

Online Appendix: Payoff Diagrams for Futures and Options

As we have seen, derivatives provide a set of future payoffs based on the price of the underlying asset. We discussed how derivatives can be mixed and matched to create synthetic financial instruments that mimic the behavior of more traditional financial instruments. Payoff diagrams help to illustrate this concept. This appendix introduces payoff diagrams and explains how to use them.

Futures Contract Payoffs

Recall that the buyer of a futures contract agrees to purchase a certain quantity of a particular commodity or financial instrument at a pre-specified price and time. The seller of the futures contract promises to deliver the commodity or financial instrument on the appointed date in return for payment at the settlement price. The value of these promises (to the buyer) increases as the price of the underlying asset rises.

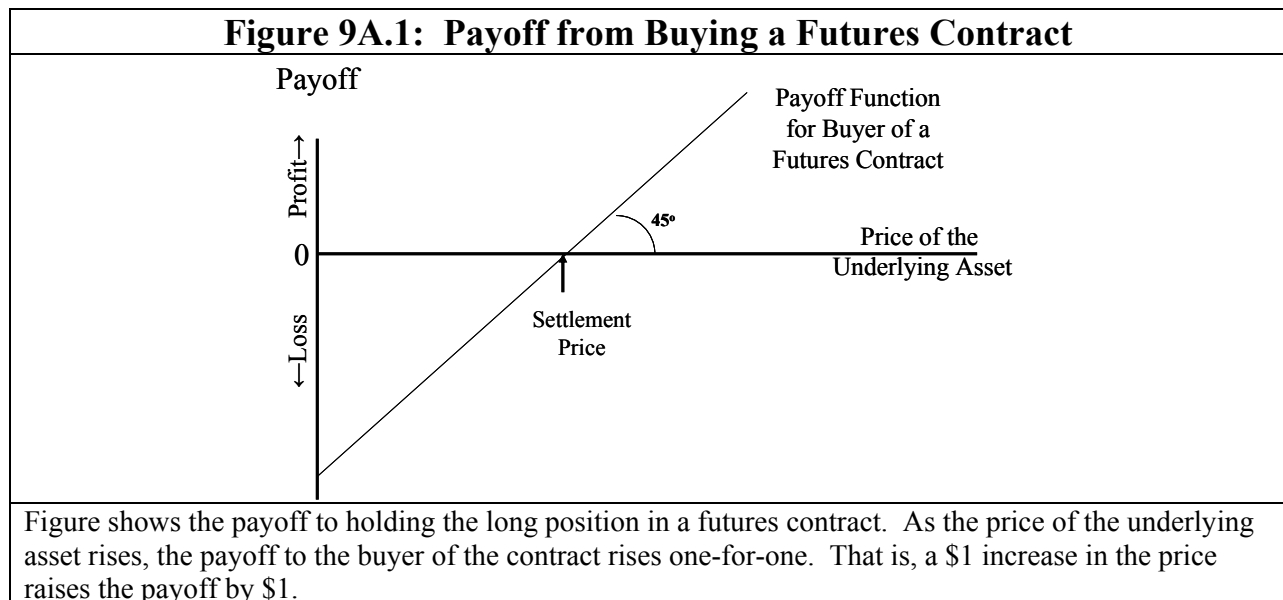
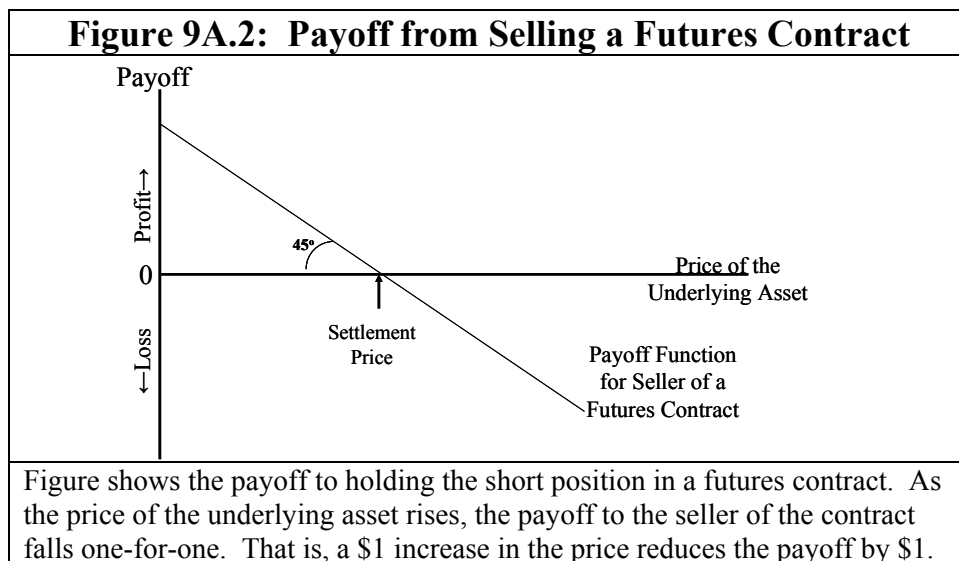


