

**FUNDING INVESTMENTS**  
**FINANCE 238/738, Spring 2008, Prof. Musto**  
**Class 2 – Treasury Market**

**Today:**

- I. Treasury Auction Schedule
- II. Yield-to-Maturity and Discount Rate
- III. Bonds vs. STRIPs
- IV. Spread between off- and on-the-run

**I. Treasury Auction Schedule**

The reference points, i.e. “benchmarks,” for fixed-income pricing are the securities sold by the Treasury when they are *on the run*

- A Treasury is *on the run* until the next Treasury of that maturity becomes available
  - On 11/15/07, the Treasury issued a ten-year note (i.e. maturing 11/15/17), which will be the on-the-run ten-year until 2/15/08, when it will issue a *new* ten-year note (maturing 2/15/18), which will be the on-the-run note until the Treasury issued the *next* ten-year on 5/15/08, at which point the ten-year maturing 11/15/17 will become the *old* ten-year.
- Sometimes the next auction is of the same security
  - On 2/15/08 the Treasury will issue a thirty-year note, maturing 2/15/38, and on 5/15/08 the Treasury is planning to issue more of this same note (by then 29 <sup>3</sup>/<sub>4</sub> years to maturity), called *re-opening*

[Tentative Auction Schedule](#)

*Generally:*

**Bills:**

13 & 26 Week	Every Thursday (auction Monday)
4 Week	Every Thursday (auction Tuesday) (re-opening)

**Notes:**

2 Year & 5-Year	End of each month
10-Year	15 <sup>th</sup> of Feb, May, Aug and Nov

**Bonds:**

30-year	15 <sup>th</sup> of Feb (reopened in August)
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Treasury also issues TIPS ([Principal amount increases with CPI](#))

There are seven on-the-runs: 4 weeks, 3 months, 6 months, 2 years, 5 years, 10 years and the 30-year (sometimes 3-years as well)

- Almost all discussion about the Treasury market is about these securities
- “Treasury Yield Curve” in the newspaper plots only these points

Trading is concentrated in on-the-run issues

- Much higher volume, smaller spreads
  - 64% of trade volume is of on-the-run securities
  - 12% is of *when-issued* securities
    - Announced, but not auctioned yet
  - 24% is of all the off-the-run securities put together
- Higher prices (reflecting higher liquidity)
- More about this at the end of class

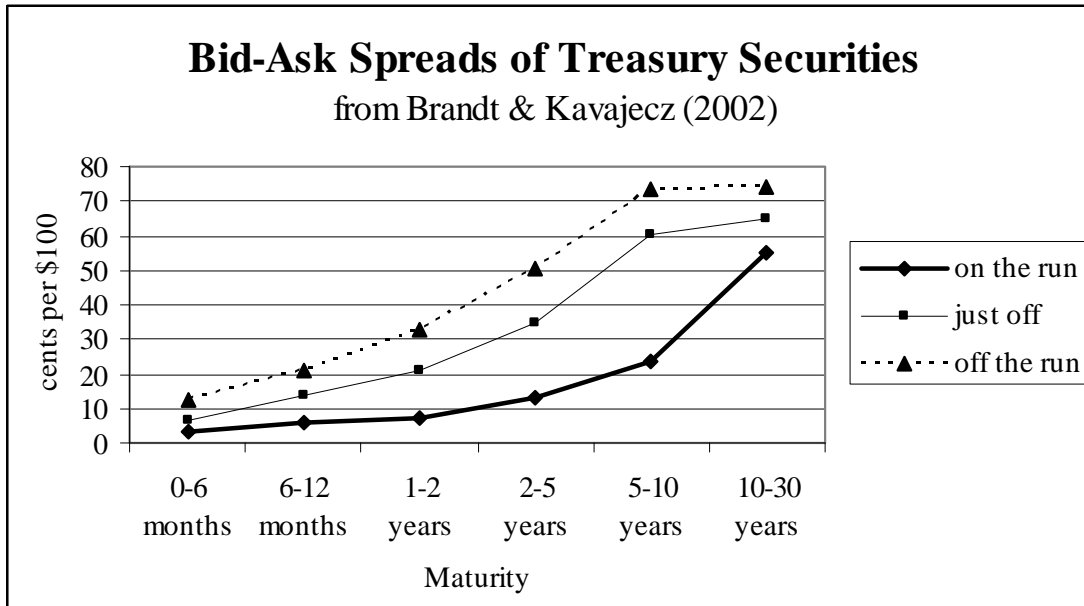
*When Issued* – Treasuries start trading *before* they even exist, in the *when-issued* market

