Leverage and nonlinearity
Derivatives: A **derivative** is a security whose value depends on the value of another security

1. Derivatives as a Whole

Up until now, all the securities we've seen are known as **spot securities**. We turn now to a new type of security, which is called a derivative. A **derivative** is a security whose value depends on the value of another security. It's a derivative because its value is *derived* from the prices of another security. If we know the value of the underlying security, then through the mathematics of stochastic processes and the art of securities hedging and replication, we are likely going to know the price of the derivative. More precisely, a derivative is a security whose value depends on another security or even another measurable quantity. The value of a derivative is known precisely at a given point in time, either at the creation of the derivative or at its expiration.

There are essentially four types of derivatives:

- Futures
- Forwards
- Swaps
- Options

We will save swaps for another course. In this module, we will introduce futures, forwards, and options.

Before we jump into derivatives, note that all derivatives have an expiration date. This is different from fixed income products like bonds, which have a maturity date, and from equities or ETFs, which have no end date; equities do not have a date where they pay back any principal. However, all derivatives have an expiration date after which the derivative expires, and either it 1.) is converted to a security or cash flow equivalent, or 2.) expires worthless! In the next section, we'll begin our look at derivatives with futures. Be sure to read Chapter 12 of Saylor.

Futures contracts deal with a variety of underlying assets: gold, tin, copper, sugar, pork belly, live cattle, stock indices, currencies, Treasury bonds, interest rates, and more.

Futures contracts are standardized in the sense that the exchange must specify the elements that characterize the exact nature of the agreement between the two parties involved. These normally consists of the following:

- Characteristic of the assets. For some commodities, there may exist several grades of the same product, and the exchange decides which grades of the commodity can be accepted. For other underlying assets like financial contracts, things are definitely less ambiguous.
- Contract size. In this case the exchange specifies the amount of assets that must be delivered to fulfill a contract. This is actually a very important decision because if the minimum size is too large for many investors, then it would be too expensive for them. On the other hand, if the contract's size is too small, investors may be forced to transact on many contracts with higher associated costs.
- Delivery arrangements. The contract usually indicates where delivery will be made. You can imagine that this is very important for commodities that are perishable and also when considering transportation costs.
- Delivery months. The exchange usually specifies the months and the exact period during the month when delivery can be made, which can vary among contracts.
- Price quotes. The exchange decides how prices will be quoted. In addition, for many contracts, the exchange could also indicate daily price movement limits. Price limits are set to prevent large price movements, particularly in the case of speculative investments.

From the description we offered, the student should have recognized that a futures contract is a derivative because it has an underlying asset.

When we buy a stock, the position is settled within a given period. This period, as of May 28, 2024, in the U.S., is $T+1$, i.e., the settlement happens one business day after the day on which the trade took place. However, we might buy a future today, but the settlement/delivery could be in 3 months, 6 months, or even further into the future.

We must stress that a futures contract **obligates** the buyer of the future to proceed with the purchase, and it **obligates** the seller of the future to proceed with the sale. This derivative is a legally binding agreement between both parties. Each side agrees to honor the terms, even though the prices may move in such a way that the terms become very unfavorable to one party.

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Initial margin and margin call:

> **Example**. *It is now June 30, 20XX. Suppose trader A wants to buy three December gold futures contracts. The current price of gold is $2,370 per ounce. The future establishes a size of 100 ounces. Then, trader A has committed to buy a total of 300 ounces of gold at a price of $2,370 per ounce. This transaction takes place via a broker. The value of the transaction is $711,000. The broker will ask trader A to deposit a certain amount of money in a margin account, and this amount must be deposited at the time the contract is entered, i.e., June 30, 20XX. This margin is known as the initial margin. We assume that the margin required is $300,000. From this moment on, the margin account is adjusted each day to reflect trader A's gains or losses (daily settlement). On July 1, 20XX, the futures price has dropped from $2,370 per ounce to $2,350 per ounce. Trader A has lost $300 X 20 = $6000 (note that the 300 ounces that he contracted to buy for $2370 per ounce can now be sold for $2,350 per once). The balance in the margin account goes from $300,000 to $294,000. If on July 2, 20XX, the price of gold goes up to $2,380 per ounce, the balance in the margin account increases by* $300 \times 30 =$ *9,000 and becomes $303,000. Trader A is entitled to withdraw any balance in excess of the initial margin. Also, there is a maintenance margin. If the balance in the margin account falls below the maintenance margin, trader A receives a call asking him to deposit additional funds (usually by the end of the next day) to re-establish the initial margin account. These additional margins are called variation margins. If trader A fails to do so, the broker will close out trader A's position.*
>
> Why does the exchange require this margin? The reason is an old friend we've discussed: credit risk. Without the margin, a buyer could theoretically show up on the delivery date with insufficient funds to proceed with the trade. Consistent margin calls by the exchange ensure this doesn't happen. In doing so, exchanges help to mitigate credit risk.
>
> Forwards are similar to futures contracts except that forward contracts are not exchange-traded. Forwards trade on over-the-counter markets. They may have custom dates and notional amounts since they are legal agreements between two counterparties. Compare this to futures, which are exchange traded. In a futures contract, the counterparty is actually the exchange itself. This allows the exchange to measure and monitor the credit of each side, requiring margin calls where needed and eliminating credit risk. Therefore, forwards have counterparty risk, whereas futures do not. To repeat: exchanges require margin calls to provide ready cash so that one side of the futures will have sufficient cash on hand to carry out the trade. This distinction is why forwards have more credit risk than the corresponding futures.

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Options:

3. Options

An option is a derivative that provides the holder with optionality, or choice, in whether to trade a security in the future at a specific price. The two basic types of options are calls and puts.

A **call option** grants the holder, for a limited period of time, the right, but not the obligation, to purchase the underlying asset at a fixed price. That is, the holder calls in the underlying at the price that was fixed.

A **put option** grants the holder, for a limited period of time, the right, but not the responsibility, to sell the underlying asset at a fixed price. That is, the holder puts the security on sale at a fixed price.

The fixed price common to calls and puts is known as the **strike price**, or **strike level**, or simply the **strike**. It is usually denoted by K.

Where does the option buyer purchase the option? This would most likely be on an options exchange. Vanilla options trade on exchanges. A **vanilla** option is the name given to an option that has a standard payoff. An **exotic** option is the name given to an option that has a payoff different from the standard one.

Let us consider the payoff of the classic type of option, calls and puts.

An option costs money to purchase. The price of any option is known as the **premium**. The premium is the price the buyer pays to enter a call or to buy a put. But note that the price of a call and a put with the same time to expiration, strike, and underlying assets are not the same in general.

Once an option buyer pays the premium, they own the option. They will also never lose more money than the premium. Unlike stocks, options cannot be bought using margin. The premium must be paid in its entirety. Does that mean that options do not have leverage? Absolutely not. Options have lots of leverage–something we'll discuss later in this module.

For now, let's suppose that the option is of a European style, i.e., it can only be exercised at its expiration. The payoff of a call option is equal to the maximum of the final stock price minus the strike level, or zero. In formula

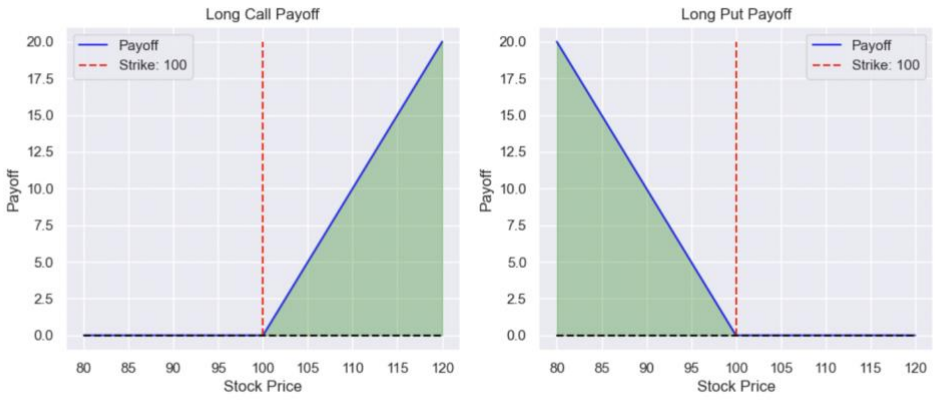
$$\text{call payoff } = \max\{S_T - K, 0\},$$

where T is the time at expiration, S_T is the price of the underlying at time T, and K is the strike price.

