Financial Market Analysis (FMAx)
Module 1

Pricing Money Market Instruments

Preamble:
At the end of this module you will be able to:

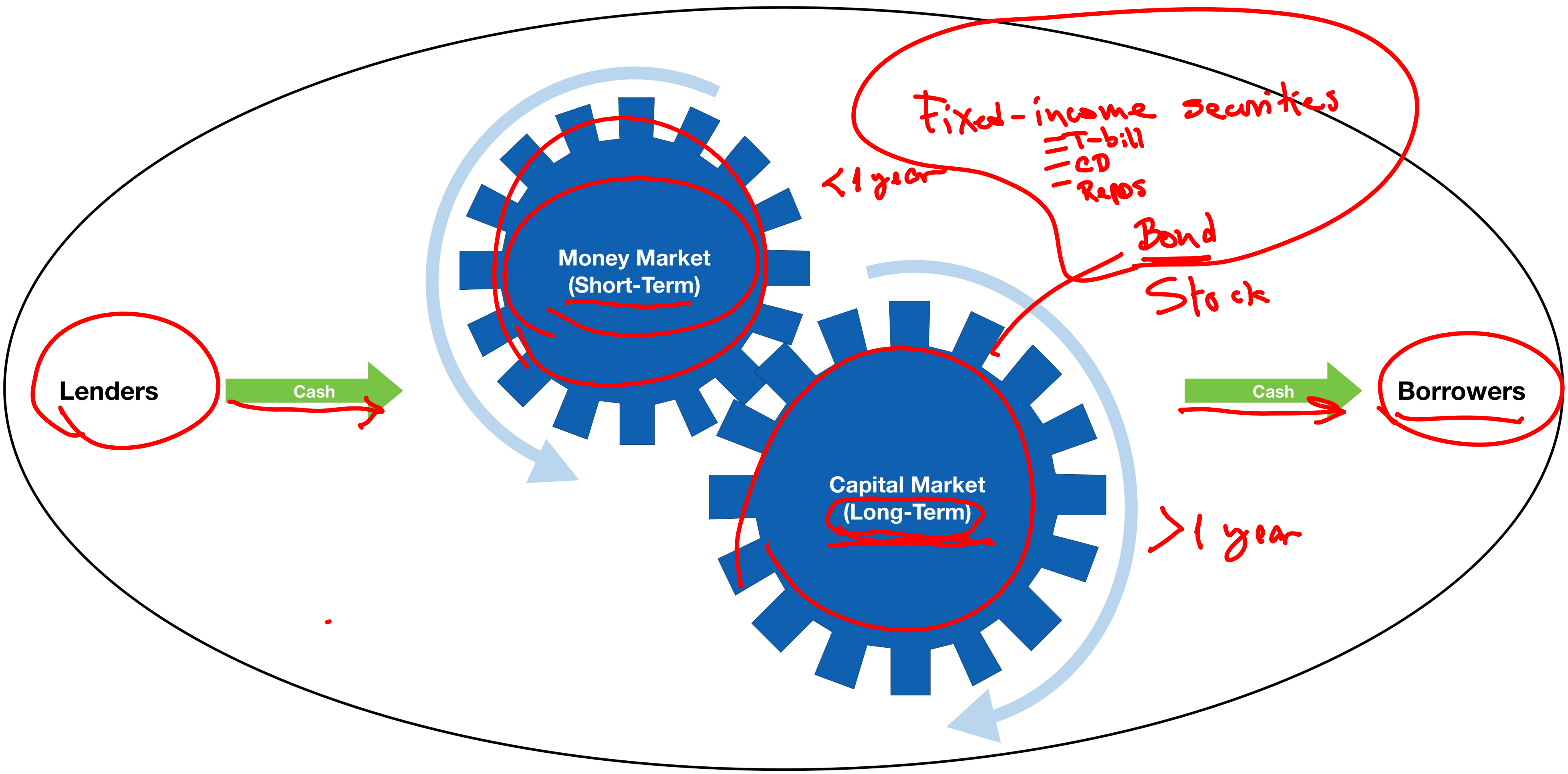
- Describe the money market and its relation with the capital market
- Explain the nature and use of key money market instruments
- Apply fundamental principles of financial mathematics
- Calculate the price and return of money market instruments

The Relevance to You

You might be…

- An **investor**
- A **central banker**: the first link in monetary policy transmission
- A **public debt manager** or a **company treasurer**
  - Source of short-term funding
  - Facilitates liquidity management
- A **financial supervisor**
  - Links banks with other financial institutions
  - Entails a channel for the propagation of financial shocks

Financial Markets



Defining the Money Market

Market for short-term liquid instruments.

Appeal for Investors:

Liquidity and safety of investment (low-risk, low return).