Figure 9A.1 shows the payoff from buying a futures contract. As the price of the underlying asset rises above the settlement price, the payoff to the futures contract buyer goes up

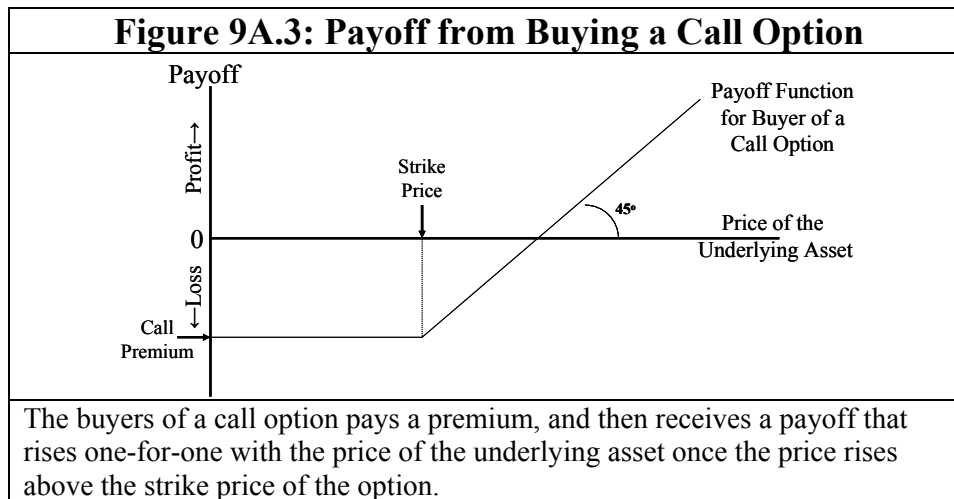
one for one – that is to say, a \$1 dollar increase in the price of the underlying asset raises the payoff to the long position by \$1. As the price falls below the settlement price, the value of the long position falls. In fact, the payoff from purchasing the underlying asset itself is exactly the same as the payoff from buying a future, since arbitrage forces the futures price to move with the price of the underlying asset. The crucial difference is that, in buying a futures contract, all the buyer needs to do is post margin. While buying a futures contract is substantially cheaper than buying the underlying asset, it means accepting greater risk.



