Capital Markets
Homework # 3 (Due in class)
Preparation for Friday, November 5, 2004

Topic: Bond Arbitrage and T-Bills

Please clearly indicate "Homework #3" in the header of your turned-in answers for proper grade recording.

Preparatory Readings:

Re-read CP-2, Fabozzi, pp. 130-131

CP-3, Livingston, Chapter 8 (pp. 121-128)

Knowing how to read Wall Street Journal quotations is essential for solving the following problems. See pages 94-95 in The Wall Street Journal Guide to Understanding Money and Investing. Make sure that you locate the relevant column before looking for a specific security. For instance, for problem 1, you should first find the "Treasury Bills" column.

Bonds are quoted using a bid-asked spread. The difference between bid and asked is the profit a broker makes for "making a market". You buy a bond using the asked price. You sell a bond using the bid price.

1. Use the attached page from the Nov. 16th 1999 *Wall Street Journal* (quotations as of Nov. 15th). There is a Treasury bill that matures on Jan. 6th, 2000. Assume the settlement date is Nov 16th.

    a) What is the bill's quoted bank discount asked yield?

    b) What is the price you would have to pay to buy this bill at the quoted price on Nov. 16th?

    c) Adjust this yield to compare it with the quoted yield on U.S. Treasury notes and bonds (i.e. adjust it to a bond-equivalent yield).

2. Use the attached issue of the *WSJ* to answer the following questions. Assume all trades settle (money exchanges hands) on November 15th at the prices quoted.

    a) If you wanted to buy a $1,000,000 face value position in the 7½ % Treasury Note which matures on November 15, 2001, what is the "invoice" price you would have to pay? i.e. the *WSJ* quote plus accrued interest?

    b) What is the correct yield to maturity for this security at the quoted price?

    c) What would the quoted price of this bond have to be in order for its yield to maturity to equal 6.00%?

d) Construct a schedule of cash flows resulting from the purchase of $1,000,000 face value of this note assuming it is held to maturity.

e) Now assume that settlement is on November 16th, rather than the 15th. What is the "invoice" price the buyer would pay if the *WSJ* quoted price remained the same?

3. *It is easier to solve this next problem with a spreadsheet. The key point of this exercise is that the cash flow generated by buying one treasury security can be replicated by buying a series of other treasury securities. The costs of buying these cash flows, however, may be different. It is like buying exactly the same goods (i.e., "cash flows" in our case), but paying different prices when buying single goods rather than an assortment pack. What would you do to attempt to profit from this potential mispricing situation? . . . of course something can be done after you map out the cash flows in question, construct a replicating portfolio using other securities, and calculate how much it will cost you to buy all the cash flows.*

   Refer to the bond in Question 2 to answer the following questions. Settlement date remains Nov. 15, 1999.

   a) Consider the schedule of cash flows constructed in Question 2 part (d) for the 7½% Treasury Note which matures on November 15, 2001. Can a portfolio of Treasury Strips be purchased which would replicate the cash flows of the Treasury Note referred to in Question 2? (*Hint: The answer is YES!*) If so, how? Use "ci" T. Strips for coupon interest payments and "np" T. Strips for the ending principal payment. (Hint: use the T.Strips that are marked with the dots on the attached *WSJ* Government Bond Page).

   b) What would be the total cost of creating (purchasing) such a strip portfolio? (You'll need to construct a spreadsheet for this.)

   c) Would the strip portfolio you constructed in b) be any more or less "risky" than the Treasury Note? Why is this important to know?

   d) Now consider a situation where you already own the Treasury Note in Question 2. What are the total proceeds you could likely get for it if you sold it?

   e) Compare the sales price calculated in d) to the cost of the portfolio calculated in b). Is there a difference? Is there a profit (i.e., *arbitrage*) opportunity for an investor here?

   f) Now consider a situation where you already own the strip portfolio that replicates the Treasury Note. How much could you likely get for this portfolio if you liquidated it (i.e. the bid price)?

   g) Compare the sales price calculated in f) to the total price in part a) of Question 2. Is there a difference? Is there a profit (i.e., *arbitrage*) opportunity for an investor here?

   h) **Advanced Question**: If this Note were being bought or sold on a <u>non</u>-coupon payment date (rather than an exact treasury six-month aniversary), what changes in your calculations would need to be made?