The payoff of a European style put option is equal to the maximum of the strike level minus the final stock price, or zero. Here is the formula:

$$\text{put payoff } = \max\{K - S_T, 0\}.$$

Figure 2: Long Call and Long Put Payoffs



You should have noticed from the formulae that the payoff of an option is known only at expiration. And you should also have paid attention to the fact that payoffs have a choice because the $\max\{\cdot\}$ function is applied and therefore calls and puts have non-negative payoffs. Be sure not to confuse this fact with the value of an option that, like for many other securities, can fluctuate over time.

Let's consider a European call option. Buying an option means you are long the option. It also means you are the option holder. For the long option side, you paid a premium to enter the position, and your payoff is given by the above formula. The P&L for a call option buyer is

$$\text{call PnL} = \max\{S_T - K, 0\} - \text{premium}.$$

While the payoff term is never negative, the P&L can be negative because of the premium. Indeed, even if the payoff term is positive, if it is smaller than the premium, the P&L can still be negative. For a European put, we instead have

$$\text{put PnL} = \max\{K - S_T, 0\} - \text{premium},$$

and the same remarks about the fact that the P&L could be negative apply in the case of a European call.

We've been discussing options from the buyer's perspective. The **option writer** is selling the option and is considered to be **short** the option. Let's look at the payoff and P&L formulae from their perspective. The payoffs for long and short calls, respectively, are:

$$\text{long call payoff} = \max\{S_T - K, 0\}$$

and

$$\text{short call payoff} = -\max\{S_T - K, 0\}.$$

Note that the sum of the two payoffs is 0. **Options are a zero-sum game**. The gains by one side equal the losses to the other side. Options are contracts between two counterparties, and the company or third parties are not involved in the writing or P&L of these options.

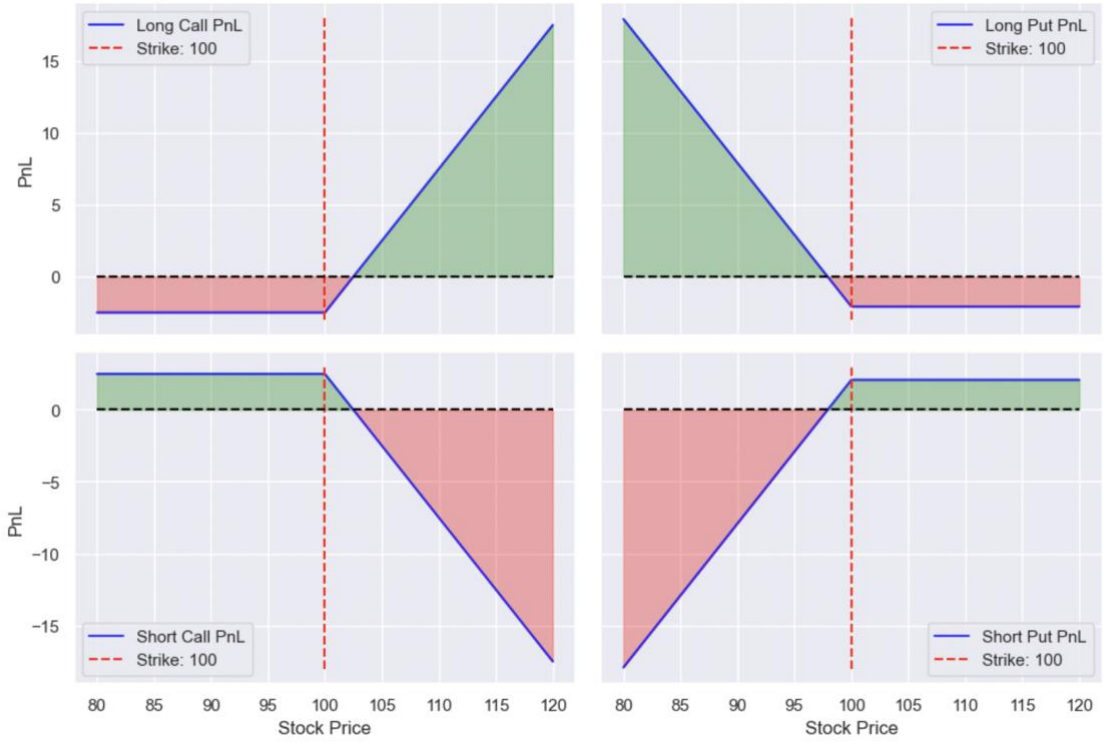
Likewise, the formulae for the payoff of long and short puts, respectively, are:

$$\text{long put payoff} = \max\{K - S_T, 0\},$$

and

$$\text{short put payoff} = -\max\{K - S_T, 0\}$$

Figure 3: Long/Short Call/Put PnLs - The shape of the plots resemble a diamond.



An option's **intrinsic value** is its payoff at any given time. There are three categories of intrinsic value:

- **in the money** (ITM) when the payoff is positive.
- **at the money** (ATM) when the payoff is 0 because the strike and stock price are equal.
- **out of the money** (OTM) when the payoff is 0 because we are on the flat part of the payoff diagram.

For a call, $S > K$ makes an option ITM. For a put, $K > S$ makes an option ITM.

For a call, $S < K$ makes an option OTM. For a put, $S > K$ makes an option OTM.

For the call writer, the premium is income rather than a cost. The premium is the most that the writer can actually make. If the option expires ITM, then the writer will make less than the premium amount. Indeed, it's possible for the writer to have a huge loss if the stock price greatly increases. For the call buyer, the premium is a fixed cost. If the option expires OTM, then the holder will make nothing. Indeed, it is easy to lose your entire premium by purchasing an option that expires out of the money.

Please be sure to distinguish an options premium from its payoff. The premium is the price that you would pay for the option for the weeks or months before its expiration date. The payoff of the option is only applicable at the option's expiration date.

The premium itself can be understood as having two sources of value:

- Intrinsic value: this is the same as the payoff if the option could be immediately exercised.
- Time value: this is the time value of the option.

Hence:

$$\text{Premium} = \text{Intrinsic Value} + \text{Time Value}$$

The premium should always be positive. If premiums were 0 (or negative), then you would basically have a free option. That means there would certainly be an arbitrage. You would get something today that costs nothing and a chance to get a positive payoff in the future. This is effectively a free lottery ticket. In order for the left-hand side to be positive, the right-hand side must also always be positive. That means the sum of the intrinsic value and time value must be positive. Imagine you had an option that is deeply OTM. Clearly, there would be no intrinsic value. All of the cost in the premium would come from time value.

Factors that affect the price of options:

4. Option Dependency 1: Underlying Price

The options' underlying security is the security from which the option derives its value. Let's suppose we have stock options. Then, the specific stock, say Netflix (NFLX), is an explicit part of the option's terms. During the life of the option, we would use the dynamically changing stock price in a model that helps us price the option's premium. At the option's expiration, we use the stock's closing price, which we compare to the strike to determine if the option is in the money. For calls, as the price of the underlying increases, the value of the call increases. Why? Looking at the call's payoff, we have the term $S_T - K$. A higher stock price will lead to a higher payoff.

For puts, as the price of the underlying increases, the value of the put decreases. Why? Looking at the put's payoff, we have the term $K - S_T$. A higher stock price will lead to a lower payoff.