Main Participants:

(1) Banks;
(2) Money market funds and other financial institutions;
(3) Large corporations;
(4) Central Banks; and
(5) Governments

Characteristics:

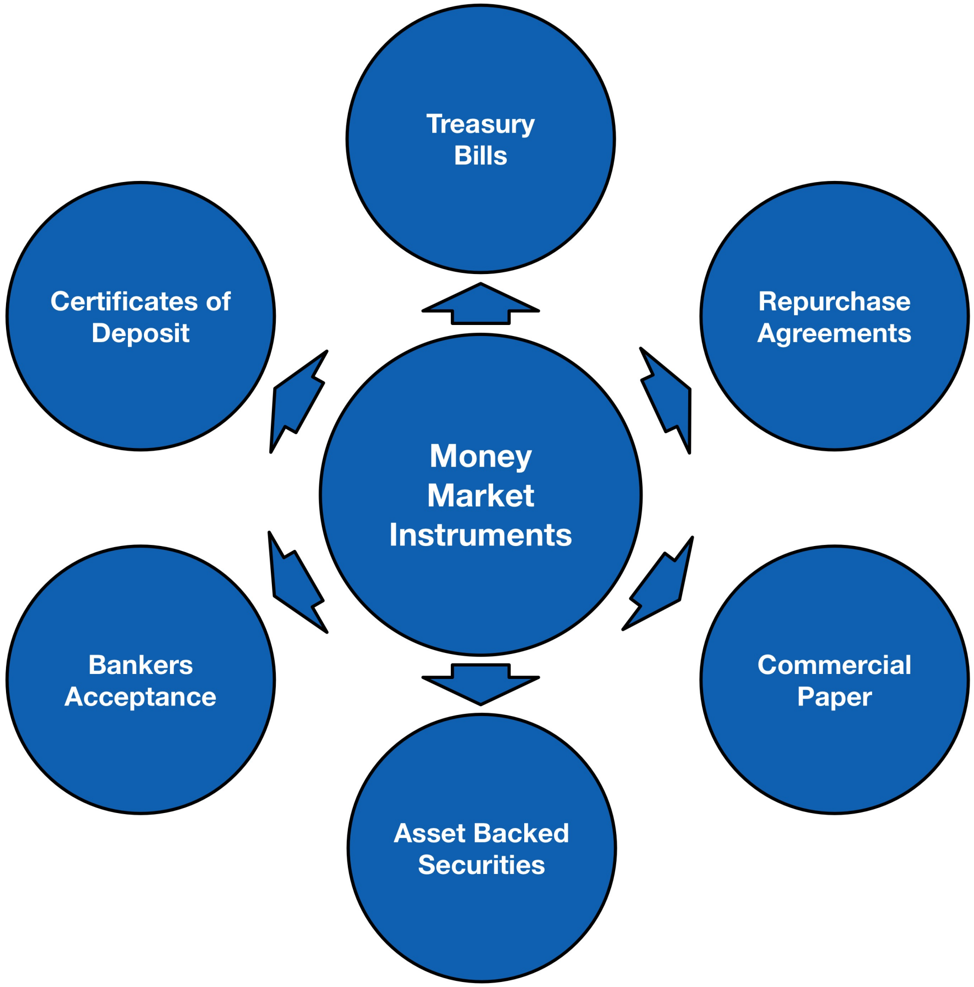
(Typically) dealer market, lack of trading floor.

Money Market Instruments

Typical Characteristics

- Short maturity (less than one year)
- High liquidity
- Low risk
- Low return
- Large denomination

Money Market Instruments



Treasury Bills

- Government debt with maturity lower than one-year
- Typical maturities: 90 days, 181 days, 360 days
- Typical denominations: $1,000 to $1 million
- No coupons
- The most marketable money market instrument

FV

maturity date

P

Int_1 Int_2 Int_3 Int_4

Repurchase Agreements

Repos

Similar to a collateralized loan contract, but asset property is actually transferred to lender (lower risk).

Lender

- **Buys** collateral from borrower.
- Agrees to **sell back** at given price at a future date.

P

P+Int

Cash

Cash

Borrower

- **Sells** collateral to lender.
- Agrees to **repurchase** at given price at a future date.

