Economics 435
The Financial System
(9/28/16)

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Future Value and Present Value

- If the present value is \$100 and the interest rate is 5%, then the *future value* one year from now is:

$$\$100 + \$100(0.05) = \$105$$

- This also shows that the higher the interest rate, the higher the future value.
- In general:

$$FV = PV + PV(i) = PV(1 + i)$$

- And:

$$PV = \frac{FV}{(1+i)}$$

Future Value and Compound Interest

- What if you leave your $100 in the bank for two years at 5% yearly interest rate?
- The future value is:

$$\$100 + \$100(0.05) + \$100(0.05) + \$5(0.05) = \$110.25$$

$$\$100(1.05)(1.05) = \$100(1.05)^2$$

- In general

$$FV_n = PV(1 + i)^n$$

$$PV = \frac{FV}{(1 + i)^n}$$

Complications

- What if payments, X_t, occur all the way along until the end?
- What if the interest rate, i_t, is not constant?

$$PV_t = \left[\frac{X_{t+1}}{(1+i_t)} + \frac{X_{t+2}}{(1+i_t)\times(1+i_{t+1})} + \ldots\ldots + \frac{X_{t+n}}{(1+i_t)\times(1+i_{t+1})\ldots(1+i_{t+n-1})} \right]$$

- But at time t, one doesn't know t+n information … so:

$$PV_t = \left[\mathcal{E}_t \frac{X_{t+1}}{(1+i_t)} + \mathcal{E}_t \frac{X_{t+2}}{(1+i_t)\times(1+i_{t+1})} + \ldots\ldots + \mathcal{E}_t \frac{X_{t+n}}{(1+i_t)\times(1+i_{t+1})\ldots(1+i_{t+n-1})} \right]$$

Bond Basics

- The most common type of bond is a coupon bond.
  - Issuer is required to make annual payments, called coupon payments.
  - The annual interest the borrower pays (i_c), is the coupon rate.
  - The date on which the payments stop and the loan is repaid (n), is the maturity date or term to maturity.
  - The final payment is the principal, face value, or par value of the bond.

Bond Prices

1. Zero-coupon or discount bond

- Promise a single payment on a future date
- Example: Treasury bill

2. Fixed-payment loan

- Sequence of fixed payments
- Example: Mortgage or car loan

3. Coupon bond

- periodic interest payments + principal repayment at maturity
- Example: U.S. Treasury Bonds and most corporate bonds

4. Consol

- periodic interest payments forever, principal never repaid
- Example: U.K. government has some outstanding

Zero-Coupon Bonds

- U.S. Treasury bills (T-bills) are the most straightforward type of bond.
  - Each T-bill represents a promise by the U.S. government to pay $100 on a fixed future date.
  - No coupon payments - zero-coupon bonds
  - Also called pure discount bonds (or discount bonds) since the price is less than face value - they sell at a discount.
- Price of $100 face value zero-coupon bond

$$= \frac{\$100}{(1+i)^n}$$

Zero-Coupon Bonds

Assume $i = 5\%$

Price of a One-Year Treasury Bill

$$= \frac{100}{(1+0.05)} = \$95.24$$

Price of a Six-Month Treasury Bill

$$= \frac{100}{(1+0.05)^{1/2}} = \$97.59$$

Zero-Coupon Bonds

- For a zero-coupon bond, the relationship between the price and the interest rate is the same as we saw on present value calculations.
- When the price moves, the interest rate moves with it, in the opposite direction.
- We can compute the interest rate from the price using the present value formula.

The price of a one-year T-bill is \$95.

i = (\$100/\$95) - 1 = 0.0526 = 5.26%

Fixed-Payment Loans

- Home mortgages and car loans are fixed-payment loans.
  - They promise a fixed number of equal payments at regular intervals.
  - Amortized loans - the borrower pays off part of the principal along with the interest for the life of the loan.
- Value of a Fixed Payment Loan =

$$\frac{FixedPayment}{(1+i)} + \frac{FixedPayment}{(1+i)^2} + \cdots + \frac{FixedPayment}{(1+i)^n}$$

- The sum of the present value of the payments.

