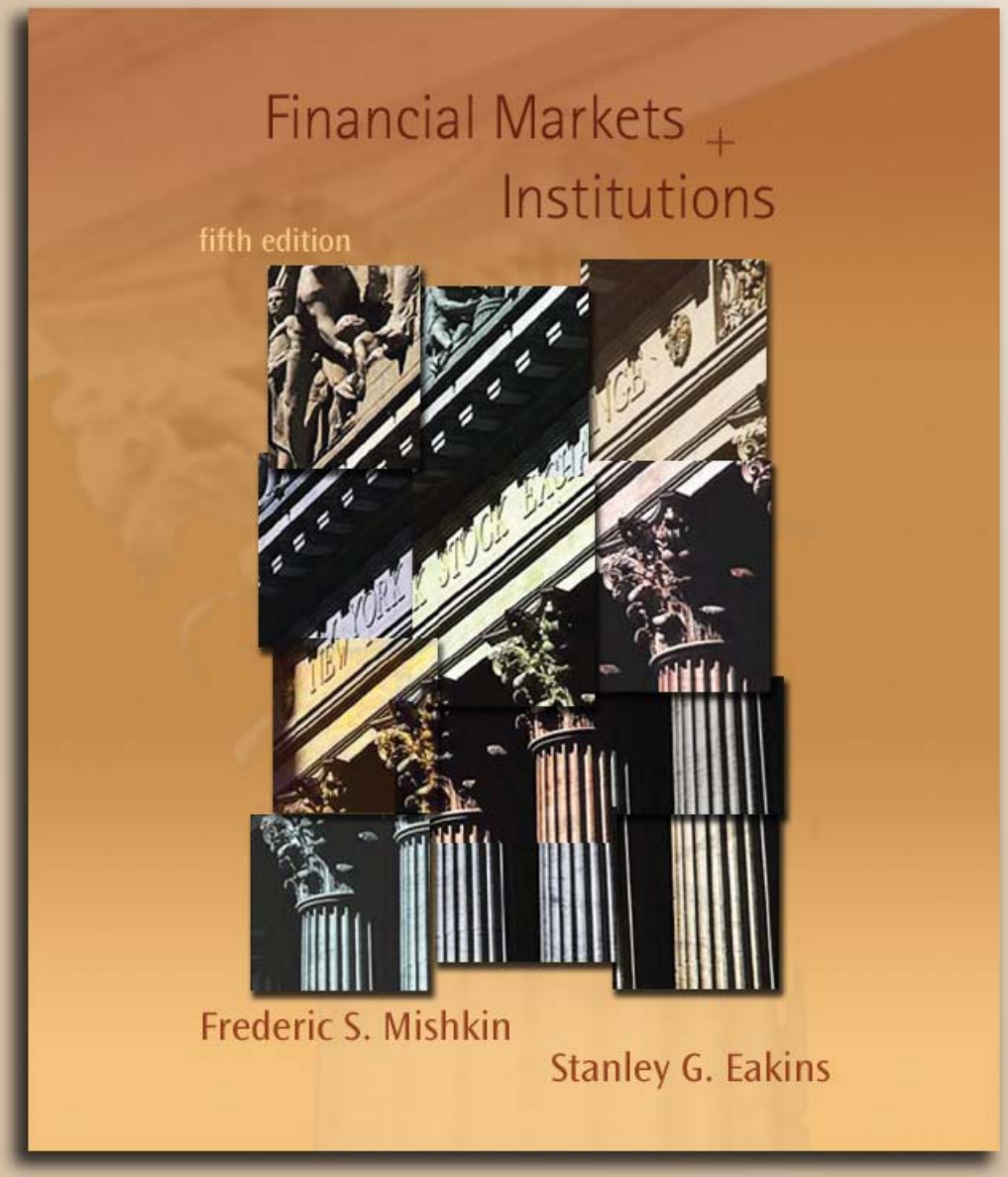


Class 1

Interest Rates

PEARSON Addison Wesley

Time value of money

- Example
  - Suppose you have won $1 mln in a lottery
  - But this amount is spread equally over the next 10 years
  - This is worth much less than a million!

Time value of money

- We need to discount future cash flows to the present
  - We prefer money now
  - We fear inflation
  - We avoid uncertainty

Asset valuation

- Discounted cash flow approach:

$$P_0 = \Sigma_t \, CF_t/(1+r)^t$$

  - CF: cash flows
  - r: discount rate
  - P_0: current price (value)

