Chapter 2

Forwards and Options

2.1 Asset prices

We will denote time by the continuous independent variable, t, and the price of a single asset (a share price for example) by the symbol:

$$S(t) \qquad \text{or equivalently} \;\; S_t$$

The subscript (index) notation, S_t, is useful and one can think of the function as a vector with a continuous index. As we have intimated at, this function will, in general, behave in an erratic way. Let us take $t = 0$, as the *present*, and therefore $t < 0$ refers to the past, for which we have a historical record of the share price. The value of the asset at any time $t = T > 0$ is, of course, unknown. A schematic picture of the price variation is shown in figure 2.1.

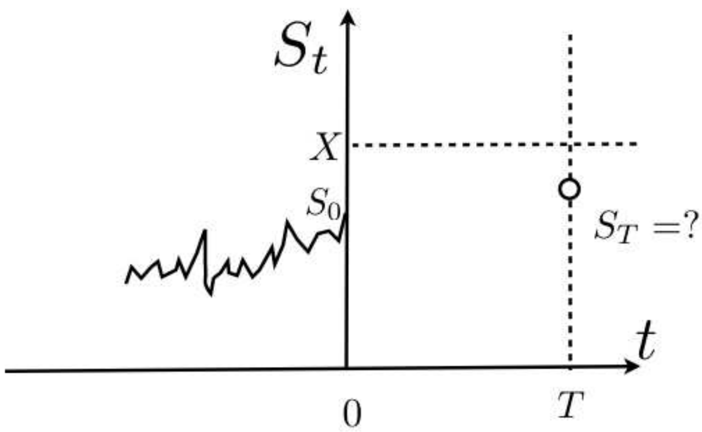


Figure 2.1: Diagram representing an asset price variation, S_t over time. The historical price record for $t < 0$ is known, the current asset (*spot*) price is known (S_0), while the future value at time $t = T$, S_T, is unknown. A *forward contract* agreed (now) at $t = 0$ with a strike price X and expiry date $t = T$, means that the party long in the contract is obliged to buy the asset from the party short the forward at the price X, and the party short is obliged to sell.

2.2 Forward contracts

A *forward contract* is a legally-binding agreement between two parties to buy (sell) an asset a a specified date in the future at a specified price.

(a) Alice

(b) Bob

The date at which the purchase (sale) occurs is called the *maturity date* and the price written into the contract is called the *delivery price*. A forward contract is agreed between the parties directly, rather than through an intermediary (such as an *exchange*) and as such is called *over-the-counter* (OTC) to indicate that it is a customised contract.

The party that agrees to *buy* the asset at the specified future date, is said to be *long in the forward* (let's call her Alice), and the party who agrees to *sell* the asset on that date (let's call him Bob) is said to be *short in the forward*.

Since the current time is $t = 0$, the current price (or *spot price*) of the asset is S_0. In a forward contract, one party agrees to sell the other, at a time $t = T$ in the future, the asset for a *strike* price X. A contract means that both parties are legally obliged to fulfil their obligations at expiry/maturity of the contract. Since both parties are agreeable to this arrangement, and both parties agree that (from their respective perspectives) the strike price X is fair, there is no fee (premium) in this arrangement and no money changes hands at this time. Money will change hands at the expiry/maturity.

At maturity, $t = T$, the *spot price* of the asset is given by S_T (see figure 2.1), which almost certainly differs from the strike price agreed in the contract, X, at $t = 0$. Nonetheless the contract now must be fulfilled. Alice pays Bob X and in return Bob must give her the asset, current price S_T. If $S_T > X$ then Alice has made a profit, since she has bought something currently worth S_T for a lower price X. She can then promptly sell this asset on the market at S_T and thus emerge with a cash profit $S_T - X$. We say the forward contract is '*in-the-money*' when she makes a profit.

On the other hand, if $S_T \leq X$, Alice is still obliged to buy, but is now paying X for something worth (at current prices) S_T. So if Alice were to immediately resell the asset she has just acquired, then she will make a net loss (a negative profit if you like): $S_T - X < 0$. We say that the contract is '*out-of-the-money*' when the holder (long in the forward) makes a loss. A contract for which $S_T = X$, is said to be *at-the-money*, and no profit or loss arises.

So Alice's pay-off (profit) from being long in the forward contract will be:

$$\boxed{\textsf{pay} - \textsf{off long forward} : F_T^L = S_T - X} \quad . \tag{2.1}$$

We use the symbol F to denote the value of the *forward*, the subscript T denotes the time of maturity, and the superscript L means 'long' in our notation.