5. Option Dependency 2: Strike Price

Unlike the stock price, the strike does not change. The strike represents a hurdle for the stock price that must be on a particular side for the option to be in the money. Notice that for both calls and puts, the signs of the stock price and strike are always opposite. Therefore, the higher the strike, the less a call is worth; the lower the strike, the more a call is worth.

The call's payoff $S_T - K$ will be maximized when we choose the lowest strike.

The put's payoff $K - S_T$ will be maximized when we choose the highest strike.

The strike level is something the option buyer selects at the time of purchasing the option and must live with while the option position is held.

Suppose you bought two different call options: one with a strike of 110 and another with a strike of 120. Suppose the final stock price is 118. The first option is 118-110 = $8 in the money. The second strike is out of the money because 118 < 120. Choose your strikes carefully!

For a call option, we can see that the higher the strike price, the harder it is to produce a payoff. Clearly then, these options will be less expensive because they are less likely to be in the money than options (on the same underlying) with lower strikes.

Note that the hurdle analogy is not a one-time phenomenon. If the stock price in our previous examples dropped down to 105, then neither the 110-strike nor the 120-stirke option would be in the money. Be sure you understand the payoff formula: the stock price used is at expiration, given at time T. This is our next dependency.

6. Option Dependency 3: Expiration Time

The stock price that is used to determine the payoff is the stock at time T, the time at which the option expires. The option's expiration is the end of the story. It is very objective: either the option is in the money, or it does not pay off. That is, if an option ends up at the money or out of the money, the option holder has a security that is effectively worthless. How could it lose all its value? The option grants a powerful right: the right to trade at a level that is favorable to the market. Unlike a future, it does not force the holder to execute at this price. If this were to continue indefinitely, options would be difficult to price and likely too expensive. Who knows what can happen many years from now? The option expires at a certain time, which helps to contain the uncertainty by shortening the interval of time.

Of all the random variables involved, time is the easiest to understand. It only moves in one direction and at a constant rate. As options draw closer to their expiration date, the tendency is that they lose time value. All else being equal, their overall cost is likely declining. Note: There are exceptions that will be addressed in a future course, but for now, think of this as the general trend.

If you were to compare two options that are near the money and that are similar in all aspects EXCEPT that one has a longer expiration date, then the longer-dated option will be worth more, simply because it offers more optionality. Note that this relationship is the same whether the option is a call or a put.

Let's reiterate: the optionality in options is a limited-time offer. That means that at some future point in time, the optionality of the holder to trade at the strike expires. This means that it's possible to hold an option to a point where it expired worthless. When the stock price exceeds the strike price, the calls are in the money, but the puts are out of the money.

If the option expires in the money, the holder will undoubtedly exercise the option. If the option is out of the money, then the payoff is 0 and the option is not exercised. It is in this last case that 100% loss of investment is possible. When it expires in the money, any gain is possible.

The price at which you trade could be quite favorable to the current price and if the option is deep in the money. Indeed, for call options, the stock price is unbounded, so there are infinite stock price paths that exceed the strike level.

Typically, the more time you have until expiration, the more value the option has. The less time you have, the less valuable it becomes. Time value affects values when there is a specified expiration date or deadline. Imagine that you are selling a concert ticket to see a very popular band. Imagine that you have one week before the concert to sell it. You may find that you can charge a much higher price. Now imagine the concert starts in 5 minutes. Once the concert starts, the ticket will become worthless; the time value of this ticket has decreased. It is the prospective ticket buyer who benefits from this, as the seller becomes very highly motivated to sell the ticket. Otherwise, they could lose the cost of the ticket.

7. Option Dependencies 4 & 5: Risk-Free Rate and Dividend Yield

Options depend on the interest rate that applies to the period that matches the length of time of the option's expiration. We refer to the rates as r. Similarly, options depend on the income-generating power of the underlying stock, namely the dividend yield. We refer to the dividend yield as q. We will postpone the details of option prices dependent on interest rates and dividend yields. The reason is that to understand this, we will actually want to know how an option is hedged, and that comes later in the program. For now, let's just state the relationships:

- Calls increase in value if interest rates increase OR if dividend yields decrease.
- Puts decrease in value if interest rates increase OR if dividend yields decrease.

Some students struggle to understand these relationships. For instance, why does the value of a call option goes up when the risk-free rate goes up? While options will be dealt more thoroughly in later courses, let's look in this problem as it is simple and it teaches us how to think about these issues.

Say that we want to buy 100 shares of stock FGH and FGH shares currently trade at $100 per share. We plan to stay invested for 1 year as we expect that by then FGH shares will have gone high enough for us to sell them and realize a profit. A 1 year American style call option on FGH can currently be purchased for $11, instead.

We have two ways to purchase those 100 shares:

(1) We buy the 100 shares which would cost us $10,000;

(2) We buy 1 call contract which would cost us $100 X $11 = $1,100. And we could deposit the difference, $8,900, in a saving account where the money earns an interest rate. If the interest rate in our saving account were, say 4%, then we could earn $8,900 X 4% = $356 a year.

Which strategy is more appealing? Note that the upside potential is the same. So, the second strategy looks more compelling and hence call options are desirable in this respect. Furthermore they become more advantageous the higher the risk-free interest rate is. Hence, if call options are more desirable, it means that more investors will want them, and if more investors want them, the bidding price will go up and so the value of the call option rises.

8. Option Dependency 6: Volatility

We have one remaining option: dependency. In fact, this is the most important influence on an option's price. It is also the most complex. It is the volatility of the underlying. In other words, the option does not merely depend on S, K, T, r, and q. Typically, K is fixed, and the other value can easily be read by market prices or data. Why is the underlying so important? Because the nature of the underlying influences what the call option is worth.

The option's value is very dependent upon the specific underlying stock. What is so important about the stock? Certainly, we can see that the price of a stock is important because the price at the option's expiration is in the formula itself for the payoff. What does not appear in the formula, however, but is the most important input into an option, is the stock's volatility. If there is more volatility, there is a chance for the stock to have more extreme values. Will this make the option's values more extreme? It may appear so because volatility is agnostic about direction: more volatility means more movement in either direction. So will higher volatility cause the option to be worth more? The answer is a resounding yes. We'll dive into the reasons why in the next lesson.

9. How are options exercised?

Arguably, most students are aware of how to buy and sell shares. But how about options? Say that you own a European style call option to buy 100 shares of MNQ for $60 a share. The stock has risen to $68 per share and the option is expiring today. Clearly, you want to exercise the call as *it is in the money.* How do you do that?

- First of all, we must be aware that the OCC, the **Options Clearing Corporation**, has the control over all exercises and assignments after the trades are made. The term assignment will become clear after you read below.
- The first step you must take is to instruct your broker to exercise the option for you. Typically, you need to have a broker that supports options trading, whose fees are adequate for your needs and provides a suitable platform usability together with customer service, and educational resources. Keep in mind that to trade options, the broker must approve you and the broker may have several levels of approvals where the riskiest strategies could be available to selected sophisticated investors only. However, here, we are just dealing with basic option contracts.
- At this point, the broker will notify his administrative staff to exercise and buy the stock. The administrative staff knows all the steps required to exercise options in a manner conformal to the rules.
- Hence, the order is then sent to the OCC: exercise one contract of the MNQ June 60 call series.
- In this step, the OCC selects a firm who is short the MNQ June 60 call (this is what is known as the **assignment process**). The assignment could be a simple random assignment or follow a *first in, first out* basis.
- The firm that was selected in the assignment process is required to deliver 100 shares of MNQ at $60 per share to

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- The firm that was selected in the assignment process is required to deliver 100 shares of MNQ at $60 per share to the firm that exercised the option, i.e., you!
- The OCC is usually indifferent about the method of delivery as long as the 100 shares of MNQ are delivered and paid $60 per share. You, as the person who exercised the call can keep the stock in your account if you want to, but must pay cash or margin it fully. Clearly you may want to sell it in the open market for a price higher than $60 and realize a profit. If you decide to hold on to the shares, then you are exposed to market risk as the shares, after climbing could even go down in price afterwards and if they went below $60 you would realize a loss if you sold your shares.
- However, if you have a margin account with your broker, you can sell the shares immediately.