Attached is the *WSJ* Government Bond Page for use with Questions 1, 2 , and 3.

TREASURY BONDS, NOTES & BILLS

Monday, November 15, 1999

Representative Over-the-Counter quotations based on transactions of $1 million or more.

Treasury bond, note and bill quotes are as of mid-afternoon. Colons in bid-and-asked quotes represent 32nds; 101:01 means 101 1/32. Net changes in 32nds. n-Treasury note. Treasury bill quotes in hundredths, quoted on terms of a rate of discount. Days to maturity calculated from settlement date. All yields are to maturity and based on the asked quote. Latest 13-week and 26-week bills are boldfaced. For bonds callable prior to maturity, yields are computed to the earliest call date for issues quoted above par and to the maturity date for issues below par. *-When issued.

Source: Telerate/Cantor Fitzgerald

U.S. Treasury strips as of 3 p.m. Eastern time, also based on transactions of $1 million or more. Colons in bid-and-asked quotes represent 32nds; 99:01 means 99 1/32. Net changes in 32nds. Yields calculated on the asked quotation. ci-stripped coupon interest. bp-Treasury bond, stripped principal. np-Treasury note, stripped principal. For bonds callable prior to maturity, yields are computed to the earliest call date for issues quoted above par and to the maturity date for issues below par.

Source: Bear, Stearns & Co. via Street Software Technology Inc.