- If you buy in this market, it is understood that you will get your security when it is issued
  - The seller then has to buy the necessary securities in the auction, or the subsequent secondary market, to deliver to you
  - Squeezing sellers in the when-issued market was the apparent goal in the Treasury-auction scandal in the early 90’s
    - Any one bidder can’t buy more than 35% of an issue
      - When-issued purchases plus auction purchases
      - Rule is intended to reduce fears of cornering the market
      - In the scandal, Salomon controlled ~92% of an issue
        - Trick was, placing bids in the names of customers who weren’t actually buying
        - This trick is not legal
  - The focus of trading shifts from the old bond to the new one when the new one starts trading on a when-issued basis

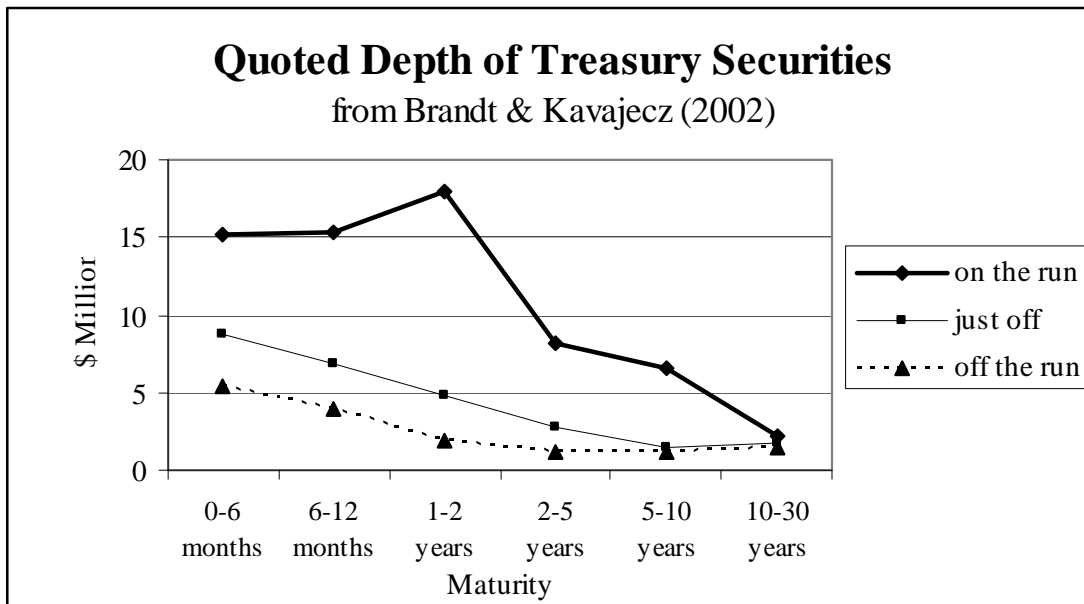
If we sort bonds into 1) on the run, 2) *just* off the run, and 3) off the run, we see this liquidity advantage

- Smaller spreads (Ask minus Bid)

- Larger *Quoted Depth* – amount the market maker will trade at his quoted spread



Spreads increase substantially as the security goes off the run



Quoted depth shrinks substantially

Here are all the actives and recent notes on 1/2/08:

