Module 7: Derivative Securities

(BUSFIN 4221 - Investments)

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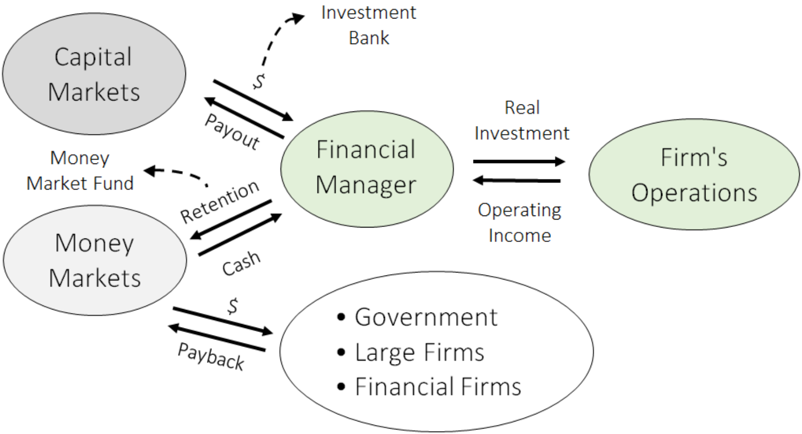
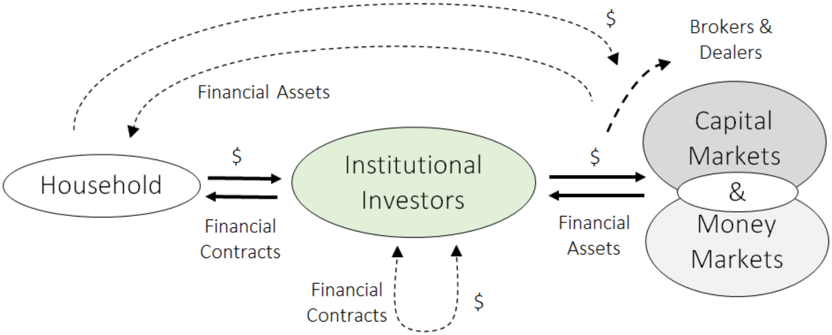
Module 1 - The Demand for Capital



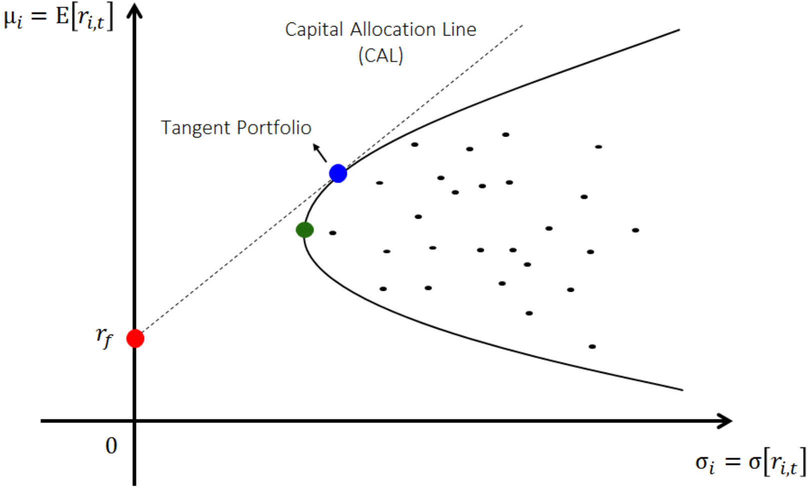
Module 1 - The Supply of Capital



Module 1 - Investment Principle

$$PV_t = \sum_{h=1}^{\infty} \frac{\mathbb{E}_t\left[CF_{t+h}\right]}{\left(1 + dr_{t,h}\right)^h}$$

Module 2 - Portfolio Theory



Module 3 - Factor Models

$$\mathbb{E}[r_i] = r_f + \beta_i \cdot (\mathbb{E}[r_M] - r_f)$$

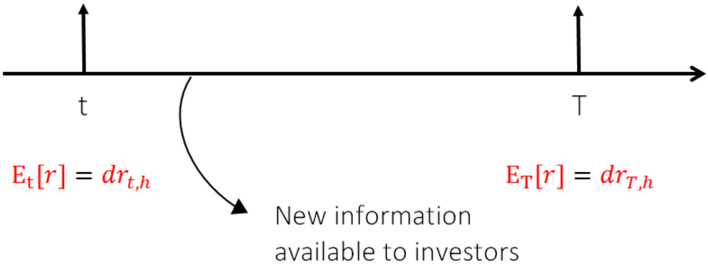
$$+ \beta_{i,A} \cdot \mathbb{E}[r_A - r_a]$$

$$+ \beta_{i,B} \cdot \mathbb{E}[r_B - r_b]$$

$$+ \ldots$$

Module 4: Market Efficiency

$$P_t = \sum_{h=1}^{\infty} \frac{E_t[CF_{t+h}]}{(1 + E_t[r])^h} \qquad\qquad P_T = \sum_{h=1}^{\infty} \frac{E_T[CF_{T+h}]}{(1 + E_T[r])^h}$$



$$E_t[r] = dr_{t,h} \qquad\qquad E_T[r] = dr_{T,h}$$

Module 5: Debt Securities

$$P_t = \frac{c \cdot F}{(1+y)^1} + \frac{c \cdot F}{(1+y)^2} + ... + \frac{c \cdot F + F}{(1+y)^H}$$

Module 6: Equity Securities

$$P_t = \frac{\widehat{D}_{t+1}}{(1+dr)^1} + \frac{\widehat{D}_{t+2}}{(1+dr)^2} + \frac{\widehat{D}_{t+3}}{(1+dr)^3} + \ldots$$

where $\widehat{D}_{t+h} = D_t \cdot (1+\widehat{g})^h$

This Module: Derivative Securities

What is a derivative?

- Derivative: "Contract in which the payout depends on (or derives from) the value of other underlying asset/variable"
- John is a farmer. This last May he spent 100 Million dollars to plant wheat, which he is planning on selling on September.
- His profits are uncertain since he does not know the wheat price in September
- Price changes represent a risk to John, which he can "hedge against" by entering a contract in which he agrees to sell his wheat for 5 cents per busher (in September) to somebody else.
- If September price is higher than 5 cents, John will get a profit lower than he could (since he will be obligated to sell it for 5 cents). However, he is insured against price decreases.
- The derivative payout depends on the September wheat price.