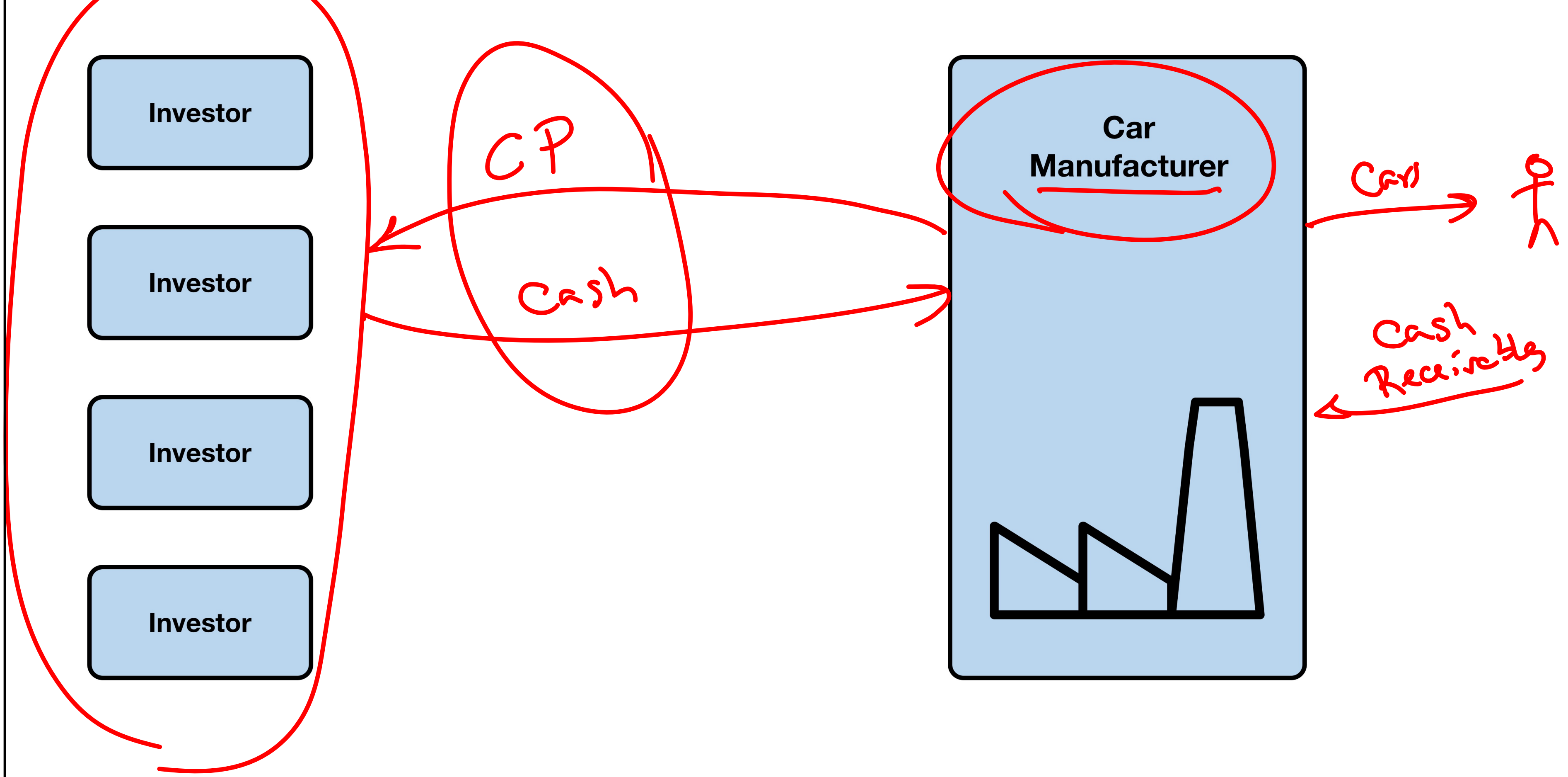
Certificates of Deposit (CDs)

Characteristics include:

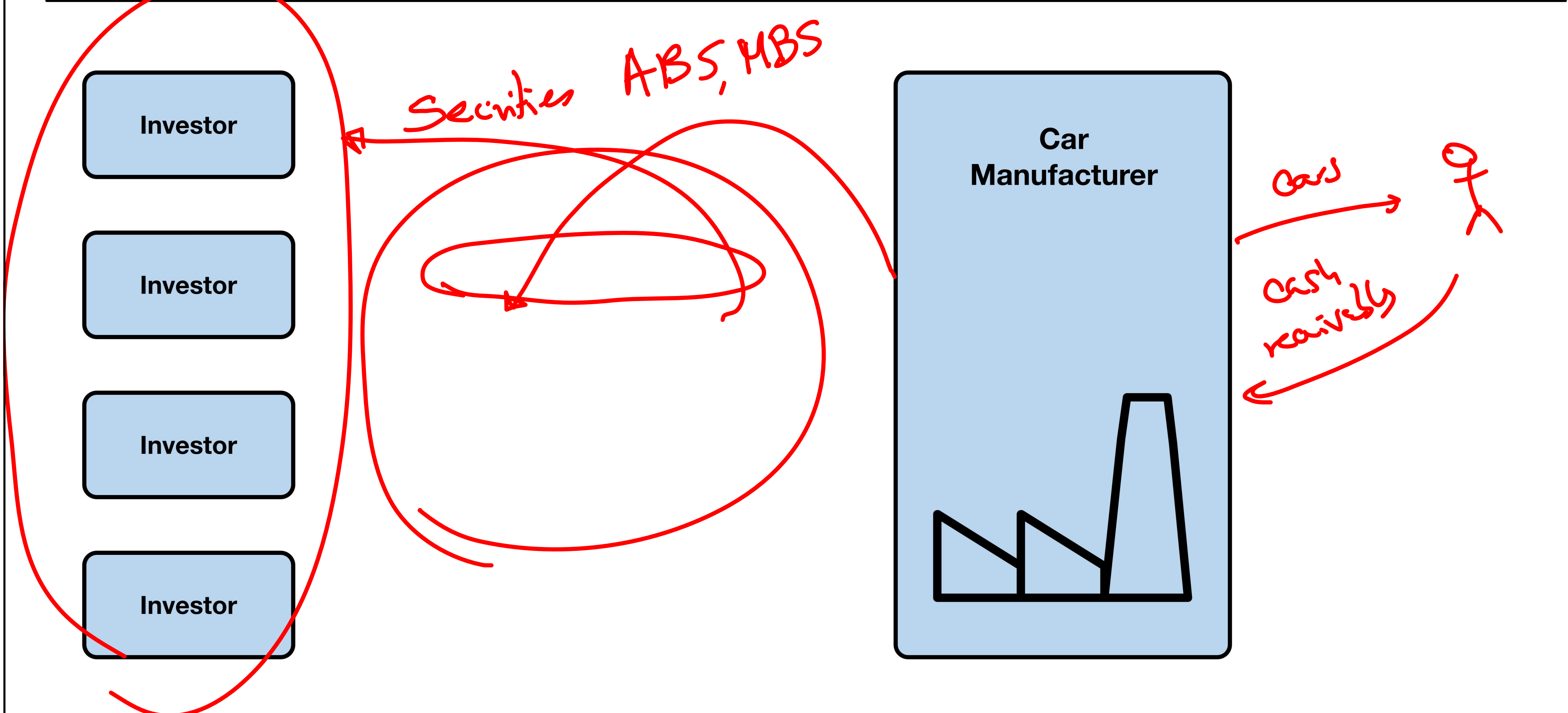
- Time deposit with a bank
- But traded in secondary markets
- Issued in any denomination
- Typical maturities 3-month to 5 years
- Covered by deposit insurance up to a certain amount

