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Research & Product Development

Understanding U.S. Treasury Futures

John W. Labuszewski, Managing Director
Research & Product Development
Tel: 312-446-2666, E-mail: jlab@cmegroup.com

Frederick Sturm, Director
Research & Product Development
Tel: 312-347-5235, E-mail: Frederick.Sturm@cmegroup.com

This document is intended to provide an overview of the fundamentals of trading U.S. Treasury bond and note futures.[1] We assume only a cursory knowledge of coupon-bearing Treasury securities, providing a grounding in cash Treasury markets; some detail regarding the features of the U.S. Treasury futures contracts; and, a discussion of risk management applications with U.S. Treasury futures.

Treasury futures represent a flagship product group for the CME Group. U.S. Treasury futures were originally introduced on the Chicago Board of Trade (CBOT). CBOT was merged with Chicago Mercantile Exchange in 2007 and is now operated as a unit of CME Group.

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 shareholders. 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.[2] Treasury securities are often considered "riskless" investments given that the "full faith and credit" of the U.S. government backs these securities.

[1] These contracts were originally introduced on the Chicago Board of Trade (CBOT). CBOT was merged with Chicago Mercantile Exchange (CME) in July 2007 and is now operated as a unit of the CME Group (CMEG).

[2] Inflation Indexed Treasury Securities were introduced in 1997. These securities are offered with maturities of 30 years; 10 years; and, five years. They are sold with a stated coupon but promise the return of the original principal adjusted to reflect inflation as measured by the Consumer Price Index over the period until maturity. Thus, their coupons are typically established at levels that reflect the premium of long- or intermediate-term interest rates relative to inflation. Clearly, these have some investment appeal to those concerned about the long-term prospects for inflation.

A Treasury bond or note entitles the holder to receive periodic, generally semi-annual, coupon payments, culminating in the repayment of the face value or corpus of the security at maturity.

The security buyer can either hold the bond or note until maturity, at which time the face value becomes due; or, the bond or note may be sold in the secondary markets prior to maturity. In the latter case, the investor recovers the market value of the bond or note, 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.

- You purchase $1 million face value of the 4-1/2% note maturing in May 2017. This security pays half its stated coupon or 2-¼% of par on each six-month anniversary of its issue. Thus, you receive $45,000 (= 4.5% of $1 million) annually, paid out in semi-annual installments of $22,500 in May and November. Upon maturity in May 2017, the $1 million face value is re-paid and the note expires.

There is an inverse relationship between bond and note prices and yields. As yields rise, prices fall. As yields decline, prices advance.

***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 decline 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 an investor purchases a 10-year note with a 6% coupon when yields are at 6%. Thus, the investor pays 100% of the face or par value of the security. Subsequently, rates rise to 7%. The investor decides to sell the original bond with the 6% yield, but no one will pay par as notes are now quoted at 7%. Now he 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, one receives 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 frequently quoted in percent of par to the nearest 1/32nd of 1% of par. For example, one may quote a bond or note at 106-20. This equates to a value of 106% of par plus 20/32nds. The decimal equivalent of this value is 106.625. Thus, a one million-dollar face value security might be priced at $1,066,250. If the price moves by 1/32nd from 106-20 to 106-21, 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 bond or note in the example above were to rally from 106-20/32nds by 1/64th, it may be quoted at 106-20+. The trailing "+" may be read as +1/64th.

Quotation Practices

Cash Market Quote	Means	Decimal Equivalent	Futures Market Quote
106-20	106-20/32nds	106.625% of par	106-20
106-202	106-20/32nds + 1/128th	106.6328125% of par	106-202
106-20+	106-20/32nds + 1/64th	106.640625% of par	106-205
106-206	106-20/32nds + 3/128ths	106.6484375% of par	106-207

Or, you may quote to the nearest 1/128th. If, for example, our bond were to rally from 106-20/32nds by 1/128th, it might be quoted on a cash screen as 106-202. The trailing "2" may be read as +2/8ths of 1/32nd; or, 1/128th. If the security rallies from 106-20/32nds by 3/128ths, it may be quoted as 106-206. The trailing "6" may be read as +6/8ths of 1/32nd or 3/128ths.

Bonds and notes are quoted in percent of par. But they are further quoted in increments of 1% of par down to the nearest 1/32nd, 1/64th or even 1/128th of 1% of par.

Futures quotation practices are similar but not entirely identical. A quote of 106-202 is the same no matter whether you are looking at a cash or a futures quote. It means 106% of par plus 20/32nds plus 1/128th. But in the case of the cash markets, that trailing "2" means 2/8ths of 1/32nd = 1/128th. In the case of the futures markets that trailing "2" represents the truncated value of 0.25 x 1/32nd or 1/128th. A quote of 106-20+ in the cash markets is equivalent to 106-205 in the futures market. That trailing "5" represents 0.5 x 1/32nd or 1/64th. A quote of 106-206 in the cash markets is equivalent to 106-207 in the futures market. The trailing "7" represents the truncated value of 0.75 x 1/32nd = 3/128ths.

Treasury quotations practices may differ slightly in the context of the cash or spot Treasury markets vs. Treasury futures markets.

The normal commercial "round-lot" in the cash markets is $1 million face value. Anything less might be 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. 30-year Treasury bond, 10-year Treasury note and 5-year Treasury note futures, however, are traded in units of $100,000 face value. 3-year and 2-year Treasury note futures are traded in units of $200,000 face value.

***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 Wednesday, July 25, 2007. You purchase $1 million face value of the 4-½% security of May 2017 (a ten-year note) for a price of 96-27 ($968,437.50) to yield 4.90%, for settlement on Thursday, July 26, 2007. In addition to the price of the security, you must further compensate the seller for interest of $8,804.35 accrued during the 72 days between May 15, 2007 (the issue date) and the settlement date of July 26th. This interest is calculated relative to the 184 days between the issue date of May 15th and the next coupon payment date of November 15th or $8,804.35 [= (72/184) x ($45,000/2)]. The total purchase price is $977,241.85.

Price of Note	$968,437.50
Accrued Interest	$8,804.35
Total	$977,241.85

When you purchase a Treasury bond or note, you are obligated to compensate the seller for any interest accrued since the last semi-annual interest payment date.

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.

One normally "settles" or receives delivery vs. cash payment of a Treasury security on the next business day. But it is possible to defer settlement for another day or more.

Unlike the futures market where trades are settled on the same day they are transacted, it is customary to settle a cash 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 securities are auctioned on a regular basis by the U.S. Treasury which accepts bids on a yield basis from security 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. As a security is auctioned and the results announced, the Treasury affixes a particular coupon to bonds and notes that is near prevailing yields. At that time, coupon bearing bonds and notes may be quoted on a price rather than a yield basis although bills continue to be quoted and traded on 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 actively traded of Treasury securities and, therefore, are often referenced as pricing benchmarks. Less recently issued securities are known to as "off-the-run" securities and tend to be less liquid.

The U.S. Treasury issues securities of varying structures and maturities on a regular schedule.

The most recently auctioned Treasury of a particular maturity or tenor is referred to as the "on-the-run" security. As opposed to less recently auctioned securities which are considered "off the run."

The Treasury currently issues 4-week, 13-week and 26-week bills; 2-year, 3-year, 5-year, 7-year and 10-year notes; and, 30-year bonds on a regular schedule. In the past, the Treasury had also issued securities with a 4-year and 20-year maturity. Further, the Treasury may issue very short term cash management bills along with Treasury Inflation Protected Securities or "TIPS."

U.S. Treasury Auction Schedule

	Maturity	Auctioned
Cash Management Bills	Usually 1-7 Days	As Needed
Treasury Bills	4-, 13- and 26-Week	Weekly
Treasury Notes	2-, 3-, 5- and 7-Year	Monthly
	10-Year	February, May, August and November
Treasury Bonds	30-Year	February & August with re-openings in May and November
Treasury Inflation Protected Securities (TIPS)	5-Year	April with re-openings in October
	10- and 20-Year	January with re-openings in July

***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 4-week 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.

The most recently issued bond is often referred to as the "long bond." But the most recently issued security of any tenor may be referred to as the "new" security. Thus, the second most recently issued security of a particular original tenor may be referred to as the "old" security, the third most recently issued security is the "old-old" security, the fourth most recently issued security is the "old-old-old" security.

Quoting 'the Run'
(As of July 25, 2007)

	Coupon	Maturity	Bid	Ask	Chg	Ask Yield
1-Week Bill	Na	8/02/07	4.93%	4.92%	+0.01	5.01%
3-Mth Bill	Na	10/25/07	4.84%	4.83%	-0.03	4.97%
6-Mth Bill	Na	01/24/08	4.85%	4.84%	-0.01	5.04%
2-Yr Note	4-7/8%	Jun-09	100-07+	100-08	-	4.74%
3-Yr Note	4-1/2%	May-10	99-12+	99-13	+00+	4.73%
5-Yr Note	4-7/8%	Jun-12	100-13	100-13+	+01+	4.78%
10-Yr Note	4-1/2%	May-17	96-27	96-28	+01	4.90%
30-Yr Bond	4-3/4%	Feb-37	95-22+	99-23+	+00+	5.03%

Treasury bonds and notes frequently trade prior to their actual auction and issuance on a "when issued" or "WI" basis. They are quoted in terms of yield rather than price when traded on a WI basis to the extent that the Treasury defers identification of the specific coupon until actual issuance. In fact, periodic Treasury auctions are conducted on a yield and not on a price basis.

As of this writing, the most recently issued 10-year note may be identified as the 4-½% note maturing in May 2017; the old note is the 4-5/8% note of February 2017; the old-old note is the 4-5/8% of November 2016; the old-old-old note is the 4-7/8% of August 2016. Beyond that, one is expected to identify the security of interest by coupon and maturity. For example, the "5-1/8s of '16" refers to the note with a coupon of 5-1/8% maturing on May 15, 2016. As of this writing there were not any "WI" or "when issued" 10-year notes. Note, however, that WIs typically trade on a yield basis in anticipation of the establishment of the coupon subsequent to the original auction.

Most Recently Issued 10-Year Notes
(As of July 25, 2007)

	Coupon	Maturity	Price	Yield
WI				
On-the-Run Note	4-1/2%	5/15/17	96-26	4.913%
Old Note	4-5/8%	2/15/17	97-24	4.923%
Old-Old Note	4-5/8%	11/15/16	97-26+	4.918%
Old-Old-Old Note	4-7/8%	8/15/16	99-20	4.926%
	4-1/2%	2/15/16	97-06	4.906%
	5-1/8%	5/15/16	101-13+	4.923%
	4-1/2%	11/15/15	97-09	4.902%
	4-1/4%	8/15/15	95-24	4.894%
	4-1/8%	5/15/15	95-02+	4.890%
	4%	2/15/15	94-15	4.884%
	4-1/4%	11/15/14	96-09	4.860%
	4-1/4%	8/15/14	99-14	4.836%
	4-3/4%	5/15/14	99-16	4.836%

One important provision is whether or not the security is subject to call. A "callable" security 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 at that time, 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.[3]

***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.

On-the-run securities are typically more actively traded or "liquid" than off-the-run securities. That liquidity is valuable and, therefore, on-the-runs are typically bid up to a higher price and lower yield than other recently issued securities of the same tenor.

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 subjects of a strip transaction per the STRIPS program.

In any event, as these securities find a home, supplies may become rare. As a result, bid/offer spreads may 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.

Treasury dealers will often quote "the roll" or the difference between the yield on the on-the-run security vs. the 2nd most recently auctioned security of the same tenor or the "old bond" or "old note," as the case may be.

Traders will frequently quote a "roll" transaction where one sells the old security in favor of the new security. The "old note" in our table above was quoted at a yield of 4.923% while the "new note" was seen at 4.913%. Clearly, someone is willing to give up a basis point (0.01%) in yield for the privilege of holding the new note vs. the old note. In other words, liquidity has some observable value. Dealers may quote a

[3] 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 STRIP is usually less than a comparable maturity coupon-bearing Treasury. Beginning with 10s and 30s issued in February 1986, the Treasury began assigning separate CUSIP numbers to the principal value and to tranches of coupon payments associated with these securities. A CUSIP number 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.

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

A repurchase or repo transaction represents a way to borrow on a short-term basis using Treasury securities as collateral.

A reverse repo implies that one is the lender in the repo transaction, accepting the Treasury as collateral.

***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.

Sometimes supplies of particular Treasury securities become "tight" and are in high demand. These securities are said to go "on special" as lenders offer higher rates so that they may accept these securities as collateral.

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, one 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.

Treasury Futures Delivery Practices

While one might refer to Treasury bond futures as "30-year bond futures," that reference is a bit misleading. Treasury bond futures permit the delivery in satisfaction of a maturing contract of *any* U.S. Treasury security provided that it does not mature and is not callable for a period of at least 15 years from the date of delivery. It is likewise tempting to refer to U.S. Treasury bond futures as "6% bond contracts." This too may be somewhat misleading. T-bond futures are based *nominally* upon a 6% coupon security. But in point of fact, the contract permits the delivery of *any* coupon security, again provided that it meets the maturity specification mentioned above. In other words, shorts are not necessarily required to deliver 6% coupon bonds and, of course, there may come a time when in fact there may be no eligible for delivery bonds carrying a 6% coupon!

Because of the rather broadly defined delivery specifications, a significant number of securities, ranging widely in terms of coupon and maturity, may be eligible for delivery. This applies with equal effect to 2-, 3-, 5- and 10-year Treasury note futures as well.