The **physical settlement** of options contracts is the most common form of settlement and, as the name suggests, it involves the physical or actual delivery of the underlying security at settlement. However, one should be aware that there is also such thing as a **cash settlement**. This form of settlement occurs when cash exchanges hands at settlement instead of an underlying security or physical commodity. In our example, you would receive $8 per share or $$800 for the full contract minus commissions and fees. In the case of commodities there could be an economic reason for a cash settlement since, in doing so, we avoid the costs of storage. Cash settlement is also the primary settlement in the case of index options for the simple reason that an index is not deliverable.

Leverage:

1. Leverage

We mentioned leverage several times in this and in previous lessons. In Lesson 2, we are going to discuss options as an investment choice, and we'll see how leverage comes into play when working with options.

The first thing we'll discuss is the **leverage** that's built into options. A possible definition of leverage is that we borrow capital to invest more deeply in an investment than merely by investing with our cash on hand. The return on capital is expected to exceed the rate of borrowing, so leverage is a double bet: that the investment itself will have a positive return, and that the rate of return exceeds the cost of borrowing so that it will have a net positive return on borrowed funds as well.

The beauty of options is indeed that they are a leveraged investment because they **leverage** the returns. How? Not by borrowing funds. Indeed, **an option can only be paid for in full**. Instead, options use leverage through a conversion factor greater than 1. The conversion factor is the number of shares of stock that can be traded for one option. For stock options, the conversion factor is 100. One long equity option entitles the holder to trade 100 shares of the underlying stock. Buying one call option would grant the buyer the right (and not the obligation) to buy 100 shares of stock at the strike level. Note that this option costs less than buying 100 shares. So for a lower initial investment than buying stocks, or even buying stock on margin, the equity option offers a leveraged approach to investing.

Let's compare the approaches of buying stock with cash, buying stock with financing, and buying options. Suppose we are bullish on a stock on a company. Let's examine each of these ways that we could invest in that company. Let's imagine that the company is expected to make a return of 10%.

2. Buying Stock Using Cash

The first thing we could do is buy the stock using cash. Suppose that the stock price is $500 per share. We want to trade 100 shares. We need $500/share * 100 shares = $50,000. Recall our expected return is 10%. So our $50,000 would increase 10% or $5,000. Our return is $5,000 on a $50,000 investment or 10%. Buying stocks for cash is unleveraged. The returns are in no way magnified because no debt was incurred to borrow funds and no derivatives were used to increase the exposure size. This is the most expensive way to make $5,000 because we need $50,000 of capital upfront to do so.

3. Buying Stock Using Financing

Consider a second example: we're buying stocks using financing. This is indeed what many hedge funds do. For example, let's say that you bought $100,000 worth of stock. Now, $50,000 of that amount is your actual cash on hand. The other $50,000 is borrowed. Of course, you will have to pay a financing fee for the cost of those funds. However, suppose the stock indeed increases 10% overnight. Assuming the financing costs are negligible for the overnight rate, it appears we make $10,000 on $100,000, which is 10%. However, remember that only $50,000 was the initial investment. Indeed, once you return the other $50,000 that was borrowed, we can see that the return is actually $10,000 on an initial $50,000 investment or 20%. In other words, when we leveraged 2:1, our return was doubled from 10% to 20%.

$$\text{leveraged return} = \frac{\text{amount invested} + \text{amount borrowed}}{\text{amount invested}} \times \text{raw return}$$

In our example, we have:

$$\text{leverage return} = \frac{50,000 + 50,000}{50,000} \times 10$$

The beauty of leverage is that it can take small returns and make them larger! It can also help you achieve high returns more quickly. Leverage can help investments earn higher returns.

Suppose we only had $25,000 cash. We could borrow another $25,000, making our total investment $50,000. Then, we earn 10% on the total, which is $5,000. Since we only put in $25,000, we actually earn 20%. Leveraging 2 to 1 means we double our return, regardless of our starting position. The point here is that we needed only $25,000, and not $50,000, to earn $5,000.

In the examples involving financing, recall that we will have to pay some interest for borrowing funds. That's why we hypothesize the returns happen quickly, so that we can ignore these. In reality, though, if the investment is strong, the return should exceed the borrowing rates.

Let's consider another optimistic example. Suppose you could put down only 5% of the cost, say $5,000 and borrow 95% or $95,000. What would our leveraged return be if the raw return were 10%?

$$\text{leveraged return} = \frac{5,000 + 95,000}{5,000} \times 10$$

Leverage has turned a simple 10% investment into one that triples the money. We start with $5,000 and end up with $15,000 (our original $5,000 and a gain of $10,000). Before getting too excited, note that there are restrictions in different stock exchanges for the amount that can be borrowed. To prevent excessive leverage, there is regulation that caps the leverage for stocks for most investors at 50%.

Our examples have been optimistic. Let's switch to pessimistic examples. Suppose we were leveraged 2 to 1, or 20 to 1, and had a 10% price drop:

$$\text{leveraged return} = \frac{50,000 + 50,000}{50,000} \times -10$$

Now instead of making 20%, we lose 20%. Leverage causes us to have extreme losses. Like volatility, leverage is indifferent to direction. Two to one leverage can just as easily give a big return or a very small return. The problem with extremely negative returns is that we may not be able to withstand the loss in the portfolio.

$$\text{leveraged return} = \frac{5,000 + 95,000}{5,000} \times -10$$

Indeed, with leverage, it is possible to lose your entire investment. It is even possible to lose more than your investment if you are highly leveraged. In this example, we started with $5,000 and lost an additional $10,000, for a total loss of $15,000. This is -200%. This is one of the reasons that regulation exists: to limit the amount of leverage and avoid catastrophic losses.

To recap: leverage multiplies a raw return by the ratio of the total investment to your original investment. Leverage is indifferent to whether the return is positive or negative; it is a mere multiplier. Consequently, leverage can make a lot of money quickly, or it can also lose a lot of money quickly. Indeed, there are leveraged investments that cause losses people cannot sustain and can wipe out an entire investment portfolio. Being overleveraged is a risk. Prudent credit lenders will restrict the amount of leverage based on portfolio size, experience, and the volatility of the exchange.

Using a **3:1 leverage** means you're investing with **three times the amount of your own capital**. If you invest $20,000 with 3:1 leverage, it means:

- Your total investment = $20,000 * 3 = $60,000.
- Your own capital = $20,000.
- Borrowed funds = $40,000.

4. Buying Options

Enter options. Options can only be bought fully with cash. That is, the option itself cannot be purchased using borrowed funds. This is because options already have leverage in them through a conversion factor rather than through borrowed funds. Recall that the conversion factor is 100: one option controls 100 shares of stock. If the stock price went up a dollar, in theory, the option should be worth about $100 more because each of those shares that it controls increases by one. It's not as simple as that because the pricing is a complex combination of stock price and the other five factors discussed in the previous lesson. But the cost is going up a lot more than $1 to be sure. Unlike the stock examples, there is not a hard and fast number like doubling or tripling on a raw return. However, it is possible for options to increase 100% or more. In other words, options have even more leverage than buying stocks on margin does. The leverage is *inherent* to the option.

5. Stocks or Options?

So clearly if you were bullish on a stock, you could decide to use all the funds to buy an option rather than buying the underlying or buying extra underlying with borrowed funds. What are the differences among these strategies?