Commercial Paper

lack of collateral



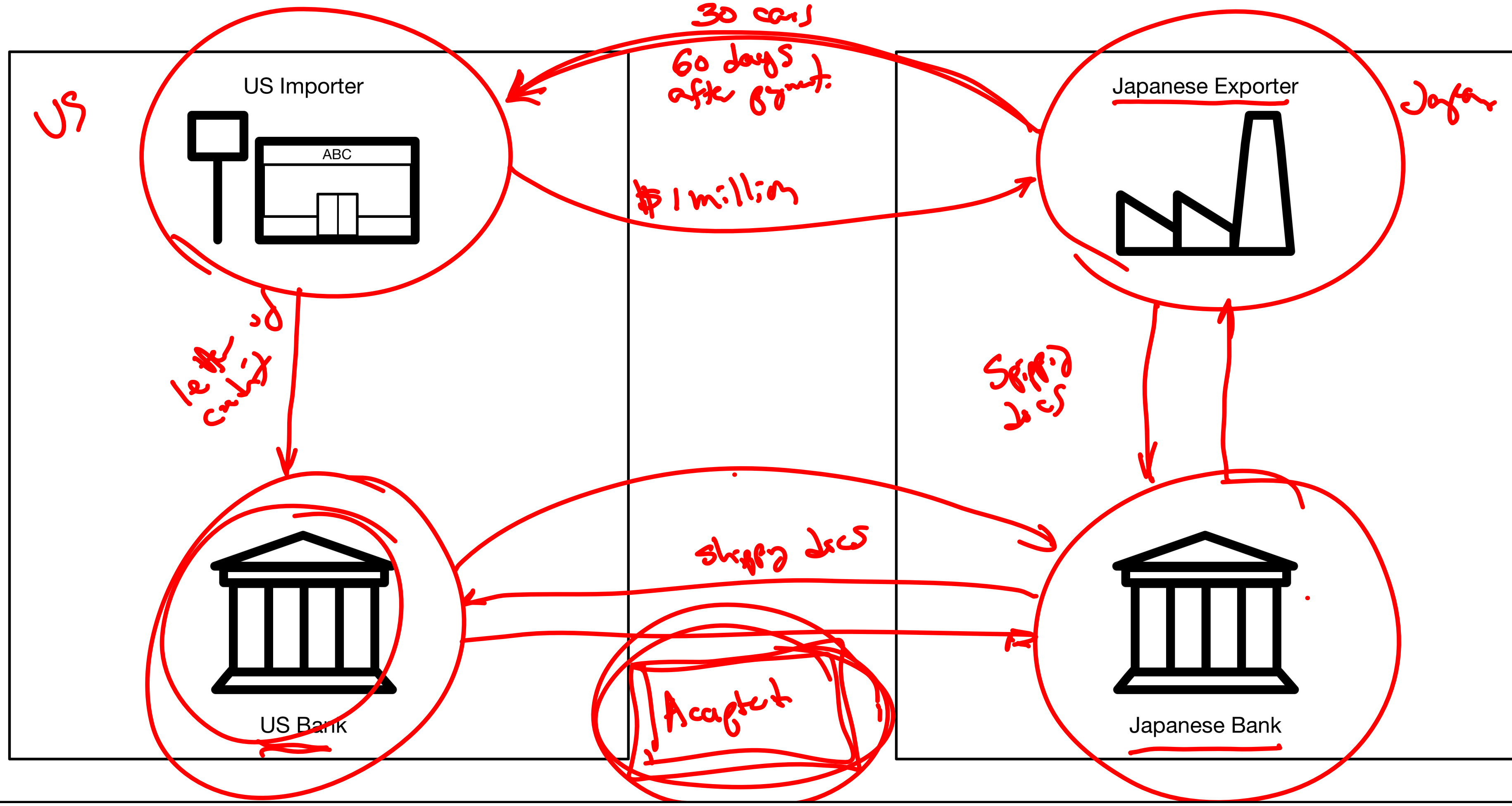
Asset Backed Securities and SPVs



Bankers Acceptance

Financing
Reducing risk

Instrument created to finance commercial trade. A bank accepts the ultimate responsibility to repay a loan.



An Introduction to Fixed Income Securities

What is a fixed-income security?

- A promise to deliver future known cash flows.
- Examples: Treasury bonds, notes, and bills; and corporate bonds.
- Money market instruments are fixed-income securities.

Characteristics of Fixed Income Securities

Indenture:
Contract between issuer and holders specifying interest, principal and other items.

Par (Face) Value:
The amount of money paid at maturity.

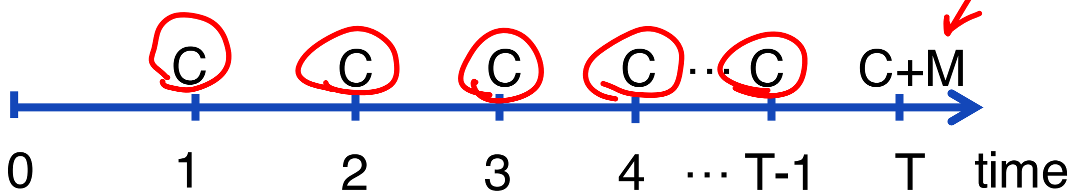
Maturity:
The end date of the security's life.

Coupon Payments:
Interest payments made periodically through the life of the security.

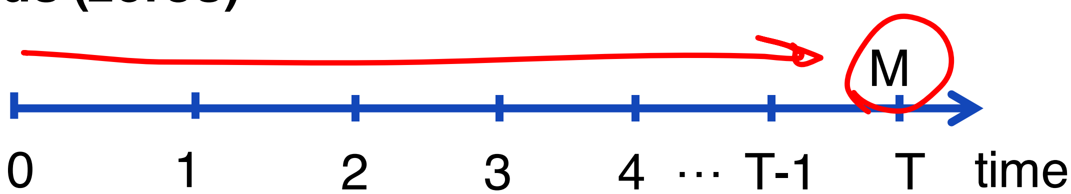
Quoted Prices

Key Types of Fixed Income Securities

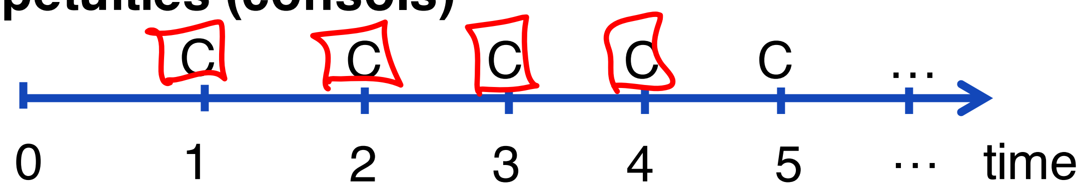
Coupon Bonds



Zero Coupon Bonds (zeros)



Annuities and Perpetuities (consols)



