CFA Institute

DERIVATIVES AND RISK MANAGEMENT

CFA® Program Curriculum

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CONTENTS

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The CFA® Program exams measure your mastery of the core knowledge, skills, and abilities required to succeed as an investment professional. These core competencies are the basis for the Candidate Body of Knowledge (CBOK™). The CBOK consists of four components:

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The curriculum development process is rigorous and involves multiple rounds of reviews by content experts. Despite our efforts to produce a curriculum that is free of errors, we must make corrections in some instances. Curriculum errata are periodically updated and posted by exam level and test date on the Curriculum Errata webpage (www.cfainstitute.org/en/programs/submit-errata). If you believe you have found an error in the curriculum, you can submit your concerns through our curriculum errata reporting process found at the bottom of the Curriculum Errata webpage.

OTHER FEEDBACK

Please send any comments or suggestions to info@cfainstitute.org, and we will review your feedback thoughtfully.

Derivatives and Risk Management

LEARNING MODULE

1

Options Strategies

by Adam Schwartz, PhD, CFA, and Barbara Valbuzzi, CFA.

Adam Schwartz, PhD, CFA, is at Bucknell University (USA). Barbara Valbuzzi, CFA (Italy).

LEARNING OUTCOMES

Mastery	*The candidate should be able to:*
☐	demonstrate how an asset's returns may be replicated by using options
☐	discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a covered call position
☐	discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a protective put position
☐	compare the delta of covered call and protective put positions with the position of being long an asset and short a forward on the underlying asset
☐	compare the effect of buying a call on a short underlying position with the effect of selling a put on a short underlying position
☐	discuss the investment objective(s), structure, payoffs, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of the following option strategies: bull spread, bear spread, straddle, and collar
☐	describe uses of calendar spreads
☐	discuss volatility skew and smile
☐	identify and evaluate appropriate option strategies consistent with given investment objectives
☐	demonstrate the use of options to achieve targeted equity risk exposures

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1 INTRODUCTION

Derivatives are financial instruments through which counterparties agree to exchange economic cash flows based on the movement of underlying securities, indexes, currencies, or other instruments or factors. A derivative's value is thus *derived* from the economic performance of the underlying. Derivatives may be created directly by counterparties or may be facilitated through established, regulated market exchanges. Direct creation between counterparties has the benefit of tailoring to the counterparties' specific needs but also the disadvantage of potentially low liquidity. Exchange-traded derivatives often do not match counterparties' specific needs but do facilitate early termination of the position, and, importantly, mitigate counterparty risk. Derivatives facilitate the exchange of economic risks and benefits where trades in the underlying securities might be less advantageous because of poor liquidity, transaction costs, regulatory impediments, tax or accounting considerations, or other factors.

Options are an important type of contingent-claim derivative that provide their owner with the right but not an obligation to a payoff determined by the future price of the underlying asset. Unlike other types of derivatives (i.e., swaps, forwards, and futures), options have nonlinear payoffs that enable their owners to benefit from movements in the underlying in one direction without being hurt by movements in the opposite direction. The cost of this opportunity, however, is the upfront cash payment required to enter the options position.

Options can be combined with the underlying and with other options in a variety of different ways to modify investment positions, to implement investment strategies, or even to infer market expectations. Therefore, investment managers routinely use option strategies for hedging risk exposures, for seeking to profit from anticipated market moves, and for implementing desired risk exposures in a cost-effective manner.

The main purpose of this reading is to illustrate how options strategies are used in typical investment situations and to show the risk–return trade-offs associated with their use. Importantly, an informed investment professional should have such a basic understanding of options strategies to competently serve his investment clients.

Section 2 of this reading shows how certain combinations of securities (i.e., options, underlying) are equivalent to others. Sections 3–6 discuss two of the most widely used options strategies, covered calls and protective puts. In Sections 7 and 8, we look at popular spread and combination option strategies used by investors. The focus of Section 9 is implied volatility embedded in option prices and related volatility skew and surface. Section 10 discusses option strategy selection. Sections 11 and 12 demonstrate a series of applications showing ways in which an investment manager might solve an investment problem with options. The reading concludes with a summary.

2 POSITION EQUIVALENCIES

☐ demonstrate how an asset's returns may be replicated by using options

It is useful to think of derivatives as building blocks that can be combined to create a specific payoff with the desired risk exposure. A synthetic position can be created for any option or stock strategy. Most of the time, market participants use synthetic positions to transform the payoff profile of their positions when their market views change. We cover a few of these relationships in the following pages. First, a brief recap of put–call parity and put–call–forward parity will help readers to understand such synthetic positions.

