Financial Derivatives

Futures, Options, and Swaps
A *derivative* is a financial instrument whose value depends on – is derived from – the value of some other financial instrument, called the underlying asset.

Common examples of underlying assets are stocks, bonds, corn, pork, wheat, rainfall, etc.
Basic purpose of derivatives

- In derivatives transactions, one party’s loss is always another party’s gain.
- The main purpose of derivatives is to transfer risk from one person or firm to another, that is, to provide insurance.
- If a farmer before planting can guarantee a certain price he will receive, he is more likely to plant.
- Derivatives improve overall performance of the economy.
Major categories of derivatives

1. Forwards and futures
2. Options
3. Swaps
Forwards and Futures

- A forward, or a forward contract, is:
  An agreement between a buyer and a seller to exchange a commodity or a financial instrument for a prespecified amount of cash on a prearranged future date.

- Example: interest rate forwards (in text)

- Forwards are highly customized, and are much less common than the futures
Futures

- A future is a forward contract that has been standardized and sold through an organized exchange.

- Structure of a futures contract:
  - Seller (has short position) is obligated to deliver the commodity or a financial instrument to the buyer (has long position) on a specific date.
  - This date is called settlement, or delivery, date.
Part of the reason forwards are not as common is that it is hard to provide assurances that the parties will honor the contract.

In futures trading, this is done through the clearing corporation.

How? Through *margin accounts*.

Margin accounts guarantee that when the contract comes due, the parties will be able to pay.
Margin accounts and marking to market

- Clearing corporation requires initial deposits in a margin account
- Tracks daily gains and losses and posts these to margin accounts
- This is called *marking to market*
- Analog: a poker game
  - At the end of each hand, wagers transfer from losers to the winner
Example

- Suppose there is a futures contract for the purchase of 1000 ounces of silver for $7 per ounce.
- Seller (short position): guarantees delivery of 1000 ounces for $7000 on the delivery date.
- Buyer (long position): is obligated to pay $7000 on the delivery date for 1000 ounces of silver.
- Suppose price rises to $8 per ounce: the seller needs to pay $1000 to the buyer so the buyer still only pays $7000.
- The seller's margin account is debited $1000 and the buyer's account is credited $1000.
- If price falls to $6, the reverse happens: the buyer needs to pay the seller $1000 to ensure that the seller receives $7000.
Hedging and Speculating with Futures

- Often, agents hedge against adverse events in the market using futures
  - E.g., a manager wishes to insure the firm against the rise in interest rates and the resulting decline in the value of bonds the firm holds
  - Can sell a futures contract and lock in a price

- Producers and users of commodities use futures extensively to hedge their risks
  - Farmers, oil drillers (producers) sell futures contracts for their commodities and insure themselves against price declines
  - Food processing companies, oil refineries (users) buy futures contracts to insure themselves against price increases
Speculators

Speculators try to use futures to make a profit by betting on price movements:
- Sellers of futures bet on price decreases
- Buyers of futures bet on price increases

Futures are popular because they are cheap

An investor only needs a relatively small amount – the margin – to purchase a contract that is worth a great deal
A futures contract for delivery of $100,000 face value worth of 10-year, 6% coupon US Treasury bond requires a margin of $2700 through Chicago Board of Trade.

Suppose that the price of this contract fell 10/32 per $100 face value worth of bonds.

The value of contract changes by

\[(10/32)\times(1000)=312.5\]

If you were the seller, with an initial investment of $2700 you gained $312.5 (a return of 11.6%).

If you owned the bonds and sold the future, you would earn a return of only 0.313%.

A speculator can obtain large amounts of leverage at low cost.
Arbitrage and Futures Prices

- On the delivery date, the price of the futures contract must equal the price of the asset the seller is obligated to deliver.
- If this were not true, it would be possible to earn instantaneous risk-free profit.
  - If bond price were below the futures price, buy a bond, sell the contract, deliver the bond, and earn the profit.
- Practice of simultaneously buying and selling financial instruments to benefit from temporary price difference is called arbitrage.
- Existence of arbitrageurs ensures that at delivery date, the futures price equals the market price of the bond.
- Why? Supply and demand logic.
Arbitrage and Futures Prices

- But what happens before the delivery date?
- Principle of arbitrage still applies
- Suppose market price of a bond is lower than the futures contract price
- Arbitrageur borrows funds to buy a bond and sells the futures contract, gets the difference in prices as instant profit
- Keeps the bond until the delivery date, pays loan interest with interest earned from the bond
- This is costless, but earn instant profit
- Market eliminates such opportunities
- Futures price must be in lockstep with the market price of a bond
Example

- Spot (market) price of 6% coupon 10-year bond is $100
- Current interest rate on 3 month loan is 6% annual rate

- Futures price for delivery of 6% 10-yr bond 3 months from now is $101

- What does an arbitrageur do?
  - Borrow $100
  - Sell a futures contract for $101
  - Use interest payments from the bond to pay the loan interest