Coupon Bonds

- The issuer of a coupon bond promises to make a series of periodic interest payments (coupon payments), plus a principal payment at maturity.

Price of Coupon Bond =

$$P_{CB} = \left[\frac{CouponPayment}{(1+i)^1} + \frac{CouponPayment}{(1+i)^2} + ... + \frac{CouponPayment}{(1+i)^n} \right]$$

$$+ \frac{FaceValue}{(1+i)^n}$$

Consols

- Consols or perpetuities, are like coupon bonds whose payments last forever.
- The borrower pays only interest, never repaying the principal.
- The U.S. government sold consols once in 1900, but the Treasury has bought them all back.
- The price of a consol is the present value of all future interest payments.

$$P_{Consol} = \frac{\text{Yearly Coupon Payment}}{i}$$

Bond Yields

- We know how to calculate bond prices given an interest rate.
- We also need to be able to go in the other direction.
  - Calculate the return to an investment, implicit in the bond's price.
- We will combine information about the promised payments with the price to obtain the *yield*:
  - A measure of the cost of borrowing and the reward for lending.
  - We will use the terms *yield* and *interest rate* interchangeably.

Yield to Maturity

- The most useful measure of the return on holding a bond is called the yield to maturity:
  - The yield bondholders receive if they hold the bond to its maturity when the final principal payment is made.

$$\text{Price of 1yr 5\% Coupon Bond} = \frac{\$5}{(1+i)} + \frac{\$100}{(1+i)}$$

- The value of i that solves the equation is the yield to maturity.

Current Yield

Example:

1 year, 5% coupon bond selling for \$99

$$\text{Current Yield} = \frac{5}{99} = 0.0505 \text{ , or } 5.05\%$$

Yield to maturity for this bond is 6.06 percent found as the solution to:

$$\frac{\$5}{(1+i)} + \frac{\$100}{(1+i)} = \$99$$

Holding Period Returns

- The *one-year holding period return* is the sum of the yearly coupon payment divided by the price paid for the bond and the change in the price divided by the price paid.

$$= \frac{\text{Yearly Coupon Payment}}{\text{Price Paid}} + \frac{\text{Change in Price of the Bond}}{\text{Price of the Bond}}$$

$$= \text{Current Yield} + \text{Capital Gain (as a \%)}$$

Data on "Treasury Notes and Bonds"

http://online.wsj.com/mdc/public/page/2_3020-treasury.html

U.S. Treasury Quotes

TREASURY NOTES & BONDS

GO TO: Bills

Tuesday, September 27, 2016 Find Historical Data | WHAT'S THIS?

Treasury note and bond data are representative over-the-counter quotations as of 3pm Eastern time. For notes and 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.

