,000 [0.0506 x (360/360)]
= \$949,400

Substituting into our formula, we arrive at a BEY of 5.33% - which you will note is quoted in our table above as “ask yield” and is comparable to yields quoted on coupon bearing securities.

$$\text{BEY} = \frac{(-360/365) + \sqrt{([360/365]^2 - [((2 \times 360)/365) - 1]\,[1 - (1/0.9494)])}}{[(360/365) - 0.5]}$$

$$= 5.33\%$$

If you are looking at an “add-on” instrument such as a Eurodollar, substitute (FV plus Interest/1) for the term (1/Price) in our EBY calculation.

3. Measuring Risk of Coupon Bearing Securities

“You can’t manage what you can’t measure” is an old saying with universal application. In the fixed income markets, it is paramount to assess the volatility of one’s holdings in order to reasonably to manage them.

Two particular characteristics of a coupon-bearing security will clearly impact upon its volatility: its maturity and its coupon. Defining volatility as the price reaction of the security in response to changes in yield, we see that:

The Longer the Maturity $\uparrow$ **the Greater the Volatility** $\uparrow$

The Higher the Coupon $\uparrow$ **the Lower the Volatility** $\downarrow$

All else held equal, the longer the maturity of a bond, the greater its price reaction to a change in yield. This may be understood when one considers that the implications of yield movements are felt over longer periods, the longer the maturity.

On the other hand, high coupon securities will be less impacted, on a percentage basis, by changing yields than low coupon securities. This may be understood when one considers that high coupon securities return a greater portion of one’s original investment sooner than low coupon securities. Your risks are reduced to the extent that you hold the cash!

There are several ways to measure the risks associated with coupon-bearing (and money-market) instruments including basis point value (BPV) and duration.

Basis Point Value (BPV) BPV represents the absolute price change of a security given a one basis point (0.01%) change in yield. These figures may be referenced using any number of commercially available quotation services or software packages. BPV is normally quoted in dollars based on a \$1 million (round-lot) unit of cash securities. The following table depicts the BPV of the securities on-the-run as of July 24, 1998.

Measuring Volatility

(As of Friday, July 24, 1998)

	Coupon	Maturity	Ask	Ask Yield	BPV	Duration
3-Mo. Bill	Na	10/29/98	5.00%	5.14%	$26.11	0.26
6-Mo. Bill	Na	1/28/99	5.01%	5.21%	$51.39	0.51
1-Yr. Bill	Na	7/22/99	5.06%	5.33%	$100.00	1.00
2-Yr. Note	5-3/8%	6/00	99-27	5.46%	$180.46	1.81
3-Yr. Note	5-5/8%	5/01	100-14	5.45%	$257.46	2.56
5-Yr. Note	5-3/8%	6/03	99-20	5.46%	$426.03	4.28
10-Yr. Note	5-5/8%	5/08	101-11	5.45%	$758.21	7.48
30-Yr. Bond	6-1/8%	11/27	106-09	5.68%	$1,487.03	13.99

• If the yield on the 5-year note should rally from 5.46% to 5.47%, this implies a $426.03 decline in the value of the security.

Duration - If BPV measures the absolute change in the value of a security given a yield fluctuation, duration may be thought of as a measure of relative or percentage change. The duration (typically quoted in years) measures the expected percentage change in the value of a security given a one-hundred basis point (1%) change in yield.

Duration is calculated as the average weighted maturity of all the cash flows associated with the bond; i.e., repayment of "corpus" or face value at maturity plus coupon payments - all discounted to their present value.

• The 10-year note has a duration of 7.48 years. This implies that if its yield advances from 5.45% to 6.45%, we expect a 7.48% decline in the value of the note.

In years past, it had been commonplace to evaluate the volatility of coupon-bearing securities simply by reference to maturity. But this is quite misleading. For example, if one simply examines the maturities of the current 2-year note and 10-year note, one might conclude that the 10-year is five times as volatile as the 2-year. But by examining durations, we reach a far different conclusion: the 10-year note (duration of 7.48 yrs.) is only about 4.13 times as volatile as the 2-year note (duration of 1.81 yrs.). The availability of cheap computing power has made duration analysis as easy as it is illuminating.

4.The Shape of the Yield Curve

The shape of the yield curve, if closely studied, may be interpreted as an indicator of the direction in which the market believes interest rates may fluctuate. Let's look at this topic more closely and find ways to trade on expectations regarding the changing shape of the curve.

Explaining the Shape of the Curve - Three fundamental theories address the shape of the yield curve, each successively more sophisticated yet complementary. These theories are: (1) the expectations hypothesis; (2) the liquidity hypothesis; and (3) the segmentation hypothesis.

Let's begin by assuming that the yield curve is flat, i.e., investors normally express no particular preference for long- vs. short-term securities. Hence, long- and short-term securities have similar yields. The expectations hypothesis alters this assumption with the supposition that fixed income market participants are basically rational. They will alter the composition of their portfolios to correspond to the anticipated direction of interest rates.

For example, portfolio managers will shift their investments from the long-term to the short-term in anticipation of rising interest rates and falling fixed income security prices. This is due to the fact that longer-term securities tend to react more dramatically to shifting rates than do shorter-term securities (as measured by BPV or duration).

By selling long-term securities and buying short-term securities, the portfolio manager assumes a defensive posture. The effects of this strategy are similar to those associated with a portfolio manager who hedges by selling futures against long-term security holdings.