Asset valuation

- Bonds:

$$P_0 = \Sigma_{t=1:T}\, C/(1+r_t)^t + F/(1+r_T)^T$$

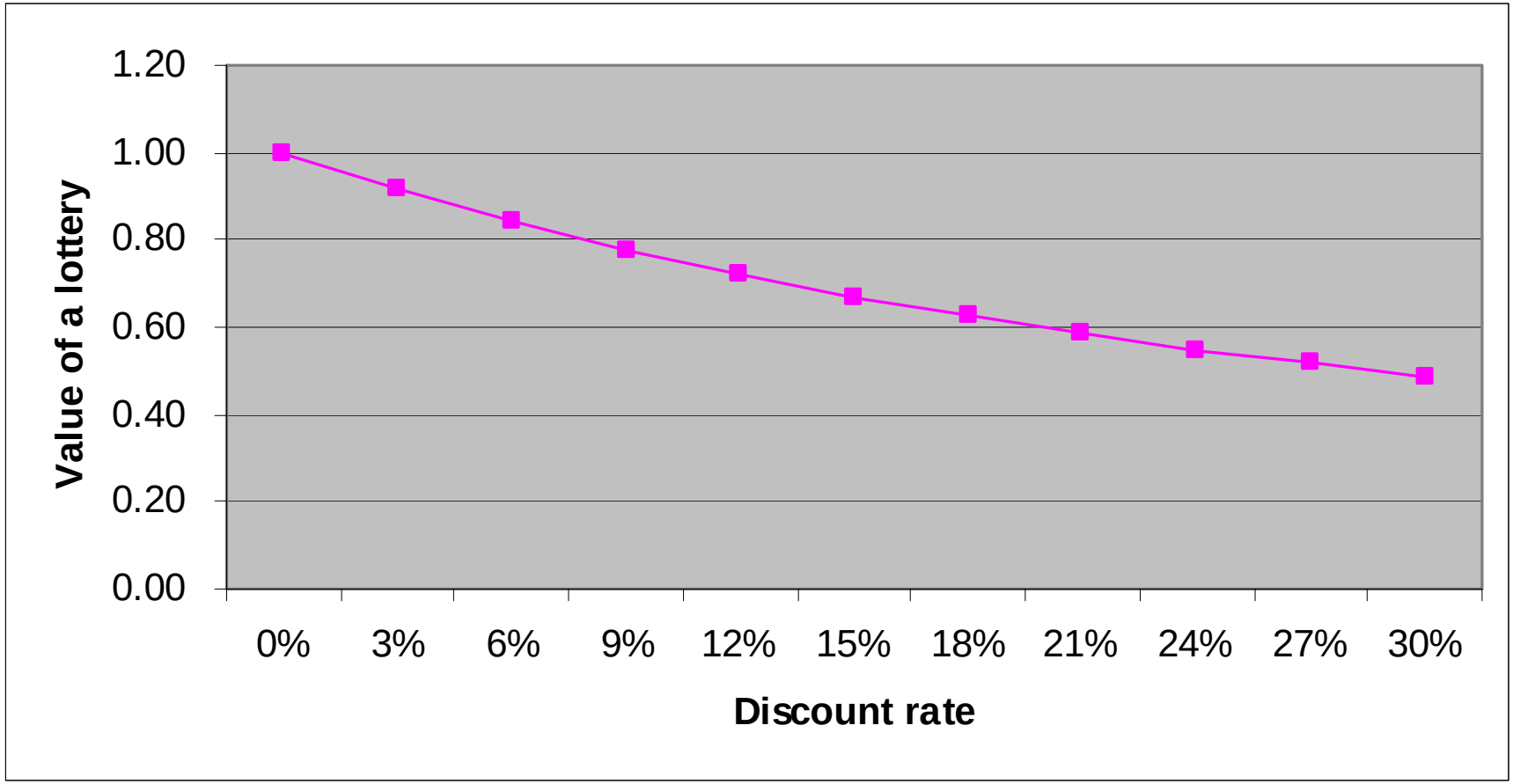
- Stocks:

$$P_0 = (P_1+Div_1)/(1+r)$$

$$P_0 = \Sigma_{t=1:\infty}\, Div_t/(1+r)^t$$

  - Constant dividends: $P_0 = Div_1/r$

What is the true value of $1 mln?



Definitions of rates

- Treatment of inflation π: Fisher equation
  - Real vs. nominal rates:

$$\text{Nominal rate} \approx \text{real rate} + \pi$$

- Reinvestment:
  - Simple vs compound interest for T periods:

$$P_T = P_0(1+r_S^T) = P_0(1+r_C)^T$$

Definitions of rates

- Frequency of compounding:
  - Nominal (coupon) rate (payments *m* times a year)…
  - vs effective (annual) rate:

$$r_E = (1+r_N(m)/m)^m - 1$$

- Continuous compounding:
  - Log-return:

$$r_C = \log(1+r_E) = m \log(1+ r_N(m)/m)$$

Definitions of rates

- Yield to maturity / internal yield / bond yield
  - Rate that equates cash flows on the bond with its market value
  - Internal rate of return earned from holding a bond to maturity
    - Assuming reinvestment at same rate
    - Different from the actual return over a specific holding period!

Definitions of rates

- Par yield
  - Coupon rate that causes the bond price to equal its face value
- Current yield
  - Annual coupon payment divided by the bond's price
  - Often quoted but useless

Definitions of rates

- Zero rate (at *t* for payment at *T*):

$$y(t, T) = [1 / P(t, T)]^{1/(T-t)}$$

  - YTM of a zero-coupon bond maturing at *T*, with current price P(t, T) and face value of 1
  - How to get zero rates from coupon bond prices?
    - Bootstrapping method: coupon bond as a ptf of zero-coupon bonds

Definitions of rates

- Spot rate:

$$r(t) \equiv y(t, t+1)$$

  - One-period zero rate

- Forward rate:

$$f(t, T) = P(t, T) / P(t, T+1)$$

  - Rate on a one-period credit from T to T+1

Risk Structure of Long Bonds in the U.S.

