BUSM 411: Derivatives and Fixed Income

2. Forwards, Options, and Hedging

This lecture covers the basic derivatives contracts: forwards (and futures), and call and put options. These basic contracts are widely used and form the fundamental building blocks for other more complicated derivatives. We'll cover how these contracts work, and introduce payoff and profit diagrams for understanding derivatives positions. We'll then introduce how derivatives are used for hedging and risk management.

2.1. Forward contracts

A relatively simple derivative is a **forward contract**. It is an agreement to buy or sell an asset at a certain time in the future for a specified price. This is in contrast to a **spot contract**, which is an agreement to buy or sell an asset immediately.

- The time at which the contract settles is called the **expiration date**
- The asset or commodity on which the agreement is based is called the **underlying asset**
- Aside from any commission or bid-ask spread, it is costless to enter a forward contract (i.e. no money exchanged upfront)
- Forward contracts trade on the over-the-counter market, usually between two financial institutions or between a financial institution and one of its clients

Long and short positions in a forward agreement:

- One party assumes a **long position** and agrees to buy the underlying asset on the expiration date for a specified price
- The other party assumes the **short position** and agrees to sell the asset on the same date for the same price

2.1.1 Forward contracts on foreign exchange

Forward contracts on foreign exchange are very popular

- Most large banks employ both spot and forward foreign-exchange traders
- (*Pull up example of currency forward quotes online*) Currency forwards are quoted in **forward points**, or the amount that you would add or subtract to the spot rate to get the forward rate for that period.
  - The number of decimals is just considered "known," that is, 2 for the yen, 5 for most other liquid currencies
  - The actual forward rate is know as the **outright**

Hedging foreign currency risk with forward contracts:

- Suppose you work in the treasurer's office of a US corporation that has agreed to purchase £1 million of goods from a supplier in the UK three months from now. What risk does it face?

- At what rate could the

2.1.2 Payoffs from forward contracts

Consider the position of the corporation we just described. What are the possible outcomes?

- What happens if the spot rate rises over the next three months? What if it falls?

In general, the payoff from a long position in a forward contract on one unit of an asset is

$$S_T - K$$

where K is the delivery price and S_T is the spot price of the asset when the contract matures at time T. Similarly, the payoff from a short position in a forward contract on one unit of an asset is

$$K - S_T$$

We can graph the potential payoffs from a forward position as follows (*draw on board*). Because it costs nothing to enter into a forward contract, the payoff is also the trader's total loss or gain from the contract.

2.1.3 Forward prices and spot prices

For a quick preview of why forward and spot prices are related (which we will discuss in detail later in the course), consider a stock that pays no dividend and is worth \$60. You can borrow or lend money for one year at 5%. What should the 1-year forward price of the stock be?

- The answer is \$60 grossed up at 5% for 1 year, or \$63. Why?

- What if the forward price were \$67? How could you take advantage?

- What if the forward price were \$58?

2.2. Futures contracts

Like a forward contract, a futures contract is an agreement between two parties to buy or sell an asset at a certain time in the future for a certain price. In fact, a futures contract is essentially a forward contract that has been formalized in standardized so that it can trade on an exchange.

- To make trading possible, the exchange specifies certain standardized features of the contract

- Exchange provides mechanisms to guarantee that the contract will be honored

- The largest exchanges for futures contracts are the CBOT and the CME, which have merged to form the CME group.

- A wide range of commodities and financial assets form the underlying assets for contracts traded on these and other exchanges around the world
- Futures price is determined the same way as other prices (i.e., by supply and demand): if more traders want to go long than short, the price will go up, and vice versa

We will cover the mechanics and details of trading futures, such as margin requirements, daily settlement procedures, delivery procedures, bid-offer spreads, and the role of the exchange clearing house later in the course.

2.3. Options

Options are traded both on exchanges and in the over-the-counter market. There are two types of options:

- A **call option** gives the holder the right (but not the obligation) to buy the underlying asset on (or in some cases, before) a certain date for a specified price
- A **put option** gives the holder the right to sell the underlying asset by a certain date for a certain price.
- The price in the contract is called the **exercise price** or **strike price**
- The date in the contract is known as the **exercise date** or **maturity**

There are two styles of options:

- **American options** may be exercised at any time up to the expirations date
- **European options** can only be exercised on the expiration date itself
- Most options traded on exchanges are American
- In the exchange-traded equity option market, one contract is typically an agreement to buy or sell 100 shares

An option gives the holder the *right* to do something. The holder does not have to exercise this right. This is the key feature that distinguishes options from forwards and futures. This optionality is inherently valuable, so a related difference is that there is a cost to acquire an option, whereas there it costs nothing to enter a forward or futures contract.

[OPEN EXAMPLE QUOTE FROM CBOE]
Looking at actual option quotes illustrates a couple of properties of options:

- The price of a call option decreases as the strike price increases, while the price of a put option increases
- Both types of options tend to be more valuable as the maturity i farther out

Suppose you want to buy a call option (pick one)

- The (offer) price is the price of an option to buy one share. Contracts are typically for 100 shares
- You pay $C \times 100$ to the exchange, who passes it on to the other party in the transaction
- You have obtained, at the cost of $C \times 100$, the right to buy 100 shares of the stock for a price of K per share.
- If the price does not go above K by time T, you don't exercise the option, and have "lost" $C \times 100$.
- If the price does go above K, you would exercise the option, receiving S worth of stock for K dollars.

An alternative trade might would be to sell a put option. What are the possible outcomes?

Draw the payoff profiles for these positions (assuming that the will not be exercised early).