By shortening the average maturity of their holdings in a rising rate environment, investors will tend to bid up the price of short-term securities and drive down the price of long-term securities. Thus, short-term yields fall while long-term yields rise; i.e., the shape of the yield curve steepens.

On the other hand, portfolio managers will tend to lengthen the maturity of their portfolios in anticipation of falling rates by selling short-term securities and buying long-term securities. This activity will have the effect of bidding up the price of long-term securities and driving down the price of short-term securities. Thus, long-term yields will fall while short-term yields rise, i.e., the yield curve flattens or inverts!

Yields Expected to Rise → Yield Curve Steepens

Yields Expected to Fall → Yield Curve Flattens

Thus, the shape of the curve may be used as an indicator of the possible direction in which yields may fluctuate.

The *liquidity hypothesis* rejects the initial proposition described above. According to this theory, investors are not indifferent between long- and short-term securities even when yields are expected to remain stable.

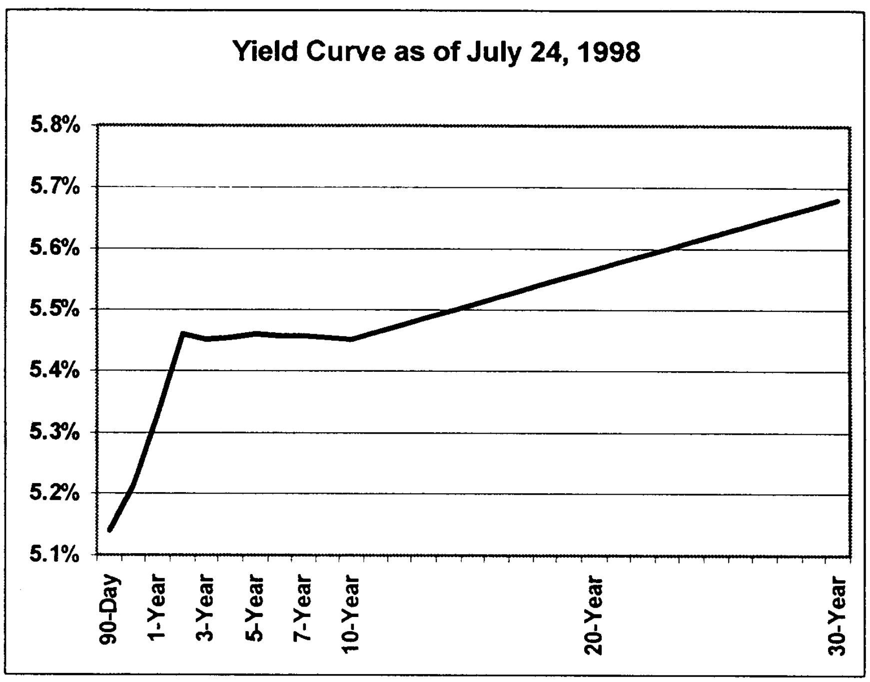
All else being equal, investors will tend to prefer short-term securities over long-term securities. A long-term security implies that an investor commits his funds over a lengthy period of time. Short-term investments, on the other hand, may roll over frequently, providing the investor with augmented flexibility to alter the composition of the portfolio to correspond to breaking events.

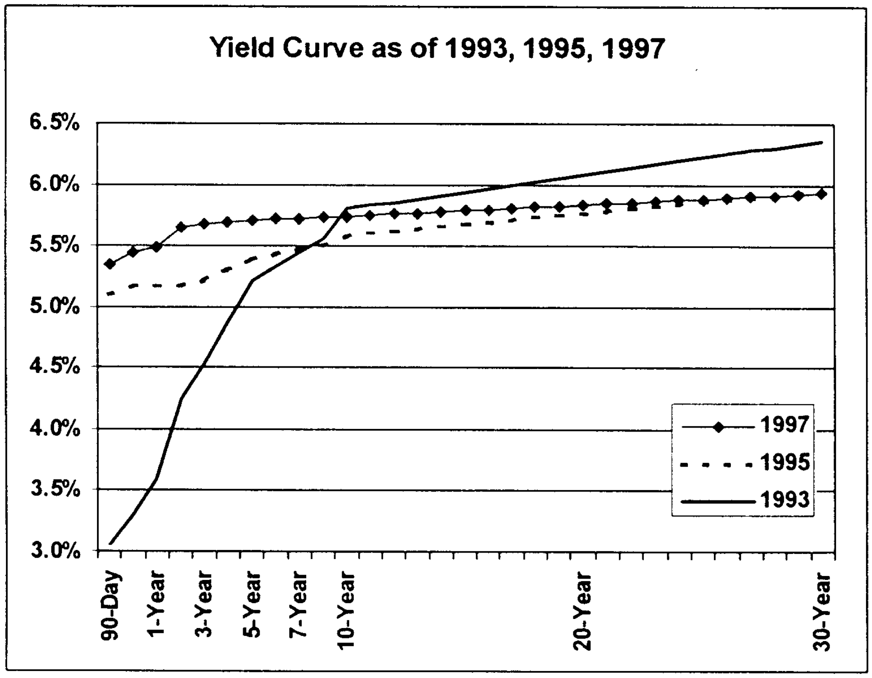
In other words, short-term investments are close to cash. Given similar yields, it is better to own the more liquid and readily divestable security. Thus, long-term securities must pay a “liquidity premium.” So as a rule, long-term yields tend to exceed short-term yields even when yields are expected to remain relatively stable; i.e., there is a natural upwards bias to the yield curve.