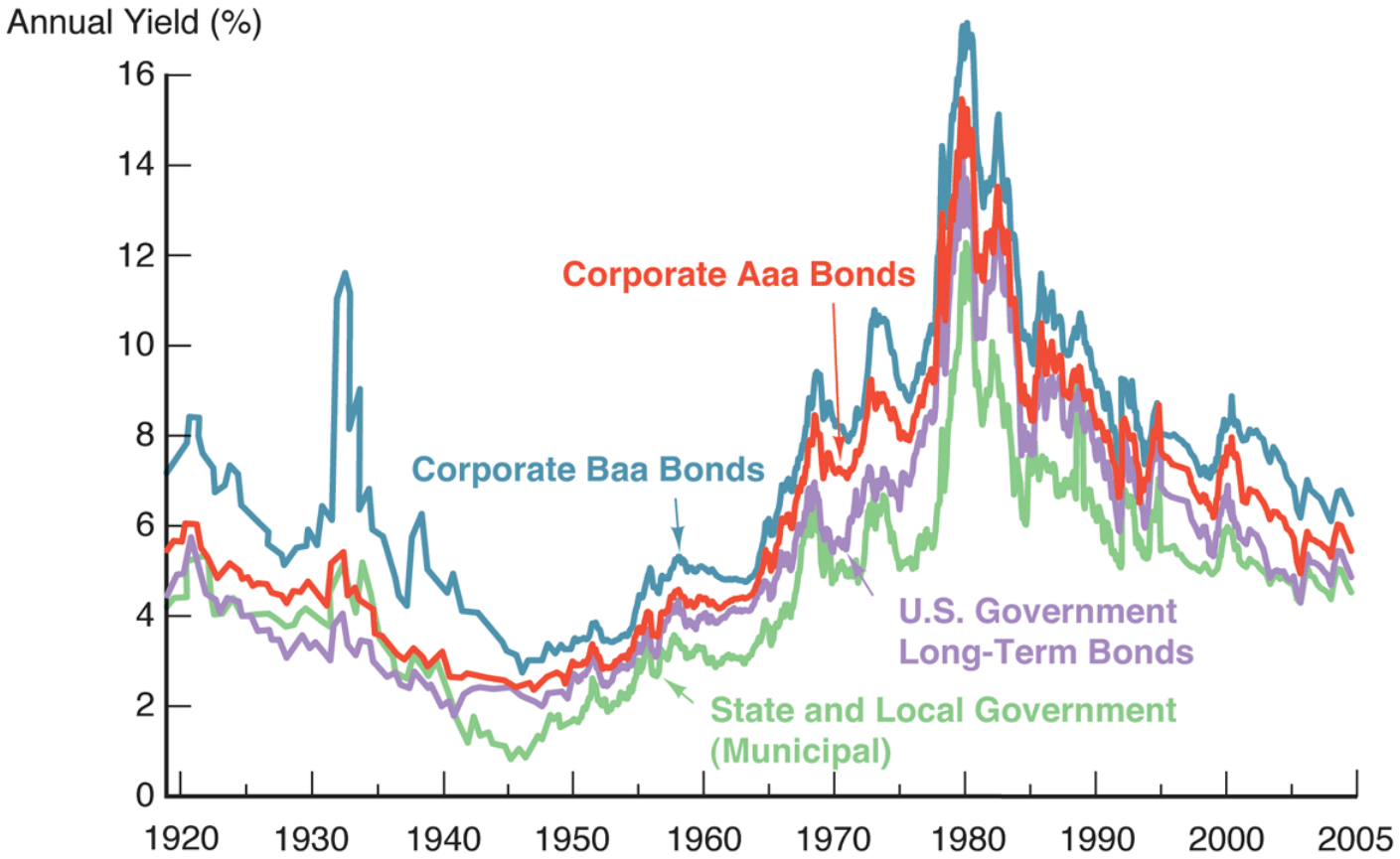


Figure 5.1 Long Term Bond Yields, 1919–2004

Interest rates of bonds with different risks
http://www.federalreserve.gov/release/h15/data.htm

Risk structure of interest rates

- Default Risk
  - When the issuer is unable or unwilling to make promised interest payments
  - *Risk-free* bonds: U.S. Treasury bonds
  - *Risk premium*: spread between the interest rates on bonds with default risk and default-free bonds

Bond Ratings

TABLE 1 *Bond Ratings by Moody's and Standard & Poor's*

Rating			
Moody's	**Standard & Poor's**	**Description**	**Examples of Corporations with Bonds Outstanding in 2004**
Aaa	AAA	Highest quality (lowest default risk)	General Electric, United Parcel Service, Nestle
Aa	AA	High quality	3M, Koch Ind., Illinois Tool Works
A	A	Upper medium grade	Honeywell, Rockwell Intl., General Dynamics, Boeing
Baa	BBB	Medium grade	Itt Ind., Northrop, Goodrich, FedEx
Ba	BB	Lower medium grade	Westinghouse, Allied Waste Products, IKON Office Solutions
B	B	Speculative	Jacuzzi, Sabreliner Corp., American Airlines
Caa, Ca	CCC, CC, C	Poor (high default risk)	Delta Airlines, McDermott, Schutt Int.
C	D	Lowest grade	US Airways, United Airlines, Citation Corp.