Maturity	Coupon	Bid	Asked	Chg	Asked yield
9/30/2016	0.500	99.9844	100.0000	0.0156	0.499
9/30/2016	1.000	99.9844	100.0000	0.0078	0.998
9/30/2016	3.000	99.9922	100.0078	0.0078	1.553
10/15/2016	0.625	100.0078	100.0234	0.0156	0.120
10/31/2016	0.375	100.0078	100.0234	0.0156	0.114
10/31/2016	1.000	100.0625	100.0781	0.0234	0.128
10/31/2016	3.125	100.2500	100.2656	0.0156	0.160
11/15/2016	0.625	100.0391	100.0547	0.0234	0.205
11/15/2016	4.625	100.5547	100.5703	unch.	0.247
11/15/2016	7.500	100.8906	100.9063	-0.0078	0.533
11/30/2016	0.500	100.0469	100.0625	0.0156	0.137
11/30/2016	0.875	100.1016	100.1172	unch.	0.194
11/30/2016	2.750	100.4297	100.4453	0.0078	0.161
12/15/2016	0.625	100.0703	100.0859	0.0078	0.221
12/31/2016	0.625	100.0703	100.0859	-0.0078	0.288
12/31/2016	0.875	100.1406	100.1563	0.0078	0.262
12/31/2016	3.250	100.7266	100.7422	-0.0156	0.339
1/15/2017	0.750	100.1094	100.1250	0.0156	0.327
1/31/2017	0.500	100.0391	100.0547	0.0156	0.339
1/31/2017	0.875	100.1641	100.1797	unch.	0.345
1/31/2017	3.125	100.9219	100.9375	unch.	0.360
2/15/2017	0.625	100.0938	100.1094	0.0313	0.337
2/15/2017	4.625	101.6094	101.6250	0.0078	0.346
2/28/2017	0.500	100.0391	100.0547	0.0234	0.370
2/28/2017	0.875	100.1953	100.2109	0.0078	0.375
2/28/2017	3.000	101.0859	101.1016	0.0078	0.389
8/15/2024	2.375	106.9219	106.9375	0.2188	1.441
11/15/2024	2.250	105.9688	105.9844	0.2266	1.466
11/15/2024	7.500	146.9609	146.9766	0.2344	1.373
2/15/2025	2.000	104.0078	104.0234	0.2578	1.488
2/15/2025	7.625	149.0469	149.0625	0.3047	1.400
5/15/2025	2.125	105.0000	105.0156	0.2656	1.503
8/15/2025	2.000	103.9453	103.9609	0.2734	1.521
8/15/2025	6.875	145.1719	145.1875	0.3828	1.437
11/15/2025	2.250	106.0234	106.0391	0.2813	1.538
2/15/2026	1.625	100.6250	100.6406	0.2734	1.551
2/15/2026	6.000	139.1250	139.1406	0.3281	1.509
5/15/2026	1.625	100.5938	100.6094	0.2813	1.557
8/15/2026	1.500	99.5078	99.5234	0.2969	1.552
8/15/2026	6.750	147.8203	147.8359	0.4141	1.518
11/15/2026	6.500	146.3516	146.3672	0.4453	1.539
2/15/2027	6.625	148.5547	148.5703	0.4063	1.543
2/15/2043	3.125	117.8516	117.8828	1.0547	2.225
5/15/2043	2.875	112.5859	112.6172	1.0547	2.243
8/15/2043	3.625	128.7344	128.7656	1.1797	2.201
11/15/2043	3.750	131.5859	131.6172	1.1641	2.197
2/15/2044	3.625	128.7188	128.7500	1.1094	2.218
5/15/2044	3.375	123.3672	123.3984	1.1250	2.235
8/15/2044	3.125	118.1016	118.1328	1.1484	2.246
11/15/2044	3.000	115.3359	115.3672	1.0703	2.259
2/15/2045	2.500	104.5781	104.6094	0.9766	2.279
5/15/2045	3.000	115.3516	115.3828	1.0938	2.267
8/15/2045	2.875	112.6797	112.7109	1.0859	2.272
11/15/2045	3.000	115.4375	115.4688	1.1328	2.271
2/15/2046	2.500	104.6172	104.6484	1.0625	2.282
5/15/2046	2.500	104.7813	104.8125	1.0547	2.276
8/15/2046	2.250	99.4219	99.4531	1.0234	2.275

Accessed 9/17/2016, 5:45 CST

Data on Treasury Bills

TREASURY BILLS

GO TO: Notes and Bonds

Tuesday, September 27, 2016

Treasury bill bid and ask data are representative over-the-counter quotations as of 3pm Eastern time quoted as a discount to face value. Treasury bill yields are to maturity and based on the asked quote.

Maturity	Bid	Asked	Chg	Asked yield
9/29/2016	0.063	0.053	0.010	0.053
10/6/2016	0.063	0.053	-0.015	0.053
10/13/2016	0.095	0.085	-0.007	0.086
10/20/2016	0.120	0.110	0.018	0.112
10/27/2016	0.140	0.130	0.015	0.132
11/3/2016	0.170	0.160	0.038	0.162
11/10/2016	0.165	0.155	0.035	0.158
11/17/2016	0.180	0.170	0.028	0.172
11/25/2016	0.183	0.173	0.025	0.175
12/1/2016	0.170	0.160	0.033	0.162
12/8/2016	0.170	0.160	0.033	0.163
12/15/2016	0.138	0.128	0.013	0.129
12/22/2016	0.225	0.215	0.033	0.218
12/29/2016	0.260	0.250	0.020	0.254
6/22/2017	0.468	0.458	0.013	0.465
7/20/2017	0.523	0.513	0.015	0.522
8/17/2017	0.533	0.523	0.002	0.532
9/14/2017	0.560	0.550	-0.002	0.561