<HELP> for explanation, <MENU> for similar functions. Govt **BBT**

**U.S. TREASURY ACTIVES** Page 1/ 1

" d " = delayed

BILLS				30 YR BONDS			
1) 01/17/08	3.180 / 3.160	3.217	+0.685	17) 4 <sup>1</sup> / <sub>2</sub> 236	100-24+ / 100-25+	4.450	+4 <sup>1</sup> / <sub>4</sub>
2) 04/03/08	3.285 / 3.280	3.363	+0.020	18) 4 <sup>3</sup> / <sub>4</sub> 237	104-29 / 104-30	4.446	+4 <sup>1</sup> / <sub>2</sub>
3) 07/03/08	3.330 / 3.320	3.433	-0.060	19) 5 537	109-02 <sup>3</sup> / <sub>4</sub> / 109-03 <sup>3</sup> / <sub>4</sub>	4.441	+4 <sup>3</sup> / <sub>4</sub>
2 YR NOTES				TIPS			
4) 4 909	101-20 <sup>5</sup> / <sub>8</sub> / 101-21 <sup>1</sup> / <sub>4</sub>	3.009	+1 <sup>5</sup> / <sub>8</sub>	20) TII 5YR	103-26+ / 103-27+	1.075	+4
5) 3 <sup>5</sup> / <sub>8</sub> 009	101-02+ / 101-02 <sup>3</sup> / <sub>4</sub>	3.008	+1 <sup>3</sup> / <sub>4</sub>	21) TII 10YR	108-05 / 108-06	1.691	+2 <sup>1</sup> / <sub>4</sub>
6) 3 <sup>1</sup> / <sub>8</sub> N09	100-06 <sup>1</sup> / <sub>8</sub> / 100-06 <sup>1</sup> / <sub>4</sub>	3.018	+2 <sup>1</sup> / <sub>8</sub>	22) TII 20YR	106-07 <sup>1</sup> / <sub>4</sub> / 106-09	1.977	+4
7) 3 <sup>1</sup> / <sub>4</sub> D09	100-14 <sup>1</sup> / <sub>4</sub> / 100-14+	3.014	+2	Curve Trades			
5 YR NOTES				23) 2YR vs 5YR	41.49 / -42.23		-2.41
8) 4 <sup>1</sup> / <sub>8</sub> 812	103-01 / 103-01+	3.411	+1	24) 2YR vs 10YR	100.53 / -101.13		-3.08
9) 4 <sup>1</sup> / <sub>4</sub> 912	103-18+ / 103-19	3.421	+1 <sup>1</sup> / <sub>2</sub>	25) 5YR vs 10YR	58.70 / -59.23		-0.67
10) 3 <sup>7</sup> / <sub>8</sub> 012	102-01 / 102-01+	3.410	+1 <sup>1</sup> / <sub>4</sub>	Other Markets			
11) 3 <sup>3</sup> / <sub>8</sub> N12	99-24+ / 99-25	3.423	+1 <sup>1</sup> / <sub>4</sub>	26) US Long(CBT)	9:12 d 116-12	--	
12) 3 <sup>5</sup> / <sub>8</sub> D12	100-27+ / 100-28	3.433	+1 <sup>1</sup> / <sub>4</sub>	27) 10Y Fut(CBT)	9:12 d 113-11		-1 <sup>1</sup> / <sub>2</sub>
10 YR NOTES				28) 5Yr Fut(CBT)	9:12 d 110-09	--	
13) 4 <sup>5</sup> / <sub>8</sub> 217	104-19 <sup>1</sup> / <sub>4</sub> / 104-19 <sup>3</sup> / <sub>4</sub>	4.015	+1	29) DowJones	13264.820	--	
14) 4 <sup>1</sup> / <sub>2</sub> 517	103-22 <sup>1</sup> / <sub>4</sub> / 103-23	4.019	+1	30) NASDAQ Cmp	2652.280	--	
15) 4 <sup>3</sup> / <sub>4</sub> 817	105-22 <sup>1</sup> / <sub>4</sub> / 105-22 <sup>3</sup> / <sub>4</sub>	4.027	+3 <sup>4</sup> / <sub>4</sub>	31) S&P 500 Ind	1468.360	--	
16) 4 <sup>1</sup> / <sub>4</sub> N17	101-26 / 101-26+	4.023	+1 <sup>2</sup> / <sub>2</sub>	32) Nymex wti crd	8:52 d 97.690		+1.710

T/ACT BILLS T/0-1 T/1-2 T/2-5 T/5-10 T/10-20 T/20-30 TIPS STRIPS AG/OTR AGENCIES CURVES

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000  
 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2008 Bloomberg Finance L.P.  
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And here are all the quotes for one of those notes (the old 10-year):

<HELP> for explanation. Govt **BBTQ**

T 4 <sup>3</sup>/<sub>4</sub> 08/15/17 Market **105-23+ / 105-23<sup>3</sup>/<sub>4</sub>** Prev 105-21+

Options Bloomberg Bond Trader 09:24

Security: T 4 <sup>3</sup>/<sub>4</sub> 08/15/17 **BBT**

	Bid Price / Ask Price	Bid Size	x	Ask Size	*	Bid Yld / Ask Yld	Change
MZ	105-23+ / 105-23 <sup>3</sup> / <sub>4</sub>	10	x	3		4.024 / 4.024	+ 02 <sup>1</sup> / <sub>4</sub>
	105-23+ / 105-24	SC	50	x	5	4.024 / 4.023	+ 02+
	105-23+ / 105-24 <sup>1</sup> / <sub>8</sub>	MZ	10	x	10	4.024 / 4.022	+ 02 <sup>5</sup> / <sub>8</sub>
JF	105-23 <sup>3</sup> / <sub>8</sub> / 105-24 <sup>1</sup> / <sub>8</sub>	WS	10	x	5	4.025 / 4.022	+ 02 <sup>5</sup> / <sub>8</sub>
SC	105-23 <sup>1</sup> / <sub>4</sub> / 105-24 <sup>1</sup> / <sub>4</sub>		5	x	10	4.025 / 4.022	+ 02 <sup>3</sup> / <sub>4</sub>
WS	105-23 <sup>1</sup> / <sub>8</sub> / 105-24+		5	x	50	4.026 / 4.021	+ 03
	105-23 / 105-24+	JF	3	x	10	4.026 / 4.021	+ 03
	105-22 <sup>3</sup> / <sub>4</sub> / 105-24 <sup>3</sup> / <sub>4</sub>		10	x	10	4.027 / 4.020	+ 03 <sup>1</sup> / <sub>4</sub>
GX	105-22 <sup>5</sup> / <sub>8</sub> / 105-25 <sup>1</sup> / <sub>4</sub>	GX	9	x	9	4.028 / 4.018	+ 03 <sup>3</sup> / <sub>4</sub>