The *segmentation hypothesis* attacks the second proposition associated with the expectation hypothesis - namely, that investors are ready and willing to alter the structure of their portfolios quickly and efficiently to take advantage of anticipated yield fluctuations. While portfolios may be altered to a limited degree in anticipation of yield curve shifts, investors are often constrained in regard to how quickly and how extensively they can adjust their holdings.

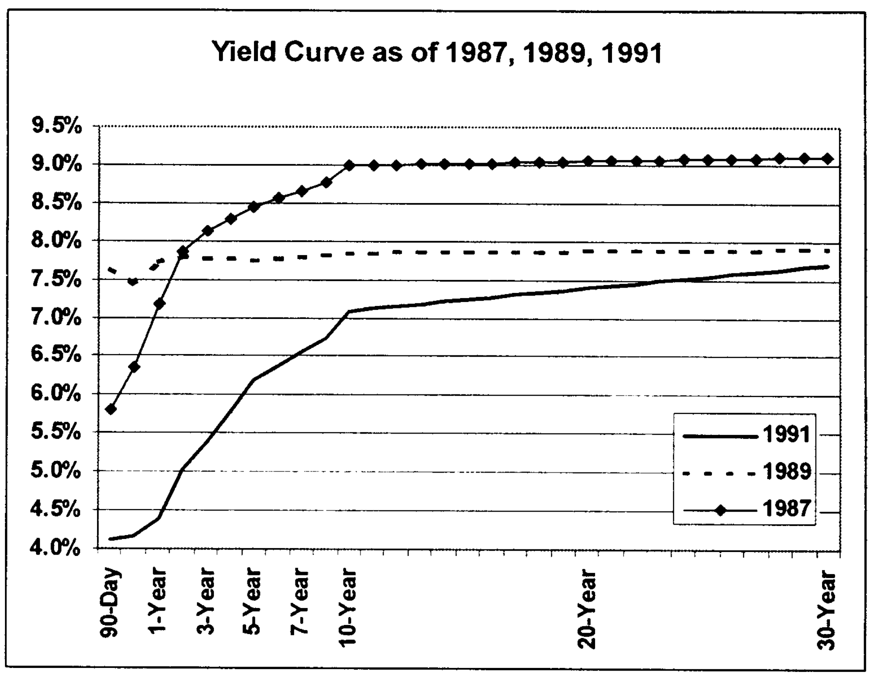
For example, regulatory requirements often restrict pension funds, requiring them to be invested in low-risk fixed income investments. The liabilities assumed by insurance companies may prompt them to invest in long-term securities. Other restrictions may be self-imposed. Finally, bid/ask spreads in some segments of the fixed income markets may be prohibitive. As such, “kinks” are often observed in the fixed income markets.

While the liquidity and segmentation hypotheses attack certain aspects of the expectations theory, all three hypotheses are basically complementary. The latter two theories may be thought of as refinements of the expectations theory.





Yield Curve as of 1993, 1995, 1997
6.5%
6.0%
5.5%
5.0%
4.5%
4.0%
3.5%
3.0%
1997
1995
1993
90-Day
1-Year
3-Year
5-Year
7-Year
10-Year
20-Year
30-Year



Yield Curve as of 1987, 1989, 1991
9.5%
9.0%
8.5%
8.0%
7.5%
7.0%
6.5%
6.0%
5.5%
5.0%
4.5%
4.0%
1991
1989
1987
90-Day
1-Year
3-Year
5-Year
7-Year
10-Year
20-Year
30-Year

Normal vs. Inverted Yield Curve - Typically, we expect the yield curve to be somewhat upwardly sloped with long-term yields exceeding short-term yields. A strong upward slope may be interpreted as an indication that the market believes that yields will rise (and prices decline). A flat, negatively sloped or inverted yield curve may be interpreted as an indication that the market believes that yields will decline (and prices rise).

Since the early 1980s, yields in the United States have generally been on the decline. As a result, the yield curve has typically been upwardly sloped.

One would have to go all the way back to the early 1980s to find a dramatically inverted yield curve environment. Recall that in October 1979, Fed Chairman Volcker initiated a campaign to control inflation (in the long-term) by limiting money supply growth at the risk of allowing rates to rise sharply (in the short-term). As a result, short-term yields peaked near 20% while long-term yields peaked near 14% - a dramatically inverted yield curve. One might argue that this foretold of eventually declining yields. Rates did in fact decline as inflation was reigned in from the double-digit levels witnessed in the late 70s.

While the yield curve is relatively flat as of this writing, we would have to go back to the Spring of 1989 to find a situation where the yield curve was slightly inverted - or at least quite flat.

Yield Spreads - It is quite common to speculate on the spread - quoted in yield - between securities of various maturities. In order to make such a quotation, of course, one must ascertain that you are "comparing apples with apples" - or using BEYs across the board! The following table depicts yield spreads in on-the-run securities.