"On the run"

Accessed 9/17/2016, 5:45 CST

Data on Treasurys

http://finance.yahoo.com/bonds

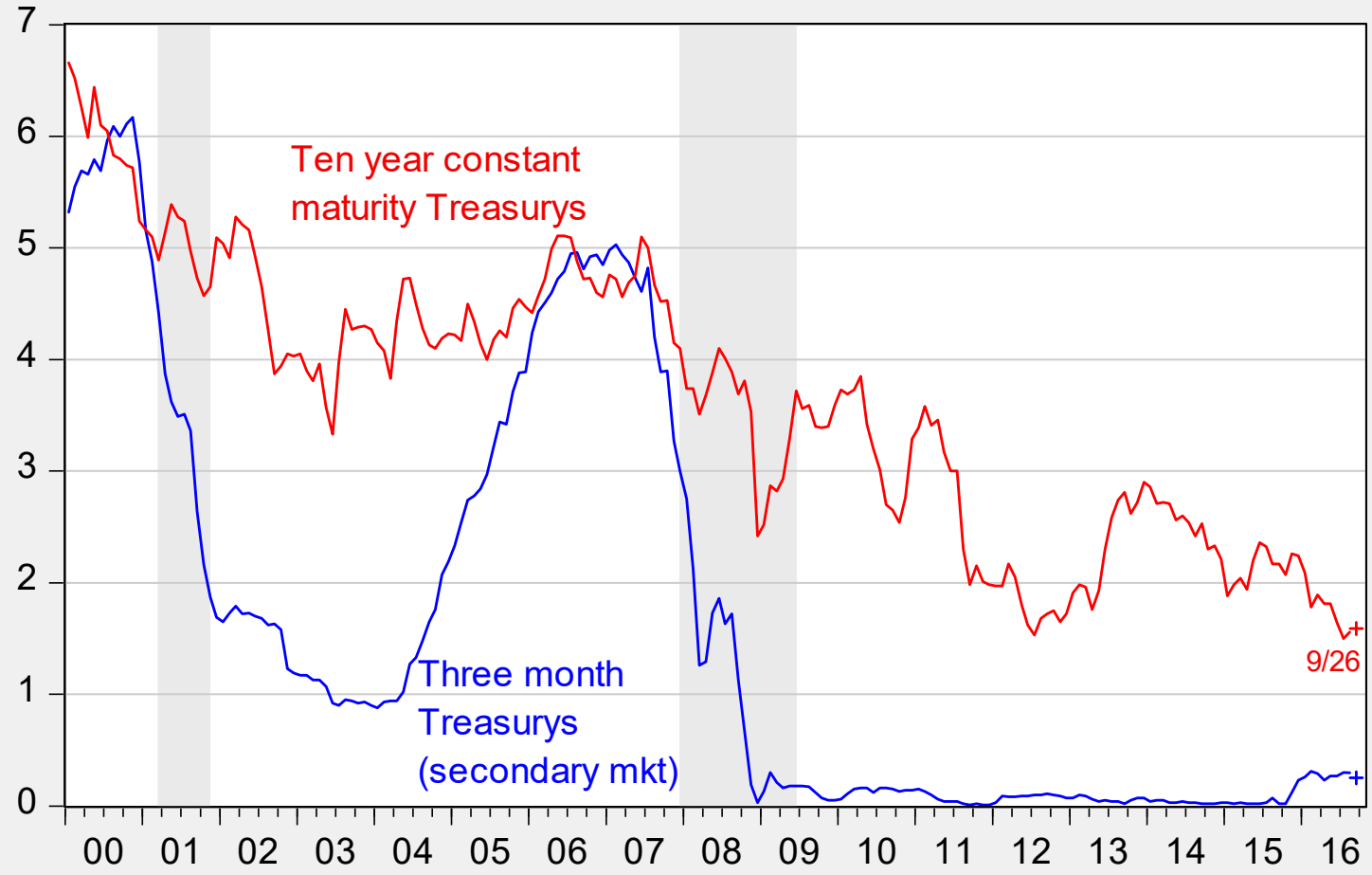
US Treasury Bonds Rates

Maturity	Yield	Yesterday	Last Week	Last Month
3 Month	0.19	0.17	0.27	0.29
6 Month	0.40	0.37	0.43	0.43
2 Year	0.71	0.71	0.75	0.82
3 Year	0.83	0.83	0.90	0.93
5 Year	1.09	1.10	1.18	1.22
10 Year	1.54	1.56	1.67	1.61
30 Year	2.26	2.30	2.41	2.26

Accessed 9/17/2016, 5:45 CST

See also: http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield

Secondary Market, Constant Maturity



Real and Nominal Interest Rates