As you may remember, put–call parity shows the equivalence (or parity) of a portfolio of a call and a risk-free bond with a portfolio of a put and the underlying, which leads to the relationship between put and call prices. Put–call parity can be expressed in the following formula, where S_0 is the price of the underlying; p_0 and c_0 are the prices (i.e., premiums) of the put and call options, respectively; and $X/(1 + r)^T$ is the present value of the risk-free bond: $S_0 + p_0 = c_0 + X/(1 + r)^T$.

A closely related concept is put–call–forward parity, which identifies the equivalence between buying a fiduciary call, given by the purchase of a call and the risk-free bond, and a synthetic protective put. The latter involves the purchase of a put option and a forward contract on the underlying that expires at the same time as the put option. In the put–call–forward parity formula, S_0 is replaced with a forward contract to buy the underlying, where the forward price is given by $F_0(T) = S_0(1 + r)^T$. Therefore, put–call–forward parity is: $F_0(T)/(1 + r)^T + p_0 = c_0 + X/(1 + r)^T$.

Synthetic Forward Position

The combination of a long call and a short put with identical strike price and expiration, traded at the same time on the same underlying, is equivalent to a **synthetic long forward position**. In fact, the long call creates the upside and the short put creates the downside on the underlying.

Consider an investor who buys an at-the-money (ATM) call and simultaneously sells a put with the same strike and the same expiration date. Technically, it should be referring to ATM spot or ATM forward. However, for practice purposes, there is usually not much distinction in the mechanics. Whatever the stock price at expiration, one of the two options will be in the money. If the contract has a physical settlement, the investor will buy the underlying stock by paying the strike price. In fact, on the expiration date, the investor will exercise the call she owns if the stock price is above the strike price. Otherwise, if the underlying price is below the strike price, the put owner will exercise his right to deliver the stock and the investor (who sold the put) must buy it for the strike price. Exhibit 1 shows the values of the two options and the combined position at expiration, compared with the value of the stock purchase at that same time. The stock in this case does not pay dividends.

Exhibit 1: Synthetic Long Forward Position at Expiration

Stock price at expiration:	40	50	60
Alternative 1:			
Long 50-strike call payoff	0	0	10
Short 50-strike put payoff	−10	0	0
Total value	−10	0	10
Alternative 2:			
Long stock at 50	−10	0	10
Total value	−10	0	10

We now compare the same option strategy with the payoff of a forward or futures contract in Exhibit 2. The motivation to create a synthetic long forward position could be to exploit an arbitrage opportunity presented by the actual forward price or the need for an alternative to the outright purchase of a long forward position. Frequently, a forward contract is used instead of futures to acquire a stock position because it allows for contract customization.

Exhibit 2: Synthetic Long Forward Position vs. Long Forward/Futures

Stock price at expiration:	40	50	60
Alternative 1:			
Long 50-strike call payoff	0	0	10
Short 50-strike put payoff	–10	0	0
Total value	–10	0	10
Alternative 3: Long forward/futures at 50			
Value	–10	0	10

EXAMPLE 1

Synthetic Long Forward Position vs. Long Forward/Futures

A market maker has sold a three-month forward contract on Vodafone that allows the client (counterparty) to buy 10,000 shares at 200.35 pence (100p = £1) at expiration. The current stock price (S_0) is 200p, and the stock does not pay dividends until after the contract matures. The annualized interest rate is 0.70%. The cost (i.e., premium) of puts and calls on Vodafone is identical.

1. Discuss (a) how the market maker can hedge her short forward position upon the sale of the forward contract and (b) the market maker's position upon expiration of the forward contract.

Solution:

a. To offset the short forward contract position, the market maker can borrow £20,000 (= 10,000 × S_0/100) and buy 10,000 Vodafone shares at 200p. There is no upfront cost because the stock purchase is 100% financed.

b. At the expiry of the forward contract, the market maker delivers the 10,000 Vodafone shares she owns to the client that is long the forward, and then the market maker repays her loan. The net outflow for the market maker is zero because the following two transactions offset each other:

Amount received for the delivery of shares: 10,000 × 200.35p = £20,035

Repayment of loan: 10,000 × 200p [1 + 0.700% × (90/360)] = £20,035

2. Discuss how the market maker can hedge her short forward contract position using a synthetic long forward position, and explain what happens at expiry if the Vodafone share price is above or below 200.35p.