Treasury futures are based "nominally" on a 6% coupon security. In practice, however, any Treasury security which meets certain maturity specifications may be eligible for delivery against the 2-, 3-, 5-, 10- and 30-year Treasury futures contracts.

Conversion Factor Invoicing System – Securities with varying characteristics, such as coupon and maturity, will of course be more or less valued by the investment community. High-coupon securities, for example, will naturally command a greater price than comparable low-coupon securities.

These differences must be reflected in the futures contract. In particular, when a short makes delivery of securities in satisfaction of a maturing futures contract, the long will pay a specified invoice price to the short. As discussed above, the futures contract permits the delivery of a wide range of securities at the discretion of the short. That invoice value must be adjusted to reflect the specific pricing characteristics of the security that is tendered. Accordingly, Treasury futures utilize a "conversion factor" invoicing system to reflect the value of the security that is tendered by reference to the 6% futures contract standard. In particular, the "Principal Invoice Amount" paid from long to short upon delivery may be identified as the Futures Settlement Price multiplied by the Conversion Factor (CF) multiplied by $1,000 (to reflect the $100,000 face value futures contract size).

Because securities with varying maturities and coupons may command very different values in the marketplace, Treasury futures provide for an adjustment in the invoice price paid from long to short upon delivery of a particular Treasury security in satisfaction of a maturing Treasury futures contract. This adjustment is made by application of the conversion factor invoicing system.

$$\text{Principal Invoice Price} = \text{Futures Settlement} \times \text{Conversion Factor} \times \$1{,}000$$

Any interest accrued since the last semi-annual interest payment date is added to the principal invoice amount to equal the "total invoice amount."

$$\text{Total Invoice Amount} = \text{Principal Invoice Amount} + \text{Accrued Interest}$$

Treasury Contracts Summary

	2-Year Note Futures	3-Year Note Futures	5-Year Note Futures	10-Year Note Futures	30-Year Bond Futures
Contract Size	$200,000 face-value U.S. Treasury notes		$100,000 face-value U.S. Treasury notes		$100,000 face-value U.S. Treasury bonds
Delivery Grade	T-notes with original maturity of not more than 5 years and 3 months and remaining maturity of not less than 1 year and 9 months from 1st day of delivery month but not more than 2 years from last day of delivery month	T-Notes with original maturity of not more than 5-1/4 years and a remaining maturity of not more than 3 years but not less than 2 years, 9 months from last day of delivery month	T-notes with original maturity of not more than 5 years and 3 months and remaining maturity of not less than 4 years and 2 months as of 1st day of delivery month.	T-notes maturing at least 6-½ years but not more than 10 years, from 1st day of delivery month.	T-bonds not callable for 15 years from 1st day of delivery month; if callable, a minimum maturity of 15 years from 1st day of delivery month.
Invoice Price	Invoice price = settlement price x conversion factor (CF) plus accrued interest, CF = price to yield 6%				
Delivery Method	Via Federal Reserve book-entry wire-transfer				
Contract Months	March quarterly cycle – March, June, September, December				
Trading Hours	Open Auction: 7:20 am-2:00 pm, Monday-Friday; Electronic: 6:00 pm - 4:00 pm, Sunday-Friday (Central Times)				
Last Trading & Delivery Day	Business day preceding last 7 business days of month; last delivery day is last business day of delivery month				
Price Quote	In percent of par to one-quarter of 1/32nd of 1% of par ($15.625 rounded up to nearest cent)		Quoted in percent of par to one-half of 1/32nd of 1% of par ($15.625 rounded up to nearest cent)		Quoted in percent of par to 1/32nd of 1% of par ($31.25)

A conversion factor may be thought of as the price of the delivered security as if it were yielding 6%. Clearly, high-coupon securities will tend to have high CFs while low-coupon securities will tend to have low CFs. In particular, bonds with coupons less than the 6% contract standard will have CFs that are less than 1.0; bonds with coupons greater than 6% have CFs greater than 1.0.

- The conversion factor for delivery of the 4-¾% Treasury note of 2014 vs. September 2007 10-year Treasury note futures is 0.9335. This suggests that a 4-¾% security is approximately valued at 93% as much as a 6% security. Assuming a futures price of 106-19, the principal invoice amount may be calculated as …

The conversion factor is calculated as the price of a security with the coupon and maturity of the particular Treasury in question as if it were to yield 6%.

Principal Invoice Amount	=	106-19 (106.59375)	x	$1,000	x	0.9335
	=	$99,505.27				

- The conversion factor for delivery of the 5-1/8% Treasury note of 2016 vs. September 2007 10-year Treasury note futures is 0.9424. This suggests that a 5-1/8% security is approximately valued at 94% as much as a 6% security. Assuming a futures price of 106-19, the principal invoice amount may be calculated as …

Principal Invoice Amount	=	106-19 (106.59375)	x	$1,000	x	0.9424
	=	$100,453.95				

In order to arrive at the total invoice amount, one must further add any accrued interest since the last semi-annual interest payment date to the principal invoice amount.

***Cheapest-to-Deliver* –** The intent of the conversion factor invoicing system is to render equally economic the delivery of any eligible-for-delivery securities. Theoretically, the short who has the option of delivering any eligible security should be indifferent as to his selection. However, the CF system is imperfect in practice as we find that a particular security will tend to emerge as "cheapest-to-deliver" (CTD) after studying the relationship between cash security prices and principal invoice amounts.

The conversion factor invoicing system is intended to render equally economic the delivery of any eligible for delivery, security. But in practice, a single security tends to stand out as cheapest or most economic to deliver in light of the relationship between the cash value of the Treasury and the pro-forma invoice amount.

- On July 25, 2007, one might have been able to purchase the 4-3/4%-14 at 106-19 ($99,505.27 per $100,000 face value unit); at the time, the 5-1/8%-16 was valued at perhaps 106-19 ($100,453.95 per $100,000 face value unit). Compare these cash values to the principal invoice amounts …

	4-3/4%-14	5-1/8%-16
Futures	106-19	106-19
x CF	0.9335	0.9424
x $1,000	$1,000	$1,000
= Invoice	$99,505.27	$100,453.95
- Cash	$99,500.00	$101,421.87
= Return	$5.27	($967.92)

The eligible for delivery security which generates the greatest gain or lowest loss upon delivery is cheapest-to-deliver (CTD).

Futures will track or price or correlate most closely with the CTD security.

Our analysis suggests that a slight gain of $5.27 may be associated with the delivery of the 4-3/4%-14 while a loss of $967.92 might be associated with the delivery of the 5-1/8%-16. One might conclude that the 4-3/4%-14 note is cheaper or more economic to deliver than the 5-1/8%-16. If one were to run this analysis for *all* eligible-for-delivery securities, one could identify *the* cheapest-to-deliver (CTD) security as the security with the lowest basis. It is important to identify the CTD security to the extent that Treasury futures will tend to price or track or correlate most closely with the CTD. This has interesting implications from the standpoint of a "basis trader" or a hedger as discussed below

10-Year T-Note Futures Basis Relationships
(as of July 25, 2007)

Coupon	Maturity	Price	Yield	Sep-07 CF	Basis	Dec-07 CF	Basis
4-1/2%	5/15/17	96-26	4.913%	0.8926	53.3	0.8946	51.9
4-5/8%	2/15/17	97-24	4.923%	0.9034	46.5	0.9054	45.1
4-5/8%	11/15/16	97-26+	4.918%	0.9054	42.2	0.9074	40.8
4-7/8%	8/15/16	99-20	4.926%	0.9242	35.6	0.9259	35.3
5-1/8%	5/15/16	101-13+	4.923%	0.9424	31.0	0.9436	32.5
4-1/2%	2/15/16	97-06	4.906%	0.9034	28.5	0.9058	25.8
4-1/2%	11/15/15	97-09	4.902%	0.9058	23.3	0.9080	21.3
4-1/4%	8/15/15	95-24	4.894%	0.8927	19.0	0.8955	14.8
4-1/8%	5/15/15	95-02+	4.890%	0.8881	13.2	0.8910	8.6
4%	2/15/15	94-15	4.884%	0.8837	8.7	0.8870	2.8
4-1/4%	11/15/14	96-09	4.860%	0.9012	7.0	0.9040	2.9
4-1/4%	8/15/14	96-14	4.836%	0.9040	2.5	0.9069	-2.0
4-3/4%	5/15/14	99-16	4.836%	0.9335	-0.2		

September 2007 10-year T-note futures were valued at 106-19 while
December 2007 10-year T-note futures were valued at 106-13

The basis is calculated as the cash price less the adjusted futures price where the adjusted futures price is calculated as the futures price multiplied by its conversion factor. The eligible for delivery security with the lowest basis is CTD.

***The Basis* –** Typically we expect to find a single security, or perhaps a handful of similar securities, will emerge as CTD. This identification has important implications for basis traders who arbitrage cash and futures markets. A basis trader will seek out arbitrage opportunities or situations where they might be able to capitalize on relatively small pricing discrepancies between cash securities and Treasury futures by buying "cheap" and selling "rich" items.

Arbitrageurs will track these relationships by studying the "basis." The basis describes the relationship between cash and futures prices and may be defined as the cash price less the "adjusted futures price" or the futures price multiplied by the conversion factor. The basis is normally expressed in 32^{nds}. *E.g.*, 1-1/4 points might be shown as $40/32^{nds}$.

Basis	=	Cash Price	-	Adjusted Futures Price
Adjusted Futures Price	=	Futures Price	x	Conversion Factor

The adjusted futures price is essentially equivalent to the principal invoice amount except that the adjusted futures price is typically expressed in percent of par while the principal invoice amount may be expressed in dollars per $100,000 face value unit. Earlier we had studied principal invoice amounts less cash values noting that the basis is analogous as it compares the cash price less the adjusted futures price.

- As of July 25, 2007, a comparison of cash and adjusted futures prices (≈ principal invoice amount) provides us with a quote for the basis associated with the 4-3/4%-14 and the 5-1/8%-16 …

	4-3/4%-14	5-1/8%-16
Cash Price	99-16	101-13+
- Futures Price	106-19	106-19
x CF	0.9335	0.9424
(Adjusted Futures Price)	≈99-162	≈101-15+
= Basis	≈–0.2/32^{nds}	≈31/32^{nds}
Return on Delivery	$5.26	($967.92)

The basis of ≈–0.2/32^{nds} associated with the 4-3/4%-14 corresponds to a slight gain on delivery of $5.26 while the basis of ≈31/32^{nds} associated with the 5-1/8%-16 corresponds to a loss on delivery of $967.92. As a general rule, the security with the lowest basis, *i.e.*, the largest gain or smallest loss on delivery, may be considered CTD. Clearly, the 4-3/4%-14 is cheaper-to-deliver than the 5-1/8%-16. By examining the table above depicting the basis for all eligible-for-delivery securities, one may confirm that in fact the 4-3/4%-14 was *the* CTD although there are quite a few securities, not coincidentally with similar coupons and maturities, which are near CTD. In fact, the entire battery of eligible for delivery securities features similar coupons and maturities

There may be many reasons why a single security typically stands out as cheapest or most economic to deliver. In particular, the conversion factor invoicing system may be considered flawed in the sense that it applies the assumption that all eligible for delivery securities are yielding 6%.

Many cash market factors impact upon the relative value of securities, not the least of which is the prevailing shape of the yield curve.

Why Is One Issue CTD? – If the conversion factor invoicing system were to perform flawlessly, all eligible-for-delivery securities would have a similar basis and be equally economic to deliver. As suggested above, however, a single security or several similar securities tend to emerge as CTD. The CF invoicing system is imperfect because it is implicitly based on the assumption that (1) all eligible for delivery securities have the same yield; and (2) that yield is 6%. There are any number of "cash market biases" that impact upon the yield of a Treasury security. Further mathematical biases in the CF calculation will tilt the field towards securities of particular coupons and maturities when yields are greater than or less than the 6% contract standard.

"Cash market biases" may be used as a catch-all phrase for anything that impacts upon the relative yields of bonds. Perhaps "supply-demand considerations" is an equally appropriate term. A key concept is that shorts will elect to deliver securities that are somehow inferior to others they would prefer to retain in their portfolios. Some specific reasons why securities, even those with similar coupons and maturities, may carry somewhat different yields include the shape of the yield curve, reinvestment risks, liquidity preferences, tax considerations, etc.

For example, in an upwardly sloping or "normal" yield curve environment, longer-term securities may carry somewhat higher yields (lower prices) than comparable shorter-term securities; and, the lower the price (relatively speaking), the greater the likelihood that a short will wish to dump the security through the deliver process. This factor may not exert a tremendous impact upon deliveries unless the yield curve shows some reasonable slant to it either upwardly sloped or inverted. In fact, we observe that the yield curve has historically been rather flat out past 15 years and, therefore, this factor has had little impact on the delivery of bonds into the 30-year T-bond contract. In our example above, however, we see that there is an approximate 8 basis point difference between the yield on the most recently issued 10-year note and the shortest maturity yet still eligible for delivery security. Thus, the slope of the yield is in fact providing some bias towards the delivery of short maturity securities vs. the 10-year T-note contract.

So-called conversion factor biases may be the most significant considerations that impact upon which security is CTD. When yields are greater than the 6% futures contract standard, there is a bias towards the delivery of long duration (low coupon, long maturity securities. When yields are less than the 6% futures contract standard, there is a bias towards the delivery of short duration (high coupon, short maturity) securities.

