VALUING BONDS

Topics Covered

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- Using The Present Value Formula to Value Bonds
- How Bond Prices Vary With Interest Rates
- The Term Structure of Interest Rates
- Explaining the Term Structure
- Real and Nominal Rates of Interest
- The Risk of Default

Bonds

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Terminology

- Bond - Security that obligates the issuer to make specified payments to the bondholder.
- Face value (par value or principal value) - Payment at the maturity of the bond.
- Coupon - The interest payments made to the bondholder.
- Coupon rate - Annual interest payment, as a percentage of face value.

Bonds

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WARNING

The <u>coupon rate</u> IS NOT the <u>discount rate</u> used in the present value calculations.

- The coupon rate merely tells us what cash flow the bond will produce
- Since the coupon rate is listed as a %, this misconception is quite common

Valuing a Bond

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The price of a bond is the present value of all cash flows generated by the bond (i.e. coupons and face value) discounted at the required rate of return

$$PV = \frac{cpn}{(1+r)^1} + \frac{cpn}{(1+r)^2} + ... + \frac{(cpn + par)}{(1+r)^t}$$

Note: "cpn" is commonly used as an abbreviation for "coupon"

Valuing a Bond

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<u>Example - France</u>

In October 2014 you purchase 100 euros of bonds in France which pay a 4.25% coupon every year. If the bond matures in 2018 and the YTM is 0.15%, what is the value of the bond?

$$PV = \frac{4.25}{1.0015} + \frac{4.25}{(1.0015)^2} + \frac{4.25}{(1.0015)^3} + \frac{104.25}{(1.0015)^4}$$

$$= 116.34 \text{ euros}$$

Valuing a Bond as an Annuity

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PV(bond) = PV(annuity of coupons) + PV(principal)

$$\text{PV (bond)} = (\text{cpn} \times \text{PVAF}) + (\text{final payment} \times \text{discount factor})$$
$$= 4.25 \times \left[\frac{1}{.0015} - \frac{1}{.0015(1+.0015)^4} \right] + \frac{100}{(1+.0015)^4}$$
$$= 116.34$$

Valuing a Bond

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Example

If today is October 1, 2015, what is the value of the following bond? An IBM Bond pays $115 every September 30 for 5 years. In September 2020 it pays an additional $1000 and retires the bond. The bond is rated AAA (WSJ AAA YTM is 7.5%)

$$\text{PV} = \frac{115}{1.075} + \frac{115}{(1.075)^2} + \frac{115}{(1.075)^3} + \frac{115}{(1.075)^4} + \frac{1{,}115}{(1.075)^5}$$
$$= \$1{,}161.84$$

Valuing a Bond

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Example

What is the price of a 7.25 % annual coupon bond, with a $1,000 face value, which matures in 3 years? Assume a required return of 0.35%.

$$\text{PV} = \frac{72.50}{(1.0035)^1} + \frac{72.50}{(1.0035)^2} + \frac{1{,}072.50}{(1.0035)^3}$$
$$\text{PV} = \$1{,}205.56$$

Valuing a Bond

Example (continued)

What is the price of a 7.25 % annual coupon bond, with a $1,000 face value, which matures in 3 years? Assume a required return of 0.35%.

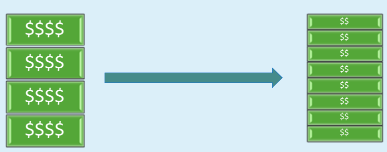
Bond prices are quoted as a percentage of par.

$$\begin{aligned} \text{Par value} \times \text{price}\ \% &= \$\ \text{price} \\ \$1{,}000 \times \text{price}\ \% &= \$1{,}205.56 \\ \text{price}\ \% &= 120.56\ \% \end{aligned}$$

Valuing a Bond

Q: How did the calculation change, given semi-annual coupons versus annual coupon payments?

Twice as many payments, cut in half, over the same time period.