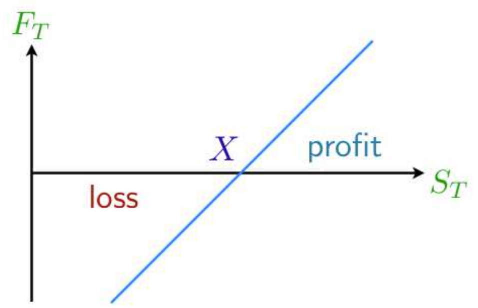
The pay-off function is thus a straight line with a gradient $+1$, figure 2.2(c), and passes through the break-even point (*at-the-money point*) $(X, 0)$.

Similarly, Bob will make a loss when $S_T > X$. He will either need to buy the asset that he promised to deliver to Alice at the spot price S_T, or he could have sold the asset for the spot price S_T on the market. In either case, Alice will only pay him X. So his profit is $X - S_T$ (negative). Conversely, if $S_T \leq X$, Bob can go to the market, buy the asset for S_T and sell this to Alice at the higher price X, making a profit of $X - S_T$.

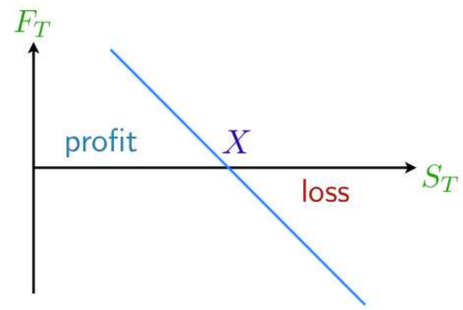
So Bob's pay-off (profit) from being short in the forward contract will be:

$$\boxed{\text{pay} - \text{off short forward} : F_T^S = X - S_T} \quad . \tag{2.2}$$

The pay-off is a straight line with gradient -1 passing through the point $(X, 0)$, see figure 2.2(d). It is useful to visualise the pay-off functions on a graph. In this case, we consider X (strike price) as the fixed parameter and see how Alice's and Bob's fortunes depend on the uncertain price of the asset S_T as shown in figure 2.2. That is Alice's pay-off (left) is a mirror image of Bob's function, that is a reflection in the x-axis. This reflection idea applies to all long vs. short positions. One party's gain is the other's loss. In other words, there is no such thing as a 'free lunch'. Profit is made at the expense of someone else; money does not appear from thin air!



(c) The pay-off function, F, for a LONG POSITION in a FORWARD CONTRACT at the expiry date $t = T$ for a strike price X, as a function of the asset spot price, S_T. The pay-off function is a straight line with gradient $+1$: $F_T^L = S_T - X$



(d) The pay-off function, F, for a SHORT POSITION in a FORWARD CONTRACT at the expiry date $t = T$ for a strike price X, as a function of the asset spot price, S_T. The pay-off function has a gradient -1: $F_T^S = X - S_T$.

Figure 2.2: The strike price is X agreed at $t = 0$ and *must*, as it is a legal *contract*, be paid for the asset at time T. The party long (short) in the contract will make a profit (loss) when $S_T > X$ and a loss (profit) when $S_T < X$. The pay-off functions for *short* and *long* positions are always mirror images (with reflection in the horizontal, $x-$axis).

2.3 Options

Options are of two basic types: *call* and *put*. We call these *vanilla options* because of their simplicity. Of course, there are more complicated options, generically termed *exotic* to distinguish them from the *vanilla* type, but these can usually be constructed from various combinations of *calls* and *puts*.

- A CALL option gives the holder the right to BUY an asset
- A PUT option gives the holder the right to SELL an asset

These rights do not come for free. One must pay for the privilege of holding an option. There are two parties involved in the purchase of the option. The buyer pays a fee (called the *premium*) to the seller to acquire the option.

The buyer is referred to as the *holder* of the option, and as such is *long* in the option. Conversely, the seller is referred to as the *writer* of the option, and is *short* in the option.

These terms are summarised in the figure below (figure 2.3).

There are three very important parameters associated with each option.