\* Note: Indicated sizes are in Millions(MM)

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000  
 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2008 Bloomberg Finance L.P.  
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## Yield-to-Maturity and Discount Rate

From what we saw last time, the yield to maturity is defined as the rate  $y$  such that *if* you discount all future cash flows at  $y$ , you get the current ask price. The one twist to the formula is that you count time in *half* years, and discount at  $y/2$  per half year.

- Also, # half years to the next coupon is  $x = (\# \text{ days to next coupon}) / (\# \text{ days from previous coupon to next coupon})$ , and # half years to the coupon  $m$  coupons after that is  $m+x$

**Discount Rate:** A Treasury Bill pays face value at maturity, but no coupons before then

- Trades at a discount from face value
- The *discount rate* is the size of that discount, normalized to a 360-day year

*Definition:*  $d = 100(360/n)(F-P)/F$

- $d$  = discount rate
- $n$  = # days to maturity
- $F$  = face value
- $P$  = current price

Rearranging to solve for the price in terms of the discount rate, we get

$$P = F - (d/100)(n/360)F$$

This is way prices are generally quoted for discount securities, not just Treasury bills but any instrument that simply pays one big lump sum in the near future (the biggest example is Commercial Paper, which we'll get to later)

Consider the on-the-run 13-week bill on the screen above

- 91 days from settlement, 1/3/08, to maturity, 4/03/08
- Discount rate is 3.18% at the bid, 3.16% at the ask

So the price to buy  $F = \$1,000,000$  face value of this bill is

$$1,000,000 - (3.16/100)(91/360)1,000,000 = \mathbf{992,012}$$

Notice that the yield-to-maturity of the bill is 3.217, *higher* than 3.16

- In fact, yield is higher than discount rate for *all* of the bills
- You can't directly compare yields and discounts, they're different units

### **Bonds vs. STRIPS**

*STRIPS*, or *Separate Trading of Registered Interest and Principal Securities* are the different payments bonds make, trading separately.

- Also called zeros, since they pay zero coupons

A STRIP simply pays you \$100 on a specific future date, so its price is the price you pay today to get exactly \$100 on a date in the future

- Treasury securities are really just bundles of STRIPS. This implies a very simple relation between their prices

An example makes this clear. Consider the 6% 8/15/09 note. On 1/2/08, the prices to buy and sell this note were

<u>Coupon</u>	<u>Maturity</u>	<u>Bid/Ask</u>
6%	8/15/09	104-19+/21+

Accrued interest as of the settlement date 1/3/08 =  $(141/184)(6/2) = 2.2989$ , implying invoice prices of

- $104+19.5/32+2.2989 = \mathbf{106.9083}$  at the bid
- $104+21.5/32+2.2989 = \mathbf{106.9708}$  at the ask

This note has four remaining payment dates: 2/15/08, 8/15/08 and 2/15/09 when it pays coupons of 3, and 8/15/09 when it pays the coupon of 3 and repays the principal of 100.

For each of these dates, there are STRIPs trading, each paying \$100 on the stated date and nothing else. The quoted prices we find are

Maturity	Bid/Ask
2/15/08	99-21/21
8/15/08	98-05+/06
2/15/09	96-26/26+
8/15/09	95-08+/09+

So, if we want to buy the same cash flows as the 6% 8/15/09 note, then we need to buy (at the ask)

- \$3 of the 2/15/08 STRIP, costing  $(3/100)(99+21/32) = 2.9897$
- \$3 of the 8/15/08 STRIP, costing  $(3/100)(98+6/32) = 2.9456$
- \$3 of the 2/15/09 STRIP, costing  $(3/100)(96+26.5/32) = 2.9048$
- \$103 of the 8/15/09 STRIP, costing  $(103/100)(95+9.5/32) = 98.1558$

For a total cost of **106.9959**

Can we make money by buying the STRIPs, reconstituting them into the bond and selling the bond? No, because the 106.9959 cost of the STRIPs exceeds the 106.9083 we would get from selling the bond

Can we make money by buying the bond, stripping it and selling the pieces? To figure this out, we need to value the STRIPs at their bid prices, because that's what we'd get for selling them. If we plug in the bid prices rather than the asks to the calculation above, we get **106.9628**

- So we could buy the bond for 106.9708 and sell its' pieces for 106.9628, and that's not profitable either

So the market keeps these prices closely in line. Not a surprise; it's a pretty simple arbitrage.