Types of Derivatives and where they Trade

- “The range of derivatives contracts is limited only by the imagination of man (or sometimes, so it seems, madmen)." (Warren Buffett, 2002)
- The most common types of derivatives are:
  - Forwards
  - Futures
  - Swaps
  - Options
- Forward and Swaps are traded over-the-counter (OTC).
  - A telephone and computer-linked network of dealers
  - Financial institutions often act as market makers
- Futures are traded in organized exchanges
- Options are traded both in exchanges and in the OTC market

Pros and Cons of the OTC Market

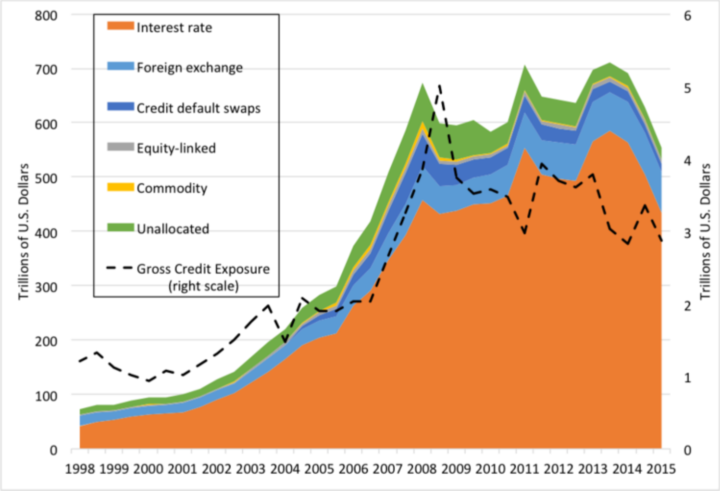
- Pros of OTC market:
  - Contracts can be tailor-made to meet specific needs
  - You can create new derivatives by negotiating with Dealers
- Cons of OTC market:
  - Liquidity can dry out quickly in OTC markets
  - There is counterparty risk
  - Domino effect due to interconnected balance sheets (induces systemic risk)
- Ex: AIG was "too interconnected to fail".
  - Regulatory response was to create a clearing house for some derivatives
  - CDS are now cleared by Intercontinental Exchange

Main Exchanges Trading Futures and/or Options

- CME Group (http://www.cmegroup.com/)
  - Formed by the merger of Chicago Mercantile Exchange (CME) and Chicago Board of Trade (CBOT) in 2007
  - Largest futures exchange in the world
- NYSE Euronext Group (http://www.nyse.com/)
- EUREX (http://www.eurexchange.com)
- Chicago Board Options Exchange - CBOE (http://www.cboe.com/)
  - First exchange to trade options, opened in 1973
  - Largest options exchange in the world
- International Securities Exchange (http://www.ise.com/)
  - Largest U.S. equity options exchange (in volume)

CME Trading Floor

The size of OTC Derivatives Market*



Source: Money, Banking and Financial Markets

Explaining the Previous Slide

This picture shows the notional amount of derivatives traded OTC. Think of it as the $ exposure of investors to derivatives market. We can see from the picture that the derivatives market is enormous. Some estimates suggest that the total size of the market is about 10 times the world GDP.

To understand the difference between the notional amount and the money that actually flows, consider a contract in which I agree to pay you 2% of $\$N$ every year and you agree to pay me back the annual interest rate, r_f, time the same base value $\$N$. This is a derivative (as we will see later, this is called a Interest rate Swap). The notional amount of this contract is $\$N$. However, in any given year only $\$(r_f - 2\%) \times N$ effectively change hands (whoever loses money pay the other). Hence, even though the risk basis (the notional amount) is large, the actual capital flowing might be much smaller.

That said, even if we think that the "effective size" of the market is only 1% its notional amount, we still get that derivatives markets are very large

For each of these contracts, answer if it can be considered a derivative contract (Yes) or not (No):

- A contract in which I agree to pay you 1 Million dollars if Hillary Clinton wins the election and you pay me 1 Million dollars if Donald Trump wins
- A contract in which I agree to pay you $1,000 times the average temperature in the next summer (in Ohio)
- A contract in which you given me 1 Million dollars today and I agree to pay you 1.1 Million dollars in one year

a) (i) Yes; (ii) Yes; (iii) Yes

b) (i) No; (ii) No; (iii) No

c) (i) Yes; (ii) No; (iii) No

d) (i) Yes; (ii) Yes; (iii) No

e) (i) No; (ii) No; (iii) Yes

This Section: Forward and Future Contracts

- What are future contracts?
- What are forward contracts?
- What are the similarities and differences between them?
- How can forward and future contracts be used to hedge?
- How can forward and future contracts be used to speculate?
- How to value forward and future contracts?

Walmart Example: The Problem

- Walmart has a large subsidiary in Brazil.
- Part of the profits are reinvested in Brazil, but part of it comes to the parent in the United States.
- Since its profits in Brazil are in BRL, they need to be converted to USD before the parent company can use it.
- As such, the exchange rate is an important risk factor for Walmart. They can use currency futures to hedge against it.
- Suppose Walmart predicts that about 1 Billion BRL of its 2017 profits (available in December of 2017) will be used in the parent company
- Today, the exchange rate is 0.32 USD per BRL and, thus, the 1 Billion BRL translates to 0.32 Billion USD. However, its USD value in December of 2017 is uncertain.

Walmart Example: The Risk*

Explaining the Previous Slide

USD is American dollar and BRL is the Brazilian Real. The graph displays the variation in the exchange rate (how many USD you can buy with 1 BRL). The key point is that it varies substantially over time. For instance, it moved from around 0.37 in December 2014 to around 0.25 in December 2015. That is a 32% decrease!

There is something confusing about how the market labels exchange rates (do not blame me, blame the market). Since the quotes displayed represent how many USD you can buy with 1 BRL, it can be represented (mathematically) as $\frac{\text{USD}}{\text{BRL}}$. However, the market calls it "BRL/USD" (as you can see in the graph). To simplify your life, you should read "BRL/USD = 0.32" as "one BRL buys 0.32 USD".

I will always try to be explicit when talking about exchange rates (so...do not worry about memorizing what means what). However, keep this in mind if you ever trade currency.