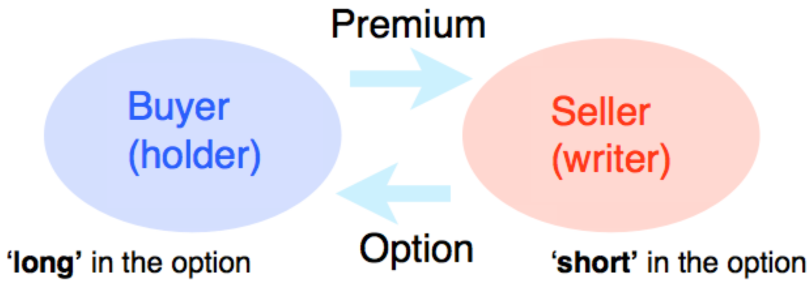


Figure 2.3: Diagram representing an option trade between the writer and holder. The *premium* is the fee paid by the buyer/holder to the seller/writer to acquire the option.

• The EXERCISE PRICE (STRIKE PRICE): the agreed price (when the option is traded) at which the ASSET will be bought/sold in the future.

• The EXERCISE DATE(S): date(s) on which the option to buy/sell may be taken up (EXERCISED) prior to the maturity.

• The EXPIRATION DATE (MATURITY): the last possible date on which the option may be taken up (EXERCISED).

An AMERICAN option may be exercised at specified dates before the *expiration date*.

A EUROPEAN option may *only* be exercised at the *expiration date*.

The name European/American has nothing to do with geographical location, it is simply a name that has become attached to the product.

The diagram (fig. 2.3) shows the trade between writer and holder for an OPTION. This is not the end of the relationship between these two parties. Recall that, as the name implies, an option offers the holder the right (not obligation) to exercise. If, however, the holder decides to exercise the option, it is then the legal obligation of the writer/seller to fulfil the agreement.

In the case of an option, the holder will only exercise the option if it makes sense to do so that is, if it is profitable to do so. In other words, if there is a *positive* pay-off.

• CALL OPTIONS

The time is the present, $t = 0$, and one unit of the asset has the spot price S_0. Suppose Alice decides to *buy* a *call option* from Bob in this asset. She pays the premium, c for each unit of asset, and now holds the right to buy one unit of the asset for an agreed strike price X, at a specified *exercise date* $t = T$.

Let us assume she bought a European call option so that this exercise date is the only time at which the option can be exercised, and that the option expires (is no longer valid) beyond this date. Suppose the *spot price* of the asset at maturity, $t = T$, has become S_T. If $S_T > X$ then Alice has the opportunity to have a positive pay-off from exercising the option. She could buy one unit of the asset for the agreed strike price X, from Bob, and then immediately sell this at the current spot price S_T, making a profit $S_T - X$. In this case, Alice will decide to *exercise* the option and oblige Bob to sell.

Alternatively, if $S_T \leq X$, Alice is NOT obliged to buy. That is the advantage of an OPTION. If Alice were to exercise the option, she would end up losing money since she would be paying X for something she could buy on the open market for a lower price S_T. Let's call this the *fundamental rule of business*:

SELL AT A PRICE HIGHER THAN YOU BUY

So, in accordance with this rule, Alice decides NOT to exercise the call option.

Her payoff function (long in a call option) is shown in figure (2.4(a)), and we see that it is never negative. It is precisely because the option offers Alice a 'no lose' position, that she must pay to have this privilege.

That is, we can say with certainty and without any advanced Mathematics, that, the premium (price) of the option at $t = 0$, which we denote by c must be positive: $c > 0$. But what should be the value of c ? Indeed this question is at the heart of this course of lectures. What should Bob charge (or Alice pay) to accord the privilege ? To answer this question requires advanced Mathematics.

However, we do know for certain the value of the option at one time - the expiry time, T. Since the pay-off in the money ($S_T > X$) is just the difference between the spot price S_T and the strike price X, then it is a broken line (or 'hockey stick' shape - to use the analogy with ice hockey). We can write this in mathematical form using the max function notation.

$$\boxed{\mathsf{pay - off\ long\ call:} \quad c_T^L = \max(S_T - X, 0)} \quad . \tag{2.3}$$

This function is plotted in figure 2.4(a). Now by pay-off we effectively mean the *value* of the call option at expiry $t = T$.