Relative prices of three bonds with the same maturity

There are three securities maturing on 8/15/15:

*Coupon*

<i>Rate</i>	<i>Maturity</i>	<i>Bid/Ask</i>
10.625	08/15/15	145-12+/14+
4.25	08/15/15	103-13/16
0	08/15/15	74-17/20+

*implying prices of*

	<i>Bid</i>	<i>Ask</i>
10.625	149.4616	149.5241
4.25	105.0346	105.1284
0	74.5313	74.6406

We can easily show: with any two of these bonds we can replicate the cash flows of another

Suppose you had bonds 1, 2 and 3, with coupon rates  $C_1$ ,  $C_2$ , and  $C_3$ , with

- The same coupon payment dates
- The same principal repayment date (i.e. same maturity)

You want a portfolio of bonds 1 and 2 with the same cash flows on every date as bond 3.

*Simple algebra problem:* find the  $x$  such that  $xC_1 + (1-x)C_2 = C_3$ . This way, buying face value  $F$  of bond 3 is *exactly* the same as buying face value  $xF$  of bond 1, and  $(1-x)F$  of bond 2. Why?

- On each coupon date you get  $xF(C_1/2) + (1-x)F(C_2/2) = FC_3/2$
- At maturity you get  $xF + (1-x)F = F$

$$x = (C_3 - C_2) / (C_1 - C_2) \text{ solves the equation}$$

For example: Replicate \$1M face value of the 4.25 ( $C_3=4.25$ ) with a combination of the 10.625 ( $C_1=10.625$ ) and the 0 ( $C_2=0$ ).

- $x = (4.25-0)/(10.625-0) = 0.4$
- Buy  $xF = (0.4)(\$1M) = \$400,000$  face value of the 10.625% bond
  - This costs  $(\$400,000)(149.5241/100) = \$598,097$  (using the *ask* price)
- Buy  $(1-x)F = \$600,000$  face value of the 0% bond
  - Costs  $\$600,000(74.6406/100) = \$447,844$
- Total cost is  $\$598,097 + \$447,844 = \$1,045,941$
- Buying \$1M of the 4.25% bond directly costs **\$1,051,284**, and selling it brings in **\$1,050,346**
  - So if you buy the portfolio of the 10.625 and the STRIP, i.e. the *synthetic* bond or the *replicating portfolio*, and sell the 4.25%, then
    - you make  $\$1,050,346 - \$1,045,941 = \$4,405$  per \$1M face value when you put on the trade
    - All future cash flows offset

This is a very small and simple example of the kind of arbitrage bond traders look to put on

- Not as riskless as the strip/reconstitution trade above, though, since you can't simply convert the synthetic 4.25% into a real one; instead, you have to wait until the prices get back in line

Notice that our formula does not restrict  $x$  to be between 0 and 1.

- If  $x < 0$  then you are buying a *negative* amount of bond 1, or in other words, *selling* it, and you will get the bid price, not the ask
- If  $x > 1$  then you are selling, not buying, bond 2 (since  $1-x < 0$ )

BTW, bond traders would not have bothered to add in accrued interest before comparing the prices of the actual 4.25 bond with the portfolio of the 10.625 and the 0, since the accrued interest is the same either way

- Notice, though, that is true only if you're replicating the coupons of one bond with the coupons of another coupon-paying bond