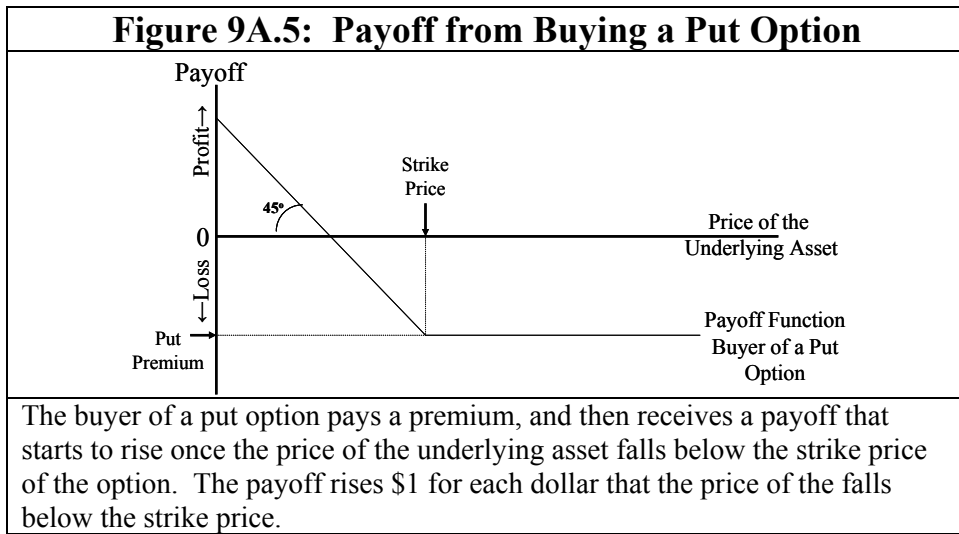
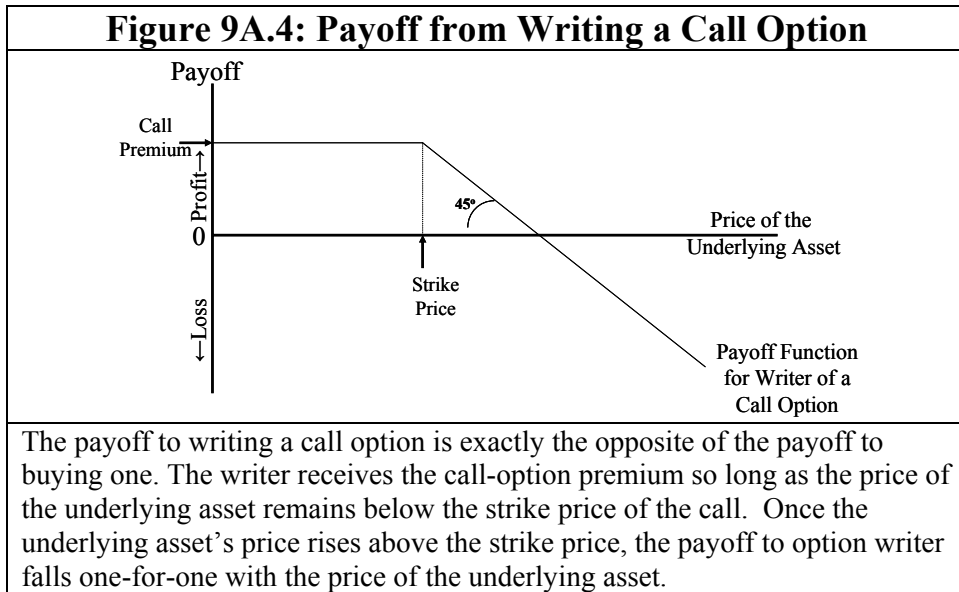
The payoff from selling a futures contract, or taking the short position, is shown in Figure 9A.2. This mirror image of Figure 9A.1 shows that the buyer's gains are the seller's losses, and vice versa. Again, the payoff to the short position rises and falls one-for-one with the price of the underlying asset – a \$1 increase in the price of the underlying asset reduces the payoff to the seller by \$1, while a \$1 fall in the price raises the payoff by \$1.