Low or generally falling yields may prove problematic to the security investor to the extent that a significant component of one's return is attributable to reinvestment income. Coupon payments, once received, will be reinvested, presumably at prevailing short-term rates. When reinvestment risks become noticeable, investors will prefer low-coupon securities, generating small coupons carrying limited reinvestment risks, over high-coupon securities. Thus, those high-coupon securities may become CTD.

As discussed above, recently issued or "on-the-run" securities generally offer enhanced liquidity relative to "off-the-run" securities. Consequently, on-the-run bond prices may be bid up, their yields pushed down and may, therefore, be unlikely candidates to become CTD. Likewise, tax considerations have the potential to tilt deliveries towards high coupon as opposed to low coupon securities.

Perhaps more important that these cash market factors, there are observable biases associated with the mathematics of the conversion factor system or "*conversion factor biases.*" For example, it is clear that long duration, *i.e.,* low-coupon, long-maturity securities, will become CTD when yields are significantly greater than the 6% contract standard. When yields fall below the 6% contract standard, these factors will bias towards the delivery of short-duration, *i.e.,* high-coupon, short-maturity securities.

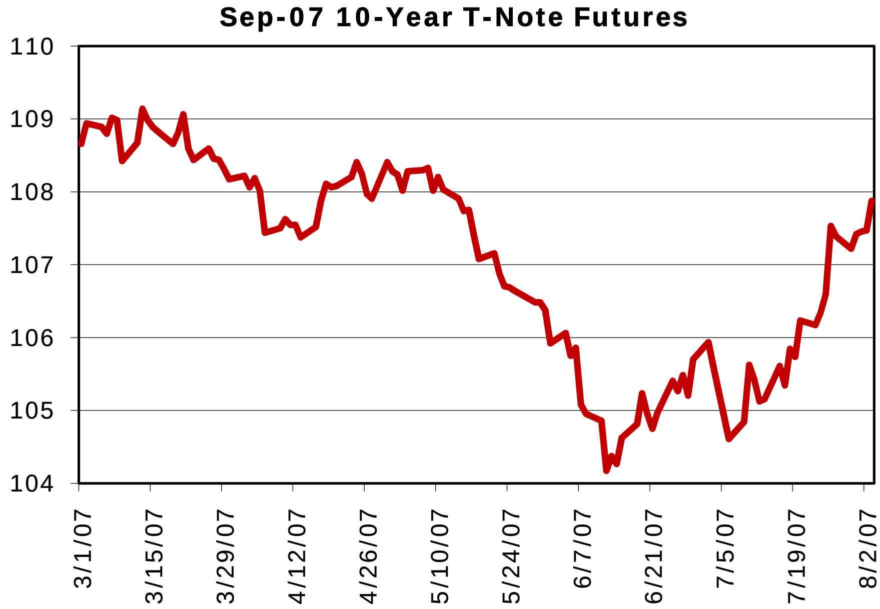
IF yields > 6%	➔	Bias to long duration (*i.e.*, low-coupon, long-maturity) securities
IF yields < 6%	➔	Bias to short duration (*i.e.*, high-coupon, short-maturity) securities

Duration is explained more thoroughly below but think of duration as a measure of risk. When yields are rising and prices are declining, investors will gravitate towards less risky or short-duration securities. They will want to dump riskier long duration securities, creating a delivery bias in favor of those long duration bonds. On the other hand, when yields are declining and prices rising, investors will prefer those riskier long duration securities. They will wish to dump less aggressive short duration securities, creating a delivery bias in favor of those short duration securities.

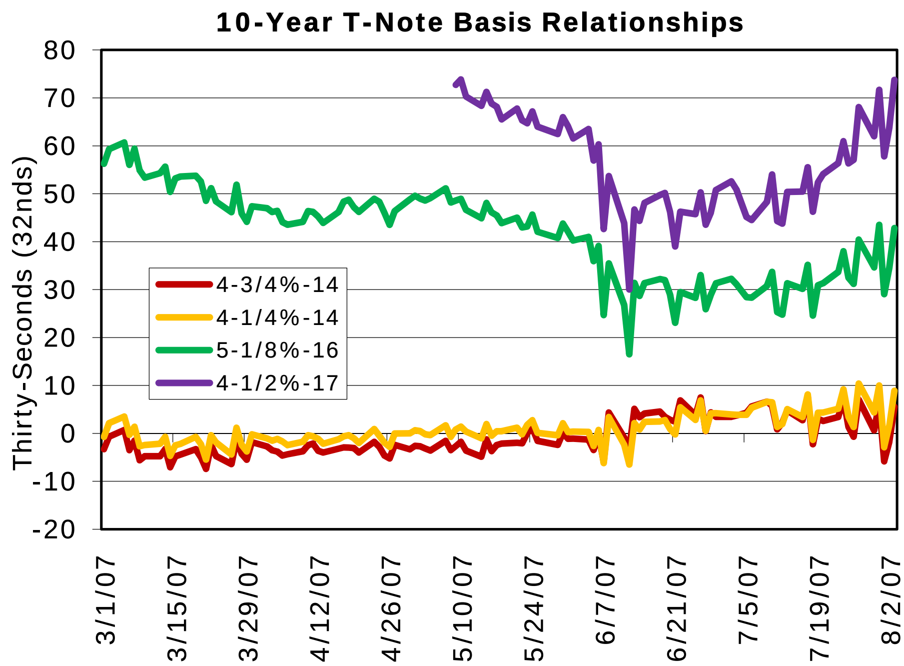
Conversion factor biases are manifested when yields fluctuate. For example, if yields were to rise up towards 6%, short duration securities may become less attractive to deliver as the basis for longer duration securities will tend to fall.

As indicated above, the 4-3/4%-14 was CTD as of July 2007. This security had a relatively low duration compared to the field of eligible for delivery securities against the 10-year Treasury note contract by virtue of the fact that it was the shortest maturity security that was actually eligible for delivery. Further contributing to its relatively short duration is the fact that its coupon at 4-3/4% was greater than all but two other eligible for delivery securities. Note that yields were in the range of approximately 4.8% to 4.9% and well below the 6% futures contract standard. As a result, conversion factor biases were exerting a slant towards the delivery of short duration securities, specifically the shortest duration yet still eligible for delivery security in the form of the 4-3/4%-14.

Note that in the period from March to June 2007, futures prices were generally declining while yields were rising up towards the 6% futures contract standard. As a result, these conversion factor biases were diminishing and we witnessed some very slight crossovers such that the basis for a somewhat longer duration security in the form of the 4-1/4%-14 became CTD at least on a temporary basis. In fact the basis for securities of an even longer duration including the 4-1/2%-17 and the 5-1/8%-16 were declining during this period as well as a function of diminishing conversion factor biases.



Subsequently during the period from June and into August 2007, prices began to rally back and yields fell farther below the 6% futures contract standard. Note that during that period, the shortest duration security in the form of the 4-3/4%-14 reestablished itself as CTD. Note further that the basis for other eligible for delivery securities such as the 4-1/2%-17 and the 5-1/8%-16 started to advance as conversion factor biases began to exert a larger influence.



Thus, it is clear that the performance of the basis is strongly driven by directional price movement in the Treasury markets. This suggests that buying the basis (buying a cash Treasury and selling futures with the possibility of subsequently making delivery) or selling basis (selling a cash Treasury and buying futures with the possibility of subsequently repossessing the security by standing long in the delivery process) may be motivated by expectations regarding rising or falling yields.

Basis traders attempt to take advantage of directional expectations by selling long duration basis and/or buying short duration basis when yields are expected to rise. Or, by buying long duration basis and selling short duration basis when yields are expected to rise.

If yields rising above 6% (prices falling) ➔

- Sell long duration basis (sell long duration securities & buy futures)
- OR, buy short duration basis (buy short duration securities & sell futures)

If yields falling under 6% (prices rising) ➔

- Buy long duration basis (buy long duration securities & sell futures)
- OR, sell short duration basis (sell short duration securities & buy futures)

Implied Repo Rate – We often suggest that the eligible for delivery security with the lowest basis is cheapest-to-deliver. But to be perfectly correct, we may point out that the structure of coupon receipts and reinvestment of such coupon income plays some (generally small) part in establishing a particular security as cheapest-to-deliver as well. Hence, traders often calculate the "implied repo rate" (IRR) associated with eligible for delivery securities to account for such factors.

A more precise way to identify the cheapest to deliver security is to calculate the implied repo rate. The IRR is a bit more accurate than simple reference to the basis because it takes into account all the cash flows associated with a basis transaction including any possible receipt of coupon income and reinvestment income associated with a coupon payment.

The IRR is calculated as the annualized rate of return associated with the purchase of a security, sale of futures and delivery of the same in satisfaction of the maturing futures contract. This calculation indeed takes into account all the cash flows associated with the security. The assumption that the basis for any particular security may completely converge to zero is implicit in the IRR calculation.

As a general rule, the security with the lowest basis will likewise exhibit the highest implied repo rate. This is indeed the case with respect to the 4-3/4%-14 with an IRR at 4.66% for delivery into the September 2007 futures contract. Buying the basis, or buying cash and selling futures with the option of making delivery in satisfaction of the maturing futures contract, may be considered as comparable to other investment alternatives of a similar term. For example, we might compare the 4.66% IRR on the CTD as comparable to the prevailing 13-week T-bill yield of 4.83%. Thus, the IRR is slightly below prevailing rates of a similar term. The disparity between the IRR of other non CTD deliver securities is even greater.

10-Year T-Note Futures Basis Relationships
(as of July 25, 2007)

Coupon	Maturity	Price	Yield	Sep-07 CF	Basis	IRR
4-1/2%	5/15/17	96-26	4.913%	0.8926	53.3	-5.27%
4-5/8%	2/15/17	97-24	4.923%	0.9034	46.5	-3.69%
4-5/8%	11/15/16	97-26+	4.918%	0.9054	42.2	-2.93%
4-7/8%	8/15/16	99-20	4.926%	0.9242	35.6	-1.45%
5-1/8%	5/15/16	101-13+	4.923%	0.9424	31.0	-0.42%
4-1/2%	2/15/16	97-06	4.906%	0.9034	28.5	-0.60%
4-1/2%	11/15/15	97-09	4.902%	0.9058	23.3	0.31%
4-1/4%	8/15/15	95-24	4.894%	0.8927	19.0	0.87%
4-1/8%	5/15/15	95-02+	4.890%	0.8881	13.2	1.79%
4%	2/15/15	94-15	4.884%	0.8837	8.7	2.53%
4-1/4%	11/15/14	96-09	4.860%	0.9012	7.0	3.01%
4-1/4%	8/15/14	96-14	4.836%	0.9040	2.5	3.87%
4-3/4%	5/15/14	99-16	4.836%	0.9335	-0.2	4.66%

September 2007 10-year T-note futures were valued at 106-19 while
December 2007 10-year T-note futures were valued at 106-13

Consider the discrepancy with respect to the CTD to represent a risk premium of sorts. If one buys the CTD security and sells futures with the intention of making delivery, the worst case scenario has the basis converging fully to zero and the hedger essentially locking in a return equal to the IRR, in this case 4.66%. But if market conditions should change such that another security becomes CTD, this implies that the basis may advance or at least fail to completely converge to zero. As a result, the trader may realize a rate of return that is in fact greater than the currently calculated IRR.

The basis, even for the CTD security, is sometimes a little above pure cost of carry considerations. Another way of saying this is that the IRR for the CTD security is typically a bit below prevailing short-term interest rates. This difference represents the probability that there will be a "crossover" such that some other security becomes CTD. This difference may further be compared to an option premium noting that there are some analogies between the basis and options.

Optionality in the Basis - In other words, there is a certain degree of "optionality" associated with the purchase or sale of the basis. Buying the basis is analogous to buying an option which, of course, implies limited risk. Buying the basis implies limited risk to the extent that under the worst of circumstances you make delivery of the security which is effectively equivalent to the possibility that the basis fully converges to zero. But crossovers may occur such that the basis converges at a slower rate than otherwise anticipated or actually advances. As a result, this short-term investment may generate a return which is (at least theoretically) unbounded on the upside. *I.e.,* limited risk accompanied by unbounded upside potential is reminiscent of the risk/reward profile of a long option position, thus the analogy between a long basis position and a long option.

The best one may hope by selling the basis, or selling securities and buying futures with the possibility of effectively replacing the sold security by standing long in the delivery process, is that the basis fully converges to zero. This implies limited profit potential. But in the event of significant changes in market conditions, the basis may advance sharply exposing the seller of the basis to (theoretically) unbounded risks. Limited profit potential accompanied by unbounded risk is reminiscent of the risk/reward profile of a short option position, thus the analogy between a short basis position and a short option.

As discussed above, the basis even for the CTD security tends to be in excess of cost of carry considerations. This is manifest in the fact that the IRR even for the CTD is typically a bit below prevailing short-term rates. This premium in the basis essentially reflects the uncertainties associated with which security may become CTD in the future. Thus, the basis performs much akin to an option. Like any other option, the basis will therefore by affected by considerations including term, volatility and strike price. The relevant term in this case is the term remaining until the presumed delivery date vs. the futures contract. Market volatility affects the probability that a crossover may occur. Rather than speak of a strike or exercise price, it is more appropriate to assess the market's proximity to a "crossover point" or a price/yield at which one might expect an alternate security to become CTD.