GOVT. BONDS & NOTES

Rate	Maturity Mo/Yr	Bid	Asked	Chg.	Ask Yld.
5 5/8	Nov 99n	100:00	100:02	+ 1	3.89
7 3/4	Nov 99n	100:02	100:04	....	4.32
5 5/8	Dec 99n	100:00	100:02	....	5.00
7 3/4	Dec 99n	100:08	100:10	....	5.03
6 3/8	Jan 00n	100:03	100:05	....	5.29
5 3/8	Jan 00n	99:31	100:01	....	5.14
7 3/4	Jan 00n	100:14	100:16	-1	5.19
5 7/8	Feb 00n	100:03	100:05	....	5.16
8 1/2	Feb 00n	100:23	100:25	-1	5.19
5 1/2	Feb 00n	100:00	100:02	....	5.22
7 1/8	Feb 00n	100:14	100:16	-1	5.29
5 1/2	Mar 00n	100:00	100:02	....	5.29
6 7/8	Mar 00n	100:16	100:18	....	5.28
5 1/2	Apr 00n	99:30	100:00	-1	5.47
5 5/8	Apr 00n	100:00	100:02	-1	5.47
6 3/4	Apr 00n	100:17	100:19	....	5.40
6 3/8	May 00n	100:12	100:14	-1	5.47
8 7/8	May 00n	101:20	101:22	-1	5.39
5 1/2	May 00n	99:30	100:00	....	5.49
6 1/4	May 00n	100:10	100:12	-1	5.53
5 3/8	Jun 00n	99:27	99:29	-1	5.52
5 7/8	Jun 00n	100:05	100:07	....	5.50
5 3/8	Jul 00n	99:25	99:27	-1	5.59
6 1/8	Jul 00n	100:10	100:12	-1	5.56
6	Aug 00n	100:07	100:09	-1	5.60
8 3/4	Aug 00n	102:06	102:08	-2	5.62
5 1/4	Aug 00n	99:18	99:20	....	5.61
6 1/4	Aug 00n	100:13	100:15	-1	5.62
4 1/2	Sep 00n	98:30	99:00	....	5.69
6 1/8	Sep 00n	100:10	100:12	-1	5.67
4	Oct 00n	98:13	98:15	....	5.67
5 3/4	Oct 00n	100:01	100:03	....	5.64
5 3/4	Nov 00n	100:01	100:03	....	5.65
8 1/2	Nov 00n	102:21	102:23	-1	5.66
4 5/8	Nov 00n	98:29	98:31	....	5.66
5 3/8	Nov 00n	99:29	99:31	....	5.65
4 5/8	Dec 00n	98:25	98:27	....	5.70
5 1/2	Dec 00n	99:23	99:25	....	5.70
4 1/2	Jan 01n	98:17	98:19	-1	5.72
5 1/4	Jan 01n	99:14	99:16	....	5.68
5 3/8	Feb 01n	99:17	99:19	-1	5.71
7 3/4	Feb 01n	102:12	102:14	-1	5.69
11 3/4	Feb 01	107:04	107:06	-2	5.69
5	Feb 01n	99:02	99:04	....	5.71
5 5/8	Feb 01n	99:27	99:29	....	5.69
4 7/8	Mar 01n	98:25	98:27	-1	5.76
6 3/8	Mar 01n	100:24	100:26	-1	5.74
5	Apr 01n	98:30	99:00	-1	5.72
6 1/4	Apr 01n	100:21	100:23	-1	5.73
5 5/8	May 01n	99:25	99:27	....	5.74
8	May 01n	103:05	103:07	-1	5.73
13 1/8	May 01	110:12	110:16	-2	5.71
5 1/4	May 01n	99:08	99:10	....	5.72
6 1/2	May 01n	101:01	101:03	-1	5.74
5 3/4	Jun 01n	99:29	99:31	-1	5.77
6 5/8	Jun 01n	101:07	101:09	-1	5.78
5 1/2	Jul 01n	99:16	99:18	-1	5.77
6 5/8	Jul 01n	101:10	101:12	-1	5.76
7 7/8	Aug 01n	103:11	103:13	-1	5.79
13 3/8	Aug 01	112:11	112:15	-2	5.77
5 1/2	Aug 01n	99:16	99:18	....	5.71
6 1/2	Aug 01n	101:04	101:06	-1	5.78
5 3/8	Sep 01n	99:22	99:23	....	5.78
6 3/8	Sep 01n	100:30	101:00	-1	5.80
5 7/8	**Oct 01n**	**100:05**	**100:06**	-1	**5.77**
6 1/4	Oct 01n	100:25	100:27	-1	5.79
7 1/2	Nov 01n	103:03	103:05	[redacted]	
15 3/4	Nov 01	[redacted]			
5 7/8	Nov 01n	100:04	100:06	-1	5.77
6 1/8	Dec 01n	100:18	100:20	-1	5.80
6 1/4	Jan 02n	100:27	100:29	-1	5.80
14 1/4	Feb 02	117:15	117:19	-3	5.79
6 1/4	Feb 02n	100:28	100:30	-1	5.80
6 5/8	Mar 02n	101:23	101:25	....	5.81