Default rates

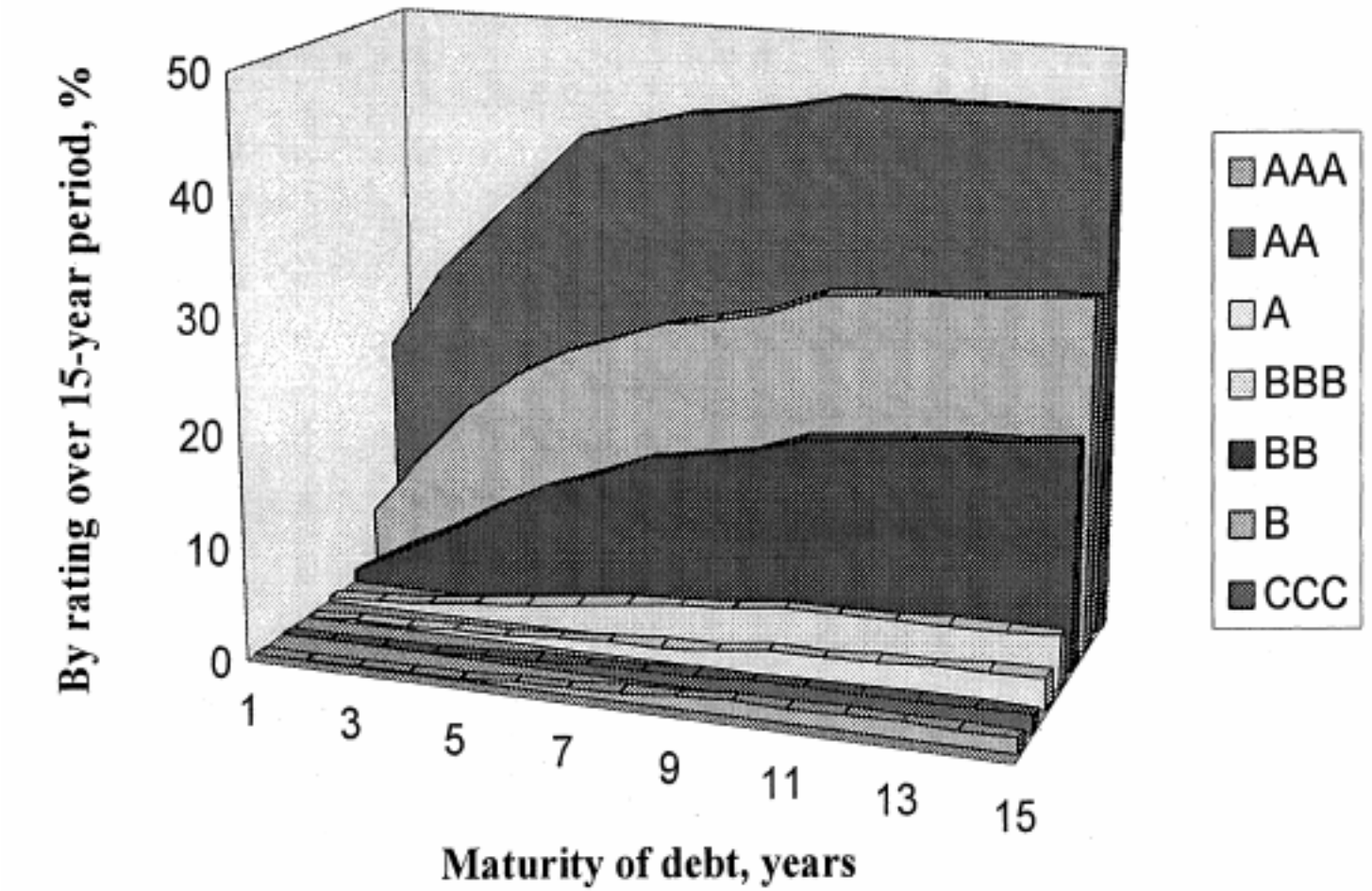


Fig. 4. Average cumulative default rates (%) (*source:* Standard & Poor's CreditWeek April 15, 1996).

Risk structure of interest rates

- Liquidity
  - A liquid asset can be quickly and cheaply converted into cash
  - U.S. Treasury bonds are the most liquid of all long-term bonds
  - Corporate bonds are not as liquid

Risk structure of interest rates

- Income Tax, e.g. in the US
  - Interest payments on municipal bonds are exempt from federal income taxes
  - Treasury bonds are exempt from state and local income taxes
  - Interest payments from corporate bonds are fully taxable

Term structure of interest rates

- Relationship between yields and maturities
  - For bonds of a uniform quality (risks and taxes)
  - E.g., Treasury or same credit rating
- Equivalent ways to present TSIR:
  - Discount curve: $P(t, T)$, with $P(T, T) = 1$
  - Zero curve: $y(t, T) = [1 / P(t, T)]^{1/(T-t)}$
  - Forward curve: $f(t, T) = P(t, T) / P(t, T+1)$
- Upward sloping yield curve:
  Fwd Rate > Zero Rate > Par yield