Valuing a Bond

Example - USA

In November 2014 you purchase a 3 year US Government bond. The bond has an annual coupon rate of 4.25%, paid semi-annually. If investors demand a 0.965% semiannual return, what is the price of the bond?

$$PV = \frac{21.25}{1.004825} + \frac{21.25}{(1.004825)^2} + \frac{21.25}{(1.004825)^3} + \frac{21.25}{(1.004825)^4} + \frac{21.25}{(1.004825)^5} + \frac{1021.25}{(1.004825)^6}$$

$$= \$1{,}096.90$$

Treasury Yields

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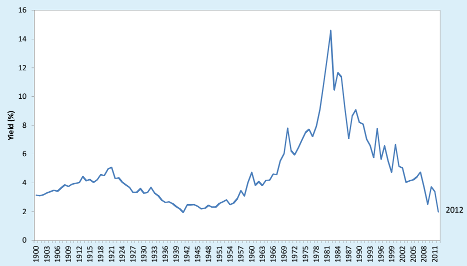
The interest rate on 10-year U.S. Treasury bonds
1900-2012



Bond Rates of Return

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Rate of Return – Total income per period per dollar invested

$$\text{Rate of return} = \frac{\text{total income}}{\text{investment}}$$

$$\text{Rate of return} = \frac{\text{coupon income} + \text{price change}}{\text{investment}}$$

Bond Rates of Return

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Example

A bond increases in price from $963.80 to $1,380.50 and pays a coupon of $21.875 during the same period. What is the rate of return?

$$\text{Rate of return} = \frac{21.875 + (1380.50 - 963.80)}{963.80} = .455$$

$$\text{ROR} = 45.5\%$$

Duration Formula

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$$\text{Duration} = \frac{1\times \text{PV}(C_1)}{\text{PV}} + \frac{2\times \text{PV}(C_2)}{\text{PV}} + \frac{3\times \text{PV}(C_3)}{\text{PV}} + \ldots + \frac{T\times \text{PV}(C_T)}{\text{PV}}$$

$$\text{Modified duration} = \text{volatility } (\%) = \frac{\text{duration}}{1+\text{yield}}$$

Duration Calculation

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	Year (t)							
	1	2	3	4	5	6	7	
Payment	$90	$90	$90	$90	$90	$90	$ 1,090	
PV(C_t) at 4%	$86.54	$83.21	$80.01	$76.93	$73.97	$71.13	$ 828.31	PV = $1,300.10
Fraction of total value [PV(C_t) / PV]	0.0666	0.0640	0.0615	0.0592	0.0569	0.0547	0.6371	
Year × fraction of total value [t × PV(C_t) / PV]	0.0666	0.1280	0.1846	0.2367	0.2845	0.3283	4.4598	Total = duration = 5.69

Duration Calculation

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Year	C_t	PV(C_t) at 5.0%	Proportion of Total Value [PV(C_t)/ V]	Proportion of Total Value Time
1	100	95.24	0.084	0.084
2	100	90.7	0.08	0.16
3	1100	950.22	0.836	2.509
		V = 1136.16	1	Duration= 2.753 years

Duration

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Example

Calculate the duration of our 6 $^{7}/_{8}$% bond @ 4.9% YTM

Year	CF	PV@YTM	% of Total PV	% × Year
1	68.75	65.54	.060	0.060
2	68.75	62.48	.058	0.115
3	68.75	59.56	.055	0.165
4	68.75	56.78	.052	0.209
5	1068.75	841.39	.775	3.875
		1085.74	1.00	**Duration 4.424**

Interest Rates

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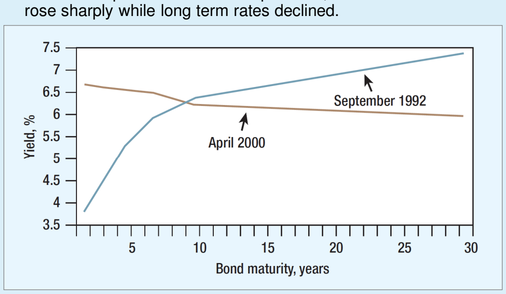
- Short- and long-term interest rates do not always move in parallel. Between September 1992 and April 2000, U.S. short-term rates rose sharply while long term rates declined.



Term Structure of Interest Rates

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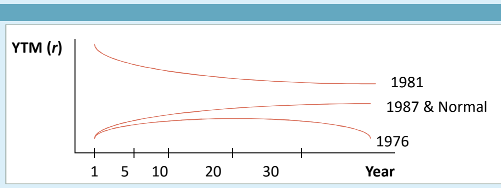

Spot Rate - The actual interest rate today ($t = 0$)

Forward Rate - The interest rate, fixed today, on a loan made in the future at a fixed time