Yield Curve Spreads

(As of Friday, July 24, 1998)

	Yield	3-Mo.	6-Mo.	1-Yr	2-Yr.	3-Yr.	5-Yr.	10-Yr.	30-Yr.
3-Mo.	5.14%	-							
6-Mo.	5.21%	0.07%	-						
1-Yr.	5.33%	0.19%	0.12%	-					
2-Yr.	5.46%	0.32%	0.25%	0.13%	-				
3-Yr.	5.45%	0.31%	0.24%	0.12%	-0.01%	-			
5-Yr.	5.46%	0.32%	0.25%	0.13%	0.00%	0.01%	-		
10-Yr.	5.45%	0.31%	0.24%	0.12%	-0.01	0.00%	-0.01%	-	
30-Yr.	5.68%	0.54%	0.47%	0.35%	0.22%	0.23%	0.22%	0.23%	-

If you believe that the yield spread will widen while the curve steepens, i.e., the yield on the long-term security will rise relative to the yield on the short-term security, you might “buy the curve.” You do so by buying the short-term security and selling the long-term security. If you believe the yield spread will narrow while the curve flattens or inverts, i.e., the yield on the long-term security will decline relative to the yield on the short-term security, you “sell the curve.” This is accomplished by selling the short-term security and buying the long-term security.

Buy the Curve → Buy ST / Sell LT

Sell the Curve → Sell ST / Buy LT

But consider what might happen if you were to sell the curve (in anticipation of falling yields and a flattening curve) by selling an equal face value of short-term and long-term securities. Long-term securities are more reactive to changing yields than short-term securities. Thus, it is possible that yields fall and the curve flattens but you lose money! In other words, your prediction is correct but you still lose money - because you failed to recognize that securities of varying coupons and maturities react differently to fluctuating yields.

Fortunately, the BPVs or durations discussed above provide a convenient reference by which to “weight” the spread. For example, if one were to sell 2s/10s (sell the 2-year note/buy the 10-year note), one might weight the spread on a ratio of 4.13 to 1. In other words, sell 4.13 face value units of the 2-year to 1 face value unit of the 10-year. Given that a commercial round-lot is generally considered to be $1 million face value, one might sell $4 million 2-years/buy $1 million 10-years; or, sell $33 million 2-years/buy $8 million 10-years.

Yield Curve Spread Weights

(As of Friday, July 24, 1998)

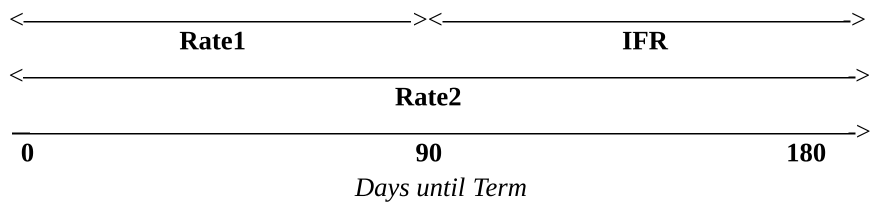
	Duration	3-Mo.	6-Mo.	1-Yr.	2-Yr.	3-Yr.	5-Yr.	10-Yr.	30-Yr.
3-Mo.	0.26	-							
6-Mo.	0.51	1.96	-						
1-Yr.	1.00	3.85	1.96	-					
2-Yr.	1.81	6.96	3.55	1.81	-				
3-Yr.	2.56	9.85	5.02	2.56	1.41	-			
5-Yr.	4.28	16.46	8.39	4.28	2.36	1.67	-		
10-Yr.	7.48	28.77	14.66	7.48	4.13	2.92	1.75	-	
30-Yr.	13.99	53.81	27.43	13.99	7.73	5.46	3.27	1.87	-

By weighting the spread in this way, you assure that the profit or loss on your spread will be a function of the changing shape of the curve - not yield levels per se.

5.The Yield Curve, Implied Forwards and Strips

There is much valuable information implicit in the shape of the yield curve, not the least of which is an indication of where short-term interest rate futures prices should be. Let us study how one might empirically derive such information.

Implied Forward Rates - An “implied forward rate” or IFR answers this question: What short-term yield may be expected to prevail in the future? For example, what yield will be associated with a 90-day investment instrument 90 days in the future?



The 90-day implied forward rate 90 days in the future $IFR_{(90,90)}$ may be found as a function of the 90-day term rate $Rate_1$ or simply “R_1” and the 180-day term rate $Rate_2$ or simply “R_2”. (180 days = 90 +90.) Let’s designate the number of days in each period as $days_1$ or simply d_1=90 days; $days_2$ or simply d_2=180 days; and $days_3$ or simply d_3=90 days.[2]

The assumption is that an investor should be indifferent between investing for a 6-month term and investing for a 3-month term, rolling the proceeds over into a 3-month investment 90 days hence.

$$1+R_2(d_2/360) = [1+R_1(d_1/360)][1+IFR(d_3,d_1)(d_3/360)]$$

Solving the equation for IFR:

$$1+IFR(d_3,d_1)(d_3/360) = [1+R_2(d_2/360)] \div [1+R_1(d_1/360)]$$

$$IFR(d_3,d1)(d_3/360) = [[1+R_2(d_2/360)] - 1] \div [1+R_1(d_1/360)]$$

$$IFR(d_3,d_1) = [[1+R_2(d_2/360)] \div [(d_3/360)[1+R_1(d_1/360)]]] - [1 \div (d_3/360)]$$

- Assume that the 90-day term rate equals 5-11/16% or 5.6875% while the 180-day term rate equals 5-3/4% or 5.75%. What is the 90-day implied forward rate 90 days hence?

$$IFR_{90,90} = [[1+(0.0575)(180/360)] \div [(90/360)[1+(0.056875)(90/360)]]] - [1 \div (90/360)]$$
$$= 0.05731 \text{ or } 5.731$$

This analysis represents a precise but somewhat less than intuitive method for determining the IFR. Let’s explore a more intuitive means of determining IFRs given the conditions described above.