Let's consider **timing**. Suppose we continued to believe the stock was going to increase 10%, but now we put a time horizon on that: within 1 month. So our three strategies would be:

1. Buy the stock with cash
2. Buy the stock with 50% cash and 50% borrowed funds
3. Buy a call option that expires within the month at a suitable strike

Now, suppose we get the time horizon wrong. It took 1 month and 2 days. The stocks make the same returns as in the previous example, but the option expires worthless. The stocks have the same returns because the underlying has no time constraint on earning a return; there is no expiration date. For the unleveraged stock investment, you're simply making the unleveraged return. For the leveraged stock, you would earn the leveraged return but have a slightly higher cost due to borrowing funds for a little more than a month. The double-digit return of the leveraged portfolio should more than compensate the investor for the extra interest on those borrowed funds. For the option however your return is -100%! That's right: it is possible to lose all your money by purchasing an option that then expires out of the money.

Options expire. If they do expire out of the money, they expire worthless. You had to pay a premium for that option; you don't get that premium back. The cost of that premium is effectively your loss. It's a -100% return, meaning a 100% loss. For the unsuspecting option trader, buying options can be daunting, as there are dozens of options to trade. Consider options on the company Meta, formerly known as Facebook. You could buy calls or you could buy puts. Suppose the stock price is currently trading at $200 per share. You could buy options with strikes at $2.50 intervals above and below the $200 price. In other words, there are calls and puts with strikes of $200, $197.50, $195, $192.50, … as well as $202.50, $205, $207.50, $210, etc. There are over twenty different strikes for which there are market makers offering to buy or sell options. Similarly, you could buy calls that expire this month, or one month from now, two months from now, three months from now, and so on. When you combine the numbers for types (calls and puts), strikes, and expiration dates, there could easily be over 100 options for a given stock. Which one do you choose?

In order to make money trading options, you have to get three things correct:

- Direction: Choose calls if the price should go up or puts if the price should go down.
- Timing: If you believe that it's going to take one month for your stock to go into the money above the strike, then make sure that you pick the right amount of time for that. In other words, make sure that there is enough time for the stock price to move into the money. Otherwise, the stock moving too slowly and not exceeding the strike will make the option expire worthless.
- Strike: Even if the stock price moved up, it may not move up far enough to be above the strike. For example, suppose you bought a one-month option when the stock price was $200 and your strike was $210. Suppose the final stock price was $209. You could have made money buying options with the strike of $205.00 or a strike of $207.50, but the strike of $210 produced a hurdle that the stock price did not overcome by its expiration.

Unfortunately, option traders don't get partial credit: getting only two out of three items (direction, timing, and strike) right means the option will expire out of the money.

7. Option Payoff: Nonlinear

The option payoff--whether for calls or for puts--looks like hockey sticks. This is what is known as a **nonlinear** payoff. This is unlike anything we have seen. Bonds have a convex relationship to interest rates. Stocks and futures have linear payoffs. But options are different from everything else.

Let's examine the payoff of a call option. On the left side, we have a flat line. This flat line goes from 0 to K. (Since stock prices are non-negative, we set the lower limit of the x-axis to 0.) This means that when the stock price is less than the strike level, the payoff for that call option is zero.

The next part of the payoff is where it slopes upward. This goes from K to infinity. Whenever the stock price exceeds the strike level, the option is in the money. When the stock price equals the strike level, the option is at the money (ATM). Even there, the payoff is zero, so the only positive payoff is when the stock price exceeds the strike level.

Each one of these segments is linear, but together, they combine to make the overall option payoff nonlinear. This is the key. Options have nonlinear payoffs, meaning that there is a "line in the sand"--the strike level--that is either crossed or not when the option expires.

As you remember, the payoff of the option only applies at the expiration. However, it would be helpful to know what the payoff would be during the lifetime of the option. Let's call it the intrinsic value. The intrinsic value is the option's payoff as if it could be exercised now. For a call option, the option's intrinsic value is zero when the stock price is less than the strike.

So here are three ways to say the same thing: an option with no intrinsic value is out of the money and would expire worthless if its expiration time was immediate.

As we have demonstrated, options have this nonlinear payoff. Where else do we see a nonlinear payoff? For this, let's turn next to the housing market.

Each one of these segments is linear, but together, they combine to make the overall option payoff nonlinear. This is the key. Options have nonlinear payoffs, meaning that there is a "line in the sand"--the strike level--that is either crossed or not when the option expires.

Home equity as an option:

1. Benefits

Suppose you want to purchase a home, but you don't have enough funds for the entire cost. You can find a mortgage in the mortgage market. There are different types of mortgages, but there is one key property they have in common: leverage. Buying a home by financing some of the expense is exactly like buying equity with borrowed costs. In each case, you buy a valuable asset (home or stock) by borrowing money (mortgage or cash) while pledging the asset as collateral (home or stock again). Mortgages inherently have leverage through the idea of borrowed funds. Therefore, the benefits of having a mortgage apply to your house as an investment, just as there are benefits to buying stock with financing.

One difference is that home ownership is not considered speculative since you may actually live there, perhaps even as your primary residence. Some homes are secondary residences, and these tend to have different rates and terms for the mortgage. Buying and living in an 80% mortgaged home is not considered to be speculative. In particular, it is less speculative than buying stocks with 80% financing. Therefore, in real estate, the amount of leverage tends to be more generous. In U.S. markets, a regulatory agency called the SEC limits stock buyers to financing up to 50% of the stock price. However, in U.S. mortgage markets, it's possible to buy a home with just 20% down, financing 80% of the cost. Recall that if the home increases 10% in price, you would actually make $5 \times 10\% = 50\%$ on your investment.

Some people argue that homes are not straightforward investments; they are also consumables. Home ownership can be expensive in terms of the **carry cost**. The carry cost includes mortgage payments, real estate taxes, insurance costs, energy bills and other utilities, and the maintenance required due to wear and tear. Unlike financial assets, real assets have wear and tear. They tend to need storage, insurance, and maintenance--costs that are largely irrelevant for financial assets like stocks or bonds. Like financial assets, house prices are subject to volatility. It's possible to buy a home and then the price drops in value (a "housing correction"), in which case you could lose money when you sell it. Nevertheless, a house provides a real, tangible place to live.

This lesson is not meant to provide best practices on buying or financing a home but rather to illustrate one important similarity between mortgaged homes and options. To understand this similarity, let's review an idea going back to Module 1: credit risk.

One of the first models in credit risk was done by a researcher named Robert Merton. Indeed, this is the same Merton that was part of the Black-Scholes-Merton option pricing model, which earned Myron Scholes and Robert Merton the Nobel Prize in Economic Sciences in 1997. Unfortunately, Fischer Black had died prior to this date. In Merton's honor, this model is known as the Merton model.

Imagine a company that has issued stock and bonds (or more precisely, a single bond). The bond is a debt that the firm will owe at some time, T, in the future. The stock is held by the owners of the company. In his model, Merton imagined that the value of a stock can be thought of as an option. The Merton option states that the stockholders have a call option on the assets of the firm, with a strike price at the debt of the firm.

Imagine all the stock that the shareholders own. Merton said that this is equivalent to owning a call option on the assets of the firm. The strike price is the debt that the firm has. The firm is due at time T, which is the option's expiration. Let's imagine three scenarios:

1. Suppose the asset price is 120. The firm can liquidate its assets (at the market price of 120). It can repay its debt at 100. It has 20 left over to share among the stockholders. Thus, the payoff of the stockholders is positive because the assets were valuable enough to pay off the debt and have some left over.
2. Suppose the asset price is 100. The firm liquidates its assets at the market price of 100, but the entire proceeds are used to satisfy the debt. There is nothing left over for the stockholders. The stocks are worthless.
3. Suppose the asset price is 90. The firm liquidates its assets at the market price of 90, but those proceeds are insufficient to satisfy the debt. Nevertheless, the debt holders are paid the entire proceeds, which is insufficient to satisfy their debt. Once again, there is nothing left over for the stockholders.

All three scenarios have the classic formula that

$$\text{Equity Value} = \max\{\text{Asset}_{\text{Final}} - \text{Debt}, 0\}.$$

This is the exact same formula for a call option. Recognize the similar property: nonlinearity.