2.3.1 min and max

The function max means the larger of the two numbers and has the following mathematical definition:

$$\max(A, B) \equiv \begin{cases} A & , \quad A \geq B \\ B & , \quad A < B \end{cases} \tag{2.4}$$

Obviously,

$$\max(A, B) = \max(B, A) \quad , \quad \max(A, A) = A \quad . \tag{2.5}$$

and, for any positive constant $\lambda > 0$,

$$\lambda \max(A, B) = \max(\lambda A, \lambda B) \quad . \tag{2.6}$$

We also have, for any constant, C:

$$C + \max(A, B) = \max(C + A, C + B) \quad . \tag{2.7}$$

For a negative constant, $\mu < 0$, we have:

$$\mu \max(A, B) = \min(\mu A, \mu B) \quad . \tag{2.8}$$

where we have introduced the min function:

$$\min(A, B) \equiv \begin{cases} B & , \quad A \geq B \\ A & , \quad A < B \end{cases} \quad , \tag{2.9}$$

which gives the smaller of the two variables in the argument.

The properties of the min function are similar to those of the max function:

$$\min(A, B) = \min(B, A) \quad , \quad \min(A, A) = A \quad . \tag{2.10}$$

We also have, for any positive constant $\lambda > 0$,

$$\lambda \min(A, B) = \min(\lambda A, \lambda B) \quad . \tag{2.11}$$

and for any constant,C:

$$C + \min(A, B) = \min(C + A, C + B) \quad . \tag{2.12}$$

For any negative constant, $\mu < 0$, we have:

$$\mu \min(A, B) = \max(\mu A, \mu B) \quad . \tag{2.13}$$

Another relation connecting these functions is:

$$\boxed{\min(A, B) = A - \max(A - B, 0)} \quad . \tag{2.14}$$

This can be easily proven since:

$$\min(A, B) = A + \min(A - A, B - A) = A - \max(0, A - B) \quad .$$

Occasionally, you might encounter the alternative notations:

$$\max(A, B) \equiv A \vee B \quad , \quad \min(A, B) \equiv A \wedge B \quad . \tag{2.15}$$

2.4 Short the option

For the short position in the call option (Bob's position) the pay-off will be the mirror image of Alice's. So, for the strike price X, we have:

$$\boxed{\mathsf{pay-off\ short\ call:} \quad c_T^S = -\max(S_T - X, 0)} \quad . \tag{2.16}$$

That is, according to (2.8):

$$-\max(S_T - X, 0) = \min(X - S_T, 0) \quad . \tag{2.17}$$

Thus we can also write:

$$\boxed{c_T^S = \min(X - S_T, 0)} \quad . \tag{2.18}$$

This pay-off function is sketched in figure (2.4(b)) alongside its mirror image; the long call pay-off, figure 2.4(a). As explained before, the pay-off function for the short position is a mirror image around the x (S_T) axis of the long position.

Different notations are used by authors, and one that is frequently used is:

$$\max(S_T - X, 0) \equiv (S_T - X)_+ \quad ,$$

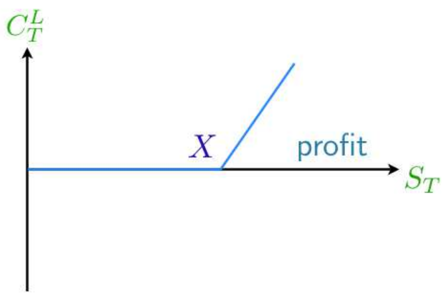
and

$$\min(X - S_T, 0) \equiv (X - S_T)_- \quad ,$$

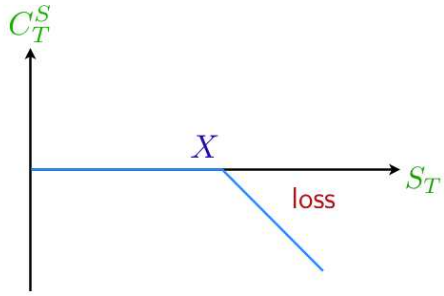
• PUT OPTIONS

The second type of option is the put option; the right (not obligation) to sell an asset for an agreed strike price X at a specified time T. At present, $t = 0$, the asset spot price is S_0. Alice decides to *buy* a *put option* from Bob. She pays Bob the premium (p) for each unit of asset with an agreed strike price X, for the *exercise date* $t = T$. That is, Alice has bought the *right* to *sell* Bob one unit of the asset for a price X at the time $t = T$.

As before, we can establish the value of the option at the expiry date, p_T. Consider the scenario at expiry/maturity, $t = T$. The *spot price* of the asset is now S_T. If $S_T < X$ then Alice has the opportunity to make the option pay off. She could now exercise her option. Alice would go to the market, buy one unit of asset at the spot price X and then exercise her right to sell this asset to Bob at the higher price, X. Bob has no choice in the matter.



