Financial Derivatives

Futures, Options, and Swaps

Defining Derivatives

- 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

Futures (cont'd)

- 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 sellers 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

Example of leverage

- 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)*(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*0.5+10*0.5=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