[2] Note that, for the sake of convenience, we assume that there are precisely 90 days in each period from Eurodollar futures maturity date to date. Clearly, this is not the case in practice where this assumption introduces gaps between the value date of one futures contract + 90 days; and, the value date of the next futures contract. We further assume that the “stub” - or the period between the current (settlement) date and the value date for the first futures contract - is also precisely 90 days.

- If you invest one million dollars at a rate of 5.75% over a 180-day or six-month period, you will accumulate the total of $28,750 as follows:

$$\$1{,}000{,}000 \times 0.0575 \times (180/360) = \underline{\$28{,}750}$$

As an alternative, one might have invested that one million dollars at the spot 90-day rate of 5.6875% and earned $14,219 over the first 90-day period. The IFR is the rate of return one must earn in the second 90-day period in order to become indifferent between a term 180-day investment and the prospect of investing for 90 days, subsequently rolling over into another 90-day investment 90 days hence at the IFR. Clearly, one must earn a total of $14,531 over the second 90-day period to accumulate the sum total of $28,750.

$$\begin{aligned} \$1{,}000{,}000 \times 0.056875 \times (90/360) &= \$14{,}219 \\ \$1{,}014{,}219 \times \text{IFR} \times (90/360) &= \underline{\$14{,}531} \\ & \underline{\$28{,}750} \end{aligned}$$

Note that the second strategy means that you will benefit from the compounding effect. By investing in a 90-day term instrument, one realizes the return of the original one million dollars plus interest of $14,219 at the conclusion of 90 days. Thus, one has more cash to invest during the second 90-day period than the first. Solving for the IFR:

$$\begin{aligned} \text{IFR} &= \$14{,}531 \div [\$1{,}014{,}219 \times (90/360)] \\ &= 5.731\% \end{aligned}$$

Note that this IFR is slightly above the spot 90-day rate. This implies an expectation of slightly rising yields in the future.

- The 90-day rate is 6.00% and the 180-day rate is 6.25%; i.e., the yield curve displays a “normal” upward slope. Find the 90-day IFR for 90 days hence.

$$\begin{aligned} \text{IFR}_{90,90} &= [[1+(0.0625)(180/360)] \div [(90/360)[1+(0.06)(90/360)]]] - [1 \div (90/360)] \\ &= 0.06404 \text{ or } 6.404\% \end{aligned}$$

This IFR exceeds the 90-day and the 180-day term rates. Thus, it implies an expectation of rising yields and is consistent with the expectations hypothesis discussed above.

- The 90-day rate is 6.00% and the 180-day rate is 5.75% - well below the shorter-term rate. Thus, the yield curve is negatively sloped or inverted. Find the 90-day IFR for 90 days hence.

$$\begin{aligned} \text{IFR}_{90,90} &= [[1+(0.0575)(180/360)] \div [(90/360)[1+(0.06)(90/360)]]] - [1 \div (90/360)] \\ &= 0.05419 \text{ or } 5.419\% \end{aligned}$$

This IFR is lower than either the 90-day or the 180-day term rates. This implies an expectation of falling yields and is consistent with the expectations hypothesis discussed above.

• The 90-day rate is 6.00% and the 180-day rate is 6.00%. Thus, the yield curve is flat. Find the 90-day IFR for 90 days hence.

$IFR_{90,90}$ = [[1+(0.06)(180/360)] ÷ [(90/360)[1+(0.06)(90/360)]]] - [1 ÷ (90/360)]
= 0.05911 or 5.911%

This IFR is lower than the 90-day and the 180-day term rates. This implies an expectation of falling yields! This would appear superficially to run contrary to the expectations hypothesis as one might assume that a flat curve is indicative of stable expectations. We can explain this discrepancy from either a mathematical or an intuitive viewpoint.

	90-Day Rate	180-Day Rate	IFR
Curve Steepens	6.00%	6.25%	6.404%
Curve Inverts	6.00%	5.75%	5.419%
Curve Flat	6.00%	6.00%	5.911%

Mathematically, it is clear that a flat curve indicates falling IFRs. This is due to the effect of compound interest. Note that over the second 90-day period, the investor has more cash to reinvest. The 180-day investment means that the investor's cash is tied up for the full 180-day term with no opportunity to benefit from the effects of compound interest. Thus, the investor may be content with a slightly lower rate over the second 90-day period.

From an intuitive standpoint, the liquidity hypothesis suggests that, in the absence of expectations of rising or falling rates, the yield curve should maintain a slight upward slope. This slight upward or "normal" slope is expected given investors'normal preference for shorter-term, more liquid, as opposed to longer-term and presumably less liquid securities. Thus, a flat curve is actually indicative of an expectation for slightly falling interest rates.

IFRs and Futures - Whereas the cost of carry analysis discussed in prior sections is often quite useful in identifying "normal" relationships in many futures markets, the IFR concept may be referenced as an indication of where short-term interest rate futures may be trading.

A Eurodollar or T-bill contract essentially represents a three-month or 90-day term investment taken some n days in the future. This is readily comparable to an IFR. In fact, by comparing IFRs to futures prices, you may identify arbitrage opportunities to the extent that IFRs basically represent where these short-term futures should be trading!