6 3/8	Apr 02n	101:25	101:27	....	5.81
7 1/2	May 02n	103:25	103:27	....	5.82
6 1/2	**May 02n**	**101:17**	**101:19**	....	**5.81**
6 1/4	Jun 02n	100:30	101:00	-1	5.83
3 5/8	Jul 02l	99:11	99:12	-1	3.87
6	Jul 02n	100:13	100:15	....	5.81
6 3/8	Aug 02n	101:08	101:10	-1	5.85
6 1/4	Aug 02n	100:30	101:00	-1	5.85
5 7/8	Sep 02n	100:01	100:03	-1	5.84
5 3/4	Oct 02n	99:23	99:25	-1	5.83
11 5/8	Nov 02	115:11	115:15	-1	5.92
5 3/4	Nov 02n	99:21	99:23	....	5.85
5 5/8	Dec 02n	99:09	99:11	....	5.86
5 1/2	Jan 03n	98:27	98:29	....	5.88
6 1/4	Feb 03n	100:30	101:00	....	5.90
10 3/4	Feb 03	113:26	113:30	-1	5.96
5 1/2	Feb 03n	98:26	98:28	....	5.88
5 1/2	Mar 03n	98:25	98:27	....	5.88
5 3/4	Apr 03n	99:16	99:18	....	5.89
10 3/4	May 03	114:23	114:27	-1	5.98
5 1/2	May 03n	98:22	98:24	....	5.90
3 7/8	Jan 09l	98:13	98:14	....	4.08
5 1/2	May 09n	96:25	96:26	-1	5.94
9 1/8	May 04-09	111:14	111:18	-2	6.14
6	**Aug 09n**	**100:16**	**100:17**	**-2**	**5.93**
10 3/8	Nov 04-09	117:26	117:30	-2	6.15
11 3/4	Feb 05-10	124:18	124:24	-2	6.16
10	May 05-10	117:16	117:20	-2	6.17
12 3/4	Nov 05-10	132:13	132:19	-2	6.17
13 7/8	May 06-11	140:17	140:23	-2	6.17
14	Nov 06-11	143:19	143:25	-4	6.19
10 3/8	Nov 07-12	125:11	125:17	-2	6.27
12	Aug 08-13	137:29	138:03	-2	6.28
13 1/4	May 09-14	149:01	149:07	-2	6.29
12 1/2	Aug 09-14	144:17	144:23	-2	6.29
11 3/4	Nov 09-14	140:00	140:06	-2	6.28
11 1/4	Feb 15	147:14	147:20	+ 1	6.33
10 5/8	Aug 15	141:28	142:02	+ 2	6.36
9 7/8	Nov 15	134:24	134:30	....	6.36
9 1/4	Feb 16	128:24	128:30	....	6.37
7 1/4	May 16	109:05	109:07	....	6.34
7 1/2	Nov 16	111:24	111:28	....	6.35
8 3/4	May 17	124:26	125:00	+ 1	6.36
8 7/8	Aug 17	126:10	126:16	+ 2	6.36
9 1/8	May 18	129:19	129:25	+ 1	6.36
9	Nov 18	128:20	128:26	+ 2	6.36
8 7/8	Feb 19	127:14	127:20	+ 2	6.36
8 1/8	Aug 19	119:16	119:20	+ 2	6.36
8 1/2	Feb 20	123:29	124:03	+ 1	6.37
8 3/4	May 20	126:28	127:02	+ 1	6.37
8 3/4	Aug 20	127:01	127:07	+ 2	6.37
7 7/8	Feb 21	117:14	117:18	+ 2	6.36
8 1/8	May 21	120:13	120:19	+ 3	6.36
8 1/8	Aug 21	120:15	120:21	+ 3	6.36
8	Nov 21	119:07	119:11	+ 1	6.36
7 1/4	Aug 22	110:27	110:31	+ 1	6.33
7 5/8	Nov 22	115:12	115:16	+ 2	6.34
7 1/8	Feb 23	109:20	109:22	+ 1	6.32
6 1/4	Aug 23	99:16	99:18	+ 1	6.28
7 1/2	Nov 24	114:29	115:01	+ 2	6.30
7 5/8	Feb 25	116:22	116:26	+ 1	6.29
6 7/8	Aug 25	107:12	107:14	+ 1	6.29
6	Feb 26	96:16	96:18	+ 1	6.27
6 3/4	Aug 26	105:29	105:31	+ 1	6.29
6 1/2	Nov 26	102:26	102:28	+ 1	6.28
6 5/8	Feb 27	104:15	104:17	....	6.28
6 3/8	Aug 27	101:10	101:12	+ 1	6.27
6 1/8	Nov 27	98:09	98:11	+ 1	6.25
3 5/8	Apr 28i	92:09	92:10	-1	4.08
5 1/2	Aug 28	90:13	90:15	....	6.21
5 1/4	Nov 28	87:11	87:13	-2	6.19
5 1/4	Feb 29	87:25	87:26	-2	6.15
3 7/8	Apr 29i	96:13	96:14	-2	4.08
6 1/8	**Aug 29**	**101:07**	**101:08**	**-3**	**6.03**