## II. Spread between off- and on-the-run

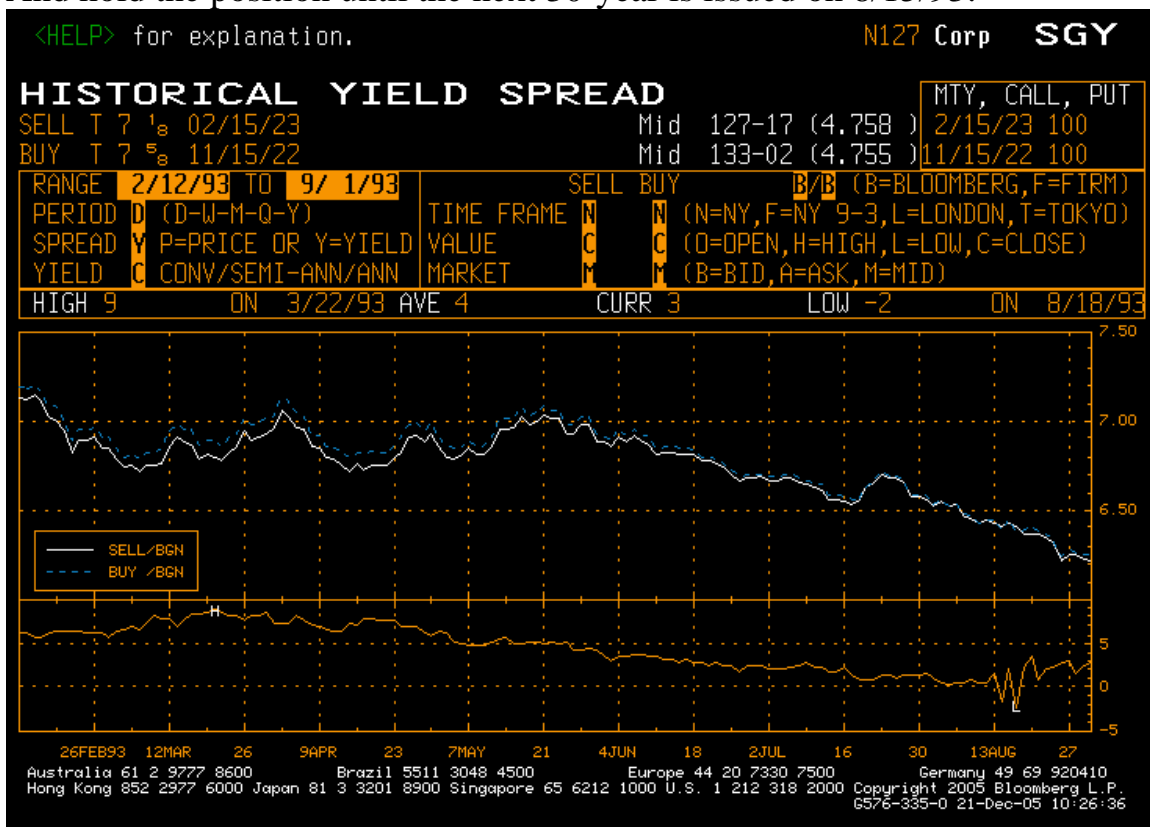
Off-the-runs sometimes trade at a spread over on-the-runs, reflecting their lower liquidity. But this spread goes away when the on-the-run goes off-the-run, when the next bond is issued

- If you think liquidity is not a problem for you, this looks like an arbitrage
  - Pocket the price difference by selling the on-the-run and buying the most recent off-the-run (often called the “old” bond)
  - Wait until both are off-the run, when the spread should be gone, and gradually unwind the position

Here’s what this looked like in 1993. On 2/15/93, the Treasury issued a new 30-year bond, maturing 2/23. At that point, the old bond was the one issued 11/15/92, maturing 11/22. To execute the trade you would have gone

- Long the old bond, i.e. the 11/22 bond, and
- Short the new bond, i.e. the 2/23 bond

And hold the position until the next 30-year is issued on 8/15/93:



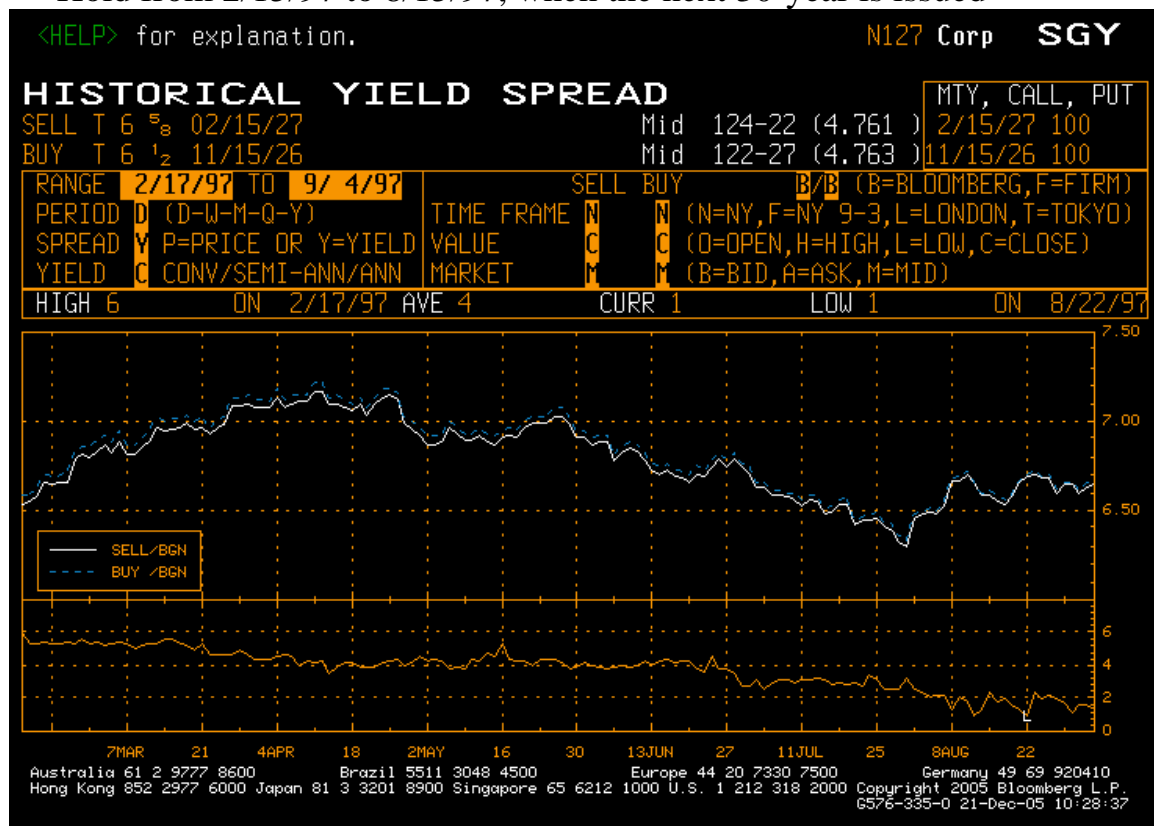
The upper graph shows the yields of the two bonds, and the lower graph shows the yield of the old bond minus the yield of the new bond. This is what should start out high and then go to zero by the time the next bond is issued. You can see it starts around 6bp, and is 0bp by 8/15/93.

This is one of the trades LTCM put on, and is a very simple but representative example of the kind of trade they looked for

- Driven by a temporary imbalance in liquidity demands
- Converges by a known date in the future

Here's the same trade four years later, when LTCM was active

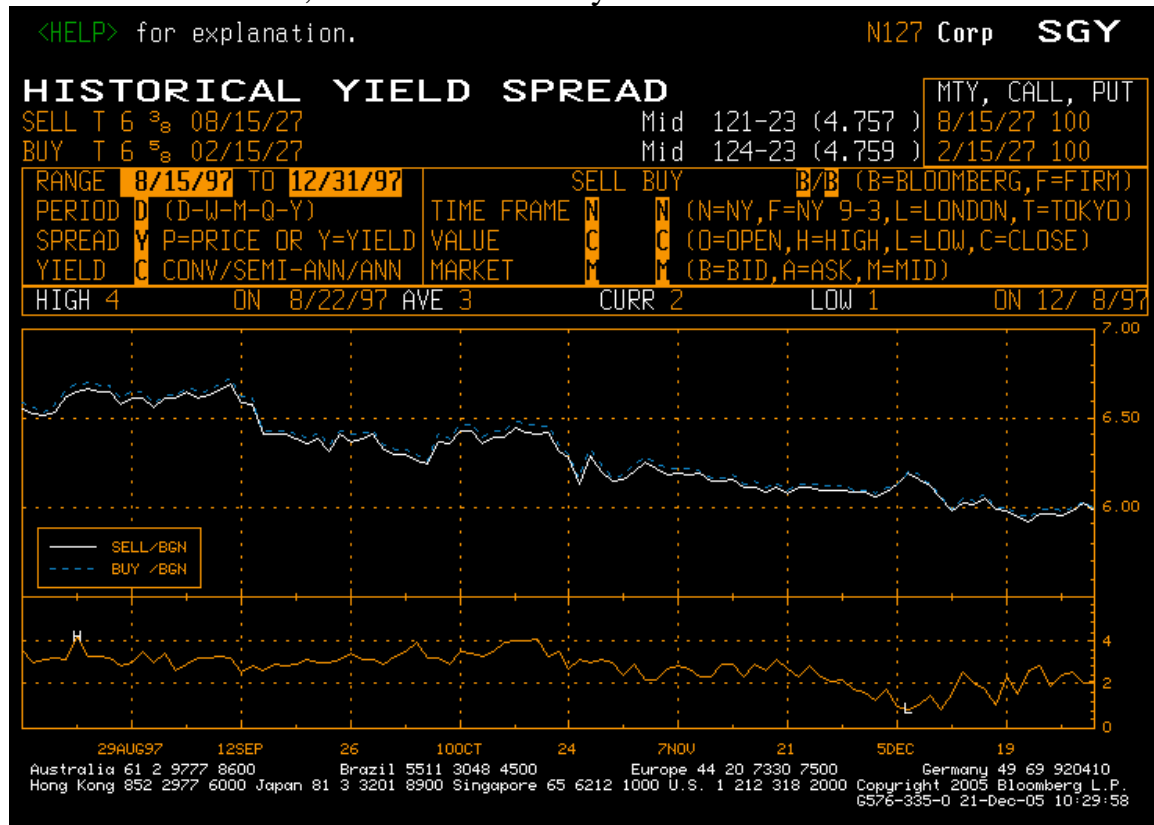
- Long the 11/26 bond and short the 2/27 bond
- Hold from 2/15/97 to 8/15/97, when the next 30-year is issued