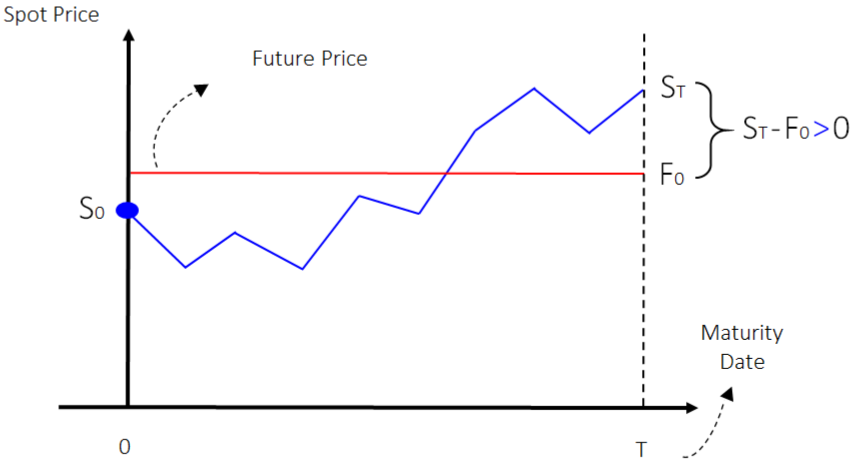
Walmart Example: The Hedge

- The exchange rate can move a lot over the period of 1 year
- A decrease of 0.1 in the exchange rate is equivalent to 100 Million USD less in profits for the parent company to keep
- Walmart can enter an agreement to exchange BRL for USD in December of 2017 at a prespecified exchange rate.
- Such agreement is called a foreign currency future and Walmart would take a long position on it (i.e., it would agree today to buy USD in December of 2017)
- The December 2017 futures contract is at 0.29 (as of today) $\Longrightarrow$ 0.29 Billion USD guaranteed for the parent company in December 2017 (the cash flow is "hedged")
- The current exchange rate was $0.32 > 0.29$. Why?
  We need to understand "future contracts" to answer this

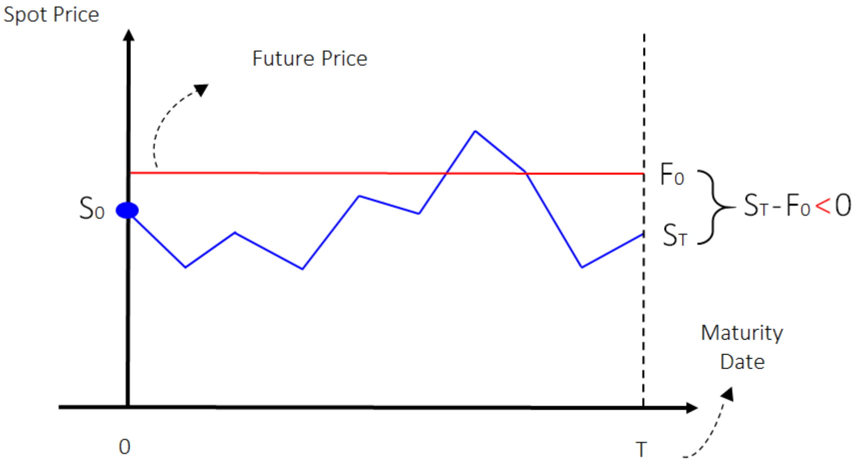
Future Contracts: Categories

- There are four broad categories of "underlying asset/security":
  - Agricultural commodities (e.g., wheat)
  - Metals and Minerals (e.g., gold)
  - Foreign Currencies (e.g., $\frac{\text{USD}}{\text{BRL}}$)
  - Financials (ex: fixed income securities and stock indexes)
- Other smaller categories exist (elections, weather, ...)
- Futures are exchange traded and, thus, the contracts are very standardized and specify all necessary details regarding the underlying asset being delivered
- Being exchange traded also means that there is no counterparty risk (you always trade with a clearing house)

Future Contracts: Long Position*



Future Contracts: Long Position*



Explaining the Previous Slide

The future price, F_0, is decided (set by financial markets) today. It is just a quote based on what market participants are willing to offer/demand. If current price is S_0 and you enter a long position on the future at price F_0, you are agreeing to pay F_0 at time T to receive an asset worth S_T.

- If prices move in your favor such that $F_0 < S_T$, you will pay F_0 to get an asset that can be sold by more than that (your profit is $S_T - F_0$).
- If prices move against you such that $F_0 > S_T$, you will pay F_0 to get an asset that can be sold by less than that (your loss is $S_T - F_0$).

When you make a profit, someone makes a loss (the payoff for the short side is $F_0 - S_T$). There is always someone on the other side of the trade. It can be the case that you are both hedging your own risks (think of the Walmart example and consider a situation in which Walmart is trading with a company that wants to bring money from the US to Brazil).

However, it can also be the case that one of you is speculating (taking risk). For instance, if you buy a future contract on an underlying to which you have no exposure to, then you must be betting that the spot price in the future, S_T, will be higher than the current future price today, F_0.

Future Contracts: Closing Positions

- Future contracts specify an underlying asset to be delivered at maturity (e.g., corn)
- Most trades do not lead to physical delivery. How come?
- Recall that the payoff of a long position is $S_T - F_0$ while the payoff of a short position is $F_0 - S_T$.
- If you enter a long position at time 0 and a short position at time t, then your payoff at time T will be:

$$\begin{aligned} Payoff &= (S_T - F_0) + (F_t - S_T) \\ &= F_t - F_0 \end{aligned}$$

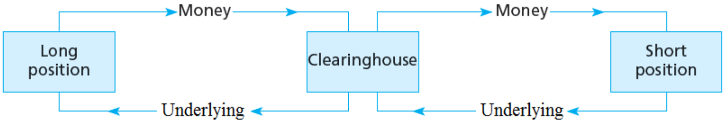
- At time t, F_t is known and you are effectively closing your position (you know what your payoff will be at time T)
- If you close your position, the clearing house will not require you to deliver the underlying asset (net contracts out)

Future Contracts: Marking to Market

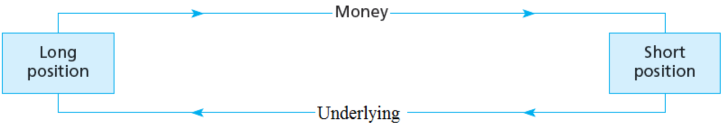
- Recall that there is a clearing house to make sure there are no defaults (no counterparty risk). How come?
- Even though it costs 0 to enter a future contract, your broker will require a margin account. You will need to post (let's say) 10% of F_0 when you enter the contract
- Margin can be invested in liquid assets (no opportunity cost)
- As time passes, your position has gains/losses
- At time t, your total gains/losses are $F_t - F_0$ (recall that this is how much you get if you close a long position)
- Your gains/losses are accrued to your margin account on a daily basis and this process is called Marking to Market
- If your margin account fall below the "maintenance margin", you will receive a margin call (your broker will require more money) and this assures no defaults ever happen

Differences Between Forward & Future Contracts*

Future Contracts: Exchange Traded



Forward Contracts: Traded OTC



Explaining the Previous Slide

A forward contract is effectively a future contract that is traded over-the-counter (OTC). This fact turns out to have important implications:

- While future contracts are restricted to the underlying assets that are specified in exchanges, you can build any forward contract you would like (you just need to find a dealer willing to take the other side of the trade)
- Future contracts are very standardized, which induces the existence of a large secondary market. As a consequence, you can close your position at any time at a relatively low cost (future contracts are liquid). In contrast, forward contracts are very different one from another and this prevents secondary markets to form. You can find dealers to close your position, but the costs will be much higher (forward contracts are illiquid)
- Trading OTC means that you trade directly with a dealer. There is no margin account and, thus, there is no marking to market (losses/gains are realized at the maturity of the contract)
- Since losses/gains are only realized at maturity, there is counterparty risk (your counterparty might not be able to pay you at the maturity of the contract). Hence, the value of a forward contract depends on the counterparty you have. This was quite important in the Financial Crisis (for several derivatives traded OTC). Many traders did not want to have Lehman as a counterparty since they perceived (correctly) counterparty risk to be too high there.