Buying the basis for the CTD security is like buying an option because you can assume that the worst case scenario is full cash/futures convergence. Thus, the loss of the basis, adjusted by cost of carry considerations, represents the maximum possible loss … like buying an option. But if there is a crossover, the basis may appreciate considerably, implying "open ended" profit potential akin to the purchase of an option.

Consider the purchase or sale of the CTD basis. The degree to which this basis performs like a call or a put option is contingent upon the relationship between market prices and the 6% futures contract standard.

If yields are below the 6% futures contract standard, the CTD basis may be expected to advance if prices decline (rates rise) towards 6%; or, decline if prices advance (rates fall). Thus, buying the CTD basis when rates are below 6% is akin to the purchase of a put option. Conversely, the sale of the CTD basis when rates are less than 6% is akin to the sale of a put option where the value of transaction is capped if prices should advance while losses may be unbounded if prices should decline.

Selling the basis of the CTD is like selling an option because there is limited profit potential implied by full cash/futures convergence. But there is open ended risk implied by the possibility of a crossover and significant appreciation in the value of the basis.

If yields are above the 6% futures contract standard, the CTD basis may be expected to advance if prices rise (rates fall) towards 6%; or, decline if prices fall (rates rise). Thus, buying the CTD basis when rates are above 6% is akin to the purchase of a call option. Conversely, the sale of the CTD basis when rates are above 6% is akin to the sale of a call option where the value of transaction is capped if prices should decline while losses may be unbounded if prices should advance.

Finally, if rates are close to the 6% futures contract standard, the basis for what is currently CTD may be dictated by considerations apart from conversion factor biases. Thus, there may be significant crossovers regardless of whether rates rise or fall. Buying the CTD basis under these considerations may be considered akin to the purchase of an option straddle (*i.e.*, the simultaneous purchase of call and put options). Under these circumstances the basis buyer may be indifferent between advancing or declining prices but has an interest in seeing prices move significantly in either direction. Selling the CTD basis when rates are near the 6% contract standard is akin to selling a straddle (*i.e.*, the simultaneous sale of both call and put options). The basis is sold under these circumstances because the trader anticipates an essentially neutral market. Of course, the basis premium over carry should accrue to the short basis trader under circumstances of continued price stability. But the short basis trader is exposed to the risk of dramatic price movements in either direction.

In order to manage the risks associated with fixed income securities, you need to measure those risks.

	Buy CTD Basis	**Sell CTD Basis**
Yields < 6%	Buy Put Option	Sell Put Option
Yields = 6%	Buy Straddle	Sell Straddle
Yields > 6%	Buy Call Option	Sell Call Option

In general, the longer the maturity and the lower the coupon associated with a Treasury security, the greater the risks. Risks are reduced with respect to shorter maturity and higher coupon Treasuries. These results are intuitive to the extent that a short maturity security implies that one will repossess the principle or corpus of the security all the more sooner than with respect to a longer maturity security. Likewise, high coupon securities imply that one receives more income now rather than later. The faster that one may secure cash flows, the lower the risk.

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 reasonably to manage them. The particular characteristics of a coupon-bearing security will clearly impact upon its volatility. Two readily identifiable ways to define coupon-bearing securities is in terms of their maturity and coupon. Defining volatility as the price reaction of the security in response to changes in yield …

The Longer the Maturity ↑ the Greater the Volatility ↑
The Higher the Coupon ↑ the Lower the Volatility ↓

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 BPVs of various on-the-run Treasuries as of July 25, 2007.

Measuring Volatility
(As of July 25, 2007)

	Coupon	Maturity	Bid	Ask	BPV	Duration
1-Week Bill	Na	8/23/07	4.93%	4.92%	$8.06	0.08
3-Mth Bill	Na	10/25/07	4.84%	4.83%	$25.56	0.26
6-Mth Bill	Na	01/24/08	4.85%	4.84%	$50.83	0.51
2-Yr Note	4-7/8%	Jun-09	100-07+	100-08	$182.70	1.86
5-Yr Note	4-7/8%	Jun-12	100-13	100-13+	$435.70	4.32
10-Yr Note	4-1/2%	May-17	96-27	96-28	$756.60	7.74
30-Yr Bond	4-3/4%	Feb-37	95-22+	99-23+	$1,481.80	15.15

This suggests that if the yield on the 30-year bond were to rise by a single basis point (0.01%), the price should decline by some $1,481.80 per $1 million face value unit.

The basis point value (BPV) of a security measures the expected dollar change in the value of the security given a 1 basis point (0.01%) change in yield.

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 measures the expected percentage change in the value of a security given a 100 basis point (1.00%) 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 30-year bond has a duration of 15.15 years. This implies that if its yield advances by 100 basis points (1.00%), we expect a 15.15% decline in the value of the bond.

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 5 times as volatile as the 2-year. But by examining durations, we reach a far different conclusion. The 10-year note (duration of 7.74 years) is only about 4.2 times as volatile as the 2-year note (duration of 1.86 years). The availability of cheap computing power has made duration analysis as easy as it is illuminating.

Risk Management with Treasury Futures

When executing a hedge, the idea is to offset any possible change in the value of the hedged security with an offsetting change in the futures contract. Thus, one may attempt to calculate the "hedge ratio" (HR) which balances those changes.

Treasury futures are intended to provide risk averse fixed income investors with the opportunity to hedge or manage the risks inherent in their investment activities. Effective use of these contracts, however, requires a certain grounding in hedge techniques. Most pointedly, one may attempt to assess the relative volatility of the cash item to be hedged relative to the futures contract price. This relationship is often identified as the futures "Hedge Ratio" (HR). Hedge ratios reflect the expected relative movement of cash and futures and provide risk managers with an indication as to how many futures to use to offset a cash exposure.

Conversion Factor Weighted Hedge – The most superficial way to approach identification of the appropriate hedge ratio is simply to match the face value of the item to be hedged with the face value of the futures contract. For example, if one owned $10 million face value of a particular security, the natural inclination is to sell or short 100 $100,000 face value futures contracts for a total of $10 million face value. However, this approach ignores the fact that securities of varying coupons and maturities have different risk characteristics.

Superficially, the conversion factor may be referenced as a quick way of assessing the prospective change in the value of the futures contract vis-à-vis any change in the value of the hedged security.

Conveniently, Treasury futures contract specifications provide a facile means by which to assess the relative risks associated with cash and futures. As discussed above, the conversion factor (CF) represents the price of a particular bond as if it were to yield 6%. In other words, the CF reflects the *relative value* and, by implication, the *relative volatility* between cash and futures prices.

- It is July 25, 2007 and you go long $10 million face value of the 5-1/8%-16 bond at 101-13+ to yield 4.923% for settlement on July 26th. This security has a conversion factor for delivery against September 2007 10-year Treasury futures contract of 0.9424. This implies that this security is roughly 94% as valuable and 94% as volatile as a 6% coupon security. Thus, one might sell 94 10-year note bond futures against that position as a hedge.

  Assume that yields uniformly rise 20 basis points (0.20%) and this hedge is held until August 28th. In other words, that the 4.923% yield on the 5-1/8%-16 rises to 5.123% and that its price falls to 100-00. If one liquidates the portfolio at that time, there is a net profit of $16,864.13 on the series of transactions or 1.80% on an annualized basis over the 33 days between July 25th and August 28th.

7/25/07	Hold $10,000,000 5-1/8%-16 @ 101-13+ (4.923%)	$10,142,187.50
	Accrued interest on 7/26/07	$101,664.40
	Sell 94 Sep-07 futures @ 106-19	-
	Initial Portfolio Value or Investment	$10,243,851.90
8/28/07	Hold $10,000,000 5-1/8%-16 @ 100-00 (5.123%)	$10,000,000.00
	Accrued interest on 8/29/07	$147,622.28
	Coupon income	$0
	Buy 94 futures @ 105-12+	$113,093.75
	Final Portfolio Value	$10,260,716.03
	Profit/Loss	$16,864.13

Return = (Profit/Loss ÷Initial Investment) x (360 ÷ Holding Period)
= ($16,864.13 ÷ $10,243,851.90) x (360 ÷ 33)
= 1.80%

This is certainly superior to the unhedged loss of $96,229.62 which equates to -10.25%. But bearing in mind that short-term rates were nearer to 5%, you could have and probably should have done a bit better.

The conversion factor hedge ratio is, however, flawed to the extent that it does not take into account the cash market biases and conversion factor biases discussed above which cause a single security to stand out as CTD.

	Return in $s	%age Return
CF Weighted Hedge	$16,864.13	1.80%
Unhedged	-$96,229.62	-10.25%

Basis Point Value Weighted Hedge – A conversion factor weighted hedge is likely to be quite effective under one particular circumstance, at least if you are hedging the cheapest-to-deliver security. Treasury futures will tend to price or track or correlate most closely with the CTD security. But other securities with varying coupons and maturities may react to changing market conditions differently. In order to understand the most effective techniques with which to apply a hedge, let us consider the fundamental objective associated with a hedge. A hedge is ideally intended to balance any loss (profit) in the cash markets with an equal and opposite profit (loss) in futures. Our goal, therefore, is to find a hedge ratio (HR) that allows one to balance the change in the value of the cash instrument to be hedged (Δ_h) with any change in the value of the futures contract (Δ_f).

$$\Delta_h = HR \times \Delta_f$$

Or, solving for the hedge ratio (HR) …

$$HR = \Delta_h \div \Delta_f$$

Unfortunately, the equation above is of an abstract nature and cannot be directly applied. Let us, therefore, backtrack a bit and discuss the relationship between Treasury futures and cash prices. We know that the principal invoice amount paid from long to short upon deliver will be equal to the price of the cash security multiplied by its conversion factor.

Rational shorts will of course elect to tender the cheapest-to-deliver security – thus, we might designate the futures price and the conversion factor of the cheapest-to-deliver as P_f and CF_{ctd}, respectively.

$$\text{Principal Invoice Amount} = P_f \text{ x } CF_{ctd}$$

One may identify the appropriate hedge ratio in the abstract by considering the change or "delta" of the hedged security and the cheapest to deliver security with which futures tend to track or price or correlate most closely.

Because the basis of the CTD is generally closest to zero, relative to all other eligible securities, we might assume that the futures price level and, by implication, any changes in the futures price level (Δ_f) will be a reflection of any changes in the value of the CTD (Δ_{ctd}) adjusted by its conversion factor (CF_{ctd}) …

$$\Delta_f \approx \Delta_{ctd} \div CF_{ctd}$$

Substituting this quantity into our equation specified above, we arrive at the following …

$$HR = \Delta_h \div (\Delta_{ctd} \div CF_{ctd})$$

But "change" is an abstract concept. Fortunately, we may operationalize this abstract concept by reference to basis point values (BPV). As a result, we may calculate a BPV hedge ratio.

Or rearranging the equation …

$$HR = CF_{ctd} \text{ x } (\Delta_h \div \Delta_{ctd})$$

Unfortunately, the concept of "change" is abstract. Let us operationalize that concept by substituting the basis point value of the hedged security (BPV_h) and the basis point value of the cheapest-to-deliver (BPV_{ctd}) for that abstract concept. Recall from our discussion above that a basis point value represents the expected change in the value of a security, expressed in dollars per $1 million face value, given a one basis point (0.01%) change in yield. Thus, we identify the "basis point value hedge ratio" …

$$BPV\ HR = CF_{ctd} \text{ x } (BPV_h \div BPV_{ctd})$$

Note that our analysis implicitly assumes that any changes in the yield of the hedged security and that of the cheapest-to-deliver security will be identical. *I.e.*, that we will experience parallel shifts in the yield curve. This analysis further presumes that you are able to identify the cheapest-to-deliver security and that it will remain cheapest-to-deliver. The latter assumption is, of course, questionable in a dynamic market.

- Let us find the basis point value hedge ratio (HR) associated with the 5-1/8%-16 security discussed in our previous example. It carried a BPV of some $713.50 per million. Recall that, as of July 25, 2007, the CTD security was identified as the 4-3/4%-14. This security had a BPV of $572.30 per million and a conversion factor of 0.9335 vs. September 2007 10-year Treasury futures. The hedge ratio may be identified as 116 contracts per $10 million face value of the 5-1/8%-16.

BPV HR = 0.9335 x ($713.50 ÷ $572.30)
= 1.1638

Note that the HR of 116 contracts is significantly greater than the 94 contracts suggested by reference to the conversion factor. This is due to the fact that the CTD 4-3/4%-14 security carries a relatively short duration of 5.70 years compared to the duration associated with the hedged security of 6.90 years. It is no coincidence that the ratio of durations is roughly equal to the ratio between the BPV and CF hedge ratios or (6.90 ÷ 5.70) ≈ (116 ÷ 94). In other words, the futures contract is pricing or tracking or correlating most closely with a shorter duration security. Consequently, futures prices will react rather mildly to fluctuating yields. Therefore one requires more futures to enact an effective hedge.

The BPV hedge ratio may be very different than the CF hedge ratio. In our example, the BPV HR was actually much higher than the CF hedge ratio. That may be explained by the fact that the CTD security was a very short duration, *i.e.*, not terribly volatile security. But if conditions change such that there is a crossover in the CTD, the appropriate HR will likewise change.