Looks similar.

Here's the next opportunity for the same trade

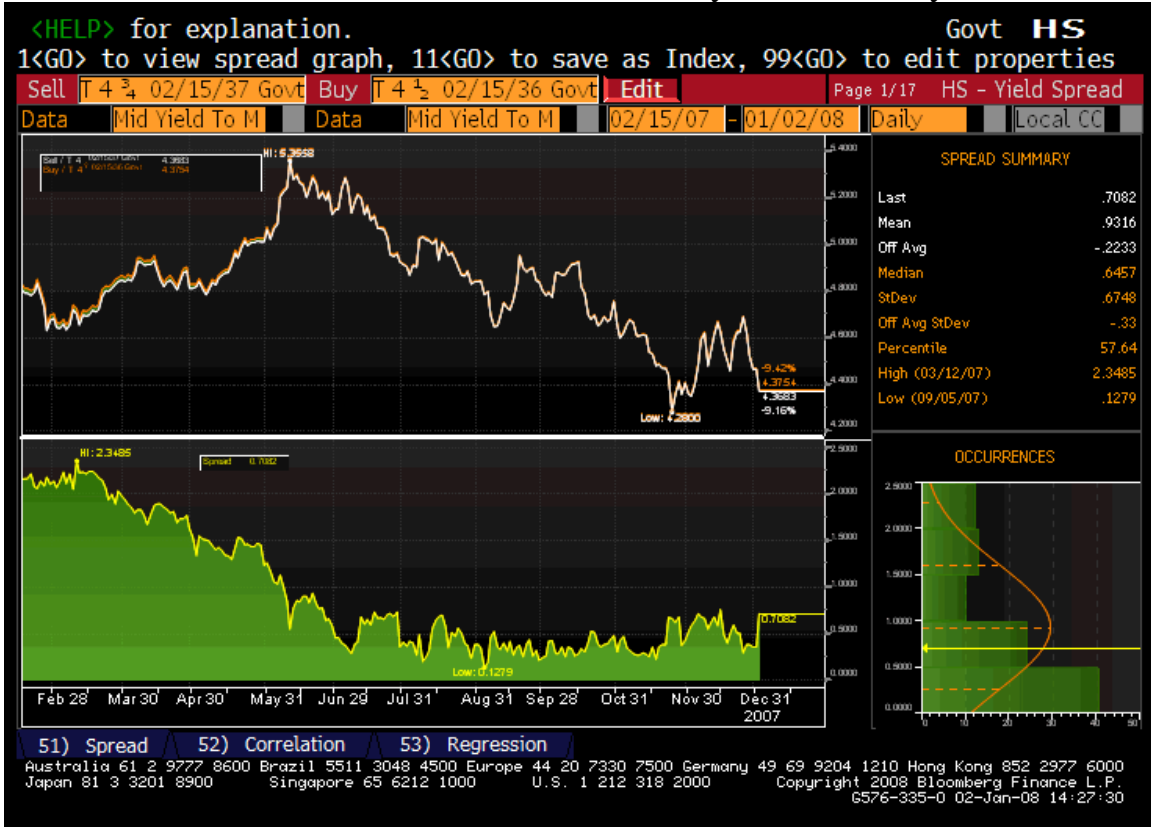
- Long the 2/27 bond and short the 8/27 bond
- Hold until 11/27, when the next 30-year is issued



Here, we see that the profitability of the trade has shrunk: the spread is smaller in the first place, and it converges less.

- It was at this time, the end of 1997, that LTCM decided it didn't have the trading opportunities to make decent returns on its invested capital, so it started giving capital back to investors
  - It would miss that capital very soon

Here's the old bond / new bond trade in the 30-year bond last year:



We can see a small but steady convergence.