U.S. TREASURY STRIPS

Mat.	Type	Bid	Asked	Chg.	Ask Yld.
Feb 00	ci	98:24	98:24	....	5.16
Feb 00	np	98:23	98:23	....	5.25
May 00	ci	97:14	97:14	....	5.33
May 00	np	97:11	97:11	....	5.53
Aug 00	ci	95:31	96:00	....	5.58
Aug 00	np	95:30	95:30	....	5.64
Nov 00	ci	94:17	94:18	....	5.70
Nov 00	np	94:16	94:17	....	5.75
Feb 01	ci	93:08	93:09	....	5.67
Feb 01	np	93:07	93:08	....	5.70
May 01	ci	91:28	91:29	....	5.74
May 01	np	91:28	91:29	....	5.73
Aug 01	ci	90:18	90:18	....	5.75
Aug 01	np	90:16	90:17	....	5.79
Nov 01	ci	89:07	89:08	....	5.78
Nov 01	np	89:06	89:07	....	5.79
Feb 02	ci	87:30	87:31	....	5.79
May 02	ci	86:21	86:22	– 1	5.80
May 02	np	86:20	86:21	– 1	5.82
Aug 02	ci	85:13	85:14	– 1	5.81
Aug 02	np	85:11	85:13	– 1	5.83
Nov 02	ci	84:04	84:07	– 1	5.82
Feb 03	ci	82:23	82:25	– 1	5.90
Feb 03	np	82:23	82:26	– 1	5.90
May 03	ci	81:14	81:17	– 1	5.93
Aug 03	ci	80:09	80:12	– 1	5.92
Aug 03	np	80:12	80:14	– 1	5.89
Nov 03	ci	79:04	79:07	– 1	5.91
Feb 04	ci	77:25	77:28	– 1	5.98
Feb 04	np	78:08	78:11	– 1	5.84
May 04	ci	76:19	76:22	– 1	5.99
May 04	np	76:24	76:27	– 1	5.94
Aug 04	ci	75:22	75:26	+ 3	5.92
Aug 04	np	75:19	75:23	– 1	5.95
Nov 04	ci	74:04	74:07	– 1	6.06
Nov 04	bp	73:30	74:01	– 1	6.11
Nov 04	np	74:10	74:13	– 1	6.01
Feb 05	ci	72:31	73:03	....	6.07
Feb 05	np	73:09	73:13	....	5.98
Mat.	Type	Bid	Asked	Chg.	Ask Yld.
Nov 12	ci	43:29	44:02		6.41
Feb 13	ci	43:06	43:11		6.41
May 13	ci	42:15	42:21		6.42
Aug 13	ci	41:24	41:29		6.43
Nov 13	ci	41:02	41:07		6.43
Feb 14	ci	40:12	40:18	+ 1	6.44
May 14	ci	39:24	39:29	+ 1	6.44
Aug 14	ci	39:03	39:08	+ 1	6.44
Nov 14	ci	38:15	38:20	+ 1	6.44
Feb 15	ci	37:27	38:01	+ 1	6.44
Feb 15	bp	38:04	38:09	+ 1	6.40
May 15	ci	37:06	37:14	+ 1	6.44
Aug 15	ci	36:22	36:27	+ 1	6.44
Aug 15	bp	36:22	36:27	+ 1	6.44
Nov 15	ci	36:03	36:08	+ 1	6.44
Nov 15	bp	36:03	36:08		6.44
Feb 16	ci	35:17	35:22	+ 1	6.44
Feb 16	bp	35:18	35:24	– 1	6.43
May 16	ci	34:31	35:04	+ 1	6.44
May 16	bp	35:16	35:22	+ 1	6.35
Aug 16	ci	34:13	34:18	+ 1	6.44
Nov 16	ci	33:30	34:03	+ 1	6.43
Nov 16	bp	34:10	34:15	+ 1	6.36
Feb 17	ci	33:13	33:19	+ 1	6.43
May 17	ci	32:29	33:03	+ 1	6.42
May 17	bp	32:30	33:04	+ 1	6.42
Aug 17	ci	32:12	32:17	– 1	6.43
Aug 17	bp	32:14	32:19	+ 1	6.42
Nov 17	ci	31:29	32:03	– 1	6.42
Feb 18	ci	31:12	31:17	+ 1	6.43
May 18	ci	30:28	31:02	+ 1	6.42
May 18	bp	30:29	31:03	+ 1	6.42
Aug 18	ci	30:12	30:18	+ 1	6.43