(a) The pay-off function for a LONG POSITION in a CALL OPTION. at the expiry date $t = T$ for a strike price X, as a function of the asset spot price: $c_T^L = \max(S_T - X, 0)$



(b) The pay-off function for a SHORT POSITION in a CALL OPTION at the expiry date $t = T$ for a strike price X, as a function of the asset spot price: $c_T^S = \min(X - S_T, 0)$.

Figure 2.4: The strike price is X agreed at $t = 0$. The party long (short) in the call will make a profit (loss) when $S_T > X$. When $S_T < X$, the call will not be *exercised* and neither party has a positive or negative pay-off. The pay-off functions for *short* and *long* positions are mirror images (with reflection in the horizontal, $x-$axis).

Alternatively, if $S_T \geq X$, Alice is NOT obliged to sell. In fact, she would lose money since she would be need to pay the market price S_T to acquire one unit of the asset, and then sell this at X to Bob (in violation of our fundamental rule).

Her payoff (long in a put) is shown in figure (2.5) and can be expressed in mathematical form as:

$$\boxed{\text{pay} - \text{off long put}: \quad p_T^L = \max(X - S_T, 0)} \quad . \tag{2.19}$$

So this is the value, to the holder, of the put option at expiry.

For the short position in the call option (Bob's position), the pay-off will be the mirror image of the long position (Alice's position). For a strike price X, we have:

$$\boxed{\text{pay} - \text{off short put}: \quad p_T^S = -\max(X - S_T, 0)} \quad . \tag{2.20}$$

That is, according to (2.9):

$$p_T^S = \min(S_T - X, 0) \tag{2.21}$$

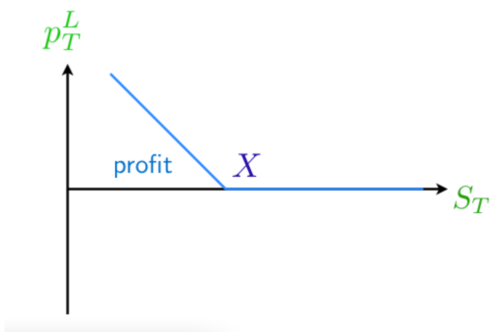
Both long and short pay-offs are sketched in figure (2.5).

Comparing figure (2.5) with figure (2.4) we see the full range of mirror symmetries, with the pay-off functions for the put option a mirror image of the pay-off functions for the call option around the vertical axis at the strike price X. This sometimes leads to confusion over which hockey-stick belongs to which option. In an attempt to summarise the different pay-offs they are gathered (schematically) in figure (2.6). In this case, one only needs to remember one quadrant, for example the long-call (top right) since all the other quadrants are simply mirror images of each other.

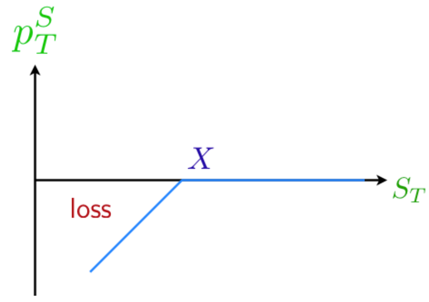
2.4.1 What is the price of an option at $t = 0$?

In a nutshell, this is the core question for this module. We know the value of the option at expiry, that is in the *future*. However, the problem is that the formula involves the asset price S_T which is completely unpredictable.

Nonetheless, without doing any advanced mathematics, we can establish a rough idea of what the price might be by setting limits for the price.



(a) The pay-off function for a LONG POSITION in a PUT OPTION. at the expiry date $t = T$ for a strike price X, as a function of the asset spot price: $p_T^L = \max(X - S_T, 0)$



(b) The pay-off function for a SHORT POSITION in a PUT OPTION at the expiry date $t = T$ for a strike price X, as a function of the asset spot price: $p_T^S = \min(S_T - X, 0)$.

Figure 2.5: The strike price is X agreed at $t = 0$. The party long (short) in the call will make a profit (loss) when $S_T > X$. When $S_T < X$, the call will not be *exercised* and neither party makes a profit. The pay-off functions for *short* and *long* positions are mirror images (with reflection in the horizontal, $x-$axis).