Equity can be positive, but it can never be negative. If a firm has insufficient assets to cover its debt, it declares bankruptcy, pays off its debtors as best it can, and writes letters to their stockholders apologizing for losing all the equity.

What does all this have to do with housing? Let's add the word "home" in front of each term.

$$\text{Home Equity} = \max\{\text{Home Price}_T - \text{Home Debt}, 0\}.$$

What does all this have to do with housing? Let's add the word "home" in front of each term.

$$\text{Home Equity} = \max\{\text{Home Price}_T - \text{Home Debt}, 0\}.$$

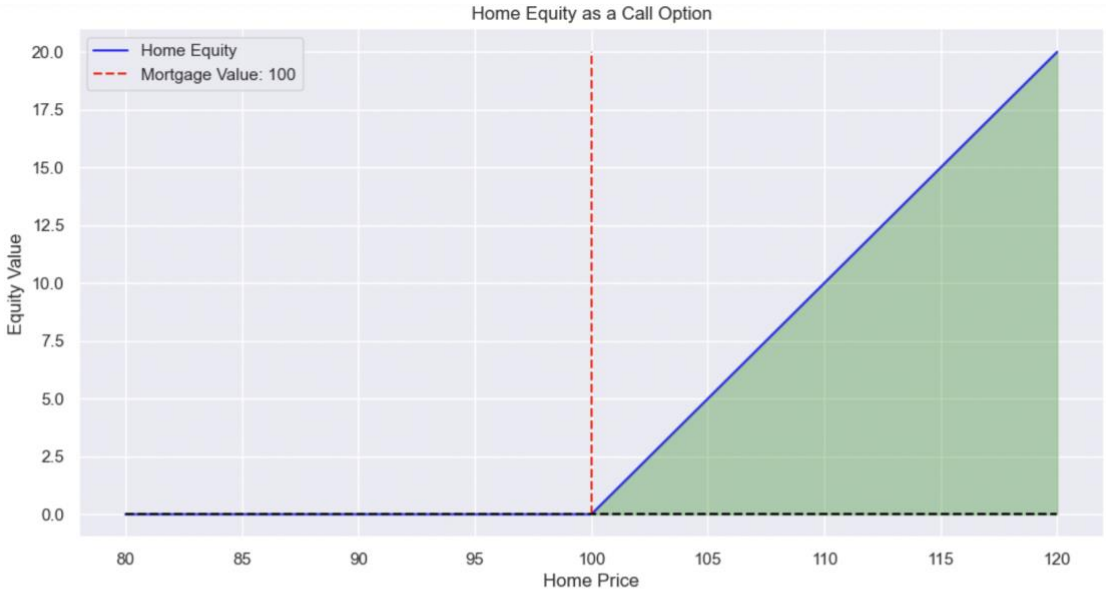
where home debt is the value of the mortgage and home equity is the homeowner's "equity" in the house. See Figure 2 for details.

As before, the Merton model states that you have some equity ownership in the house provided the home's price exceeds the mortgage. In this case, your home equity is like a call option that is in the money. Note that the horizontal axis is the market value of the house. It's not what you paid but the current market value. Since housing prices change with market conditions, this can be more or less than your purchase price.

Let's use the same examples:

- 1. Suppose the home's market price is 120. You could sell the house at 120, repay the mortgage of 100, and pocket the difference of 20 as P&L. Thus, as an investor, you could have enjoyed a capital gain of 20 on a house.
- 1. Suppose instead the home's market price is 100. When you sell the price at 100, you use the entire proceeds to pay off the mortgage of 100. There is nothing leftover; there is no home equity. You have no capital gain.
- 1. Suppose instead the home's market price is 90. When you sell at 90, you use the proceeds to pay the mortgage, but you fall short. When a house is worth less than the mortgage on it, we say the house is "*underwater*." This is the same meaning as out of the money. Instead of paying 100, you only have 90. Will the bank want to get the other 10 from you?

Well, according to the option payoff, the answer is no. The option framework simply flattens out. The nonlinearity protects you on the downside. But is an option the appropriate model for the underwater mortgage? How is it possible to just walk away?



The issue has to do with whether the mortgage is *recourse* or *non-recourse*. In the United States, different states allow different types of loans: some allow non-recourse loans, and others do not. In each type of loan, the house serves as collateral for the loan. If the homeowner fails to pay the mortgage, the lender will repossess the home. If the loan is **non-recourse**, the home is the full extent of the defaulter's (homeowner's) obligation. If the loan is **recourse**, the bank can proceed to obtain other assets to pay off the mortgage in full. See the difference? The non-recourse loan is safer for the homeowner because it uses the home, and only the home, as collateral. A recourse loan is riskier for the homeowner because it means that a person can lose even more than their home: they can lose their savings and investments.

Of course, from the bank's perspective, the recourse loan is safer because they can reclaim losses when the home is worth less than the mortgage amount. Again, from the bank's perspective, the non-recourse loan is riskier because an "underwater house" is a guaranteed loss.

Which loan type represents options? The non-recourse loan, since it allows the homeowner to walk away on an underwater loan.

Which loan type represents options? The non-recourse loan, since it allows the homeowner to walk away on an underwater loan.

2. Problems

Losing a home is traumatic and financially devastating. Having further losses can intensify the pain and suffering. Some states in the U.S., therefore, have mortgages with no recourse. Other states have mortgages that allow recourse. Non-recourse loans seem less problematic.

However, suppose you combined non-recourse loans with the ability to enter the mortgage with virtually no money down. In other words, suppose you are able to buy a home with a non-recourse mortgage with 100% financing. That's right, no money down. Now you have an at-the-money option for free. You don't have to pay for this option. Why? You needed no funds down to enter and were able to borrow the strike's price. Now you have a bet:

- *If the house price increases, flip the house: sell the house, pay off the mortgage, and collect the difference.*
- *If the house price decreases, walk away.*

In the first case, you make money. In the second case, you do not lose any money. See the problem? This is an amazing deal. It's like a free lottery ticket. There's a positive chance to make profits and virtually no chance to lose money. (Well, the reality is there are high carry costs for real estate, so there are chances to lose money.) This type of market can and will invite speculators of all kinds. Speculators will simply buy homes with little to no money down, wait and hope for the home prices to increase, and then close the trade and exit with a profit. They try to repeat this as many times as possible until the trend reverses and housing prices decline. Then, they simply walk away, leaving banks with the keys to the house.

This scenario is not hypothetical. It happened thousands and thousands of times in the U.S. during the Great Financial Crisis. Speculators flipped home after home, enjoying a real-estate bull market. Then, housing prices did not keep rising–instead they fell. Many speculators, and bona fide homeowners living in their mortgaged homes as their primary residence, defaulted on their mortgages. The homes served as collateral, which the banks then repossessed. Banks owned millions of homes that were underwater, without the ability to be made whole.

The problem of excessive speculation is that asset bubbles can be created. We will discuss this in more detail in subsequent modules.

One other note is that there is another option at play. The lender is short a put option on the assets of the firm. Let's look at their position in Figure 3.

Figure 2: Mortgage as a Short Put Option

The homeowner is long a call option on the house's value, struck at the mortgage level. The lender is short a put option on the house's value, struck at the mortgage level.

If the house price exceeds the mortgage, the proceeds will pay the lender in full. In this case, the option is out of the money. However, the lender is short, so that is good. Since they are short, they want to be out of the money.

However, if the house price is less than the mortgage, the proceeds pay the lender only in part. In this case, the option is in the money, and the lender loses some of their repayment.

In summary, giving mortgages with no money down is basically giving a free option to the homeowner. Free options are dangerous as they invite speculators and create bubbles.

Option Strategies and Scenarios:

1. Options: Exercise Type

There are three types of exercise methods for options:

1. European options can only be exercised at the option's expiration.
2. American options can be exercised throughout the option's lifetime, including expiration.
3. Bermudan options are like American options in that they can be exercised early but only on selected dates. We will discuss Bermudan options in a much later course.