Valuation: No Arbitrage Pricing

Strategy	Initial Cost of Position	Cash Flow at time T
Buy Underlying Asset	S_0	S_T
Enter Long Position	0	$S_T - F_0$
Invest $F_0/(1+r_f)^T$ in TBills	$F_0/(1+r_f)^T$	F_0
Position 1 + Position 2 =	$F_0/(1+r_f)^T$	S_T

- Since the two strategies have the same cash flow at time T, they must have the same price (initial cost of position):

$$F_0 = S_0 \cdot (1 + r_f)^T$$

- If this did not hold, one of the two strategies would be "cheap" and we would able to profit from it (there would be an arbitrage opportunity).

Valuation: No Arbitrage Pricing

$$F_0 = S_0 \cdot (1 + r_f)^T$$

- The derivation in the previous slide assumes that:
  - the underlying asset has no cash flows between 0 and T
  - The term structure is flat (so that the risk-free rate, r_f, is the yield for all maturities)
- Relaxing these assumptions, we can use an approach similar to the previous slide to find:

$$F_0 = (S_0 - PV_{CF}) \cdot (1 + y)^T$$

- PV_{CF} is the present value of all cash flows associated with the underlying asset between 0 and T
- y represents the bond yield for the respective maturity

Suppose you form a portfolio with the following positions:

- A short position on 1 share of Microsoft (currently valued at $60)
- A future contract to buy 1 share of Microsoft one year from now at price $70
- A position in 1 year zero-coupon treasuries with face value $70

If you do not change your positions, what is the value of your total portfolio one year from now?

a) You cannot determine (today) the value your portfolio will have one year from now since it will depend on future prices

b) Your portfolio will be worth zero

c) Your portfolio will be worth $60

d) Your portfolio will be worth $70

e) Your portfolio will be worth $70 minus whatever Microsoft stock price is at that point

This Section: Swap Contracts

- What are Swap contracts?
  - Agreements to swap one cash flow for another at multiple dates
  - They are effectively multiperiod extensions of forward contracts
- Why are they useful?
  - They can be used for risk management purpose. They allow firms (financial and non-financial) to effectively hedge recurrent risks
- Why they can induce Systemic Risk?
  - OTC trading induces different firms to be exposed to the same counterparty risks
- How can they be priced?
  - Using the "No Arbitrage Principle"

Hedge Fund vs Verizon Example: The "Plain Vanilla" Swap

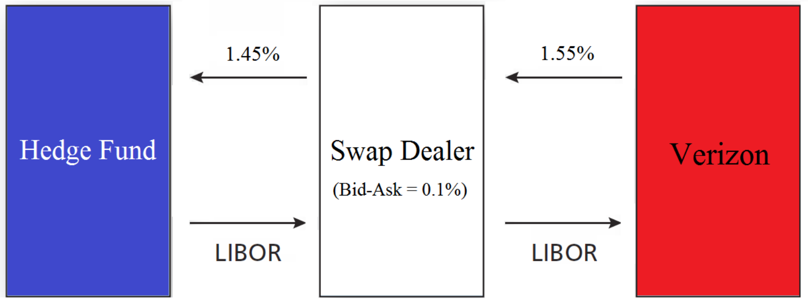
- The Interest rate (LIBOR rate) is currently at 1.5% and a Hedge Fund thinks it will decrease over the next 5 years.
- Verizon has a 5 years debt contract (notional of $100 Million) in which it pays annual interest of 4% + LIBOR.
- While the Hedge Fund wants to bet on the LIBOR rate decrease, Verizon wants to get rid of its floating interest rate
- They can enter a $100 Million contract (called an "Interest Rate Swap") in which, over the next 5 years, Verizon pays (annually) a fixed rate of 1.5% and the Hedge Fund pays (annually) whatever the LIBOR rate is at that point in time.
- The Hedge Fund makes money if the LIBOR rate decreases and Verizon transformed the interest rate of its debt contract into a fixed rate: $4\% + 1.5\% = 5.5\%$. Both are happy!

Hedge Fund vs Verizon Example: Notional = $100 Million

Year	LIBOR	Hedge Fund Obligation	Verizon Obligation	Net Cash Flow Paid
0	1.5%	$0	$0	$0
1	1.8%	$1.8 Million	$1.5 Million	$0.3 Million
2	1.6%	$1.6 Million	$1.5 Million	$0.1 Million
3	1.5%	$1.5 Million	$1.5 Million	$0.0 Million
4	1.3%	$1.3 Million	$1.5 Million	$0.2 Million
5	1.4%	$1.4 Million	$1.5 Million	$0.1 Million

- The fixed rate on the Swap contract is set at the beginning (in such a way that both parties agree that no money exchange is needed at that point). It does not need to be 1.5% (as we will see later).
- At each year, only the net cash flow is exchanged. For instance, in Year 4, only Verizon pays $0.2 Million (decreases counterparty risk)
- For Verizon, the losses/gains are offset by its debt payments (not shown in the table). As such, it is hedged

The OTC Trading Mechanism and Systemic Risk*



Explaining the Previous Slide

Swaps are among the most heavily traded derivatives. However, they are traded Over the Counter (OTC) in dealer markets. This means that (i) the market has almost no retail trader (financial companies dominate) and (ii) the contracts are not fully standardized (they are actually very flexible)

When a Hedge Fund wants to enter a Swap contract to speculate on some specific view, it does not go around looking for someone who wants the other side of the trade. It goes directly to a Swap Dealer (typically an Investment Bank like J.P. Morgan). This Swap Dealer takes the trade. At the same time, other companies (like Verizon), might want to take the opposite position and they also go to the same Swap Dealer. Both the Hedge Fund and Verizon have contracts with the Dealer (not with each other – they do not even need to know each other).

The Dealer (most often) has no intention to take any side of the trade. It is there because it prices the contract differently for the two parties in order to capture a bid-ask spread. In our example, the bid-ask spread is 0.1% per year and works through the fixed interest rate charged. However, different Swaps will have different bid-ask spreads and it happens through different mechanisms.

It is important to realize that both Verizon and the Hedge Fund are subject to counterparty risk (not relative to each other, but relative to the dealer). I have mentioned “Systemic Risk" multiple times. This is precisely one way in which it happens. Since all companies are subject to the financial condition of a few dealers, if the dealers face risk of failing, all companies are affected and this can create a “domino effect".