- What would our hedge ratio be if the CTD security was the 4-½%-16 with a duration of 6.86 years? Note that this security has a BPV of $680.10 and a conversion factor for delivery vs. September 2007 10-year T-note futures of 0.9034. Our analysis suggests that one might hedge with 95 contracts per $10 million face value of the 5-1/8%-16.

BPV HR = 0.9034 x ($713.50 ÷ $680.10)
= 0.9478

Note that this hedge ratio of 94 contracts is significantly less than the 116 contracts suggested by the BPV hedge ratio and actually quite similar to the 94 contracts suggested by the CF hedge ratio. This can be explained by the fact that the 4-½%-16 has pricing characteristics that are quite similar to 5-1/8%-16 security which is the subject of the hedge. In particular, the 4-½%-16 had a duration of 6.86 years relative to the 6.90 duration of the 5-1/8%-16. Because of the similar risk characteristics of the CTD and hedged security, the CF will do a reasonable job of identifying an appropriate hedge ratio.

This further suggests that if there is a crossover in the CTD from a short duration security to a longer duration security, the number of futures needed to hedge against the risk of declining prices is decreased. This may be a favorable circumstance for the hedger who is long cash Treasuries and short futures in a ratio prescribed by the BPV technique. Consider that as prices decline and longer duration securities become CTD, one is essentially overhedged in a declining market. If on the other hand, prices advance and even shorter duration securities become CTD, the appropriate hedge ratio will tend to increase. Thus, the long hedger becomes underhedged in a rising market. Another way of saying this is that there is a certain degree of "convexity" inherent in these relationships

If yields rise and prices decline, crossovers may occur such that more volatile, long duration securities will become CTD. If yields rise and prices advance, crossovers may cause less volatile, short duration securities to become CTD. These crossovers may benefit the hedger who is long cash and short futures (essentially long the basis). Consider that if prices decline, the long basis trader will find himself over-hedged in a bear market. Or, if prices advance, the long basis trader is under-hedged in a bull market. These can be very favorable circumstances analogous to the convexity associated with a long option.

that favors the long hedger or long basis trader (long cash and short futures). Conversely, this convexity tends to work to the disadvantage of the short hedger or short basis trader (short cash and long futures). Once again, we may liken the basis to an option to the extent that the premium structure of options are also affected by convexity. Further, because the long basis trader effectively owns the option, he pays an implicit premium in the difference between prevailing short-term yields and the return on the basis trade as simulated in the absence of any CTD crossovers. The short basis trader is effectively short an option and receives this implicit premium.

- Returning to our example above, let's shall simulate assuming that you sell 116 futures by reference to the basis point value hedge ratio. Once again, assuming that yields rise 20 basis points (0.20%) and this hedge is held until November 30th, we simulate a net profit of $148,663 or 4.77% on the hedged portfolio …

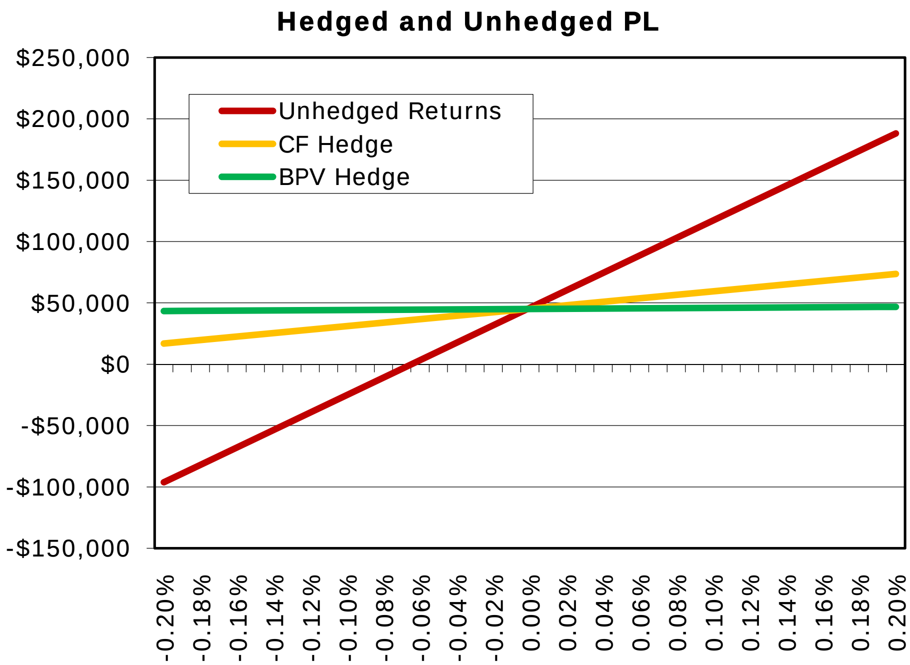
7/25/07	Hold $10,000,000 5-1/8%-16 @ 101-13+ (4.923%)	$10,142,187.50
	Accrued interest on 7/26/07	$101,664.40
	Sell 116 Sep-07 futures @ 106-19	-
	Initial Portfolio Value or Investment	$10,243,851.90
8/28/07	Hold $10,000,000 5-1/8%-16 @ 100-00 (5.123%)	$10,000,000.00
	Accrued interest on 8/29/07	$147,622.28
	Coupon income	$0
	Buy 116 futures @ 105-12+	$139,562.50
	Final Portfolio Value	$10,287,184.78
	Profit/Loss	$43,332.88

Return = (Profit/Loss ÷Initial Investment) x (360 ÷ Holding Period)
= ($43,332.88 ÷ $10,243,851.90) x (360 ÷ 33)
= 4.61%

Note that this return of 4.61% is closer to the vicinity of prevailing 3 month T-bill yields as depicted above. Still, this return is slightly less than overnight repo rates which were trading close to 5-¼%, a benchmark against which a hedged return might most appropriately be compared.

	Return in $s	%age Return
BPV Weighted Hedge	$43,332.88	4.61%
CF Weighted Hedge	$16,864.13	1.80%
Unhedged	-$96,229.62	-10.25%

Once again, this is offered with the caveat that that the BPV of a debt security is dynamic and subject to change given fluctuating yields. As a general rule, BPV declines as a function of maturity; and, as yields increase (decrease), BPVs decline (advance). This implies that the hedge ratio is likewise dynamic. Over a limited period of time, however, these long-term HRs are reasonably stable, provided there is no crossover in the cheapest-to-deliver.



While we have focused on a BPV weighted hedge ratio calculation, similar results are achievable by reference to a duration weighted hedge ratio, noting the mathematical relationship between BPV and duration.

While it is common to calculate and apply these BPV weighted hedge ratios, some prefer to base their calculations off of durations. Duration and BPV are closely related figures. Duration measures the expected percentage change in the value of a security in response to price movements while BPV measures the expected monetary change in value. Thus, it is fair to state that Duration ≈ BPV ÷ Price; or, BPV ≈ Duration x Price. Given this relationship, it is easy to substitute Duration x Price for BPV in our equation above. Either method will suffice and generate similar results although we tend to prefer the simplicity of the BPV weighted hedge.

$$\text{Duration HR} = CF_{ctd} \times [(Price_h \times Duration_h) \div (Price_{ctd} \times Duration_{ctd})$$

Locking-In a S-T Rate of Return – It is significant that the 4.61% rate of return associated with the BPV weighted hedge is similar to prevailing T-bill rates but somewhat lower than repo rates at 5-¼%. Consider the implications of a hedge, specifically, by selling futures against a long-term bond, one commits (at least temporarily) to the delivery of the security in the short-term. In other words, one effectively turns a long-term investment into a short-term investment. Accordingly, one cannot expect to earn a long-term rate of return but rather a short-term rate of return.

Given a normal, upwardly sloping yield curve, long-term rates will exceed short-term rates. Thus, the 4.61% return earned through the

A properly executed hedge may allow one to "lock-in," subject to some basis risk, a rate of return approaching prevailing short-term interest rates.

hedge falls a bit short of the prevailing yield on the hedged security in our example of 4.923%. Of course, we are aware that the shape of the yield curve defines "cost of carry." In a normal upwardly sloping yield curve environment where long-term rates exceed short-term rates, there is a positive result to buying and carrying a bond on a leveraged basis. In other words, financing costs (represented by short-term rates) are less than the payouts on the security (represented by long-term rates). As such, "positive carry" prevails and bond futures can be expected to trade at successively lower and lower levels in deferred months.

In the event of an inverted or negatively sloped yield curve where short-term rates exceed long-term rates, "negative carry" is said to prevail. In other words, financing costs (represented by short-term rates) will exceed the long-term payouts (represented by long-term rates) associated with buying and carrying a bond. As a result, bond futures can be expected to trade at successively higher and higher levels in deferred months.

When positive carry prevails, the bond basis will be positive, *i.e.*, cash prices will exceed adjusted futures prices (futures price x conversion factor). When negative carry prevails, the bond basis may become negative, *i.e.*, cash prices will be less than adjusted futures prices. Typically, the yield curve is upwardly sloped and the basis is quoted as a positive number.

Cost of carry can be calculated in terms of the payout on the bond less finance costs between the current date and the anticipated date of delivery. Note that when the yield curve is positive and positive carry prevails then shorts, who have the option of making delivery on any business day of the delivery month, can be expected to defer delivery until late in the month. When the yield curve is inverted and negative carry prevails then shorts can be expected to deliver early in the delivery period to minimize negative carry.

Theoretically, the basis for the cheapest-to-deliver security should equal its cost of carry. Yet, it is typical in practice that the basis for even the CTD security will exceed its cost of carry. And this is the *best* that one might do considering that the adjusted basis for all other eligible-for-delivery securities is higher. Why, therefore, would anyone ever wish to make delivery?

Let us suggest that this premium of basis over cost of carry represents the uncertainty as to what will be CTD by the time the delivery month rolls around. As market conditions change, for example as yields rise or fall, other securities may "crossover" to become CTD. The premium of the basis over cost of carry essentially represents the "reverse probability" that a particular security may become cheapest-to-deliver. The greater the premium, the less likely that a security will become CTD.

This uncertainty works to the advantage of a hedger who is long cash and short futures, *i.e.,* long the basis. Consider that when rates are greater than the 6% contract standard, there will be a bias towards the delivery of long duration securities, when rates fall below the 6% standard, there will be a bias towards the delivery of short duration securities.

If one puts on a hedge using the proper BPV weighted ratio, then one is well positioned to take advantage of a crossover. If, for example, rates rise above 6% and there is a crossover towards long duration securities, the effective BPV of the futures contract, represented by the $BPV_{ctd} \div CF_{ctd}$, as discussed above, should rise. In other words, the futures contract will become increasingly sensitive to further yield advances (price declines). Thus, the futures contract will decline at a faster rate in a falling market. The basis widens and the hedger who is long the basis (long cash/short futures) benefits.

Just as there is a strong analogy between trading the basis and trading options, there is an equally strong analogy between hedging and trading options.

If, for example, rates decline below 6% and there is a crossover towards the delivery of short duration securities, the effective BPV of the futures contract should decline. The futures contract becomes desensitized to further rate declines (price advances). Futures advance at a slower rate in a rising market. Once again, the basis widens and the hedger who is long the basis benefits.

In other words, buying the basis using the proper hedge ratio is analogous to buying an option. If yields exceed 6% and the contract is tracking long duration securities, there is a probability that yields will fall (price rise), a crossover is realized and the basis widens. *I.e.,* the basis performs like a call option. If yields are less than 6% and the contract is tracking short duration securities, there is a probability that yields will rise (prices fall), a crossover is realized and the basis likewise widens. *I.e.,* the basis performs like a put option.

The premium of basis over cost of carry, at least for the CTD security whose basis might be expected to converge to zero, may be thought of as akin to an option premium. Of course, other eligible-for-delivery securities will likely not experience complete convergence or they would become CTD! Thus, the implied option premium is *not* directly represented by the premium of the basis over cost of carry for non-CTD securities.

In our example above, the implied option premium is represented in the approximate 20 basis shortfall between the return on the hedged transaction near 4.61% vs. prevailing repo rates near 5-¼%. If there is no crossover, the implied premium may be lost through the process of basis convergence in the absence of a little "pop" in the basis. Thus, someone who is long the basis may realize a return that is somewhat less than prevailing repo or Fed Funds rates. Our example above was simulated under the assumption that what was CTD would remain CTD, *i.e.*, no crossovers.

Macro Hedging with Treasury Futures

Thus far, our discussion has centered about comparisons between a single security and a Treasury futures contract, a "micro" hedge if you will. But it is far more commonplace for an investor to become concerned about the value of a portfolio of securities rather than focus on a single item within a presumably diversified set of holdings. How might one address the risks associated with a portfolio of securities, *i.e.*, how to execute a "macro" hedge?

Most investors are not concerned so much with the fluctuations in the value of a single security on their books so much as they are concerned about the value of a portfolio of securities on their books. Let us extend our analysis from a "micro" hedge of a single security to a "macro" hedge of a security portfolio.

- Let's begin with a hypothetical set of holdings as illustrated in the accompanying table. We have arbitrarily assumed that an investor holds a variety of Treasuries spread amongst 2-, 5-, 10- and 30-year Treasuries. Of course we may assess the risks associated with any portfolio constituent by reference to their respective BPVs and durations. Further, we may summate the BPVs or take the weighted average of the modified durations to find the portfolio BPV and portfolio duration. In this example, our aggregate BPV suggests a loss on the order of $48,559 in response to a general 1 basis point advance in yields. The portfolio duration of 5.97 years suggests a 5.97% decline in the value of the portfolio given a uniform 1% advance in yields.