- The nominal interest rate you agree on (i) must be based on *expected inflation* (π^e) over the term of the loan plus the real interest rate you agree on (r).

$$i = r + \pi^e$$

- This is called the *Fisher Equation.*
- The higher expected inflation, the higher the nominal interest rate.

Data on Treasury Inflation Protected Securities (TIPS)

http://online.wsj.com/mdc/public/page/2_3020-tips.html

Treasury Inflation-Protected Securities

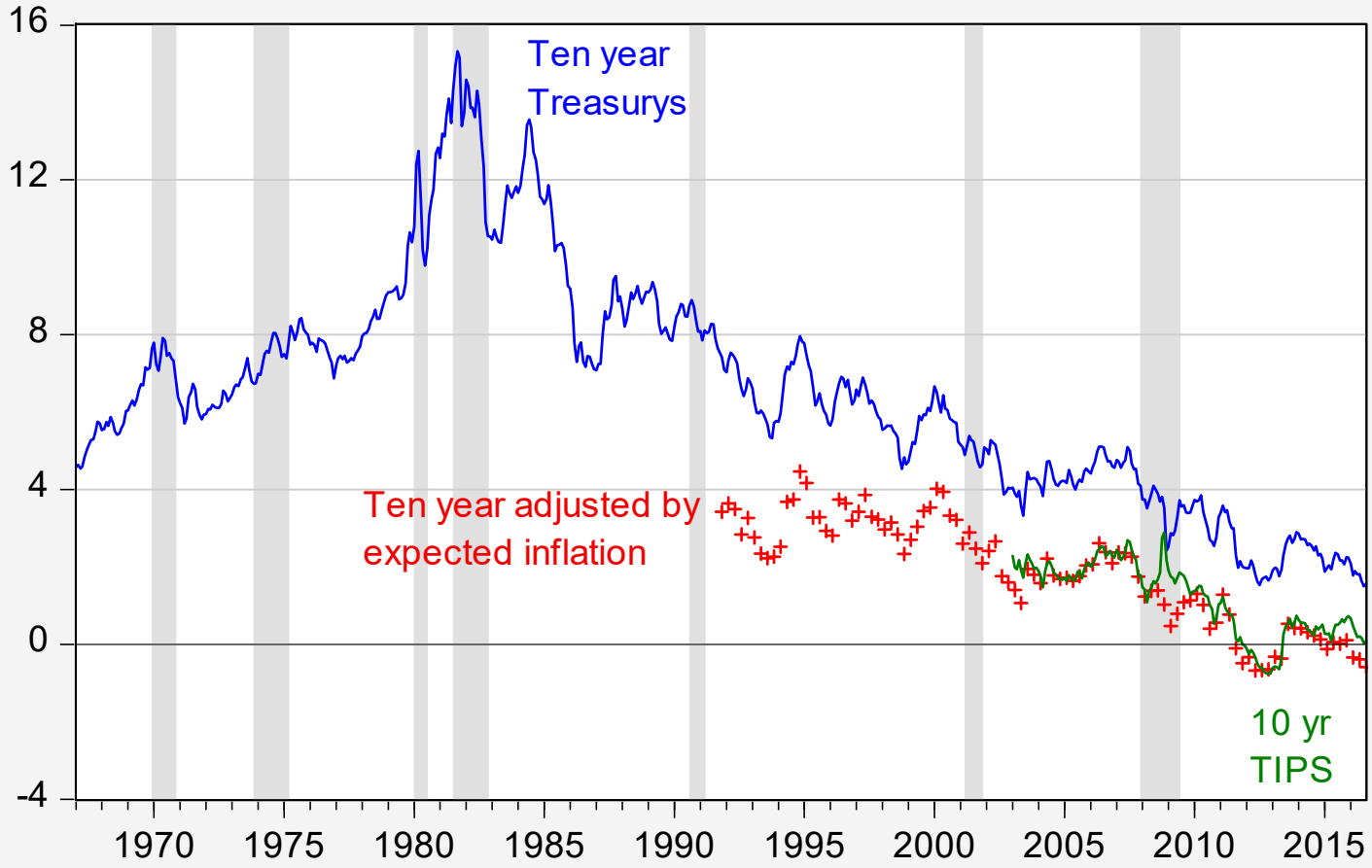
Tuesday, September 27, 2016 Find Historical Data | WHAT'S THIS?