This can be exacerbated if the dealers start taking only one side of the trade. Before the financial crisis, many dealers (including Lehman) were providing insurance through Credit Default Swaps (CDS) for Mortgage Backed Securities (MBS). Since most investors wanted the insurance, but few investors were providing insurance, the dealers start having large positions that were not offset by the “other side of the trade”. As a result, they were highly exposed to risks in the Real Estate market. When the shock hit the Real Estate market, the Dealers start having trouble and Systemic Risk became an important concern (the risk spread through the Balance Sheet of Dealer Banks). Eventually, even companies like General Motors had trouble (the financial system end up affecting the real economy since companies depend on the Supply of Capital side of the economy).

Valuation: No Arbitrage Pricing

- We can use the Fundamental Valuation Equation to price Swaps. However, it becomes complicated. Instead, we approach it the same way we do it with Futures/Forwards (No Arbitrage Pricing Principle).
- One way is to view a Swap as a basked of Forward contracts and price it based on the Forward pricing.
- Another way is to think directly about the underlying assets of the Swap contract and price it accordingly. We will focus on this approach since is the simplest (obviously, all three approaches lead to the same final pricing equation).
- In our simple example, the underlying assets are a Floating Rate Bond and a Fixed Rate Bond. Let's take the Hedge Fund perspective (the company paying the floating rate). Since it is a zero sum game, the other is negative of that.

Valuation: No Arbitrage Pricing*

- If the Hedge Fund receives the fixed rate and pays the floating rate, it effectively has a long position on the fixed rate bond and a short position on the floating rate bond:

$$P_{swap} = P_{fix} - P_{float}$$

- If we can value the bonds, we can value the Swap.

- The floating rate bond trades at face value on coupon days. This is because its "coupon rate" is basically being adjusted to match the yield to maturity every time it pays coupon. Hence, it trades at par: $P_{float} = \text{Notional Value} = \text{N}$

- The fixed rate bond is a regular bond and, thus:

$$P_{swap} = \underbrace{\left[\frac{\text{N}}{(1+y)^H} + \sum_{h=1}^{H} \frac{(\text{fixed rate}) \cdot \text{N}}{(1+y)^h}\right]}_{P_{fix}} - \underbrace{\text{N}}_{P_{float}}$$

Explaining the Previous Slide

The value of the Swap is the value of a portfolio composed by a long position on the fixed rate bond and a short position on the floating rate bond: $P_{swap} = P_{fix} - P_{float}$.

The floating rate bond trades at par when coupons are being paid. Intuitively, this happens because you can always pay face value to invest in a short-term instrument paying whatever the current interest rate is. Since that is exactly what the floating rate bond offers, it needs to trade at face value and we have: $P_{float} = \mathrm{N}$ (the notional value, N, is the total size of the Swap position and represents the Face Value of both Bonds). Outside coupon dates, there is an adjustment for accrued interest, but we will ignore it here since it is relatively small and does not change the logic of anything we discuss.

The fixed rate bond is the same type of bonds we studied in Module 5 (we know how to price them). Its coupon rate is the fixed rate in the Swap contract and its face value is the notional amount in the Swap contract.

The final formula in the previous slide is simply $P_{swap} = P_{fix} - P_{float}$ after accounting for what we know about fixed rate and floating rate bonds.

Valuation: No Arbitrage Pricing*

$$P_{swap} = \underbrace{\left[\frac{\mathrm{N}}{(1+y)^H} + \sum_{h=1}^{H} \frac{(\text{fixed rate}) \cdot \mathrm{N}}{(1+y)^h} \right]}_{P_{fix}} - \underbrace{\mathrm{N}}_{P_{float}}$$

- At date 0 (when the contract is issued), the fixed rate is set such that $P_{swap} = 0$. This can only happen when fixed rate equals the yield to maturity at that point, y_0 (so that the fixed rate bond is also at par). Thus: $\text{fixed rate} = y_0$
- As a result:
  - $y > y_0 \implies P_{fix} < P_{float} \implies P_{swap} < 0$
  - $y < y_0 \implies P_{fix} > P_{float} \implies P_{swap} > 0$
- The Hedge Fund position is similar to a long position on the Bond issued at par in the sense that he makes money if yields decrease. However, the Swap allows for implicit leverage.

Explaining the Previous Slide

At time 0 (when the contract is issued), the value of the Swap is zero. This required $P_{fix} = \mathrm{N}$. Since fixed rate bonds trade at par only when the coupon rate is equal to the yield to maturity, this implies that the fixed rate of the Swap contract is simply the yield to maturity of the day in which the contract was issued ($\text{fixed rate} = y_0$).

Since $P_{swap} = P_{fix} - P_{float} = P_{fix} - \mathrm{N}$, the contract value starts at zero and moves around based only on the value of the fixed rate bond, P_{fix}. This is because the notional amount, N, does not vary. Hence, the risks embedded into the Swap contract are similar to the risks embedded into a regular bond (Duration and Default risk). However, the default or counterparty risk is not as large as it is for a regular bond. The reason is that if the other party defaults you also do not pay them back.

$P_{swap} = P_{fix} - \mathrm{N}$ implies that the value of the Hedge Fund position increases when the (fixed rate) Bond value increases. Hence, the Swap price is inversely related to yields (just like Bond prices). These "Plain Vanilla" interest rate Swaps provide an efficient way to get exposure to interest rates since they require no initial capital investment (you can take implicit leverage by taking a position larger than your total capital). This is why they represent a substantial portion of the derivatives market.

There are many other Swap contracts (such as Currency Swaps, Commodity Swaps, Total Return Swaps and Credit Default Swaps). Unfortunately, we do not have time to cover the details of all of these. However, the logic underlying the valuation all of them is the same logic underlying the "Plain Vanilla" Interest Rate Swap we studied here.

Suppose at time $t = 0$ you entered a "plain vanilla" interest rate swap with notional value of \$100 Million. You agreed to pay a fixed rate of 4% and your counterparty agreed to pay you the LIBOR rate (once per year over the next 5 years). Which of the following is false regarding this situation?

a) If counterparty risk is zero, the 5-year yield to maturity of zero-coupon treasuries was 4% at $t = 0$

b) If interest rates go down, your position in this Swap contract will become less valuable

c) You are exposed to counterparty risk. The risk is higher than if you had bought (with the same counterparty) a 5-year floating rate bond paying LIBOR once per year

d) If the LIBOR rate is 3.5% in a given year, you will pay 0.5% of the notional value to your counterparty, but your counterparty will pay nothing to you

e) Your counterparty is most likely a Swap dealer since Swaps are traded over the counter (OTC)

This Section: Options

- What are option contracts?
- What is the payoff of different option positions?
- How can they be used for speculation?
- How can they be used for risk management?
- Unfortunately, option pricing requires much more time to be properly taught and, thus, we will not cover it in this class. However, its pricing is also based on the "no arbitrage principle" we learned in the previous sections

Example: Pension Fund Manager

- Suppose you are a pension fund manager holding a position on an equity index
- Your position is currently at $100 Million, but you are afraid equity markets will be too volatile over the next month (there will be a big macroeconomic announcement)
- One strategy is to leave the equity markets for the next month. However, this is costly and you lose any upside if the macroeconomic news turn out to be good
- Instead, you enter a contract with Citigroup in which you pay $1.5 Million today and they cover any equity loss in excess of 5% you have over the next month (i.e., you long a put option)
- Now, you are fine staying in the equity market since you know that your equity loss is limited to $5 Million (plus the $1.5 Million paid as a premium).