For now, let's simply consider European-style options versus American-style options. Which of these sounds more flexible? The American exercise. Indeed, the American-style option is a superset of the European option in that it contains the extra optionality to exercise early.

For puts especially, this early exercise feature can be valuable. Suppose you are long a put option at a strike of K. Suppose that the stock price went to nearly zero. If you held a European put, you could not do anything until the expiration of the option. Perhaps the stock price could rebound and then your put could actually expire worthless. For the American put, however, you would be able to exercise early, collecting $K - 0$, or K dollars. You can then take those K dollars that you would earn per share (times 100 shares) and invest in a risk-free account for the remainder of the option's life, further increasing the amount that you would earn. Early exercise can be optimal for puts, depending on its price path. In particular, for a put that is very deep in the money, the put's payoff can be near its maximum, which is simply K. You will see in a future course the details about the pricing and hedging of puts and calls, as well as the times in which it makes sense to exercise early. But for now, let's add the exercise style as another item to our list of decisions to make when selecting an option. We'll continue that in the next section.

2. Option Strikes

In the previous section, we discussed the different styles of exercise. We can now add an item to our list of things we must get correct when trading options:

1. Exercise Style
2. Direction
3. Timing
4. Size

How many choices are there in each category?

For the exercise style, we have two choices: European style or American style.

For the direction, we have two choices: calls or puts (assuming we are not volatility traders).

For timing, we have several choices: 1 month, 2 months, 3 months, ..., perhaps up to 12 months.

For strike, we have numerous choices: dozens of possibilities at $2.5 increments above and below the current stock price.

Choosing the option's strike is likely the most difficult choice to make. Choosing the strike is effectively choosing the size move within the option's lifetime. The higher the strike, the less expensive the call, but choosing too high a strike may result in the option never getting in the money. To recap, let's say you bought a one-month call at a strike of 110, when the price is 100. In one month's time, the final stock price is 109. Options struck at 102.50, 105, and 107.50 are all in the money, but the option struck at 110 is not. There is no partial credit for getting the direction (call) and timing (one month) parts right if the size (strike level) is wrong.

There are three ways we can categorize call options by their strikes:

1. **In-the-money** calls: Strikes are less than the current stock price
2. **At-the-money** calls: The strike closest to or equal to the current stock price
3. **Out-of-the-money** calls: Strikes that are greater than the current stock price

For puts, we have the same categories but need to apply the put's payoff.

1. **In-the-money** puts: Strikes are greater than the current stock price
2. **At-the-money** puts: The strike closest to or equal to the current stock price

Now, ITM options (both calls and puts) are more expensive than ATM options because they have greater intrinsic value. Both options are more expensive than OTM options for the same reason. There is no free lunch. If you buy an OTM option, it is less expensive but has high risk. Only options that expire ITM will have positive payoffs.

What specifically happens at strike? As we know from the option's payoff, the payoff slope abruptly changes from flat to upward-sloping. If you were holding an ATM option, you would like the stock's price to increase so it becomes ITM. However, the party who sold the option would like just the opposite, making the stock's price decrease so it is OTM. Indeed, there are often "tug-of-war" games that occur at strike levels to fight for options going in and out of the money.

Well, why buy an option in the first place? Let's categorize three types of traders: hedgers, speculators, and arbitrageurs.

Hedger / Speculator / Arbitrageurs

3. Hedging with Options

Let's consider the trader who wishes to minimize risk with options. We'll consider risk as volatility. We would like to minimize the standard deviation (or variance) of outcomes. Suppose you're a farmer and you need to purchase seed for this year's harvest. You're willing to pay $50 a bushel for seed. If you were to pay more, you're unsure that you could sell it at a price that would keep the farm profitable. Therefore, you want to lock in the price of $50. You might first consider going to the futures market. The futures contract would cost nothing to enter. Perhaps you could find the price at $50 bushel in three months' time. But what if the price of the seed dropped over the next three months to $30? Your competition could buy it at that lower price and sell their crops at lower rates than you because you were locked in at $50. Your higher costs would inevitably result in higher prices, weakening your competitiveness on price. Instead of a future, what if you had bought a call option? Compared to futures, options look expensive. The futures require no upfront capital but could lead to very unfavorable conditions. Although options have a premium, they never lead to trading at unfavorable prices.

Suppose instead you were to purchase a call option struck at 50 to buy seed. One of two scenarios could occur.

In scenario 1, the price of seed in three months goes well above 50. Having the option struck at 50, you have locked in that price and will buy the seed at a level much lower than the market. Later, you will be able to sell the crops at a very competitive price since your costs were relatively low.

In scenario 2, the price of seed in three months goes below 50. Having an option to buy at 50 is unhelpful, so you simply don't exercise it. You buy your seed at the lower price along with everyone else. The option served as an insurance against seed inflation.

When options are used to minimize risk, you can think of them as insurance. When futures are used, they can help to minimize risk, but they can create unfavorable terms due to price changes between the locked-in future price and the actual future price. Options minimize risk more because the premium is the maximum amount you could lose. If the option is exercised, its payoff is positive, and you can get a better price using the strike level than the current market. If the option is not exercised, it's because prices decreased, and the option provided a hedge against a price increase. The difference between futures and options is that options provide a fixed cost (the premium) paid in the present, while futures have a variable cost (the difference between the locked and market prices) paid in the future.

We've given an example of someone who's buying a call to minimize risk by guaranteeing a maximum price for their inputs. Similarly, we could construct an example of someone buying a put to minimize risk by guaranteeing a minimum price for their outputs. The same farmer might purchase a put to sell corn at $90 a bushel. For the cost of a premium, the farmer guarantees a sale at 90, even if it drops in the future, while still having the flexibility to get an even higher price than 90 if future prices increase.

hedging with options means that we reduce the uncertainty of outcomes (minimizing the standard deviation) rather than reducing the overall cost (minimizing the "mean" cost if you will). This is the goal of hedging: a reduction in uncertainty. Options can certainly help with that, though they may cost more for that reduction in uncertainty.

4. Speculating with Options

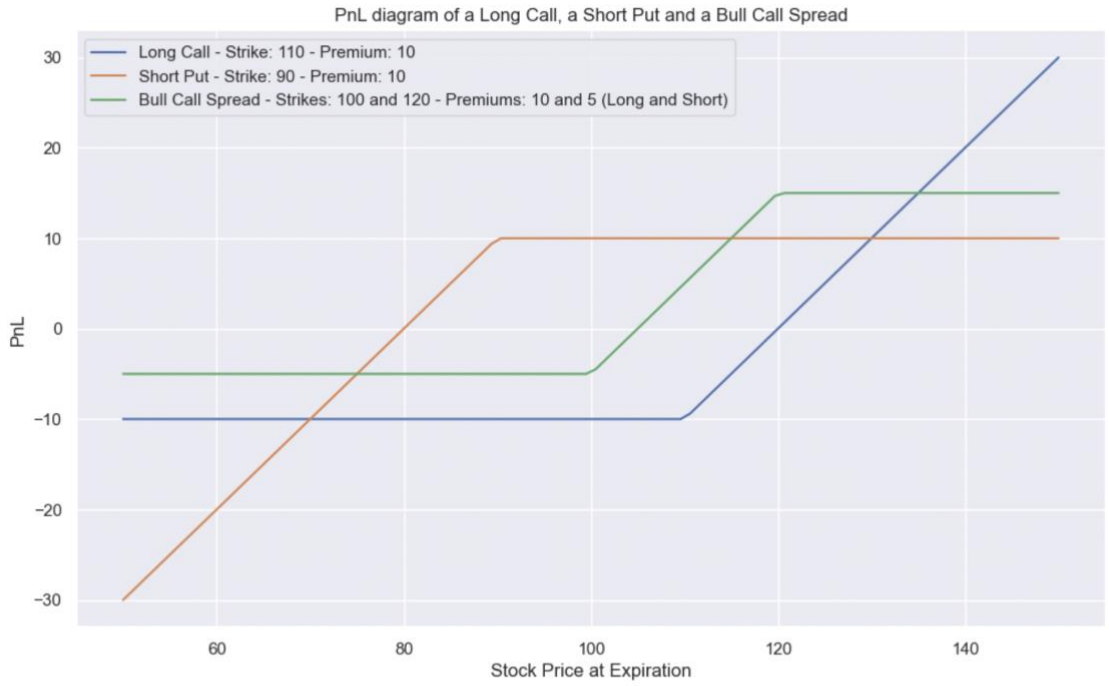
We've given an example from the point of view of risk management. But indeed, options can work the other way if you are speculating. A speculator is betting on a market direction and uses derivatives for their leverage, for example, if you were very bullish on a stock. Consider two different options strategies.