Treasury Inflation-Protected Securities, or TIPS, are securities whose principal is tied to the Consumer Price Index (CPI) . The principal increases with inflation and decreases with deflation. When the security matures, the U.S. Treasury pays the original or adjusted principal, whichever is greater. TIPS pay interest every six months. Figures after periods in bid and ask quotes represent 32nds; 101.26 means 101 26/32, or 101.8125% of 100% face value; 99.01 means 99 1/32, or 99.03125% of face value.

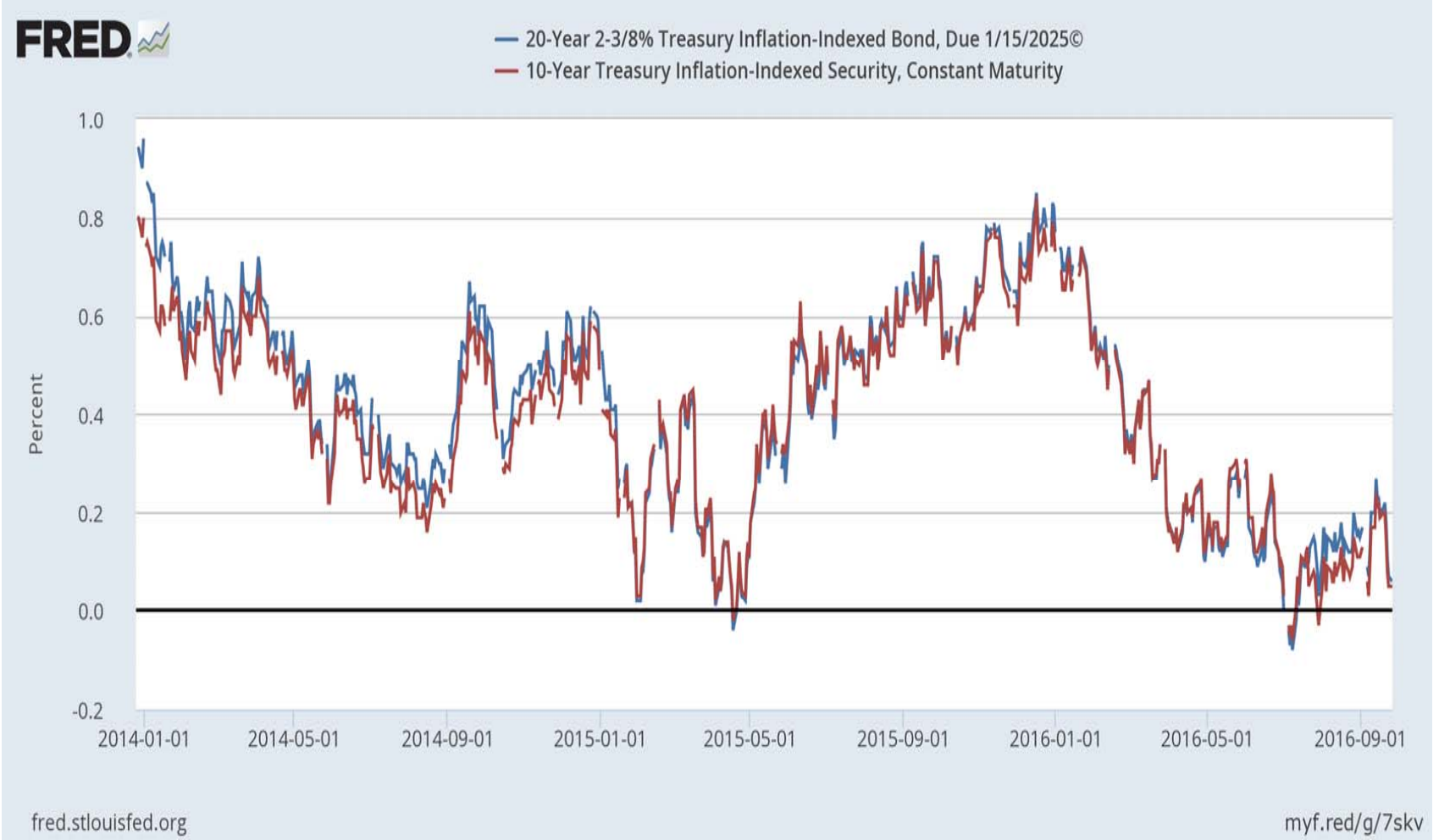
Maturity	Coupon	Bid	Asked	Chg	Yield*	Accrued principal
2017 Jan 15	2.375	100.26	100.28	unch.	-0.519	1193
2017 Apr 15	0.125	100.04	100.06	+ 1	-0.218	1059
2017 Jul 15	2.625	102.30	103.00	unch.	-1.124	1161
2018 Jan 15	1.625	102.30	102.32	unch.	-0.664	1148
2018 Apr 15	0.125	100.29	100.31	unch.	-0.493	1041
2018 Jul 15	1.375	104.00	104.02	unch.	-0.873	1116
2019 Jan 15	2.125	106.09	106.11	- 1	-0.614	1121
2024 Jan 15	0.625	104.22	104.30	+ 2	-0.051	1031