Term Structure Facts to Be Explained

1. Interest rates for different maturities move together
2. Yield curves tend to have steep upward slope when short rates are low and downward slope when short rates are high
3. Yield curve is typically upward sloping

Interest Rates on Different Maturity Bonds Move Together

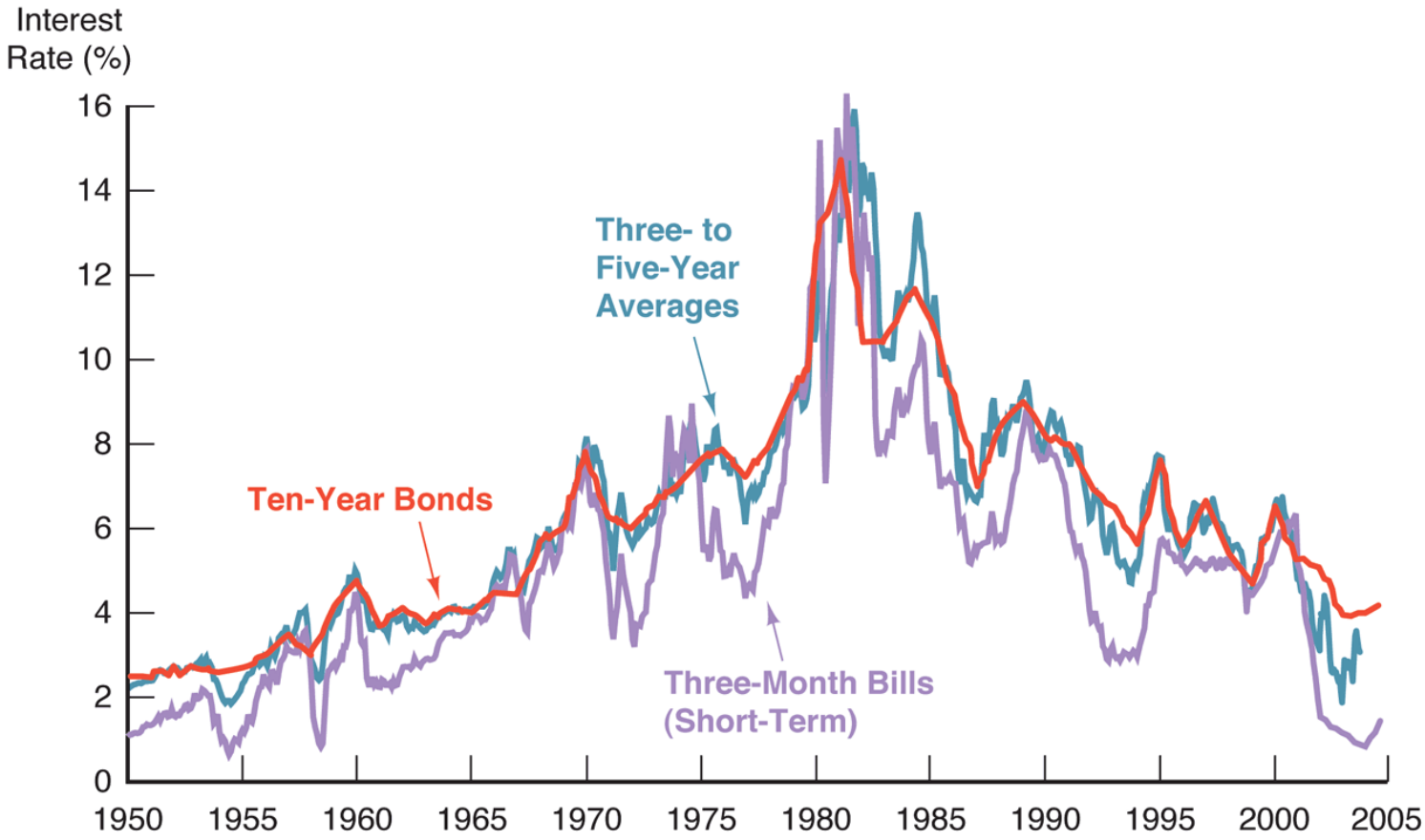


Figure 5.5 Movements over Time of Interest Rates on U.S. Government Bonds with Different Maturities