	Holdings	Yield	Value	Acc Int	BPV	Dur
7/25/07	$30 mil of 4-7/8%-09 @ 100-08	4.74%	$30,075,000	$103,329	$5,481	1.86
	$20 mil of 4-7/8%-12 @ 100-13+	4.78%	$20,084,375	$68,886	$8,714	4.32
	$18 mil of 4-1/2%-17 @ 96-28	4.90%	$17,437,500	$158,478	$13,619	7.74
	$14 mil of 4-3/4%-37 @ 99-23+	5.03%	$13,962,813	$295,760	$20,745	15.15
			$81,559,688	$626,452	$48,559	5.97

The techniques associated with a macro hedge are actually quite similar to those which might be applied to the hedge of a single security. In particular, the BPV hedge ratio calculation remains quite relevant. However, one might apply the ratio to the aggregate BPV instead of the BPV associated with any individual security within the portfolio. But which Treasury futures contract is most appropriate noting that our portfolio includes constituents of a 2-, 3-, 5-, 10- and 30-year original maturity?

- To begin, let's calculate the appropriate BPV weighted hedge ratios for our hypothetical Treasury portfolio vs. 2-, 5-, 10- and 30-year Treasury futures. The results are shown below and, consistent with intuition, suggest that one needs fewer contracts as a function of the lengthening maturity of the futures contract. Note that the 2-year Treasury contract in fact calls for the delivery of $200,000 face value of securities and, therefore, one requires fewer futures contracts than one might otherwise presume.

	CTD	CF_{CTD}	x	[BPV_{port}	÷	BPV_{CTD}]	= HR
2-Yr	4-7/8%-09	0.9815	x	[$48,559	÷	$36.58]	= 1,303 contracts
5-Yr	4-1/2%-11	0.9453	x	[$48,559	÷	$38.65]	= 1,188 contracts
10-Yr	4-3/4%-14	0.9335	x	[$48,559	÷	$57.23]	= 792 contracts
30-Yr	7-5/8%-22	1.1593	x	[$48,559	÷	$123.07]	= 457 contracts

One might attempt to hedge a portfolio of Treasuries diversified to include short-, intermediate- and long-term instruments with 2-, 3-, 5-, 10- or 30-year Treasury futures.

Bullets and Barbells – As a first pass, one might hedge a Treasury portfolio with the use of Treasury futures which correspond most closely in terms of duration to the average weighted portfolio duration. For example, if one held a portfolio with an average weighted duration of 4 years, it would be natural to look to 5-year Treasury note futures as a suitable risk layoff vehicle. Of if the portfolio duration were 8 years, that would correspond most closely to the durations associated with 10-year Treasury notes and point one in the direction of 10-year Treasury note futures.

One's first inclination is to utilize the Treasury futures contracts that most closely parallel the average maturity of the portfolio. But portfolios may be constructed in many different ways. They may be constructed as "bullet" where the portfolio is concentrated in a securities of similar maturity. Or, as a "barbell" where one holds short- and long-term securities with an average maturity somewhere in the middle.

This analysis would tend to work well when the portfolio is constructed predominantly of securities which were close in terms of their durations to the average portfolio duration. Certainly if the entire portfolio were populated with a variety of recently issued 5-year T-notes, it would behoove the hedger to utilize 5-year Treasury note futures as a hedge, minimizing basis risk and the need for any subsequent hedge management. A portfolio constructed in such a manner might be labeled a "bullet" portfolio to the extent that it contains reasonably homogeneous securities in terms of maturity and presumably coupon. Under these circumstances, one might simply "stack" the entire hedge in a single Treasury futures contract which most closely conforms to the duration of the portfolio constituents.

Of course, one may attempt to introduce a certain speculative element into the hedge by using longer- or shorter-term futures contracts as the focus of the hedge. If the yield curve were expected to steepen, a hedge using longer-term futures, *e.g.*, 10- or 30-year Treasury futures rather than 5-year futures, would allow one to capitalize on movement in the curve beyond simply immunizing the portfolio from risk. If the yield curve is expected to flatten or invert, a hedge using shorter-term futures, *e.g.*, 2-year or 3-year Treasury futures rather than 5-year futures, could likewise provide yield enhancement.

But a portfolio need not necessarily be constructed per the "bullet" approach. Consider a portfolio with a duration of 4 years that is constructed using a combination of 2- and 10-year notes and no 5-year notes whatsoever. A portfolio constructed in such a manner may be labeled a "barbell" portfolio to the extent that it is "weighted" with two extreme duration securities with no intermediate duration securities at all. If one were to simply stack the hedge into 5-year Treasury note futures, the investor becomes exposed to the risk that the shape of the yield curve becomes distorted such that 5-year yields sag below yields in the 2- and 10-year sectors of the curve.

If the yields on all securities were expected to rise and fall on a parallel basis, the choice of hedge instrument would not matter much.

The holder of a barbell portfolio might instead attempt to utilize a combination of various tenored Treasury futures which is weighted with an eye to the proportion of the portfolio devoted to each sector of the yield curve. As such, the hedger may insulate from the risks that the shape of the yield curve will shift. In our example above, we might utilize a combination of 2-, 3-, 5-, 10- and 30-year Treasury futures, applying the BPV weighted hedge ratio technique to each of the 4 securities within the portfolio. If, however, the investor wished to introduce a speculative element into the hedge, the use of longer- or shorter-maturity Treasuries driven by an expectation of a steepening or flattening yield curve, respectively, may be in order.

But if one expects the shape of the yield curve to steepen or flatten, that may have a significant impact upon one's choice of hedge instrument. In particular, one may introduce a certain speculative element into the hedging equation by selling futures based on longer-term instruments (*e.g.*, 10- or 30-year Treasury futures) against a long portfolio when one expects the yield curve to steepen. Or by selling futures based on shorter-term instruments (*e.g.*, 2-, 3- or 5-year futures) when one expects the yield curve to flatten or invert.

Targeting Portfolio Duration – Thus far, we have assumed that the hedger wishes to immunize risks altogether with the use of futures by effectively reducing the security or portfolio duration to zero. This may be unlikely in practice where investment managers are frequently committed to a particular investment strategy for the long haul and may not be completely at liberty to alter the portfolio duration so dramatically.

Rather, it may be more commonplace to utilize futures to shade the portfolio duration downwards in anticipation of rising rates; or, perhaps upwards in anticipation of declining rates. After all, risk management does not necessarily mean that the investor will always pursue a risk abatement strategy. Taking on some additional risk in pursuit of yield, within some institutionally mandated parameters, is a frequently accepted practice.

Thus far, we have calculated hedge ratios assuming that the objective is to completely immunize the security or portfolio from the effects of adverse price fluctuation. But many hedgers use futures to alter the portfolio duration, adjusting it either up or downward slightly, to take advantage of an expected price advance or decline.

Finding the requisite number of futures contracts which will effectively extend or contract the portfolio duration from the current duration ($D_{current}$) by some desired degree to the target duration (D_{target}) may readily be identified through a simple modification of the BPV hedge ratio calculation.

$$HR = [\ (D_{target} - D_{current}) \div D_{current}]\ x\ CF_{ctd}\ x\ (BPV_{portfolio} \div BPV_{ctd})$$

- Building from our prior example, assume you wish to extent the duration of the portfolio from 5.97 years to a target duration of 7 years in anticipation of falling rates and rising prices. Our analysis suggests the purchase of 137 10-year Treasury note futures for these purposes.

Ratio = [(7.00 – 5.97) ÷ 5.97] x 0.9335 x [$48,559 ÷ $57.23]
= 137 contracts

- Assume you wish to reduce risk by contracting duration of the portfolio to a target level of 4 years. This suggests the sale of 261 10-year Treasury note futures.

Ratio = [(4.00 – 5.97) ÷ 5.97] x 0.9335 x [$48,559 ÷ $57.23]
= -261 contracts

Hedging Corporates with Treasury Futures

Corporate debt markets are by some measures the fastest growing segment of the capital markets with tens of thousands of issues outstanding. Clearly corporate bonds or notes share many structural characteristics in common with Treasury securities. *E.g.*, both types of instruments call for periodic coupon payments with a final payment of the corpus or principle at maturity.

Treasury futures have also been employed on occasion to hedge the risks associated with corporate securities.

It should be noted, however, that corporate debt instruments are often issued with many features that may distinguish them from a Treasury such as call features, convertibility into other debt or equity structures or other forms of optionality. Most significantly, however, they do differ from Treasuries in terms of credit risk. *I.e.*, the risk characteristics of a double-A rated or perhaps a triple-B rated corporate bond are certainly divergent from the presumed "riskless" character of government debt. Of course, once we venture past "investment grade" debt rated triple-B or better by the rating agencies, we may encounter speculative grade or "high-yield" corporate bonds which entail even greater credit risks.

Corporate securities differ from Treasuries most obviously with respect to their credit risk. Treasuries are considered "riskless" investments to the extent that they are government obligations. Corporate risk may be measured by reference to the credit rating associated with the security.

Ideally, one may look to a liquid corporate bond derivative contract as a means of managing the risks attendant to these instruments. As of this writing, however, the futures industry has generally failed in its attempts successfully to introduce a risk-management vehicle of this nature. Not for lack of trying and, of course, we believe that further attempts will be launched in the future. Nonetheless, these circumstances often cause corporate investors to look to the Treasury futures market as a vehicle for shifting these risks.

In its most elemental form, and we presume to limit our analysis to generally highly rated corporates entailing low credit risks without any significant optionality, hedging a corporate note or bond with the use of Treasury futures is largely analogous to hedging a Treasury with Treasury futures. In particular, one might begin by examining a BPV or duration weighted hedge ratio as a start.

The same techniques that may be applied to the hedge of a Treasury security may likewise be applied to a corporate bond, *i.e.*, the BPV hedge ratio.

- Consider the General Electric (GE) corporate bond with a coupon of 5% maturing in February of 2013. As of July 25, 2007, this security had a modified duration of 4.631 years with a BPV equal to $461.30 per million. Because its maturity and duration are similar to that associated with a 5-year Treasury, one might hedge this security with 5-year Treasury futures. Or, one may consider the use of longer-term Treasury futures (such as 10-years or 30-years) to speculate on a possible steepening of the yield curve. Likewise, one may introduce a speculative element into the hedging equation with the use of shorter-term futures (such as 2-year Treasury futures) to speculate on flattening or inverting yield curve. Applying the BPV hedge ratio as discussed above, we may find hedge ratios for a $1 million face value unit of the 5%-13 GE corporate note using 2-, 5-, 10- or 30-Year Treasury futures as follows.

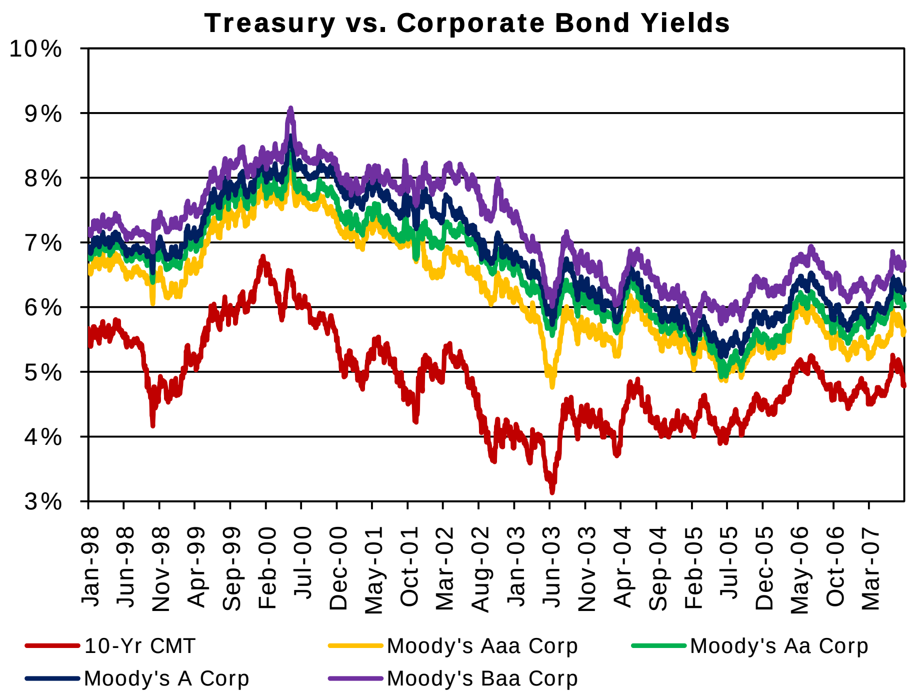
	CTD	CF_{CTD}	x	[BPV_{port}	÷	BPV_{CTD}]	= HR
2-Yr	4-7/8%-09	0.9815	x	[$461.30	÷	$36.58]	= 12.4 contracts
5-Yr	4-1/2%-11	0.9453	x	[$461.30	÷	$38.65]	= 11.3 contracts
10-Yr	4-3/4%-14	0.9335	x	[$461.30	÷	$57.23]	= 7.5 contracts
30-Yr	7-5/8%-22	1.1593	x	[$461.30	÷	$123.07]	= 4.3 contracts

* Note that 2-year and 3-year T-note futures call for delivery of $200,000 face value securities. All other contracts are based on a $100,000 face value unit.