2024 Jul 15	0.125	101.08	101.16	+ 1	-0.065	1013
2025 Jan 15	0.250	101.21	101.29	+ 2	0.020	1016
2025 Jan 15	2.375	118.30	119.06	+ 1	0.056	1276
2025 Jul 15	0.375	103.02	103.12	+ 4	-0.010	1014
2026 Jan 15	0.625	104.31	105.09	+ 2	0.056	1012
2026 Jan 15	2.000	117.06	117.16	+ 3	0.108	1212
2026 Jul 15	0.125	100.27	101.05	+ 3	0.008	1004
2027 Jan 15	2.375	122.11	122.21	+ 2	0.155	1193
2028 Jan 15	1.750	116.28	117.06	+ 6	0.210	1148
2028 Apr 15	3.625	137.28	138.10	+ 6	0.254	1488
2029 Jan 15	2.500	126.22	127.05	+ 6	0.255	1121
2029 Apr 15	3.875	143.27	144.10	+ 6	0.278	1464
2032 Apr 15	3.375	146.18	147.01	+ 10	0.281	1355
2040 Feb 15	2.125	133.22	134.06	+ 16	0.563	1113
2041 Feb 15	2.125	134.31	135.14	+ 19	0.566	1099
2042 Feb 15	0.750	103.20	104.02	+ 16	0.577	1065
2043 Feb 15	0.625	100.27	101.10	+ 16	0.572	1046
2044 Feb 15	1.375	119.14	119.30	+ 20	0.586	1032
2045 Feb 15	0.750	103.26	104.09	+ 16	0.586	1022
2046 Feb 15	1.000	111.10	111.25	+ 20	0.564	1015

*-Yld. to maturity on accrued principal.