Pricing a Fixed-Income Security

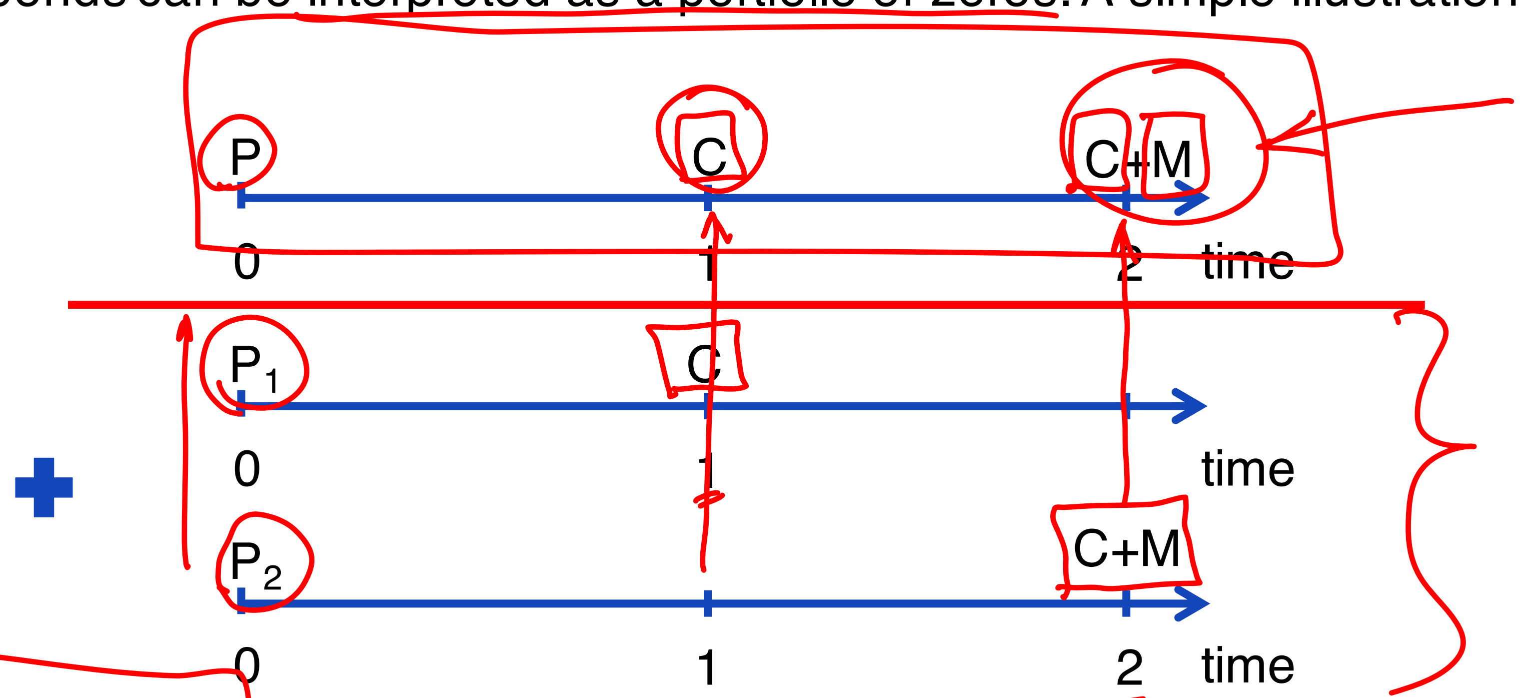
By discounting their future cash flows back to the present…

- The **price of the security is the PV of its cash flows**
- Need a discount rate: the return required by the market (i.e., investors) = **yield**
- In the case of a *T*-year zero coupon bond:

$$P = \frac{M}{(1+y)^T}$$

Coupon Bonds as Portfolios of Zeros

Coupon bonds can be interpreted as a portfolio of zeros. A simple illustration:



Claim: $P = P_1 + P_2$

A Fundamental Pricing Principle: No Arbitrage Condition

The Law of One Price (LOP):
(Identical assets should have the same price)

Identical in terms of…

- Cash flows
- Risk / Inflation / Uncertainty

If prices differ, then there would be "arbitrage" opportunities

- Possibility to make unlimited riskless profits by buying the lower-priced asset and selling the higher-priced one

No Arbitrage Condition: Intuition

Suppose two **identical** securities S_1 and S_2 have different yields. Say: $y_1 > y_2$

Investors try to purchase S_1 and sell S_2

Then P_1 increases and P_2 drops

Consequently, y_1 would fall and y_2 would increase

- This process will continue until $\boxed{y_1 = y_2}$, $P_1 = P_2$

Market equilibrium is restored and there are no more arbitrage opportunities

The Coupon Rate and Bond Yield

The coupon dictates the periodic cash flows according to bond contract.

- Example: 7% coupon, paid semi-annually
- If face value is 100, $\boxed{\$3.5}$ paid two times per year

The yield is the market interest rate used to discount the periodic flows.

present value $\rightarrow$ P $\rightarrow$ IRR = y

The coupon and yield are usually different.

- The yield is the market rate, which varies continuously
- The coupon rate is (generally) fixed

Secondary market price depends on both the coupon, face value, and market interest rate (yield).