The pay-off function for the long position in a call (or put) option is always greater than or equal to zero. To avoid a guaranteed loss for the option writer, the holder of an option must pay a fee for this privilege. We can thus state that the fee c for a call option must satisfy

$$\boxed{c \geq 0} \quad , \tag{2.22}$$

and the fee p for a put option satisfies:

$$\boxed{p \geq 0} \quad . \tag{2.23}$$

We call this a *rational bound*: an equality (mathematical relation) based on common sense without the need for mathematics. The justification is that one cannot get something for nothing. There is no *free lunch*.

2.5 Profit

Pay-off does not equal profit. As already discussed, the privilege of holding (being 'long') in an option costs a *premium*. Thus, at the time $t = 0$, Alice needs to pay Bob $c > 0$ to hold the call option, with strike price X and expiry $t = T$.

Thus, at this point Alice's balance is $-c$, while Bob has a positive income $+c$. At the option expiry Alice will again exercise her option to buy the asset at the price X so long as $S_T > X$. However she will only make a profit from the transaction if her pay-off exceeds c.

Thus the profit function for the long position in a call option, costing a premium c, with strike price, X, and expiry time $t = T$:

$$\boxed{-c + \max(S_T - X, 0) = \max(S_T - X - c, -c)} \quad , \tag{2.24}$$

where S_T is the asset spot price of the asset at time, T. Thus a *positive* profit for Alice will only arise when:

$$\max(S_T - X - c, -c) > 0$$

that is when:

$$S_T > X + c \quad . \tag{2.25}$$

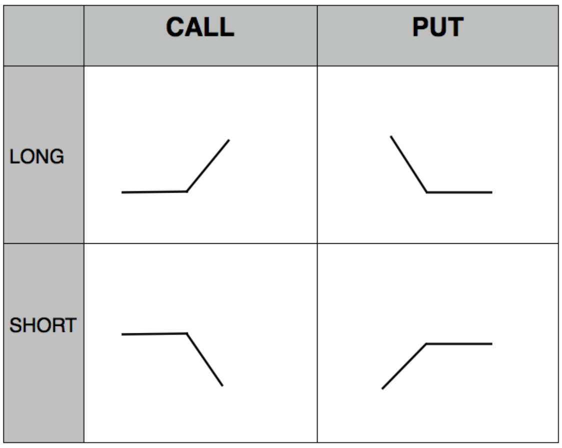


Figure 2.6: Summary of option pay-offs versus asset price, S_T, at expiry. Each quadrant is a mirror image of the neighbouring quadrants (left/right and up/down). Short/long mirrors around the horizontal x axis. Call/put mirrors around the vertical y axis at the strike price X.

The profit function for the short position in a call option, costing a premium c, with strike price, X, and expiry time $t = T$, is simply the negative of (2.24):

$$\boxed{+c - \max(S_T - X, 0) = \min(c - S_T + X, c)} \quad . \tag{2.26}$$

A *positive* profit for Alice in this case will occur when:

$$\min(c - S_T + X, c) > 0$$

that is when:

$$S_T < X + c \quad . \tag{2.27}$$

It is not surprising that this is the opposite of (2.25), when the long position is out of profit that implies that the short position is in profit, and vice versa. The cross-over point is shown in figure (2.7).

The same arguments apply to the put option. The profit function for the long position in a put option, costing a premium p, with strike price, X, and expiry time $t = T$ is:

$$\boxed{-p + \max(X - S_T, 0) = \max(-p + X - S_T, -p)} \quad , \tag{2.28}$$

where S_T is the asset spot price of the asset at time, T. Then, the profit function for the short position in a put option, costing a premium p, with strike price, X, and expiry time $t = T$, is simply the negative of (2.28):

$$\boxed{+p - \max(X - S_T, 0) = \min(p - X + S_T, p)} \quad . \tag{2.29}$$

2.6 Hedging

The question arises as to why one would buy or sell options.