But the BPV hedge ratio technique assumes a parallel movement between the yield on the hedged security and the yield on the CTD Treasury.

Use of the BPV weighted hedge ratio implies an expectation that yields on hedged security and CTD will move in parallel. But, as discussed above, the credit quality of a corporate bond may be quite different than that associated with a "riskless" Treasury investment. Of course, yields on low-rated bond exceed the yields on otherwise comparable high-rated bonds. Accordingly, we may presume that the volatility in low-rated bond yields might exceed the volatility in higher-rated bond yields.

Accordingly, the industry has often reverted to a regression analysis technique empirically to assess the relationship between yields on the hedged security vs. yields on the Treasury securities from which Treasury futures are derived. The most significant product of that analysis may be the "yield beta" (β) which may define, with some factor for error, the relationship between movements in corporate yields vs. movements in Treasury yields.



The yields on corporate securities are sometimes more volatile than the yields on Treasury securities. A simple regression analysis may help one assess the relationship between movements in corporate and Treasury yields.

$$y = a + \beta(x) + e$$

where …

Y = Yield movements in corporates

X = Yield movements in Treasuries

Once discovered, the yield beta may be applied as an adjustment to the BPV weighted HR. While this technique is often applied in the context of a hedge of corporate or other types of non-Treasury securities vs. Treasury futures, some have also found the technique useful when attempting to hedge cash Treasuries with Treasury futures.

$$\text{Adjusted HR} = \beta \times \text{BPV HR}$$

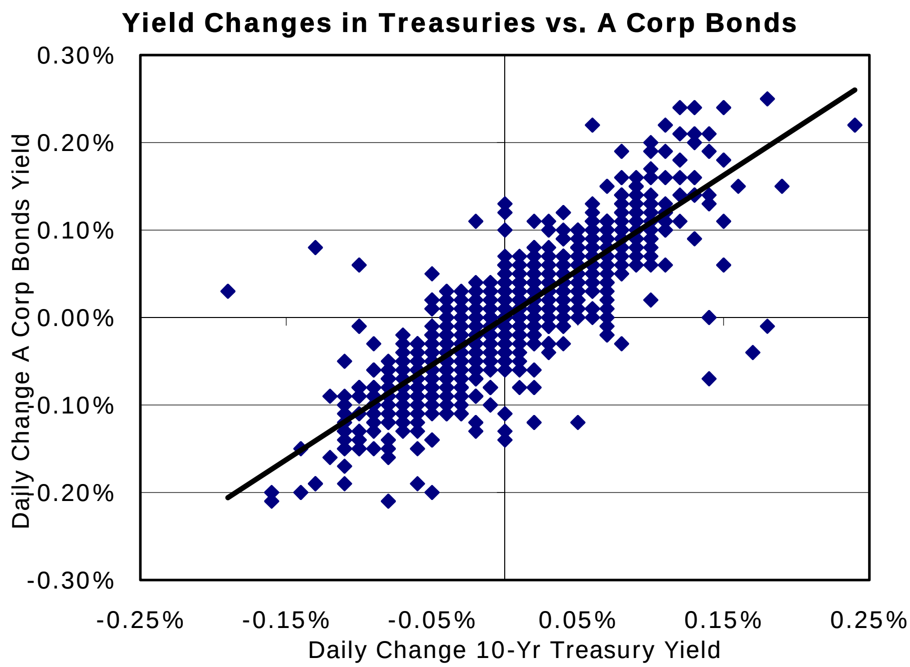
One might apply a "yield beta" to the BPV hedge ratio, thereby adjusting the ratio to reflect the presumed increased volatility in corporate over Treasury yields.

Relationships between corporates and Treasuries are, of course, subject to change. Because of the vagaries associated with any specific corporate issue, traders sometimes utilize reasonably broad characterizations of risk referenced by credit ratings. It may be more useful to utilize a regression of the yields on a corporate bond index distinguished by rating, *i.e.*, double-A, A, triple-B, etc., rather than performing a regression using any particular corporate bond.

As a general rule, the lower the credit rating of the corporate security, the greater the yield beta adjustment.

To the extent that corporate bonds tend to be issued and "put away" in investment portfolios for extended periods of time, the period during which they are marketable and actively traded tends to be rather brief subsequent to their original issuance. As such, one may not be able to accumulate a sufficient data history to conduct a reasonable regression analysis for a particular corporate issue.

In any case, a reasonable rule of thumb might be to utilize a yield beta in the vicinity of perhaps 1.02 for Aaa rated issues, ranging up to β~1.10 for Baa rated issues. Of course, these relationships may be unstable particular during times of credit distress, *e.g.*, subprime mortgage credit crisis of 2007 or the Asian financial crisis of 1998. A scatter diagram may provide one with a feel for the stability of the relationship and the error one introduces into the hedge equation by utilizing these techniques.



Trading the Yield Curve with Treasury Futures

Treasury futures may be used to speculate on the future shape of the yield curve.

Treasury futures are strategically tied to key points along the Treasury yield curve, specifically to the 2-, 3-, 5-, 10- and 30-year sector. When a Treasury trader requests quoted on "the run," he routinely expects to examine quotations for the most recently issued Treasury security of these tenors. Of course, the associated Treasury futures contracts call for the delivery of a wide variety of issues and it is a rather infrequent occurrence when the on-the-run issue becomes cheapest-to-deliver.

So while Treasury futures do not quite represent the most frequently quoted reference points along the Treasury yield curve, tied as they are to the CTD security, they are nonetheless very reasonable proxies for those key reference points. As a result, and in light of the extreme liquidity provided by Treasury futures, these contracts are frequently utilized in the form of inter-market spreads, *e.g.*, 2-year vs. 10-year or 5-year vs. 10-year, as a means to speculate on the shape of the yield curve over a particular span of the curve.

As discussed above, one may speculate on a possible steepening or flattening of the curve. In order to take advantage of a possible steepening of the curve, one may "buy the yield curve" by purchasing short-term Treasury futures and selling longer-term Treasury futures. Conversely, one may "sell the yield curve" by selling short-term and buying longer-term Treasury futures.

One "buys the curve" by buying short-term and selling long-term futures in expectation of a steepening yield curve.

Or, one may "sell the curve" by selling short-term and buying long-term futures in expectation of a flattening yield curve.

Yield curve expected to steepen	➔	"Buy the curve," *i.e.*, buy short-term and sell long-term futures
Yield curve expected to flatten or invert	➔	"Sell the curve," *i.e.*, sell long-term and buy short-term futures

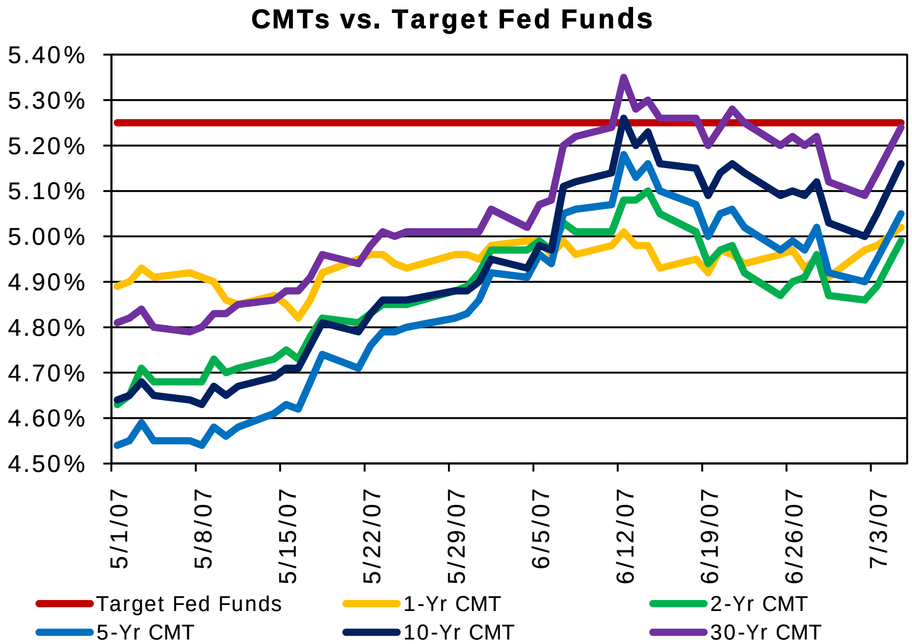
Of course, it is also possible to speculate on the changing shape of the curve over a particular span with the use of other instruments notably Eurodollar futures traded in the form of an intra-market or calendar spread. This is facilitated to the extent that Eurodollar futures are listed out a full ten (10) years into the future. Why would one choose to use Treasury futures as the vehicle for this speculation as opposed to Eurodollar futures?

It is possible to utilize Eurodollar calendar spreads or inter-market spreads between Treasury futures to speculate on possible changes in the shape of the curve. One might tend to use Eurodollar calendar spreads if the curve is changing due primarily to Fed monetary policy considerations. Use inter-market Treasury spreads if the shape of curve is shifting for reasons apart from monetary policy considerations.

Fundamentally, longer-term securities are driven by prevailing inflationary expectations while shorter-term securities are more closely tied to, and driven by, FOMC monetary policy. While this may be a bit of an oversimplification, it is reasonable to utilize intra-market Eurodollar spreads when one believes that the shape of the curve will change due to shifting Fed monetary policies. On the other hand, if one believes that other factors apart from Fed policies are likely to be the driving force behind a shift in the shape of the yield curve, it becomes reasonable to look to inter-market Treasury spreads as the means to express one's expectations.

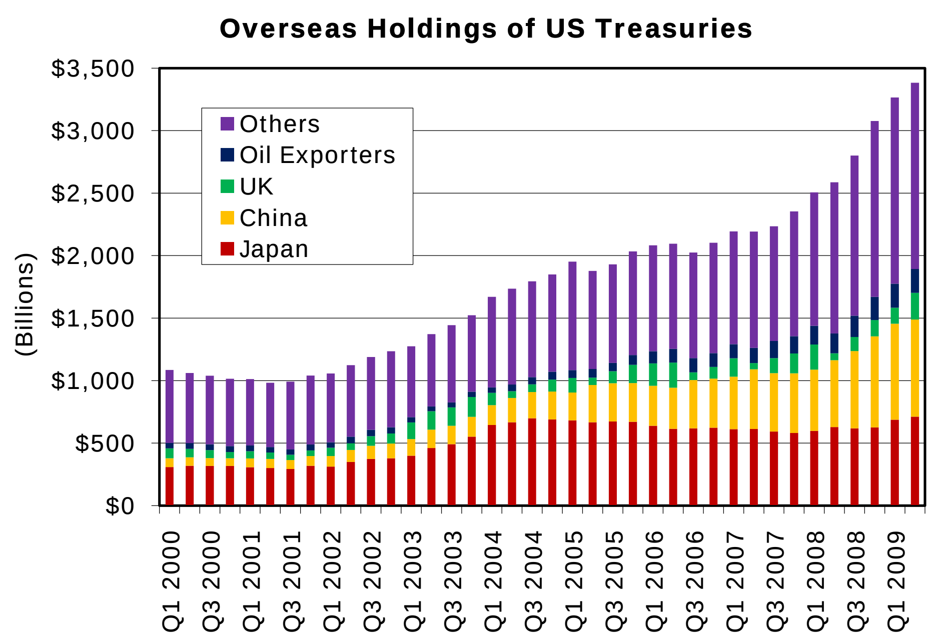
PREMISE		**THUS**
Short end of yield curve largely anchored by Federal Open Market Committee (FOMC) monetary policy	➔	Use intra-market (calendar) spreads on Eurodollar futures to trade shape of yield curve when movement driven by Fed monetary policy
Long end of yield curve driven by inflationary expectations and other supply/demand factors	➔	Use inter-market spreads between CBOT Treasury futures to trade curve shape if movement driven by other factors

***A Steepening Yield Curve* –** In May and June of 2007, Fed monetary policy had been in holding pattern for some time. The target Fed Funds rate was essentially frozen in place at 5.25%. However, there were growing tensions between monetary policies and the longer end of the yield curve. In fact, Treasury rates at all strategic points along the Treasury yield curve were valued at yields much less than the target Funds rate.



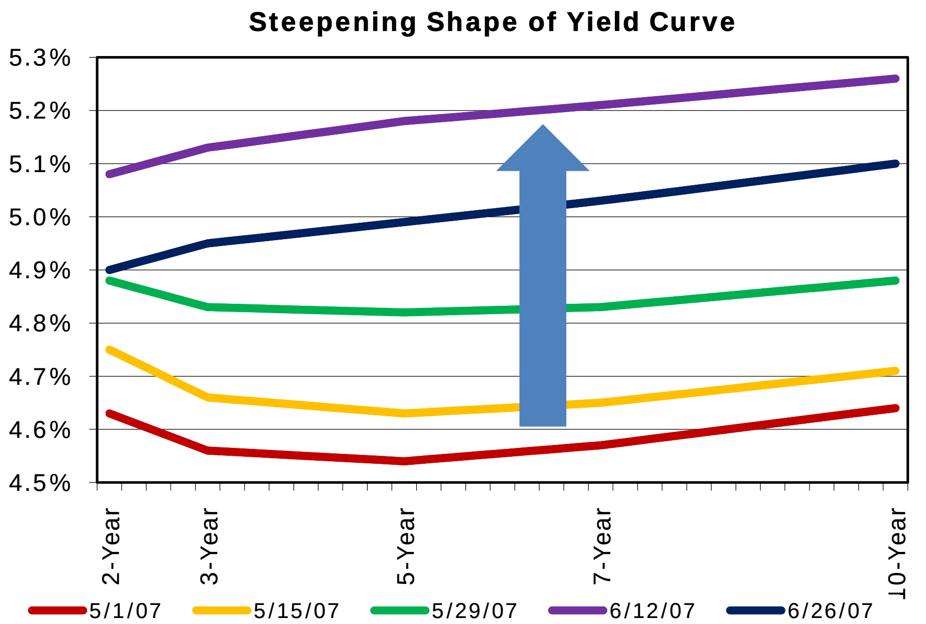
Let's consider economic conditions prevailing in May-June 2007 which led to a general steepening of the yield curve.