In strategy 1, you would simply buy calls. You have to pay the cost of the premium (with no financing). If the stock price goes up, within the option's time frame, and past the strike you chose, then the option is ITM. Of course, you have to pick the right strike and the right expiration date.

In strategy 2, you simply sell puts. Selling anything generates cash flow. Selling a put means you are exposed if the stock price drops. But if you strongly believe the stock will go up, you make money, within the option's time frame, so long as it ends up higher than the put's strike. This strategy does not require any upfront capital (except that if the price subsequently drops, then some cash will be needed to satisfy margin requirements).

In strategy 3, you buy a call at a strike, say 100, and then sell a call at a higher strike, say 110. This is known as a bull spread strategy. This means that you're paying money for the first call but you're actually collecting money for the second call because it's getting sold. Compared to strategy 1, this strategy is cheaper because you are "refunded" the cost of the second option. However, this limits the upside of your investment to the difference between the two strikes: in our example, $10. If you wanted to have a higher potential profit, then you could sell the second option at a higher strike. Strategy 3 is known as a bull spread. At the second strike, the two calls offset each other, so the P&L comes from the first call being (K2 - K1) dollars in the money. The bull spread is appropriate if you have "bounded" optimism rather than "unbounded" optimism about the stock's upside.

Figure 1: The graph below shows the option payoffs for the 3 strategies above.



The short put and bull spread have less upside than the call. The short put's upside is maxed at its strike, K. The bull spread's upside is maxed at the difference between its two strikes.

Let's compare some of these strategies. In this working example, you select options: calls or puts, long or short, and their strikes. They all have the same underlying and expiration. This graph shows the option payoffs and where the options will be in the money and out of the money.

For St > 120, the two calls offset each other, so the P&L comes from the first call being (K2 - K1) dollars in the money.
Total PnL = 20 – 10 + 5 = 15

For either hedgers or speculators, options can expire worthless. The difference for a hedger though is that the option not exercised leads to more favorable conditions (e.g., buying at a lower price). For the speculator, the worthless option is a capital loss with no favorable conditions. Since options can lose 100% of their value, they are intended to be used with great care. A buy-and-hold strategy that could work for many stocks or bonds is likely going to be inappropriate for options.

Recall that in Module 1 we looked at investments where your interest and principal could be protected. Equities eliminate the protection but still offer some dividends and ownership of assets should a company liquidate. Cryptos offer less than equities but do not have an expiration date. ETFs provide protection through diversification at one level or another. Options are in their own class. As derivatives, they inherently have both leverage and nonlinearity. The combination comes with potentially catastrophic results if one does not understand the risks.

For hedgers, the risk is similar to the cost of insurance, but for speculators, it is the entire principal. Let's say the hedger's option expires worthless. It can be thought of as the cost of insurance (like fire insurance that provides peace of mind). The fact that the hedger's option is OTM means that there's a favorable condition, such as being able to buy at an even lower price than the strike offered. This situation is most likely preferable for the hedger. Now let's say the speculator's option expires worthless. There's no other favorable condition. There is no analogy to insurance because risks were being increased, not decreased. Speculate carefully! Options can and do lose 100%. The difference between a payoff and no payoff is simply one point: the strike level.

Students are encouraged to utilize this Shiny Application to test various option strategies on a known price path. Follow the provided instructions to explore the different strategies available through combinations of long/short put/call options. By aiming to maintain a positive cumulative score on a given price path, you will gain practical insight into the application and effectiveness of each strategy. Additionally, you are encouraged to participate in forum discussions, especially when selecting and analyzing strategies on an unknown price path.

To summarize: speculators are very different traders than hedgers. Their goal is to take on risk, not to reduce it. So options could be used to decrease risk (hedging) or increase risk (speculating) with the idea of reducing the overall uncertainty of outcomes (hedging) or attempting to make a leveraged return (speculating).

To summarize: speculators are very different traders than hedgers. Their goal is to take on risk, not to reduce it. So options could be used to decrease risk (hedging) or increase risk (speculating) with the idea of reducing the overall uncertainty of outcomes (hedging) or attempting to make a leveraged return (speculating).

5. Seeking Arbitrage with Options

We'll end with a brief but exciting type of option trader: the arbitrageur. The arbitrageur could buy calls, puts, stocks, and bonds across different exchanges at the same time if the prices of equivalent payoffs differ, thereby earning a riskless profit. How? Equity options are combinations of stocks and bonds. It is possible to replicate an option with some combination of stocks and bonds. There is a relationship among calls, puts, stocks, and bonds (the formula is known as put-call parity and you will see it at work a few lines below) that shows a particular combination of some equals a particular combination of the other. If those costs are different, an arbitrageur could sell the "expensive" one, buy the "cheap" one, and pocket the difference, and the cash flows net out without any further expenses. The arbitrageur locks in a profit through a fleeting and infrequent situation that would create the opportunity.

Consider two different portfolios:

1. Portfolio A is long a call and short a put. These options are struck at K and expire at time T.
2. Portfolio B is long a stock and short a bond; the bond has notional value K, earns the risk-free rate r, and matures at time T (Note: This means that the bond's price at present is $K \times e^{-rt}$, and a student in this course should be able, at this point, to say why).

There are three states where the stock price can finish: smaller than the strike, equal to the strike, and greater than the strike.

If the options wind up ATM, then the call and put have no value. Otherwise, only one of them can end up ITM.

- If $S\backslash<K$, then the put is ITM; since the position is short the put, the payoff is $-(K-S)$, which is $S-K$.
- If $S>K$, then the call is ITM, which is $S-K$.
- IF $S=K$, then we are ATM, at which point $S-K=0$,but we can leave it as $S-K$.

So all three outcomes show that the final payoff is S - K. This matches the payoff of buying the stock and selling the bond.

Example. *Using portfolio A and portfolio B, which we just introduced above, suppose that*:

- *the cost of Portfolio A were* $8.
- *the cost of Portfolio B were* $5.

Do you see an arbitrage?

Answer. *Sell Portfolio A, buy Portfolio B, and collect $3 (=8 - 5). That is pure profit, as the two portfolios offset each other.*

To be sure, this type of arbitrage would be exploited in fractions of a second, including the time to discover it and execute across three different markets: bonds, stocks, and options. Although you could "*try this at home*," the opportunities will be gone if you blink. If you see an arbitrage--whether a $20 bill on the street or a mispriced set of options like we saw above--don't wait too long! All arbitrage opportunities are limited-time offers because if you don't act quickly enough, someone (or some computer) will.

Nevertheless, this idea of arbitrage, or rather the absence of it, will be vital when we relate the derivative's price back to the underlying.
That will be the topic of a later course. For the next module, we'll revisit mortgages and see the role they play in the housing market.

6. Conclusion

In this lesson, we wrapped up our discussion of options by detailing some strategies and scenarios. In the next module, we extend our coverage of financial instruments to the world of securitization.

To create a **synthetic** stock position using options, an investor needs to buy a call, sell a put with the same strike price.

Call writer = the seller of the call option
Put writer = the seller of the put option