Basics: What is an Option Contract?

- An option is a right to buy or sell an asset (called the underlying asset) at a given price (called the strike price) on or before a given time (called the expiration date).
- Option holders (or buyers) have a right (but not an obligation)
- Option writers (or sellers) have an obligation
- The payoff to option holders is never negative and, thus, they have to pay a premium for it.
- The payoff to option writer is never positive and, thus, they collect a premium upfront.
- It is not free to initiate a long position in options (unlike forward, futures and swaps).
- Most options are exchange traded (CBOE is the largest exchange), but there are some exotic options in OTC markets.

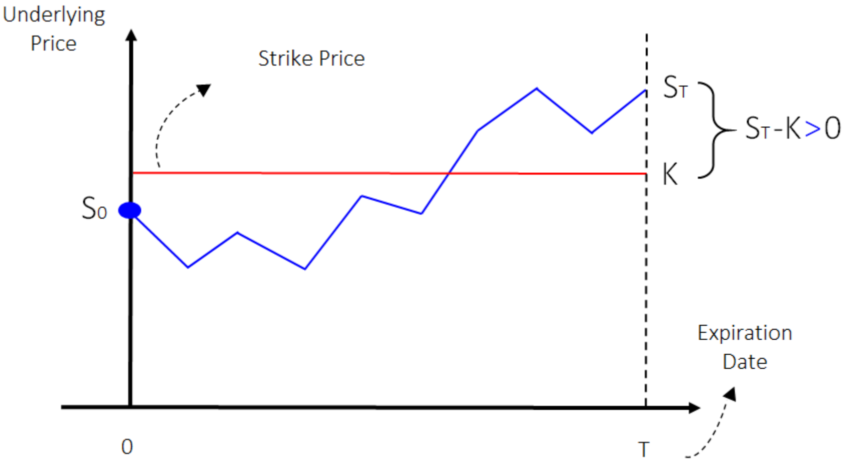
Basics: Types of Options

- A call is an option to buy the underlying asset
- A put is an option to sell the underlying asset
- An European option can be exercised only at its expiration or maturity date (this does not mean it is traded in Europe)
- An American option can be exercised at or before maturity (it does not mean it is traded in America)
- Most traded options in the US are American-style, but there are exceptions (such as stock-index options)
- Many possible underlying assets available, but most common are Stocks, Foreign Currency, Stock Indices and Future Contracts

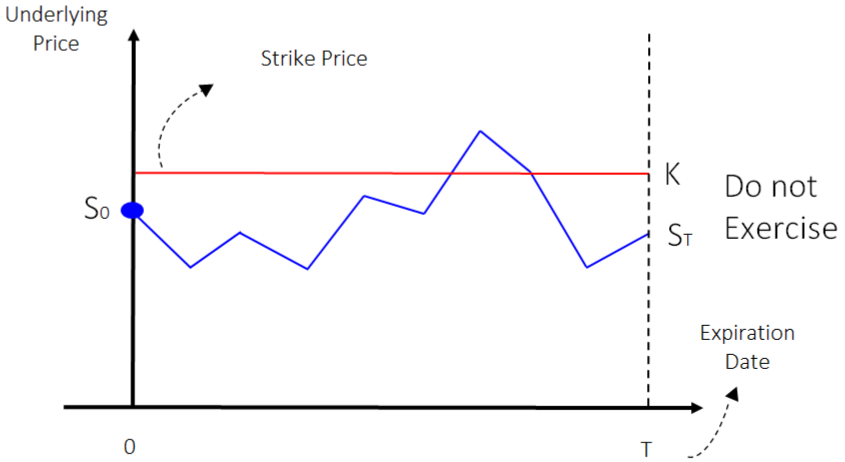
Basics: Positions

- There are 4 positions you can have when trading options:
    - Long call: you pay a premium and hold an option to buy the underlying at a later date
    - Short call: you write a call for a premium and assume the obligation to sell the underlying at a later date
    - Long put: you pay a premium and hold an option to sell the underlying at a later date
    - Short put: you write a put for a premium and assume the obligation to buy the underlying at a later date
- Derivatives are zero sum games (like a bet): the profit of the long position is the loss of the short position and vice versa

Call Options: Logic*



Call Options: Logic*



Explaining the Previous Slide

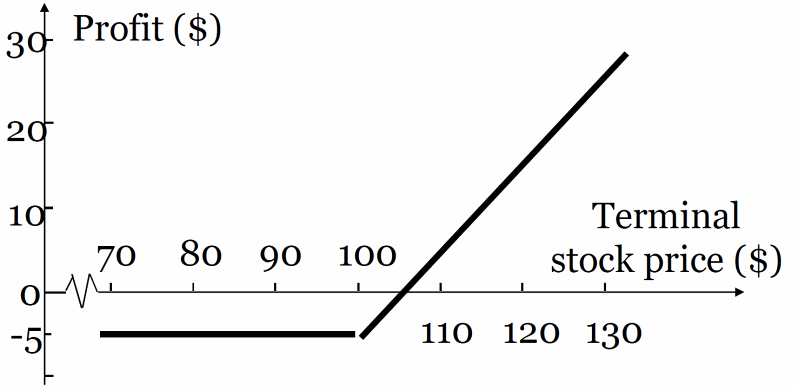
If you buy a T =1 month call option on Motorola stock (the underlying) with strike price $K = \$80$, you have the right to buy Motorola stock for \$80 over the next month. If the option is American you can buy anytime within the next month and if the option is European you can only buy at maturity.

If in one month Motorola stock is worth $S_T = \$85$, you can buy it at $K = \$80$ and sell it at $S_T = \$85$ (you make \$5). If this happens, the call writer will need to provide you with a Motorola stock for $K = \$80$ and, thus, he/she loses \$5 (he/she received the premium in the beginning of the contract to provide you with this option).