RSS1

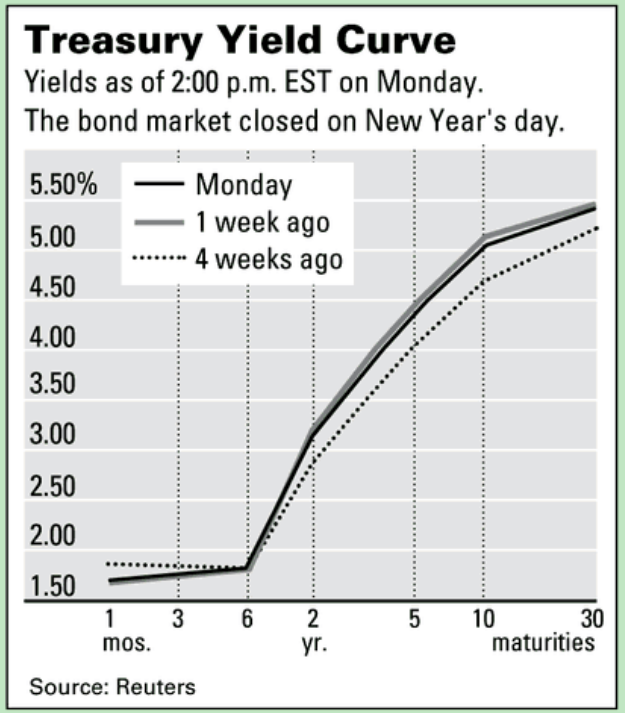
Yield Curves

FOLLOWING THE FINANCIAL NEWS

Yield Curves

The *Wall Street Journal* publishes a daily plot of the yield curves for Treasury securities, an example of which is presented here. It is typically found next to the "Credit Markets" column.

The numbers on the vertical axis indicate the interest rate for the Treasury security, with the maturity given by the numbers on the horizontal axis. For example, the yield curve marked "Monday" indicates that the interest rate on the three-month Treasury bill was 1.7%, while the two-year bill had an interest rate of 3.1% and the ten-year bond had an interest rate of 5.1%. As you can see, the yield curves in the plot has a steep upward slope.



Dynamic yield curve that can show the curve at any time in history
http://stockcharts.com/charts/YieldCurve.html

Slide 22

RSS1 Change title to: Reading the Wall St. Journal

Rick Swasey; 12.12.2004

Theories of the term structure

- Market segmentation:
  - Short, medium and long rates are determined independently of each other
    - SR%: D – corporations financing their sr obligations (e.g., trade credit), S – banks
    - LR%: D – corporations financing lr inv projects, S – insurance co-s, pension funds
  - Investors don't react to yield differentials between the maturities
  - Explains 3, but not 1 and 2

Theories of the term structure

- Expectations Theory:
  - Unbiased expectations hypothesis:

$$f(t, T) = E_t[r(T)]$$

  - Term structure is explained by expected spot rates
    - Upward sloping yield curve: signal that spot rate will increase
  - Explains 1 and 2, but not 3

Theories of the term structure

- Liquidity preference theory:
  - Investors demand a premium for bonds with higher risk
    - Long-term bonds require a liquidity premium
  - Upward sloping yield curve: forward rates higher than expected future zero rates
  - Combined with Expectations Theory explains all facts