Future Rate - The spot rate that is expected in the future

Yield To Maturity (YTM) - The IRR on an interest bearing instrument

Yield Curve

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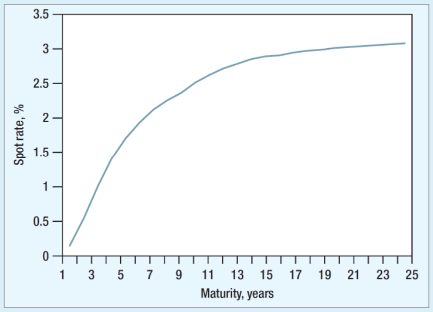
U.S. Treasury Strip Spot Rates as of November 2014



Law of One Price

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- All interest bearing instruments are priced to fit the term structure
- This is accomplished by modifying the asset price
- The modified price creates a new yield, which fits the term structure
- The new yield is called the yield to maturity (YTM)

Yield to Maturity

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Example

$1,000 Treasury bond expires in 5 years. Pays coupon rate of 10.5%. What is YTM if market price is 107.88?

C_0	C_1	C_2	C_3	C_4	C_5
−1078.80	105	105	105	105	1105

Calculate IRR = 8.5%

Explaining the Term Structure

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Expectations Theory
- o Term structure and capital budgeting
  - ✓CF should be discounted using term structure info
  - ✓When rate incorporates all forward rates, use spot rate that equals project term
  - ✓Take advantage of arbitrage

Debt & Interest Rates

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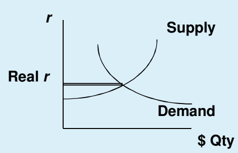
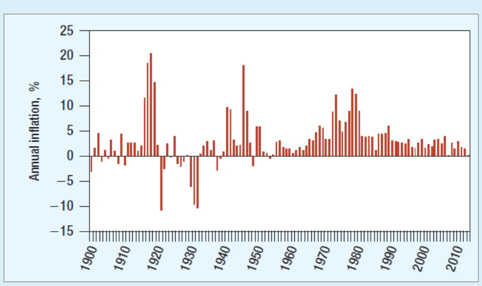
- Classical Theory of Interest Rates (Economics)
  - o Developed by Irving Fisher
- Nominal Interest Rate = The rate you actually pay when you borrow money
- Real Interest Rate = The theoretical rate you pay when you borrow money, as determined by supply and demand



Annual U.S. Inflation Rates, 1900-2014

3-27



Global Inflation Rates, 1900-2014

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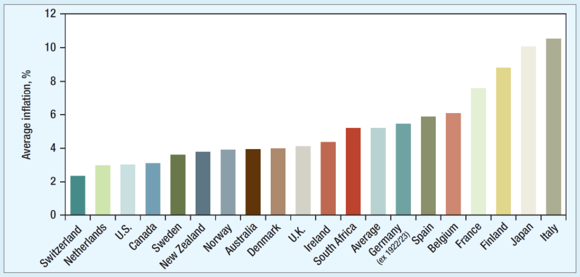

Interest Rates & Inflation

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- In the presence of inflation, an investor's **real** interest rate is always less than the **nominal** interest rate

$$1 + \text{real rate} = \frac{1 + \text{nominal rate}}{1 + \text{inflation rate}}$$

Interest Rates & Inflation

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Example

If you invest in a security that pays 10% interest annually and inflation is 6%, what is your real interest rate?

$$1 + \text{real rate} = \frac{1.10}{1.06}$$

Real interest rate = .03774 or 3.774%

Interest Rates & Inflation

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Treasury Inflation Protected Securities (TIPS)

Example

*If you invest in 5% coupon, 3 year TIPS and inflation is 3% each year, what are your **real** annual cash flows?*

Year	1	2	3
Real cash flows	**$50**	**$50**	**$1,050**

U.S. TIPS Bond Yields

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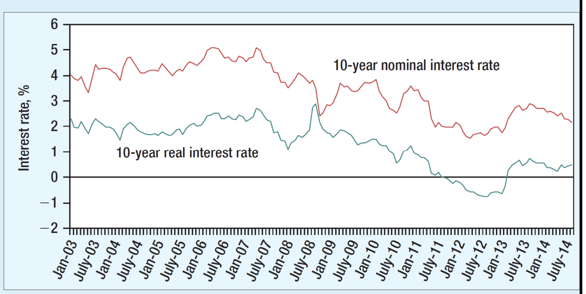