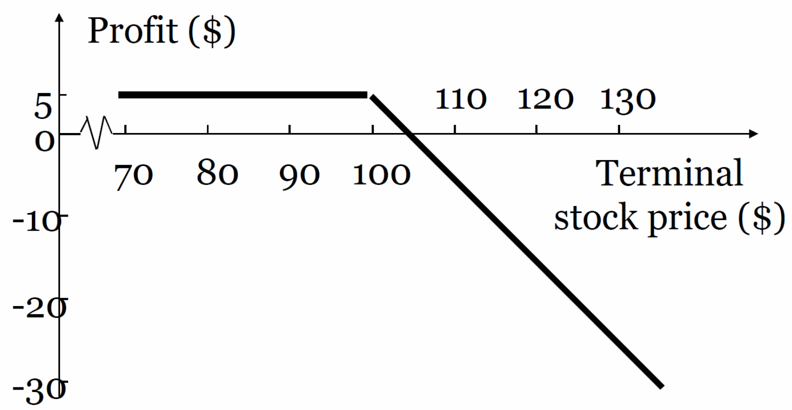
If instead Motorola stock is worth $S_T = \$75$ in a month, you would not exercise your option to buy it at $K = \$80$ (it is cheaper in the market) and, thus, you and the call writer would both have a payoff of zero (but you paid for the option while he/she received the premium in the beginning).

Note that this means that you never spend more than the original premium you paid in the beginning of the contract if you have a long call position. If you have a short position, you always receive the premium in the beginning, but your loss is theoretically unlimited (since there is no upper limit on the stock price). The exchange is associated with the "Options Clearing Corporation", which assures the call writer will not default. As such, it requires a margin account for the writer of the option.

Call Options: Long Call Profit/Loss*



Call Options: Short Call Profit/Loss*



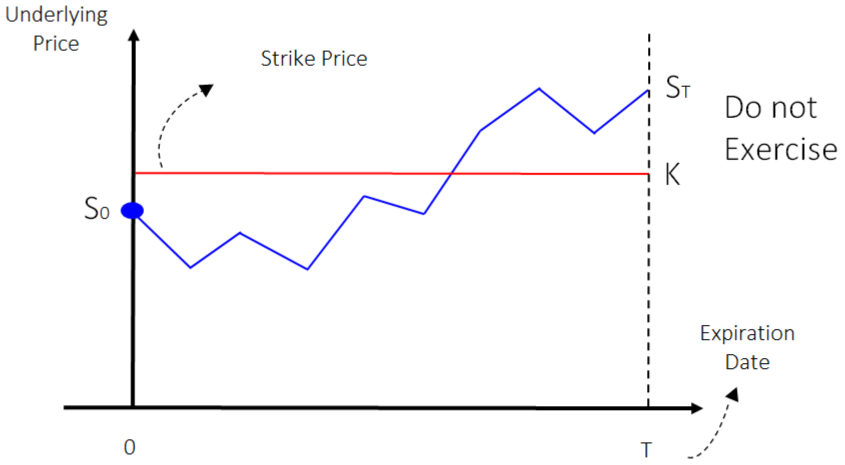
Explaining the Previous two Slides

The long call and the short call are symmetric positions (the first is buying the call and the second is selling it).

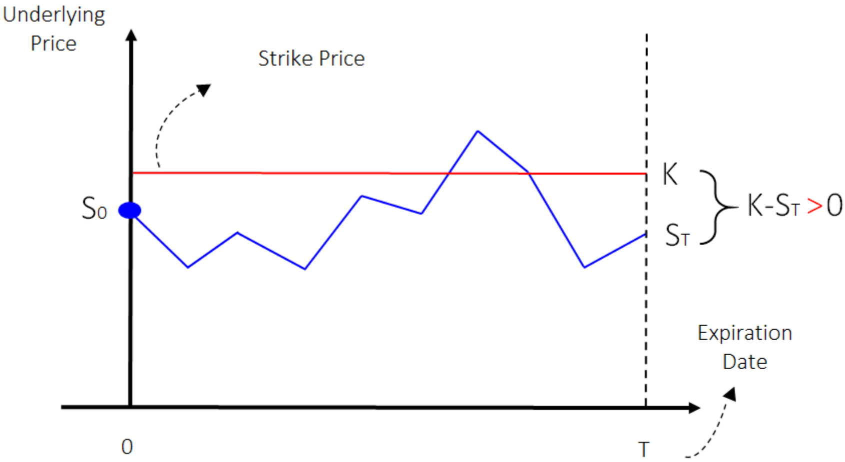
In the first graph, we have an example of a call holder who paid \$5 for the call with strike price \$100. The graph represents his potential profit for different possible values of the underlying at maturity (S_T). If the underlying is worth below the $K = \$100$, then he will not exercise the option to buy and will receive a payoff of zero at the end. Since he paid the \$5 premium, he has a loss of \$5. On the other hand, if the underlying is worth \$110, for example, he will get a payoff of \$10 (\$110 - \$100) and a profit of \$5 (\$10 - \$5). In general, $\text{payoff} = \max(0, S_T - K)$ and $\text{profit/loss} = \max(0, S_T - K) - \text{premium}$.

In the second graph, we have the writer of the same call option. His payoff and profit are the negative of the payoff and profit of the holder. If the underlying is worth below the $K = \$100$, then the holder will not exercise the option and the writer will have a zero payoff at the end. Since he received the \$5 premium, he has a profit of \$5. On the other hand, if the underlying is worth \$110, for example, the holder will exercise the option to buy and the writer will get a payoff of -\$10 (\$100 - \$110) and a loss of \$5 (\$5 - \$10). In general, $\text{payoff} = -\max(0, S_T - K)$ and $\text{profit/loss} = \text{premium} - \max(0, S_T - K)$.

Put Options: Logic*



Put Options: Logic*



Explaining the Previous Slide

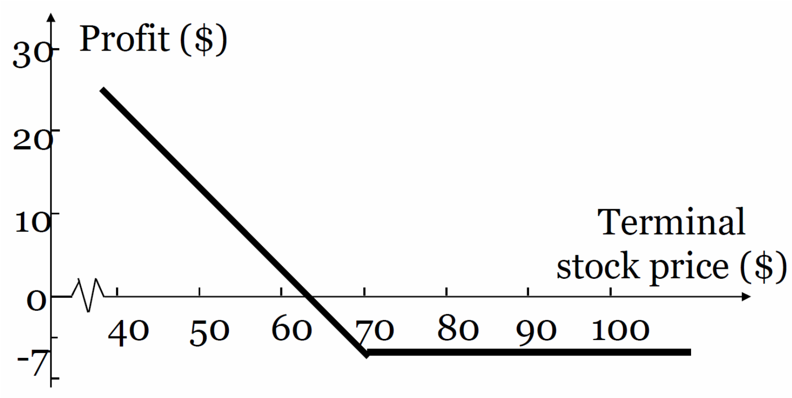
If you buy a T =1 month put option on Motorola stock (the underlying) with strike price $K = \$80$, you have the right to sell Motorola stock for \$80 over the next month. If the option is American you can sell anytime within the next month and if the option is European you can only sell at maturity.