Liquidity Premium Theory

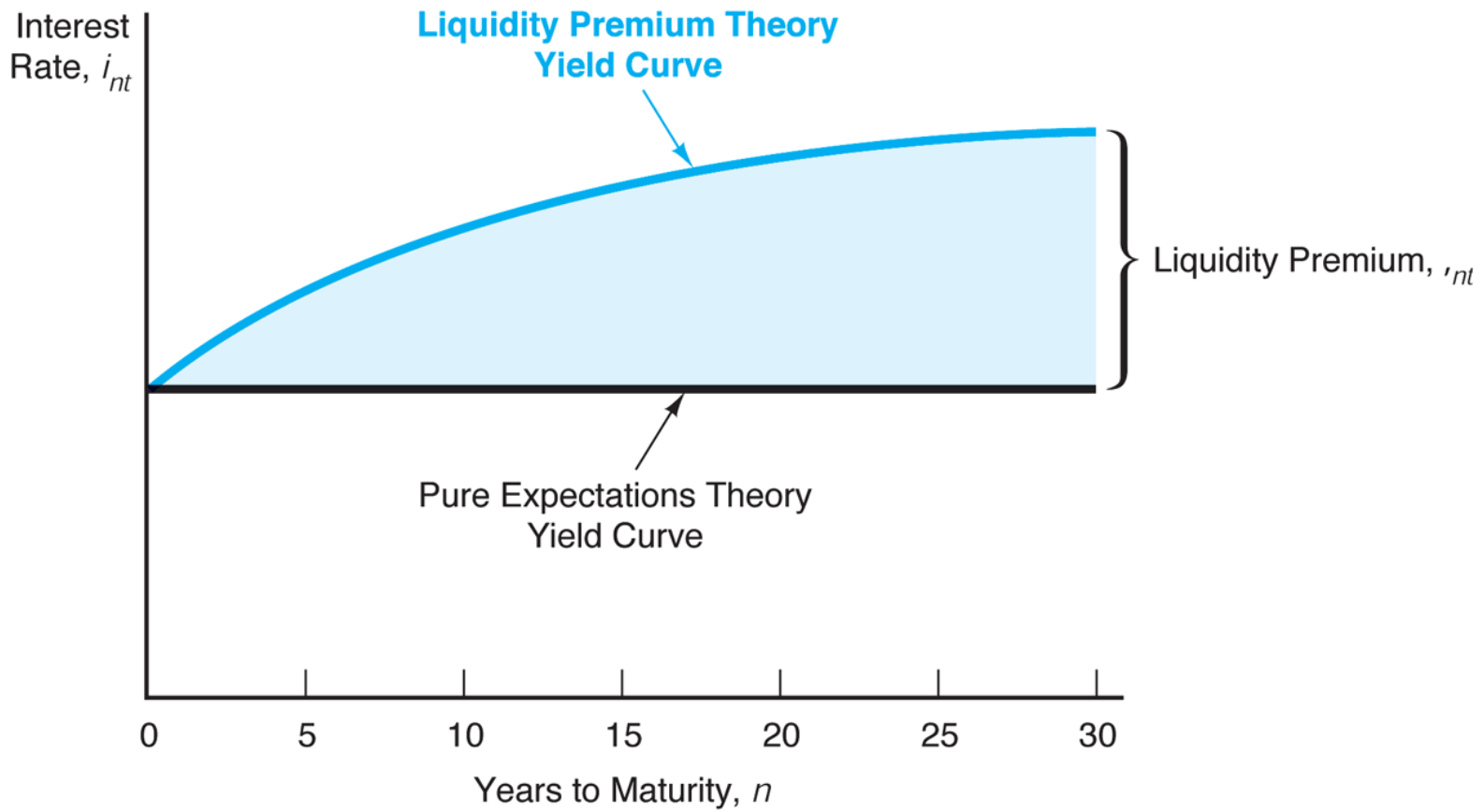


Figure 5.6 Relationship Between the Liquidity Premium and Pure Expectations Theory

Liquidity Premium Theory: Term Structure Facts

- Explains All 3 Facts
  - Explains fact 3—that usual upward sloped yield curve by liquidity premium for long-term bonds
  - Explains fact 1 and fact 2 using same explanations as pure expectations theory because it has average of future short rates as determinant of long rate