Nov 18	ci	29:30	30:03	+ 1	6.42
Nov 18	bp	29:30	30:04	+ 1	6.42
Feb 19	ci	29:14	29:20	+ 1	6.42
Feb 19	bp	29:17	29:22	+ 1	6.41
May 19	ci	29:00	29:05	+ 1	6.42
Aug 19	ci	28:20	28:25	+ 1	6.41
Aug 19	bp	28:22	28:27	+ 1	6.40
Nov 19	ci	28:06	28:11	+ 1	6.41
Feb 20	ci	27:22	27:27	+ 1	6.42
Feb 20	bp	27:25	27:30	+ 1	6.40
May 20	ci	27:09	27:14	+ 1	6.41
May 20	bp	27:10	27:15	+ 1	6.40
Aug 20	ci	26:28	27:01	+ 1	6.40
Aug 20	bp	26:29	27:02	+ 1	6.40
Nov 20	ci	26:16	26:21	+ 1	6.40
Feb 21	ci	26:03	26:08	+ 1	6.39
Feb 21	bp	26:09	26:14	+ 1	6.36
May 21	ci	25:24	25:29	+ 1	6.38
May 21	bp	25:26	25:31	+ 1	6.37
Aug 21	ci	25:11	25:16	+ 1	6.38
Aug 21	bp	25:14	25:19	+ 1	6.37
Nov 21	ci	25:02	25:07	+ 1	6.36
Nov 21	bp	25:02	25:08	+ 1	6.36
Feb 22	ci	24:19	24:24		6.37
May 22	ci	24:10	24:15		6.36
Aug 22	ci	24:00	24:05		6.34
Aug 22	bp	24:08	24:13		6.30
Nov 22	ci	23:24	23:29		6.32
Nov 22	bp	23:26	23:31		6.31
Feb 23	ci	23:14	23:19		6.31
Feb 23	bp	23:21	23:26		6.27
May 23	ci	23:04	23:09		6.30
Aug 23	ci	22:27	23:00		6.29
Aug 23	bp	23:14	23:19		6.18
Nov 23	ci	22:19	22:24		6.27
Feb 24	ci	22:11	22:16		6.25
May 24	ci	22:02	22:07		6.24
Aug 24	ci	21:24	21:29		6.23
Nov 24	ci	21:16	21:21		6.21
Nov 24	bp	21:16	21:21		6.21
Feb 25	ci	21:12	21:17		6.18
Feb 25	bp	21:12	21:17		6.18
May 25	ci	21:00	21:05		6.19
Aug 25	ci	20:23	20:28		6.18
Aug 25	bp	20:22	20:27		6.19
Nov 25	ci	20:13	20:18		6.18
Feb 26	ci	19:30	20:03		6.21
Feb 26	bp	20:08	20:13		6.15
May 26	ci	19:21	19:26		6.21
Aug 26	ci	19:12	19:17		6.20
Aug 26	bp	19:15	19:20		6.18
Nov 26	ci	19:02	19:07		6.20
Nov 26	bp	19:07	19:12		6.17
Feb 27	ci	18:28	19:01		6.18
Feb 27	bp	19:02	19:07		6.15
May 27	ci	18:18	18:22		6.19
Aug 27	ci	18:13	18:18		6.16
Aug 27	bp	18:17	18:22		6.14
Nov 27	ci	18:14	18:19		6.10
Nov 27	bp	18:14	18:19		6.10
Feb 28	ci	18:04	18:09		6.11
May 28	ci	18:01	18:06		6.07
Aug 28	ci	17:29	18:01		6.05
Aug 28	bp	18:01	18:06		6.02
Nov 28	ci	18:03	18:08		5.95
Nov 28	bp	18:01	18:06		5.97
Feb 29	ci	18:15	18:20	– 1	5.83
Feb 29	bp	18:08	18:13	– 1	5.87

TREASURY BILLS

Maturity	Days to Mat.	Bid	Asked	Chg.	Ask Yld.
Nov 18 '99	2	4.61	4.53	– 0.05	4.59
Nov 26 '99	10	4.62	4.54	– 0.07	4.61
Dec 02 '99	16	4.65	4.57	– 0.04	4.64
Dec 09 '99	23	4.62	4.54	– 0.07	4.62
Dec 16 '99	30	4.57	4.53	+ 0.01	4.61
Dec 23 '99	37	4.78	4.74	+ 0.01	4.83
Dec 30 '99	44	4.94	4.90	– 0.03	5.00
Jan 06 '00	51	4.96	4.92	....	5.02