Four ways to participate in an options contract:

- Long a call
- Short a call
- Long a put
- Short a put

2.4. Hedging and Risk Management

When an individual or company chooses to use future markets to hedge a risk, the objective is usually to take a position that neutralizes the risk as far as possible. For example, a company that produces and sells a commodity gains (loses) profit when the market price of the commodity increases (declines). To hedge, the company's treasurer should take a short futures position that is designed to offset this risk. That is, the futures position would lead to a loss when the price of the commodity rises, and a gain when it decreases

2.4.1 Short hedges: the producer's perspective

Suppose you are an oil producer and have just negotiated a contract to sell 1 million barrels of crude oil three months from now (December 7) at the market price on that date.

- You would gain \$10,000 for every 1 cent increase in the price of oil between now and December 7, and lose \$10,000 for every 1 cent decrease (*draw payoff diagram*)
- Suppose the spot price today is \$80 and the futures crude oil price for December delivery is \$79 per barrel.
- Each futures contract is for 1,000 barrels, so the company can hedge its exposure to oil prices by shorting 1,000 futures contracts
- This has the effect of locking in a price at \$79 per barrel

2.4.2 Long hedges: the buyer's perspective

Suppose that you are a manufacturer of copper wire, and you need to buy 100,000 lbs of copper three months from now to produce wire for a certain contract.

- The spot price of copper is 340 cents per pound, and the futures price for December delivery is 320 cents per pound
- You can hedge by taking a long position in four copper futures contracts for 25,000 lbs of copper each.
- This locks in the cost of your copper purchase at 320 cents per pound

2.4.3 Arguments for and against hedging

In principle shareholders can, if they wish, do the hedging themselves. They do not need the company to do it for them. They can certainly diversify risk more easily than a company. An investor with a well diversified portfolio would hold stock in both copper producers and in companies that use copper as an input, so that there is little overall exposure to fluctuations in the price of copper. If companies are acting in the interests of shareholders, it can be argued that in many cases hedging is unnecessary. So what are reasons why a company might choose to hedge?

In general, hedging can be beneficial in situations where losses are more harmful than gains are beneficial (*draw picture to illustrate why*). What are reasons why this might be the case?

- Taxes
- Bankruptcy and distress costs
- Costly external financing
- Increase debt capacity
- Managerial risk aversion

Reasons NOT to hedge:

- Transaction costs
- Costs of figuring out optimal hedging strategies and monitoring trading in derivatives
- More complicated tax and reporting requirements
- Competitive considerations, if most other firms in your industry do not hedge
- Hedging can lead to a worse outcome

2.4.4 Basis Risk

The hedges in the examples we have considered are almost too good to be true. The hedger was able to identify the precise date in the future when an asset would be bought or sold. The hedger was then able use futures markets to remove all of the risk arising from the price of the asset on that date. In practice, hedging is rarely as straightforward as this.

- The asset whose price you want to hedge may not be exactly the same as the asset underlying the futures contract
- The time at which you need to buy or sell the asset may not coincide with the maturity of available futures contracts

These problems give rise to what is called **basis risk**. The **basis** in a hedging situation is the difference between the spot price of the asset you are hedging, and the futures price of the contract you are using for the hedge.

A key factor affecting basis risk is the choice of the futures contract to be used for hedging:

1. The choice of the asset underlying the futures contract
2. The choice of the delivery month

As a general rule, you want to choose the asset whose price changes are most closely correlated with price changes in the asset you want to hedge, and choose the contract which matures soonest after the time when you will need to buy or sell the asset.

Example: Your company knows it will need to buy 20,000 barrels of crude oil at some time in October or November. Oil futures are traded every month in units of 1,000 barrels. The futures price for December contracts is \$68 per barrel. Now suppose you are ready to purchase the oil in November, at which time the spot price and futures price are \$70 and \$69.10 per barrel. You will have to close out the futures contract for a gain of \$1.10, so the effective cost of the purchase will be the spot price minus the gain on the futures contract, which is equivalent to the initial futures price plus the final basis. Because the basis is uncertain, you exposed to some degree of basis risk.

2.4.5 Cross hedging

In the previous example, basis risk arose from uncertainty about timing of the hedge. In some cases, it is impossible to find a futures contract whose underlying asset is the same as what you are trying to hedge. When the two assets are not the same, this is called **cross hedging**.

Consider, for example, an airline that is concerned about the future price of jet fuel. Because jet fuel futures are not actively traded, the company might use heating oil futures to hedge their exposure to jet fuel price changes. The question here is how large a position in heating oil futures should the company take? The ratio of the size of the position in futures contracts relative to the size of the risk exposure is called the **hedge ratio**. The idea is to find the hedge ratio that minimizes the variance of the hedged position, which we call the **minimum variance hedge ratio**.

The minimum variance hedge ratio depends on the relationship between changes in the spot price (ΔS) and changes in the futures price (ΔF). It can be shown that the minimum

variance hedge ratio h^* is the slope of the best-fit line from a regression of ΔS on ΔF. The formula for this is

$$h^* = \rho \frac{\sigma_S}{\sigma_F}$$

where σ_S is the standard deviation of ΔS, $\sigma - F$ is the standard deviation of ΔF, and ρ is the correlation between the two.

The optimal number of contracts is then

$$N^* = \frac{h^* Q_A}{Q_F}$$

where N^* is the optimal number of futures contracts used for the hedge, Q_A is the size of the position being hedge (units), and Q_F is the size of one futures contract (units).

Example: Jet fuel hedging in Excel