• Assume that it is June. Consider the following hypothetical interest rate structure in the Eurodollar (Euro) futures and cash markets:

Sep. Euro Futures	94.32 (5.68%)
Dec. Euro Futures	94.285 (5.715%)
Mar. Euro Futures	94.345 (5.655%)
3-Month Investment	offer @ 5.6875%
6-Month Investment	offer @ 5.75%
9-Month Investment	offer @ 5.78125%

Which is the better investment: (1) invest in Euros maturing in 6 months hence yielding 5.75%; (2) invest for the next 3 months at 5.6875% and buy September futures at 94.285; or (3) invest in the 9-month spot at 5.78125% and sell March futures at 94.345 (5.655%)?

Alternative #2 presumes that you will invest for the first three months at 5.6875%, and for the next three-month period (at a price determined or "locked-in" by virtue of the fact that you are long September futures) at 5.715%. The total return may be found by using the IFR equation as follows:

$$1+R(0.5) = [1+0.056875(0.25)][1+0.05715(0.25)]$$
$$R = [[1+0.056875(0.25)][1+0.05715(0.25)] - 1]/0.5$$
$$= 5.742\%$$

Alternative #3 means that you invest for nine months at 5.78125% over the next 270 days. But by selling March futures, you effectively commit to selling that Eurodollar investment 180 days hence when it has only 90 days to term. The return may also be found by using the IFR equation as follows:

$$[1+R(0.5)][1+0.05655(0.25)] = [1+0.0578125(0.75)]$$
$$[1+R(0.5)] = [1+0.0578125(0.75)] / [1+0.05655(0.25)]$$
$$R = [[(1+0.0578125(0.75)) / (1+0.05655(0.25))] - 1] / 0.5$$
$$= 5.763\%$$

Thus, the third alternative provides a (marginally) superior return at 5.763% relative to the first alternative with a return equal to 5.75% and the second alternative with a return equal to 5.742%.

Short-term futures are driven into line with these implied forward rates because of the availability of arbitrage opportunities. In the foregoing example, an arbitrage might have been constructed by selling the 6-month cash Euro foregoing a return equal to 5.75%; buying the 9-month cash Euro and selling the June futures contract, earning a return equal to 5.76%. Of course it may not be worth the effort for a 1 basis point return. In any event, the execution of such transactions has the effect of driving the market into equilibrium such that arbitrage opportunities are unavailable.

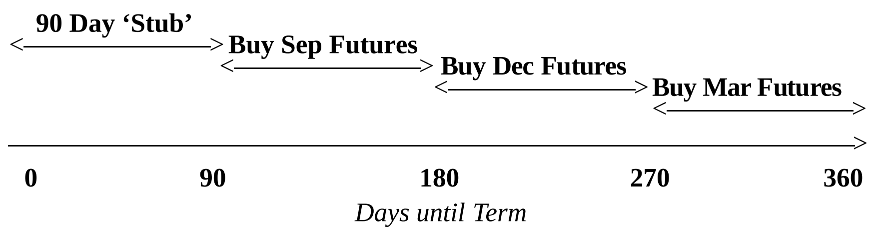
Strip Transactions - This analysis also brings to the fore the concept of a "strip." A strip may be purchased or sold by buying or selling a series of futures maturing in successively deferred months, usually in combination with a current position in the cash market.

A strip involves the purchase or sale of short-term interest rate futures in successively deferred months, usually in combination with the purchase or sale of the current cash short-term instrument.

In our example, we illustrated the first two components of a strip when we discussed the purchase of the current 3-month Euro and purchase of futures calling (nominally) for delivery of 3-month Euros three months hence.

Assume it is June and there are three months until maturity of the nearby (September) Euro futures contract. Astrip, albeit a short strip, may be constructed by investing in a 90-day or 3-month Eurodollar instrument (the “stub”), buying September, December and March futures.

When the spot Eurodollar investment matures in 90 days, one (effectively) invests in another 90-day Eurodollar investment by virtue of the fact that one may be long the nearby September contract. Subsequently, when that 3-month investment matures, one invests for another three months at a predetermined or “locked-in” price by virtue of a long position in December futures. When that 3-month investment matures, one invests for yet another three months at a predetermined or “locked-in” price by virtue of a long position in March futures.



The value of this strip may be found with another variation of the IFR formula. This value may be compared against the prospect of simply investing at the spot 12-month rate.

$$\text{Strip} = (360/d) \times [[[1+r_1(d_1/360)][1+r_2(d_2/360)] \ldots [1+r_n(d_n/360)]] -1]$$

- Let’s construct an example whereby we can apply our formula to calculate the value of a strip. Consider the following rate structure. Calculate the value of a strip constructed by investing the sum of $100 million in the 3-month “stub,” buying September, December and March futures.

3-Month ‘Stub’	5.6875%
Sep. Euro Futures	94.32 (5.68%)
Dec. Euro Futures	94.285 (5.715%)
Mar. Euro Futures	94.345 (5.655%)

$$\begin{aligned}\text{Strip} &= (360/360) \times [[[1+0.056875(90/360)][1+0.0568(90/360)][1+0.05715(90/360)] \\ &\quad [1+0.05655(90/360)]] -1] \\ &= 5.807\%\end{aligned}$$

While this calculation certainly allows one to arrive at the correct solution, it is not entirely intuitive. To explicitly illustrate how this figure was determined, let us consider the cash flows associated with this series of transactions.