Options Payoffs

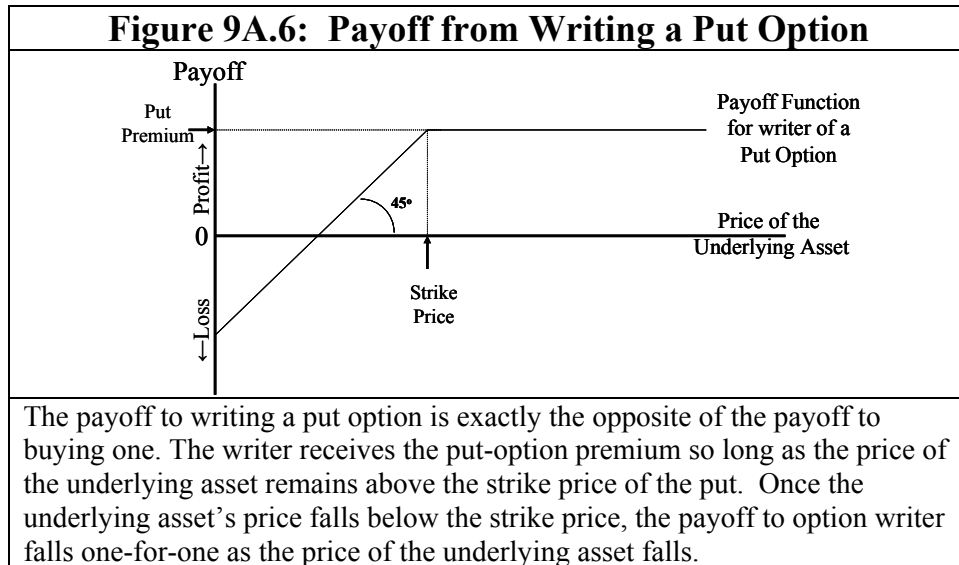
There are four ways to invest in options: buying and selling either a put or a call. We will begin with the buying of a call option. Remember that buying an option creates rights but not obligations. Because the buyer need not exercise the option, the loss from owning it cannot exceed the price paid for it. So long as the price of the underlying asset is below the strike price of the call, the holder will not exercise the option, and will lose the premium initially paid for it. This means that the payoff function is flat, beginning at an underlying asset price of zero and continuing to the strike price, with a loss equal to the call premium. As the price of the underlying asset rises beyond the strike price, the call comes into the money, and the payoff begins to rise one for one with the price of the underlying asset (see Figure 9A.3).



What benefits the call buyer costs the call writer. So long as the underlying asset price remains below the strike price of the call, the writer pockets the premium, and the payoff is positive. But when the underlying asset price rises above the strike price, the writer begins to suffer a loss. The higher the price climbs, the more the call writer loses, as Figure 9A.4 shows.



Turning to puts, we can use the same simple process to draw their payoff diagrams. The buyer of a put purchases the right to sell a stock at the strike price. Puts have value only when the price of the underlying asset is below the strike price. The payoff is highest when the price of the underlying asset is lowest. As the asset's price rises, the payoff falls, though it cannot go below the premium paid for the put (see Figure 9A.5)



Writing a put is the reverse of buying one. Again, the writer loses when the holder gains, so the maximum payoff is the premium. The best outcome for an option writer is to have the option expire worthless, so that it is never exercised. Looking at Figure 9A.6, we can see that the put writer's losses are highest when the price of the underlying asset is lowest; it declines as the price rises. So long as the asset price exceeds the strike price, the put writer's payoff equals the premium charged to write the put.

In this chapter, we learned that buying and selling options and futures in various combinations can be planned to create customized risks. Two examples were given. The first was the use of options to replicate the payoff pattern of a futures contract. Buying a futures contract is equivalent to purchasing a call and selling a put, both of which are at the money and have the same expiration date as the futures contract. Notice how putting Figure 9A.3 on top of Figure 9A.6 makes the combined payoff a continuous upward-sloping line.

The second example was the use of options to bet that a stock's price would move significantly, either up or down. Looking at the payoff diagrams, we see that buying a call yields a payoff when the price rises (see Figure 9A.3), while buying a put yields a payoff when the price falls (see Figure 9A.5). By putting the two together, an investor creates a financial instrument that loses value when prices are stable (the premium is lost when the price stays the same), but rises in value when prices are highly volatile.