Case: Interpreting Yield Curves, 1980–2004

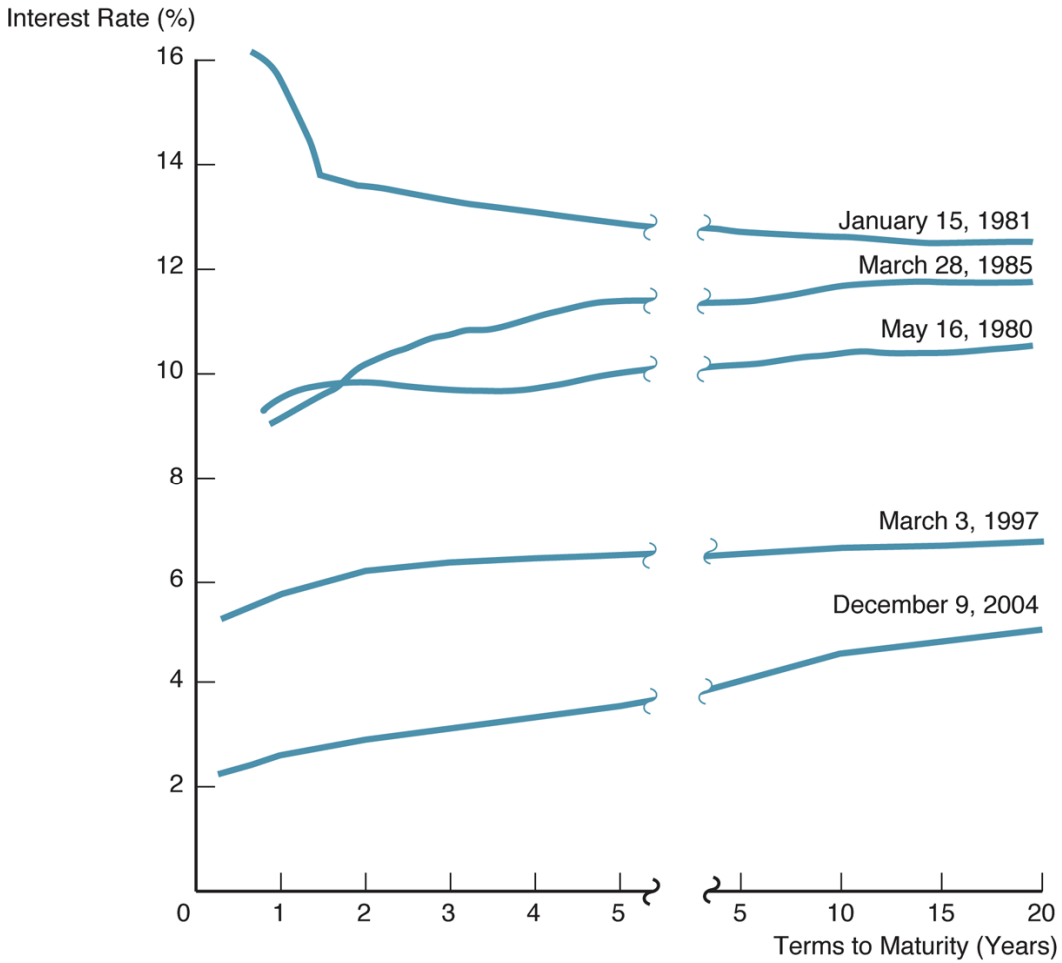
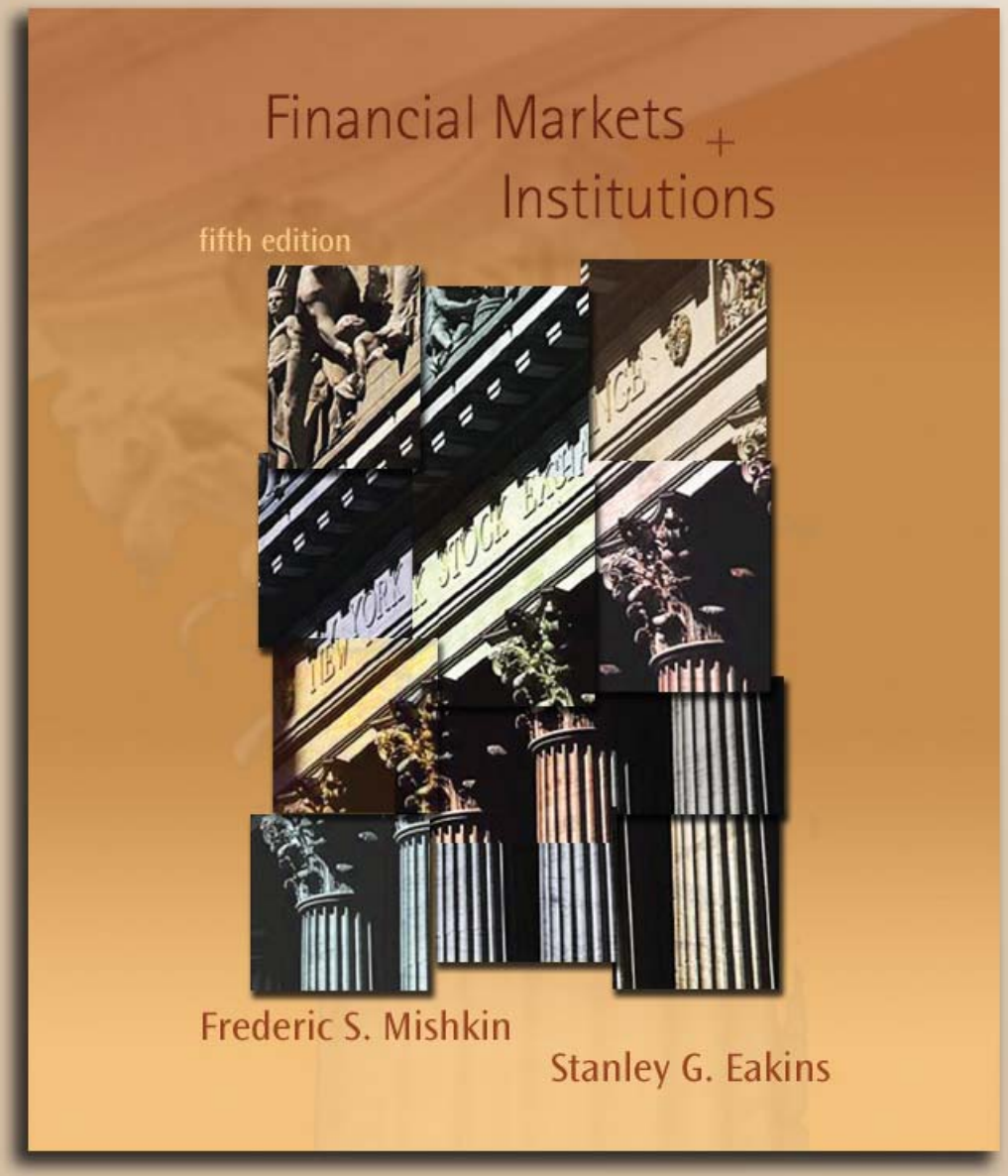


Figure 5.8 Yield Curves for U.S. Government Bonds



Discussion topic

How to measure a risk-free rate in Russia?

PEARSON Addison Wesley

Why do we need to measure a risk-free rate?

- Benchmark for risky rates
  - Risky rate = Risk-free rate + Risk premium
  - Risk premium determined from some model
- Corporate finance:
  - Used to evaluate projects
- Financial markets:
  - Used to value securities

Measuring a risk-free rate abroad

- Treasury rates: interest rates on government bills and bonds
  - Default-free, usually liquid
  - Usually, dollars and US: the largest financial market in the world
- LIBOR: London Interbank Offered Rate
  - Traded in the Eurocurrency market
  - Short-term opportunity cost of capital for AA-rated fin institutions
  - There is a small chance of default

Measuring a risk-free rate in Russia

- Treasury rate?
  - Small volumes, low liquidity
- Deposit rate in Sberbank?
  - Illiquid, below inflation

Measuring a risk-free rate in Russia

- Refinancing rate of the Bank of Russia?
  - Rarely changed
  - Not used as an instrument of the monetary policy
- Interbank rate (e.g., MIBOR)?
  - High chance of default and volatility, low liquidity

Measuring a risk-free rate in Russia

- Implied rate from the currency forward
  - Forward settlement price for T years: $F = Se^{(r-q)T}$
    - where S and F are the current and forward exchange rates,
    - r and q are local and foreign rates
  - The local risk-free rate: $r = q + (1/T)\ln(F/S)$