If in one month Motorola stock is worth $S_T = \$75$, you can buy it at $S_T = \$75$ and sell it at $K = \$80$ (you make \$5). If this happens, the put writer will need to buy a Motorola stock for $K = \$80$ and, thus, he/she loses \$5 (he/she received the premium in the beginning of the contract to provide you with this option).

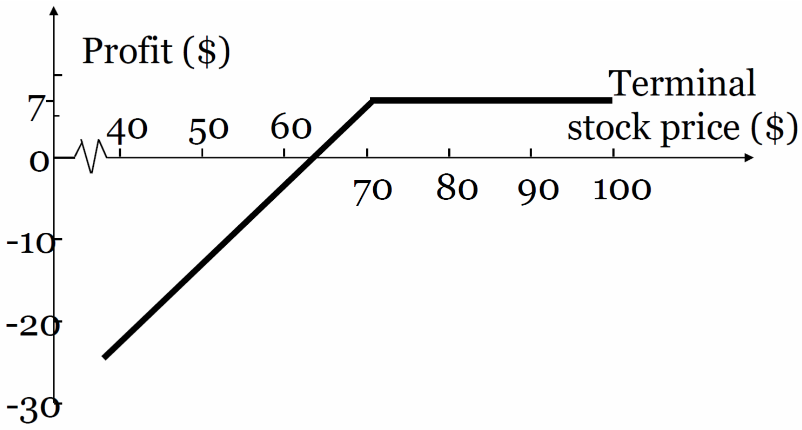
If instead Motorola stock is worth $S_T = \$85$ in a month, you would not exercise your option to sell it at $K = \$80$ (you can sell for more in the market) and, thus, you and the call writer would both have a payoff of zero (but you paid for the option while he/she received the premium in the beginning).

Note that this means that you never spend more than the original premium you paid in the beginning of the contract if you have a long put position. If you have a short position, you always receive the premium in the beginning, but your loss can be up to K (since the stock price can theoretically go to zero). The exchange is associated with the "Options Clearing Corporation", which assures the put writer will not default. As such, it requires a margin account for the writer of the option.

Put Options: Long Put Profit/Loss*



Put Options: Short Put Profit/Loss*



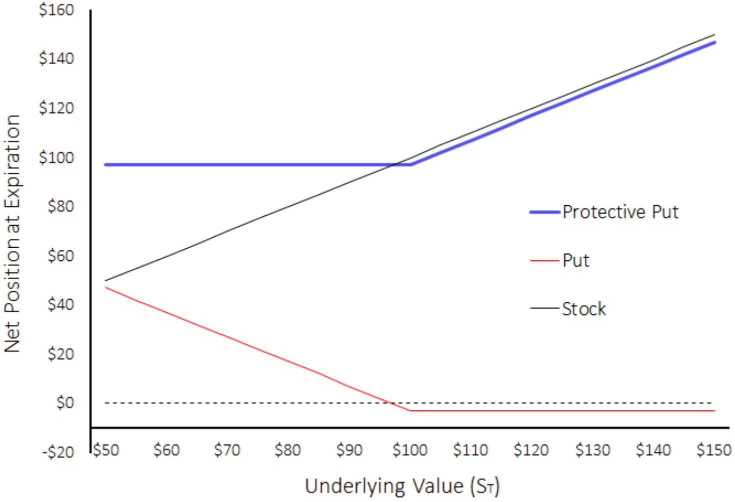
Explaining the Previous two Slides

The long put and the short put are symmetric positions (the first is buying the put and the second is selling it).

In the first graph, we have an example of a put holder who paid \$7 for the put with strike price \$70. The graph represents his potential profit for different possible values of the underlying at maturity (S_T). If the underlying is worth above the $K =$ \$70, then he will not exercise the option to sell and will receive a payoff of zero at the end. Since he paid the \$7 premium, he has a loss of \$7. On the other hand, if the underlying is worth \$60, for example, he will get a payoff of \$10 (\$70 - \$60) and a profit of \$3 (\$10 - \$7). In general, $\text{payoff} = \max(0, K - S_T)$ and $\text{profit/loss} = \max(0, K - S_T) - \text{premium}$.

In the second graph, we have the writer of the same put option. His payoff and profit are the negative of the payoff and profit of the holder. If the underlying is worth above the $K =$ \$70, then the holder will not exercise the option and the writer will have a zero payoff at the end. Since he received the \$7 premium, he has a profit of \$7. On the other hand, if the underlying is worth \$60, for example, the holder will exercise the option to sell and the writer will get a payoff of -\$10 (\$60 - \$70) and a loss of \$3 (\$7 - \$10). In general, $\text{payoff} = -\max(0, K - S_T)$ and $\text{profit/loss} = \text{premium} - \max(0, K - S_T)$.

Put Options: The Protective Put*



Explaining the Previous Slide

One of the key uses of options is to insure against adverse movements in the market. We saw this in the Pension Fund manager example in which he took a long position on put options to insure his equity portfolio against decreases of more than 5%. His position turn out to be so common (and important) that it has its own name: "a protective put". This type of position is illustrated in the previous graph.

The graph shows a stock position that has current value of \$100 and a put option with strike price $K = \$100$ (it costs \$3). When combined, these positions generates a “protective put”. This is a position with the upside potential of stocks, but that has limited downside potential.

The worst scenario is the one in which the stock decrease in value. Under this scenario, the protective put will assure the final position does not decrease in value, but the investor will still pay the \$3 and, thus, he lost 3% of his initial position (\$3/\$100) .

The negative effect of the premium can be seen in the graph since the payoff of the protective put is shifted relative to the stock position alone.

Creating Option Strategies

- Several put and call options trade at the same time (they have different maturities & strike prices).
- Traders refer to them based on their "Moneyness":
  - Some of the options would be profitable if exercised today (they are "in the money")
  - Other options would generate a loss if exercised (they are "out of the money").
  - Finally, some options have price equals to stock price and, thus, would result in a zero payoff if exercised today (they are "at the money")
- Combining different options can create alternative payoff structures that provide specific bets. These are very useful for speculation. Let's see some examples in excel.

Which of the following is true regarding option contracts?

a) The payoff of writing a call is the same as the one from buying a put

b) If you buy a call option and the price of the underlying end up below the strike price, then you have to pay the difference at the end of the contract

c) A “at the money" call should be more valuable than a “in the money" call (with all other characteristics identical)

d) If you buy a protective put you are basically paying an insurance premium to limit potential downside losses of your position on the respective underlying asset

e) Options can be used for insurance purpose, but it is hard to speculate using them

References