- Summary: Table 9.2 (Cecchetti)
Options

- Like futures, options are agreements between 2 parties
- Seller is called an **option writer**
  - *Incurs obligations*
- Buyer is called an **option holder**
  - *Obtains rights*
- 2 types of options
  - Call option
  - Put option
**Options**

- *Call option* – a right to buy an asset at a predetermined price (*strike price*) on or before a specific date
- If asset price is higher than the strike price
  - Option is *in the money*
- If asset price is exactly at the strike price
  - Option is *at the money*
- If asset price is below the strike price
  - Option is *out of the money*
- Obviously would not exercise an option that is out of the money
Options

- **Put option** – a right to sell an asset at a predetermined price on or before a specific date
  - If asset price is lower than the strike price
    - Option is *in the money*
  - If asset price is exactly at the strike price
    - Option is *at the money*
  - If asset price is higher than the strike price
    - Option is *out of the money*
American and European Options

- **American options**
  - Can be exercised at any date up to the expiration date

- **European options**
  - Can be exercised only at the expiration date

- **Most options sold in the US are American options**

- **However, very few are exercised before the expiration date**
  - Instead, they are typically sold
Understanding Profits and Losses on Futures and Options

- Use Figure 1 on p. 323
- X-axis measures bond prices at expiration
- First look at the profit from buying a futures contract: you are obligated to pay $115,000 at the delivery date (say, June 1st) for $100,000 face value of bonds
- If on June 1st, the market price of a bond is $100, you have lost (115-100)*1000=15,000
- If on June 1st, the market price is $115 dollars, you break even
- If on June 1st, the market price is $120 dollars, you gained?
- Implies a linear profit curve for the buyer of a futures contract
Understanding Profits and Losses

- Now consider a case where you bought a call option to purchase $100,000 face value bonds on June 1st for $115,000 for a premium of $2,000.
- Come June 1st, market price is $100 – do not exercise the option, lose $2,000.
- Market price is $116 – exercise the option, gain: 
  \[(116-115)(1000)-2000=1000\]
- At what market price break even?
  - Solution to: \[(x-115)(1000)-2000=0\]
  - \[X=117\]
- Market price of $120 – gain 5000-2000=3000
- Get the kinked (nonlinear) profit curve
Using options

- Options transfer risk, and are used for
  - Hedging
  - Speculating
- A hedger is buying insurance
  - Buying a call option ensures that the cost to you of buying an asset in the future will not rise
  - Buying a put option ensures that you will be able to sell your asset in the future at a prespecified price
  - Writing a call option can ensure that a producer will receive a certain payment for its product
Using options: speculation

- Options are widely used for speculation
- Purchasing a call option allows a speculator to bet that the price of the underlying asset will rise
- Purchasing a put option allows a speculator to bet that the price of the underlying asset will fall
- Table 9.3 from Cecchetti
Pricing options

- Option Price = Intrinsic Value + Option Premium

- Intrinsic Value: value of an option if it is exercised immediately

- Option Premium: fee paid for the potential benefit from buying the option

- Actual option pricing is pretty complex

- Use intuitive discussion here
Example

- At-the-money European call option on the stock that expires in 1 month
- At-the-money means current market price = exercise price (say, $100)
- Intrinsic value = 0
- Next month, stock will either rise or fall by $10 with equal probability (0.5)
- Ignore discounting
Example (cont’d)

- What is the expected payoff?
- If price falls to $90, do not exercise the option, gain nothing
- If price rises to $110, exercise the option, gain $10
- Expected payoff = 0\times0.5 + 10\times0.5 = 5
- This is the option premium
- What would the option premium be if stock price could rise or fall by $50 with equal probability?
- As volatility of the stock price rises, option premium rises
Option pricing

- As any option gives the buyer a choice, its value cannot be negative.
- At expiration, value of the option = intrinsic value.
- If not, arbitrage opportunities exist that lead to riskless profit.
- Prior to expiration:
  - The longer the time to expiration, the greater the chance that the price will change to make option valuable.
  - The longer the time to expiration, the higher the option premium.
Example

- Back to the stock that falls or rises by $10 every month with ½ probability
- What happens when the option expires in 3 months?
- 8 possibilities:
  - Up,up,up (+30)
  - Up,up,down (+10)
  - Up,down,up (+10)
  - Up,down,down (-10)
  - Down,up,up (+10)
  - Down,up,down (-10)
  - Down,down,up (-10)
  - Down,down,down (-30)
- Thus, stock:
  - Rises by 30 with probability 1/8
  - Rises by 10 with probability 3/8
  - Falls by 10 with probability 3/8
  - Falls by 30 with probability 1/8
- Option payoff is asymmetric, we only care about the upside:
  - Expected value of 3-month call is: \((1/8)*30+(3/8)*10=7.50\)=option premium
Option pricing: volatility

- Likelihood that the option will payoff depends on volatility of the underlying asset price.
- One measure is standard deviation.
- Increased volatility has no cost to the option holder (if bad things happen, chose not to exercise the option), only benefits!
- Summary in Table 9.4