$y \rightarrow$ Price $\rightarrow \boxed{IRR} = \boxed{y}$ ✓

Alternative Yield Definitions

Coupon Rate: Sum of coupons paid in a year in percent of par (face) value

$$CouponRate = \frac{SumCouponsInYear}{ParValue}$$

Coupon = y

⇒ P = Face value

Trade at par

Current Yield: Sum of coupons paid in a year in percent of bond (market) price

$$CurrYield = \frac{SumCouponsInYear}{BondPrice}$$

coupon > yield

⇒ P > face value

Yield-to-Maturity (YTM): Internal rate of return of investing in the bond

An Example: Yields

Compare the coupon rate, the current yield and the yield to maturity of a one-year $100 security that pays 5% semi-annual coupons and was purchased for $95 on the issue date.

P < FV

coupon < y

$$CouponRate = \frac{5\% \times 100}{100} = 5\%$$

$$CurrYield = \frac{\boxed{5\% \times 100}}{95} = 5.26\%$$

$$YTM \rightarrow 95 = \frac{2.5}{\left(1+\frac{y}{2}\right)} + \frac{102.5}{\left(1+\frac{y}{2}\right)^2} \rightarrow YTM = \boxed{10.4\%}$$

market rate 10.4%

Day Count Conventions

Pricing in financial markets started long before computers…

- People in different countries took different strategies to ease the calculation of accrued interests over time
- Example: 30 days per month and 360 days per year (30/360 day count methods)

Different markets price the same security differently...

- Need to be aware of conventions in different markets to compare prices

Useful Day Count Conventions

Day Count	Description	Excel Code
30/360	The number of days between two dates assuming that months have 30 days and years have 360 days	0 (or omitted) for US NASD 4 for European
Actual/Actual	The actual number of days between two dates	1
Actual/360	Number of days in year fixed to 360	2
Actual/365	Number of days in year fixed to 365	3

day in month

days in year

An Example:
Changing the Base of the Yield

How to convert ACT/360 rate y into ACT/365 rate y^*?

$$\boxed{y^* = y \times \frac{365}{360}}$$

Suppose yield y on ACT/360 is 10.5%. What is the equivalent yield y^* on ACT/365?

$$y^* = 0.105 \times \frac{365}{360} = 0.1064 = 10.64\%$$

Pricing Money Market Instruments

Price equals the present value of future cash flows…

- This principle applies to all instruments

- Money market instruments have maturity in less that one year

  Use simple interest

- Money market is linked to other markets through the principle of no arbitrage

Alternative Ways to Quote Prices: Yield and Discount

Two alternatives to express the return of fixed income securities:

- Using the **yield** (y) or **discount** (d)

Depending on the jurisdiction, prices are quoted as one or the other

- Example: Take a zero with price P and face value M

$$P = \underbrace{\frac{1}{\left(1 + y \times \frac{days}{365}\right)}}_{\text{discount factor}} M \qquad P = \underbrace{\left(1 - d \times \frac{days}{365}\right)}_{} \times M$$

yield

discount rate

An Example:
Yield and Discount – 1

You pay $80 for a $100 zero that matures in one year.
Compute the yield and the discount.

$$Yield = \frac{20}{80} = 0.25 = 25\% \qquad Discount = \frac{20}{100} = 0.20 = 20\%$$

market price ← $y > d$ → face value

Comparing Yield and Discount: Zero Coupon Bonds

Take: $$P = \frac{1}{(1 + y \times \frac{days}{365})} \times M$$

$$\boxed{\frac{1}{(1 + y \times \frac{days}{365})} = (1 - d \times \frac{days}{365})}$$

Alternatively: $$P = (1 - d \times \frac{days}{365}) \times M$$

Thus: $$d = \frac{y}{(1 + y \times \frac{days}{365})}$$

$$\boxed{y = \frac{d}{(1 - d \times \frac{days}{365})}}$$

$$\tilde{d} = d \times \frac{days}{365}$$

$$\tilde{d} = \frac{\tilde{y}}{1+\tilde{y}}$$

$$\tilde{y} = y \frac{days}{365}$$

$$y > d$$

$$\tilde{y} = \frac{\tilde{d}}{1-\tilde{d}}$$

An Example: Yield and Discount

Some Questions:

What is the 180-day discount factor of 7 percent per year?

$$\frac{1}{\left(1+0.07\times\frac{180}{365}\right)}=0.9666$$

What is the price of a $500 180-day zero-coupon bond if the yield is 7 percent?

$$0.9666\times\$500=\$483$$

What is the discount rate on the face value of the bond?

$$\left(1-d\times\frac{180}{365}\right)=0.9666 \qquad d=0.0677=6.77\%$$

Instruments Quoted on a Discount Basis

USA

- T-bills
- Bankers acceptances
- Commercial paper

U.K.

- T-bills (in pounds; in Euros quoted on yield basis)
- Bankers acceptances

Pricing Discount U.S. T-Bills

Price (per $100 face value):

$$P = \left(1 - d \times \frac{days}{360}\right) \times 100$$

Yield:

$$y = \left(\frac{FV}{P} - 1\right) \times \frac{365}{days}$$

Effective yield:

$$EAR = \left(1 + y\frac{days}{365}\right)^{\frac{365}{days}} - 1$$

How to Read U.S. T-Bill Quotes

US Treasury Bills (Quoted on Discount Basis)				
as of January 19, 2016				
Maturity	BID	ASK	CHANGE	YIELD
11/10/2016	0.373	0.363	-0.03	$\boxed{0.37}$

1/ 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.