Consider figure (2.28) in which the profit function is shown for a long call. Suppose Alice thinks (now) that the asset, current price S_0, would rise above a certain value X in the future (or, more accurately, $X + c$). Then, for a comparatively small investment, c, Alice could buy an option. Then, if it turns

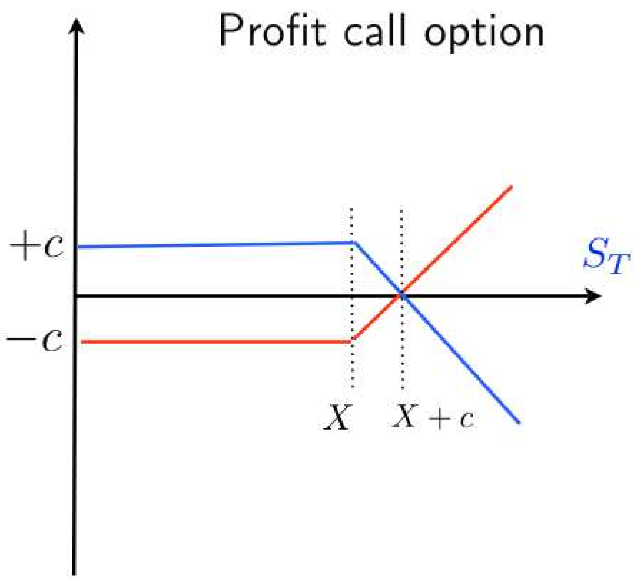


Figure 2.7: Profit for long (red line) and short (blue line) for a call option with the strike price X, premium c, as a function of the asset price at the time of option expiry, S_T. Long/call profits are mirror images. The cross-over point for profit between the long and short positions is at $S_T = X + c$.

out that $S_T \gg X$, she can obtain a very large profit, $S_T - X - c$. This profit is, in principle, unlimited. On the other hand, if $S_T < X$, then her losses are always limited. Alice simply chooses not to exercise the option, so that her loss is $-c$, no matter how low the asset price. (Note: this is a very risky investment strategy, as there is a good chance of losing the entire initial investment).

Given this scenario, why would anyone want to short a call option? Bob, who *writes* ('shorts') the option to Alice has a limited profit $c > 0$, the premium Alice gave him. He will retain this when $S_T < X$ and Alice decides not to exercise the option. On the other hand Bob faces unlimited losses if $S_T > X + c$. Remember for every winner (Alice) we also have a loser (Bob). This is what is called a *zero-sum game*: no net money/wealth is created, but rather the money is redistributed among the players.

Both Alice and Bob understand the situation perfectly. So, what rational reason would Bob have to short the asset and leave himself open to huge losses?

The following might explain why Bob would be involved in such a deal. Bob, at $t = 0$, is aware of the danger when he shorts the option. So, at $t = 0$, he also buys one unit of the asset, at the spot price S_0. We say Bob is *one unit long in the asset.* So the *balance* (total value) of Bob's cash at $t = 0$ is:

$$c - S_0 \qquad , \tag{2.30}$$

and his investments are:

$$\text{short one unit of call} \quad \& \quad \text{long one unit of asset} \ .$$

The value of his investment is thus:

$$S_0 - c \tag{2.31}$$

This type of investment strategy is called a *covered call.*

So Bob is quite sanguine about the possibility that $S_T \gg X$, since he already holds the asset. So if Alice exercises the option and pays Bob X as agreed, Bob simply hands over the asset in his possession, he doesn't need to go to the market and pay the high price S_T. So now Bob's investments (option and asset) have been liquidated (sold off) and he has only cash in his account. His profit will be his payoff

$$S_T - \max(S_T - X, 0) \quad , \tag{2.32}$$

minus his initial investment (2.31):

$$\text{Bob's profit} = S_T - \max(S_T - X, 0) - (S_0 - c) = \begin{cases} c - S_0 + X & , \quad S_T \geq X \\ c - S_0 + S_T & , \quad S_T \leq X \end{cases} \tag{2.33}$$

and this profit could be > 0 or < 0, depending on the variables. A sketch of the profit is shown in figure 2.8. In this case, Bob does not have unlimited losses. In the worst case scenario, his maximum loss is when the asset falls to zero value, $S_T = 0$, is $c - S_0$. In this case, he knows in advance what his maximum profit will be as well as his maximum loss.

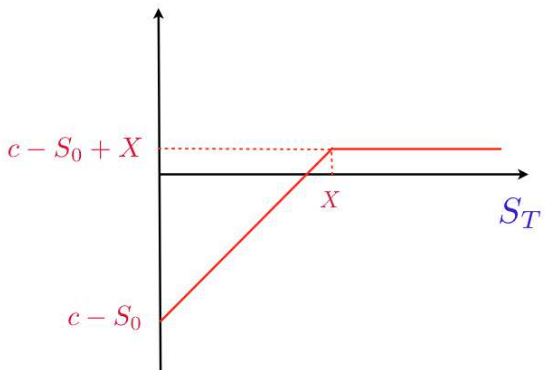


Figure 2.8: The profit for a *covered call* versus asset price, S_T, at expiry. Bob has a portfolio of short a call and long one unit of asset.