Govt. Bills vs. Inflation, 1953-2014

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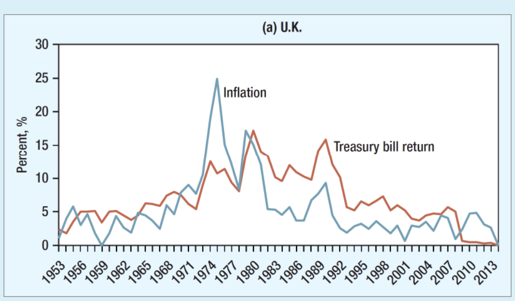
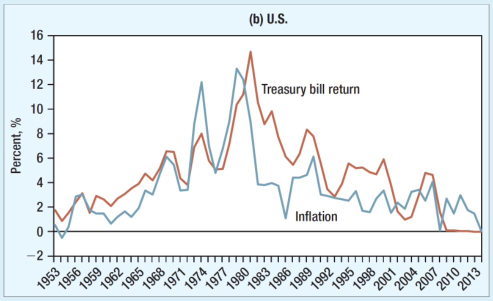


Govt. Bills vs. Inflation, 1953-2014

3-34



Govt. Bills vs. Inflation, 1953-2014

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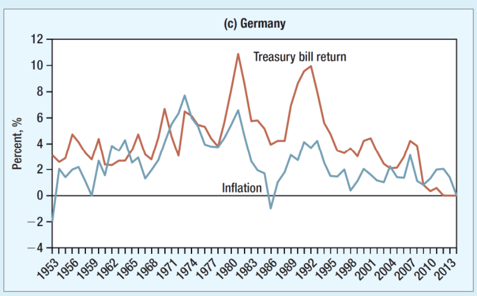

Default Risk

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- Default or Credit Risk - The risk that a bond issuer may default on its bonds
- Default premium - The additional yield on a bond that investors require for bearing credit risk
- Investment grade - Bonds rated Baa or above by Moody’s or BBB or above by Standard & Poor’s
- Junk bonds - Bond with a rating below Baa or BBB

Default Risk

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Moody's	Standard & Poor's	Safety
Aaa	AAA	The strongest rating; ability to repay interest and principal is very strong.
Aa	AA	Very strong likelihood that interest and principal will be repaid
A	A	Strong ability to repay, but some vulnerability to changes in circumstances
Baa	BBB	Adequate capacity to repay; more vulnerability to changes in economic circumstances
Ba	BB	Considerable uncertainty about ability to repay.
B	B	Likelihood of interest and principal payments over sustained periods is questionable.
Caa	CCC	Bonds in the Caa/CCC and Ca/CC classes may already be
Ca	CC	in default or in danger of imminent default
C	C	C-rated bonds offer little prospect for interest or principal on the debt ever to be repaid.

Prices and Yields of Corporate Bonds

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Issuer Name	Coupon (%)	Maturity	S&P Rating	Price (%)	Yield (%)
Johnson & Johnson	3.55	2021	AAA	108.35	2.16
Walmart	4.25	2021	AA	110.44	2.48
Alabama Power	3.95	2021	A	105.84	2.97
Dow Chemical	8.85	2021	BBB	132.39	3.49
Rosetta Restaurants	5.625	2021	BB	97.00	6.20
Elizabeth Arden	7.375	2021	B	96.25	8.14
Alpha Natural Resources	6.25	2021	CCC	50.20	20.37

Yield Spread

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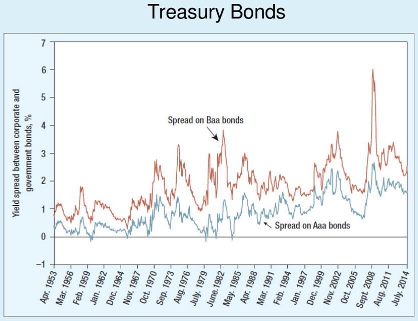
Yield Spreads between Corporate and 10-year Treasury Bonds



Sovereign Bonds and Default Risk

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- Sovereign Bonds and Default Risk
  - Foreign currency debt
    - ✓Default occurs when foreign government borrows dollars
    - ✓If crisis occurs, governments may run out of taxing capacity and default
    - ✓Affects bond prices, yield to maturity

Sovereign Bonds and Default Risk

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- Sovereign Bonds and Default Risk
  - Own currency debt
    - ✓Less risky than foreign currency debt
    - ✓Governments can print money to repay bonds

Sovereign Bonds and Default Risk

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- Sovereign Bonds and Default Risk
  - Eurozone debt
    - ✓Can't print money to service domestic debts
    - ✓Money supply controlled by European Central Bank