$100,000,000	x 0.056875	x (90/360) =	$1,421,875
$101,421,875	x 0.0568	x (90/360) =	$1,440,191
$102,862,066	x 0.05715	x (90/360) =	$1,469,642
$104,331,708	x 0.05655	x (90/360) =	$1,474,990
			$5,806,698

Return on Strip = 5.807%

As illustrated above, if you invest $100,000,000 for the first 90-day period at a rate of 5.6875%, you earn $1,421,875. By reinvesting the original $1,000,000 plus the accrued interest over the second 90-day period at a rate of 5.68%, you earn an additional $1,440,191. An additional $1,469,642 plus $1,474,990 are earned over the third and fourth periods for a total of $5,806,698. Thus, you earn $5,806,698 on a $100 million investment over the course of one year or 5.807%.

The value of a strip may be compared to the value of a comparable term investment. In the above example, we would expect a one-year term spot Eurodollar investment to yield 5.81%.

If the term investment were to yield more than 5.807%, buy spot and sell the strip. Should the term investment yield less than 5.807%, sell spot and buy the strip. Arbitrageurs who pursue such trading opportunities will tend to enforce cost of carry pricing through their activities.

Weighting the Strip - Note that in the previous example, the strip buyer becomes the beneficiary of compound interest. In other words, one has more to re-invest over subsequent periods than the amount with which one began. This implies that one should "weight" a strip by purchasing additional quantities of Euro futures in subsequent months to account for the effect of compounding.

- Assume that you began with an original investment of $100 million. Rather than buying 100 September, 100 December and 100 March futures, you might consider purchasing 101 September, 103 December and 104 March futures - by reference to the compound interest.

Many strips are constructed on a simple unweighted basis - often with the use of packs or bundles. While it may be technically advisable to construct a weighting as above, as a practical matter, one might expect quicker, superior execution with the use of packs or bundles.[3]

6. Trading the T-Note/Euro Spread

As discussed above, one might compare the yield on a strip to the yield on a comparable maturity spot Eurodollar investment. A profitable trade might be executed if there are sizable differences in yield.

However, Eurodollars are money market instruments - by definition, a money market instrument is one which has a maturity of one year or less. It is possible to trade Eurodollar strips vs. longer maturity securities such as Treasury notes. We will refer to this Treasury/Eurodollar strip trade as the "T-Note/Euro spread." (It is sometimes referred to in the marketplace as a "Term TED spread.")

3See "Picking Your Spots on the ED Strip: AGraphical Guide to 'Quick and Dirty'Hedging for Treasury Notes" by Frederick Sturm, Fuji Securities, *CME Open Interests* for a discussion of the relative effectiveness of bundles and packs vs. the more elaborate approach.

In its simplest form, one might buy the spread (buy T-Notes/sell Euro strips) in anticipation of a widening yield spread between Treasuries and Eurodollars. Or, one may sell the spread (sell T-Notes/buy Euro strips) in anticipation of a narrowing yield spread between Treasuries and Eurodollars. Thus, this may be considered a credit risk or a "flight to quality" play.

Long the T-Note/Euro Spread ➔ Buy T-Notes/Sell Euro Strips

Short the T-Note/Euro Spread ➔ Sell T-Notes/Buy Euro Strips

Spread vs. Arbitrage - Consider the possibility of trading a 2-year Eurodollar strip vs. a 2-year Treasury note. The effective term associated with either investment may be identical. But this spread is qualitatively different than trading a Eurodollar strip vs. a spot Eurodollar investment.

In particular, Eurodollars represent private credit risks vs. the reduced public credit risk implied in Treasury yields. Because credit risk is an important issue, this is indeed a "spread" and should not be considered an "arbitrage." This spread is analogous to the "simple" TED spread between Treasury bill and Eurodollar futures.[4]

A Two-Year Strip - In order to assess the value of this spread, it is necessary to "compare apples with apples." In other words, we must ascertain that the yield on the strip compares to the bond equivalent yield associated with the note (BEYnote). To illustrate this process, let's consider the construction of a two-year Treasury/Euro strip spread. There are alternative ways of quoting this spread but this is the simplest method.[5]

To compare the strip to the yield on a two-year note, we find its BEYas follows: (1) find the forward value (FV) of the strip; and (2) use that information to derive a BEY for the strip (BEY_{strip}).

FV represents the growth in value of a strip over term. The reciprocal of the FV, or "discount factor" DF = 1 / FV, is analogous to the value of a zero-coupon bond. For example, if a strip grows in value from $1.00 to $1.10 over some term (FV = 1.10), its discount factor is 0.9090; i.e., a zero coupon bond priced at 90.90% of par.

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[4] Per a "simple" TED spread, one buys (sells) Treasury bill futures; and, sells (buys) Eurodollar futures. The spread is quoted as the T-bill futures price less the Eurodollar futures price. Because bills can be expected to offer lower yields than Eurodollars of a comparable maturity due to credit considerations, the spread is positive. One buys the TED (buys bills/sells euros) if one expects credit considerations to heat up (a "flight to quality"). Or, one might sell the TED (sell bills/buy euros) if one expects credit considerations to become significant.

[5] Other methods of quoting the T-Note/Euro spread include comparing the "implied Eurodollar yield vs. Treasury yield"; or, the "fixed basis point spread to Eurodollar futures rates. There are advantages and disadvantages to each approach. See "Measuring and Trading Term TED Spreads" by Galen Burghardt, Bill Hoskins, Susan Kirshner, *Dean Witter Institutional Futures Research Note*, July 26, 1995.