By the 1st quarter of 2007, GDP growth had slowed to +0.7% or +1.9% for the previous four quarters. This was down considerably from the figure of +3.7% reported in the 1st quarter 2006 and covering the previous four quarter. Concerns accumulated regarding the general and dramatic downturn in the housing sector, mounting trade deficits and overbuilt inventories. But U.S. consumer demand remained reasonably strong in May and June of 2007. GDP growth had not actually turned negative. In fact, the consensus amongst economist was calling for expanded growth in the 3-4% range by the 2nd quarter 2007.



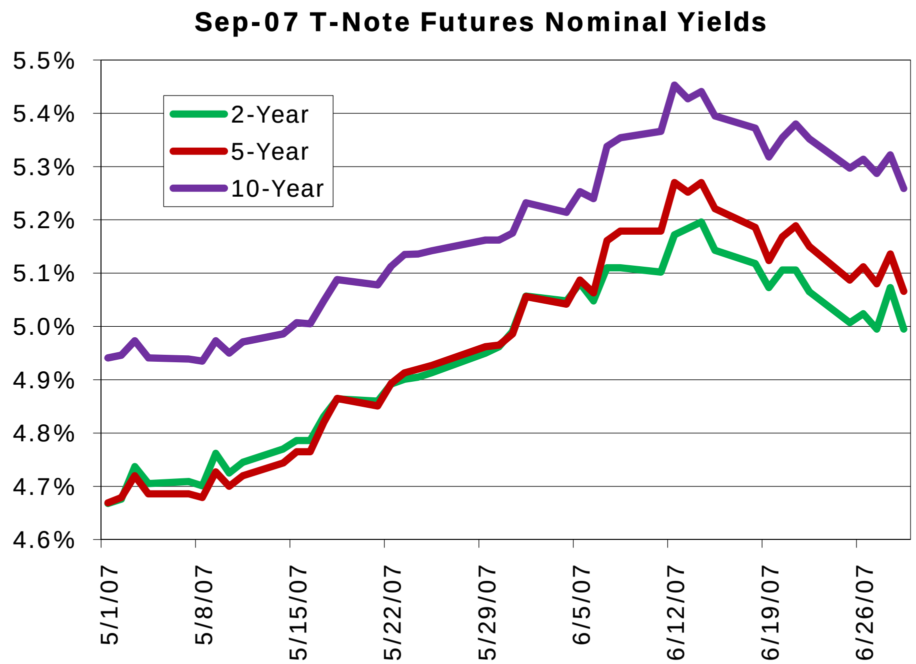
Asian investment in Treasuries on a very large scale certainly had contributed to the prior inversion in the yield curve. But some Asian central banks were becoming concerned regarding their concentrated holdings in U.S. Treasuries and weakening U.S. dollar. In particular, we note a landmark deal such that China invested some $3 billion in Blackstone, a large and diversified investment management concern. Many believed this to be a harbinger of further diversification away from U.S. Treasuries on the part of Asian investors holding significant U.S. dollar denominated reserves.

Reasonably resilient domestic economic conditions coupled with mounting international reluctance contributed to a general decline in Treasury prices and resulting advance in Treasury yields during this period. On the short end of the curve, the Federal Open Market Committee (FOMC) was holding target Fed Funds steady at 5-¼%. Of course, there had been concern expressed that Fed Funds were (artificially) held at too high a rate relative to market determined long-term term rates.

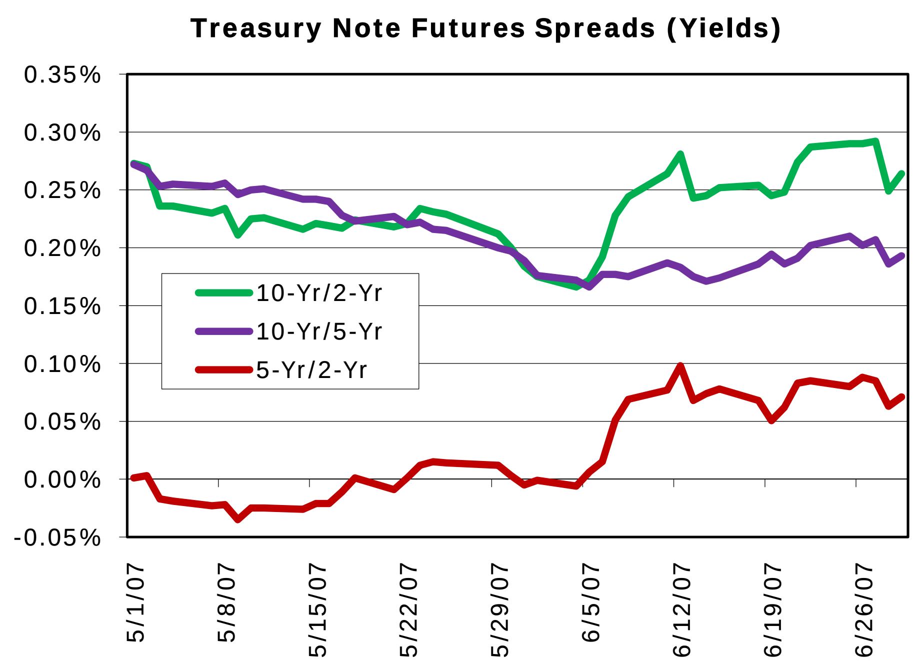


As a result of these tensions, the yield curve shifted from a generally negative to a positive slope during May-June 2007. Typically we expect that any inversion of the yield curve will right itself into a generally upward slope as a result of Fed easing, noting that an inverted curve often a harbinger of recession. But the yield curve inversion that had existed in 2006 and 2007 had not actually culminated in a recession.

Just as these factors were reflected in the cash or spot Treasury markets, they were likewise reflected in Treasury futures markets. During much of May through mid June 2007, the yields on 2-, 5- and 10-year Treasury futures rallied nicely.



The generalized steepening of the yield curve was observable by studying the spread, quoted in yields between key points along the Treasury yield curve. But that steepening was most consistent and readily observed in the span between 2- and 5-year Treasury futures.



Finding the Right Spread Ratio – It is extremely convenient to quote Treasury spreads along any particular span of the yield curve on a yield basis. Yields are readily comparable one to the next. But of course Treasury futures are not traded or quoted on a yield basis, rather they are quoted on a percent of par basis. Because 2-, 3-, 5-, 10- and 30-year Treasury futures offer very different risk exposures on an outright basis, it is not possible to trade these products on a one-for-one basis and achieve results that parallel movements measured in yield spreads. Rather, one must weight or balance spread so no profit or loss implied by parallel shift in yield curve, in much the same way that one constructs a hedge ratio as discussed at some length above.

Treasury spreads should be weighted in much the same way that one weights a hedge. In particular, the concept of a basis point value proves to be very useful in assessing the relative volatility of the two legs of the spread. The idea is to create a spread which will be insensitive to parallel shifting in the yield curve.

$$\Delta \text{ Value of 2-Year T-Note Futures} \approx \Delta \text{ Value of 5-Year T-Note Futures}$$

Determining the appropriate ratios is analogous to a calculation of the BPV hedge ratio as discussed above in the context of hedging techniques. Thus, this exercise entails an identification of the cheapest-to-deliver security vs. the particular Treasury securities referenced in the spread and a determination of the effective BPV associated with the futures contract by reference to the BPV of the cheapest (BPV_{ctd}) divided by its conversion factor (CF_{ctd}).

- On May 15, 2007, the 4%-09 was cheapest-to-deliver against the September 2007 2-Year Treasury futures. This security had a BPV of $34.48 per $200,000 face value with a CF equal to 0.9672. Thus, the basis point value of the 2-year futures contract ($BPV_{2\text{-Yr Futures}}$) may be calculated as $35.65.

$$\begin{aligned} BPV_{2\text{-Yr Futures}} &= BPV_{ctd} \div CF_{ctd} \\ &= \$34.48 \div 0.9672 \\ &= \$35.65 \end{aligned}$$

- The 4-½%-11 was CTD against September 2007 5-Year Treasury futures. It had a BPV=$40.13 per $100,000 face value with a CF= 0.9453. Thus, the $BPV_{5\text{-Yr Futures}}$ = $42.45.

$$\begin{aligned} BPV_{5\text{-Yr Futures}} &= BPV_{ctd} \div CF_{ctd} \\ &= \$40.13 \div 0.9453 \\ &= \$42.45 \end{aligned}$$

- The 4-¾%-14 was CTD against the September 2007 10-Year Treasury futures with a BPV=$61.18 per $100,000 face value and a CF=0.9335. Thus, the $BPV_{10\text{-Yr Futures}}$ = $65.53.

$$\begin{aligned} BPV_{10\text{-Yr Futures}} &= BPV_{ctd} \div CF_{ctd} \\ &= \$61.18 \div 0.9335 \\ &= \$65.53 \end{aligned}$$

- How many 2-year T-note futures are needed to balance one 5-year T-note futures contract? We may apply the following equation noting that the $BPV_{2\text{-}Yr}$ = \$35.65 while the $BPV_{5\text{-}Yr}$ = \$42.45.

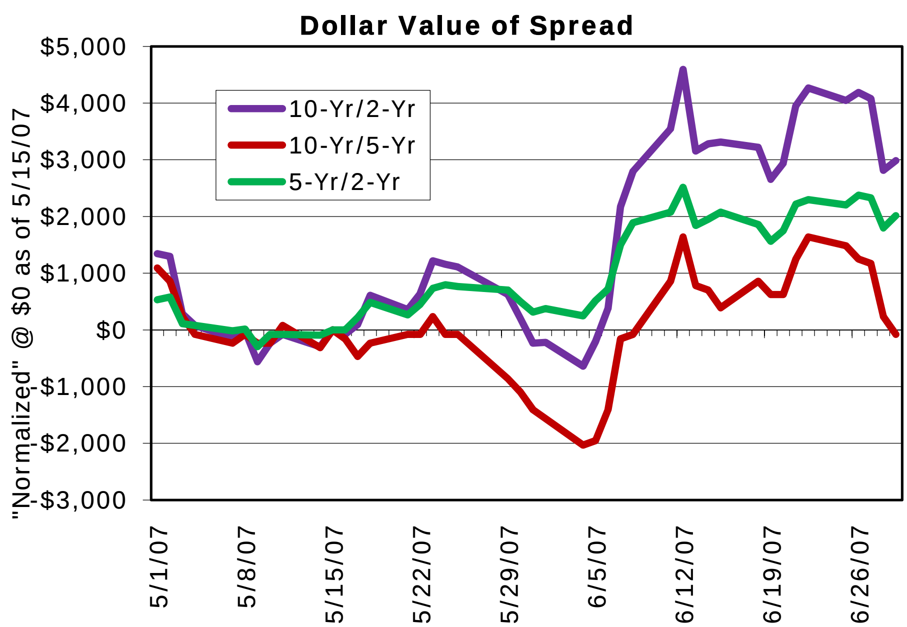
$$\begin{aligned} \text{Spread Ratio} &= BPV_{5\text{-}Yr} \div BPV_{2\text{-}Yr} \\ &= \$42.45 \div \$35.65 \\ &= \underline{1.19} \end{aligned}$$

6:5 two-year:five-year T-note futures

Similarly, the 10-year vs. 2-year spread ratio equals 1.84 or roughly 9:5 two-year:ten-year T-note futures. The 10-year/5-year spread ratio equals 1.54 or roughly 15:10 five-year:ten-year T-note futures.

One may have taken advantage of the general steepening of the yield curve in May-June 207 by buying 2-year Treasury futures and selling 5-year Treasury futures in the proper ratio.

Trading the Curve with Treasury Futures – Applying the ratios as calculated in our examples above, we may track the dollar value of the three yield curve spreads that may be constructed using a 2-, 5- and 10-year T-note futures.



- Focusing on the span of the yield curve between the 2- and 5-year sectors, we may construct an example of a yield curve play. On May 15, 2007, one may have "bought the curve" buying 6 two-year and selling 5 five-year T-note futures. Holding the spread until June 26, 2007, the yield spread rallied from -0.021% to 0.088% (+10.9 bips) for a profit of \$2,375.

	Sep-07 CBOT 2-Yr T-Note Futures	**Sep-07 CBOT 5-Yr T-Note Futures**	**Spread**
5/15/07	Buy 6 @ 102-092/32nds (4.786%)	Sell 5 @ 105-14/32nds (4.765%)	-0.021%
6/26/07	Sell 6 @ 101-266/32nds (5.024%)	Buy 5 @ 103-28/32nds (5.112%)	0.088%
	-14+/32nds or -$5,437.50	+50/32nds or +$7,812.50	+10.9 bips or +$2,375.00