Nominal vs. Real

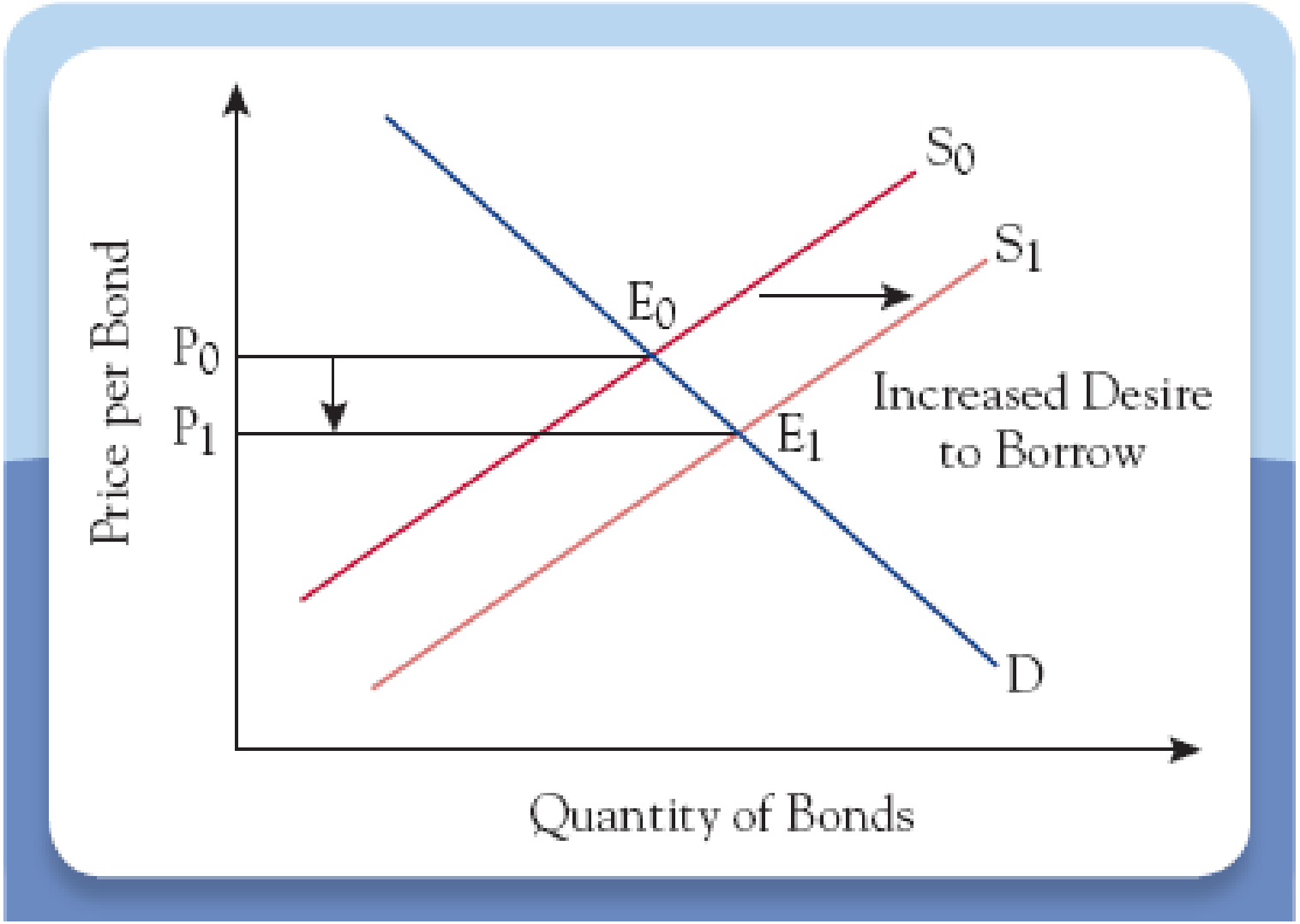


Constant Maturity vs. On the Run



Factors That Shift Bond Supply

Figure 6.2 A Shift in the Supply of Bonds



Factors That Shift Bond Demand

Figure 6.3 A Shift in the Demand for Bonds