Ask Price

Bid Price

US T-bills are quoted on a discount basis (reference price is face value).

Days to maturity

BID: discount rate offered by buyers.

ASK: discount rate offered by sellers.

CHANGE: the difference in bid discounts from the previous day.

YIELD: the annualized yield using the ask rate.

An Example:
Yields on a US T-Bill

Compute the price and yield of the following US T-bill.

US Treasury Bills (Quoted on Discount Basis)

as of January 19, 2016

Maturity	BID	ASK	CHANGE	YIELD
11/10/2016	0.373	0.363	-0.03	0.37

1/ 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.

Days to maturity: Jan 19 to Nov 10=296 days

$$P = \left(1 - d \times \frac{days}{360}\right) \times 100 = (1 - 0.00363\frac{296}{360}) \times 100 = \boxed{\$99.70} \rightarrow y = \left(\frac{100 - 99.70}{99.71}\right) \times \frac{365}{296} = 0.37\%$$

An Example:
Pricing Certificates of Deposit – 1

A 90-day CD with $100,000 face value was issued on March 17, 2015, offering a 6 percent coupon (under ACT/360 day convention) with a market yield of 7 percent.

a) Compute the payoff (Final Value)

b) Compute the price of the CD on March 17, 2015

c) On April 10, 2015, the market yield dropped to 5.5 percent. Compute the price of the CD in the secondary market

d) On May 10, the market rate further dropped to 5 percent. Compute the return of an investor that purchased the CD on April 10 and sold it on May 10 (30 days)

An Example: Pricing Certificates of Deposit – 2

a) Compute the payoff.

$$FV = 100{,}000\left(1 + .06 \times \frac{90}{360}\right) = 101{,}500$$

b) Compute the price of the CD on March 17.

$$P = \frac{101{,}500}{\left(1 + .07 \times \frac{90}{360}\right)} = 99{,}754$$

c) On April 10, 2015, the market rate dropped to 5.5 percent. Compute the price of the CD in the secondary market.

$$P = \frac{101{,}500}{\left(1 + .055 \times \frac{66}{360}\right)} = 100{,}487$$

An Example:
Pricing Certificates of Deposit – 3

d) On May 10, the market rate further dropped to 5 percent. Compute the return of an investor that purchased the CD on April 10 and sold it on May 10 (30 days).

$$P(\text{April } 10) = \frac{101,500}{\left(1 + .055 \times \frac{66}{360}\right)} = 100,487$$

$$P(\text{May } 10) = \frac{101,500}{\left(1 + .05 \times \frac{36}{360}\right)} = 100,995$$

$$\text{Return} = \left[\frac{100,995}{100,487} - 1\right] \times \frac{360}{30} = 6.07\%$$

Repurchase Agreements

Recall the way these work…

- One party sells a security to a second party, while agreeing to buy it back at a set date at a set price

  Δ price, dates

- Equivalent to first party borrowing with security acting as collateral
- Term typically short
  - Overnight repo – one day maturity
  - Term repo – maturity longer than 30 days
- Interest rate (repo rate) implied by prices

An Example:
Pricing Repurchase Agreements

a) Mybank sells 9,876,000 worth of T-bills and agrees to repurchase them in 14 days at 9,895,000. What is the repo rate?

$$y = \left[\frac{9,895,000}{9,876,000} - 1\right] \times \frac{365}{14} = 5.02\%$$

b) If the overnight repo rate is 4.5% what is the payment tomorrow for a repo of $10,000,000?

$$10,000,000 \times \left(1 + 0.045 \times \frac{1}{365}\right) = 10,001,232.88$$

Module Wrap-Up – 1

In this module we covered:

- The money market and its role in the financial system
- The main types of money market instruments
- How to price and compute returns on money market instruments

Key concepts to remember

- Security Price = Present value of future payments computed at market yields
- Market equilibrium = No arbitrage

Module Wrap-Up – 2

Future value with intra-year compounding:

$$FV = PV \times \left(1 + \frac{i}{n}\right)^{n \times t}$$

Present value:

$$\boxed{PV = \sum_{t=1}^{T} \frac{CF_t}{(1+i)^t}} \qquad PV = CF \times \left(\frac{1}{i} - \frac{1}{i \times (1+1)^T}\right)$$

Simple interests and discounts (apply to money market instruments):

$$PV = \frac{1}{\underbrace{\left(1 + y \times \frac{days}{365}\right)}} FV \qquad PV = \underbrace{\left(1 - d \times \frac{days}{365}\right)} \times FV$$