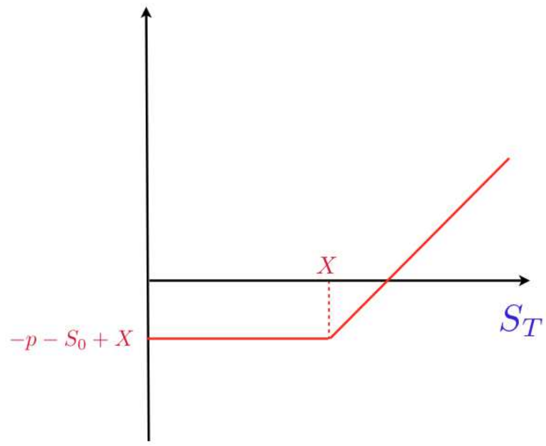


Figure 2.9: The profit for a *protected put* versus asset price, S_T, at expiry. Carol has a portfolio of long a put and long one unit of asset. Rational (*no free lunch*) pricing dictates that there must be possible loss, that is: $-p - S_0 + X < 0$ and this give the pricing boundary (2.39).

2.6.1 Lower bound for the call and put

If we consider the *covered call* investment, and the profit as sketched in figure 2.8. Now we can derive another lower limit for the price of c based on this figure. The profit function for Bob can *never* be fully below the horizontal axis. If it would be possible for this combination to be negative for all

S_T, then the mirror image would always be positive. Then Carol could make a guaranteed (risk-free) profit by acting in the opposite manner to Bob. Carol could long the call option and short the asset.

In order for Bob to have some chance of profit, we must therefore have the inequality:

$$c - S_0 + X > 0 \tag{2.34}$$

in other words:

$$c > S_0 - X \quad . \tag{2.35}$$

So combining this with (2.22) we can write:

$$\boxed{c > \max(S_0 - X, 0)} \quad . \tag{2.36}$$

The same arguments apply to a *protected put*: a case in which the investor is long in the put option and long in the asset. The initial value of such an investment is $p + S_0$, and the corresponding pay-off for this combination is:

$$\max(X - S_T, 0) + S_T, \tag{2.37}$$

so that the final profit from this combination is:

$$\max(X - S_T, 0) + S_T - (p + S_0) \quad . \tag{2.38}$$

Again, this profit cannot be fully above the horizontal axis, so for p we also have the (rational pricing) limits:

$$\boxed{p > \max(X - S_0, 0)} \quad . \tag{2.39}$$

2.6.2 Hedging

So, one reason why one would want options as part of a portfolio is to balance out assets. That is known as *hedging*. In principle, this gives us limited liability and thus reduces the risk of the asset value changing. A trader plays a balancing act with assets and their derivatives, always trying to find a certain profit.

So a wheat farmer, in Spring, might be concerned that the price of wheat might be low in the Autumn, for example due to an increase in supply due to a boycot on exports to Russia. Thus his asset, wheat, might fall in value in the next six months. He might choose to long a put option giving him the right to sell at a price X. So if the wheat price on the spot market *falls through the floor* in Autumn $S_T \ll X$, he can exercise the option to sell at a good price. Conversely, if the wheat price is very high, due to a reduced supply from Ukraine, the farmer would not exercise the option and simply sell on the spot market at the price $S_T \gg X$.

On the other hand, a pasta-making company, requiring flour to make its products, may also be concerned about wheat prices. If, in the future, wheat prices *go through the roof*, so too would the price of flour. The two prices would be closely related and this would create significant additional costs to the company. The pasta company could decide to hedge against this by longing a call option on wheat. If the price of wheat were to increase significantly, then the company could exercise the option, buy the wheat at X, then immediately sell at S_T the spot price, and use this profit to provide the extra cash needed to buy flour. An appropriate trading strategy therefore does not need to be linked directly to assets of interests, a close connection will suffice.

These linkages (correlations) are the key to make money as a trader. The more complex the correlations, the bigger the need for mathematics and computer algorithms developed from mathematics. So, in a complex trading world it is as important (if not more) to use computers and mathematics, as to use *seat-of-the-pants* intuition, or information/news.