Next, we convert that FV into a BEY using the following formula where CP represents the number of semi-annual coupon periods from settlement to maturity of the strip. This figure must include fractional coupon periods.

$$BEY = [FV^{(1/CP)} - 1] \times 2$$

- It is July 24, 1998. Let us quote the spread by comparing a two-year strip vs. the on-the-run 2-year Treasury note. The 5-3/8% note of June 2000 is quoted at 99-27 to yield 5.46%.

Futures Value Date	**Rate**	**Days**	**Forward Value**
7/27/98	5.6875%		1.00000
9/16/98	5.680%	51	1.00806
12/16/98	5.715%	91	1.02253
3/17/99	5.655%	91	1.03730
6/16/99	5.670%	91	1.05213
9/15/99	5.700%	91	1.06721
12/15/99	5.810%	91	1.08259
3/15/00	5.750%	91	1.09849
6/21/00	5.780%	98	1.11568
9/20/00	5.800%	91	1.13198

There are CP = 3.85 coupon periods between the value date of July 27, 1998 and the maturity of the two-year note on June 30, 2000. This represents WC = 3 whole coupon payments received in June 1999, December 1999 and June 2000; plus, the fractional period between July 27th and the first coupon payment on December 31st. There are D_1 = 157 days from July 27th and December 31st. There are D_2 = 184 days between the original issue date of June 30th and December 31st.

$$\begin{aligned} CP &= WC + D1 / D2 \\ &= 3 + 157/184 \\ &= 3.85 \end{aligned}$$

A seemingly minor but important point: Our 2-year note matures on June 30, 2000 while our strip extends either to June 21, 2000 or September 20, 2000. Thus, we must extrapolate between the forward value $FV_{6/21}$ = 1.11568 and the $FV_{9/20}$ = 1.13198 to find the $FV_{6/30}$ appropriate to the June 30th maturity. There are D_1 = 9 days between June 21st and June 30th. There are D_2 = 91 days between June 21st and September 20th. Thus, our extrapolated FV becomes 1.11715.

$$\begin{aligned} FV_{6/30} &= FV_{6/21} + [(D_1 / D_2) \times (FV_{9/20} - FV_{6/21})] \\ &= 1.11568 + [(9/91) \times (1.13198-1.11568)] \\ &= 1.11729 \end{aligned}$$

Putting it all together, we find a BEY = 5.845%.

$$\begin{aligned} BEY &= [FV^{(1/CP)} - 1] \times 2 \\ &= [1.11729^{(1/3.85)} - 1] \times 2 \\ &= 5.845\% \end{aligned}$$

There are additional subtleties that we might have considered. Still, by comparing the yield on our strip at 5.845% to the yield on the note of 5.46%, we have a quote of 38.5 basis points.

$$\begin{aligned}\text{T-Note/Euro Quote} &= BEY_{strip} - BEY_{note} \\ &= 5.845\% - 5.46\% \\ &= 0.385\% \text{ or } 38.5 \text{ basis points}\end{aligned}$$

Hedge Ratios - The simplest and most straightforward method of identifying a hedge ratio (HR) is simply to compare the basis point value (BPV) of the Treasury note against that of the Eurodollar futures contract.

$$HR = BPV_{note} / BPV_{strip}$$

- Our two-year note has a BPV_{note} = \$180.46 per million; Eurodollar futures have a BPV = \$25 per million. Our strip, extending some 703 days between July 27, 1998 and June 30, 2000, runs 1.95 years into the future [703/(2 x 360)] - thus, its BPV_{strip} = \$195.[6] The hedge ratio may be crudely calculated as 0.925. This suggests the purchase (sale) of roughly 9 strips vs. \$10 million face value of the note.

$$HR = \$180.46 / \$195 = 0.925$$

Please note, however, that this is a rough calculation and does not account for many factors. It is clear, for example, the performance of a strip is more heavily affected by changing values in its short-dated as opposed to long-dated components - given the compounding effects discussed above. Further, this HR is based on the unlikely assumption that Eurodollar and Treasury yields will move in parallel. 7

Non-Parallel Shifts in the Yield Curve - What if yields along the curve do not move up and down in parallel - but rather the shape of the curve is in flux? A flattening or steepening of the curve can have a dramatic effect upon our spread.

One might buy the T-note/sell the strip - in anticipation of a widening yield spread. But this further implies an interest in seeing the yield curve flatten or invert. Or, one might sell the note/buy the strip - in anticipation of a narrowing yield spread. This implies an interest in seeing the yield curve steepen.

Long the T-Note/Euro Spread ➔ Benefits from Flattening Curve

Short the T-Note/Euro Spread ➔ Benefits from Steepening Curve

For more information about the issues discussed above or other trading opportunities, please contact the Chicago Mercantile Exchange Marketing Department at 312-930-1000.

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[6] The BPVof a non-coupon bearing security equals BPV= 0.01% x [FVx (d/360)]. Thus, a \$1 million, 90-day Euro futures contract has a BPV= \$25 = 0.01% x [\$1 million x (90/360)].

[7] It is beyond the ambition of this paper to provide painstakingly precise formulae. See “Measuring and Trading Term TED Spreads” by Galen Burghardt, Bill Hoskins, Susan Kirshner, *Dean Witter Institutional Futures Research Note*, July 26, 1995, for a more detailed discussion of these issues.