Solution:

To hedge her short forward position, the market maker creates a synthetic long forward position. She purchases a call and sells a put, both with a strike price of 200.35p and expiring in three months.

At the expiry of the forward contract, if the stock price is above 200.35p, the market maker exercises her call, pays £20,035 (=10,000 × 200.35p), and receives 10,000 Vodafone shares. She then delivers these shares to the client and receives £20,035.

At the expiry of the forward contract, if the stock price is below 200.35p, the owner of the long put will exercise his option, and the market maker receives the 10,000 Vodafone shares for £20,035. She then delivers these shares to the client and receives £20,035.

Consider now a trader who wants to short a stock over a specified period. He needs to borrow the stock from the market and then sell the borrowed shares. Instead, the trader can create a **synthetic short forward position** by selling a call and buying a put at the same strike price and maturity. When using options to replicate a short stock position, it is important to be aware of early assignment risk that could arise with American-style options. As Exhibit 3 shows, the payoff is the exact opposite of the synthetic long forward position.

The same outcome can be achieved be selling forwards or futures contracts (as seen in Exhibit 3). These instruments are also commonly used to eliminate future price risk. Consider an investor who owns a stock and wants to lock in a future sales price. The investor might enter into a forward or futures contract (as seller) requiring her to deliver the shares at a future date in exchange for a cash amount determined today. Because the initial and final stock prices are known, this investment should pay the risk-free rate. For a dividend-paying stock, the dividends expected to be paid on the stock during the term of the contract will decrease the price of the forward or futures.

Exhibit 3: Synthetic Short Forward Position

Stock price at expiration:	40	50	60
Alternative 1:			
Short 50-strike call payoff	0	0	−10
Long 50-strike put payoff	10	0	0
Total value	10	0	−10
Alternative 2:			
Short stock at 50	10	0	−10
Value	10	0	−10
Alternative 3:			
Short forward/futures at 50	10	0	−10
Value	10	0	−10

Synthetic forwards on stocks and equity indexes are often used by market makers that have sold a forward contract to customers—to hedge the risk, the market-maker would implement a synthetic long forward position—or by investment banks wishing to hedge forward exposure arising from structured products.

Synthetic Put and Call

As already described, market participants can use synthetic positions to transform the payoff and risk profile of their positions. The symmetrical payoffs of long and short stock, forward, and futures positions can be altered by implementing synthetic options positions. For example, the symmetric payoff of a short stock position can become asymmetrical if the investor transforms it into a synthetic long put position by buying a call.

Exhibit 4 shows the payoffs of a synthetic long put position that consists of short stock at 50 and a long call with an exercise price of 50. It can be seen that the payoffs from this synthetic put position at various stock prices at option expiration are identical to those of a long put with a 50-strike price. Of course, all positions are assumed to expire at the same time. Note that the same transformation of payoff and risk profile for a position of short forwards or futures can also be accomplished using long call options.

Exhibit 4: Synthetic Long Put

Stock price at expiration:	**40**	**50**	**60**
Alternative 1:			
Short stock at 50	10	0	−10
Long 50-strike call payoff	0	0	+10
Total value	10	0	0
Alternative 2			
Long 50-strike put payoff	10	0	0
Value	10	0	0

EXAMPLE 2

Synthetic Long Put

Three months ago, Wing Tan, a hedge fund manager, entered into a short forward contract that requires him to deliver 50,000 Generali shares, which the fund does not currently own, at €18/share in one month from now. The stock price is currently €16/share. The hedge fund's research analyst, Gisele Rossi, has a non-consensus expectation that the company will report an earnings "beat" next month. The stock does not pay dividends.

1. Under the assumption that Tan maintains the payoff profile of his current short forward position, discuss the conditions for profit or loss at contract expiration.

Solution:

If Tan decides to keep the current payoff profile of his position, at the expiry date, given a stock price of S_T, the profit or loss on the short forward will be 50,000 × (€18 − S_T). The position will be profitable only if S_T is below €18; otherwise the manager will incur in a loss.

2. After discussing with Rossi her earnings outlook, Tan remains bearish on Generali. He decides to hedge his risk, however, in case the stock does

report a positive earnings surprise. Discuss how Tan can modify his existing position to produce an asymmetrical, risk-reducing payoff.

Solution:

Tan decides to modify the payoff profile on his short forward position so that, at expiration, it will benefit from any stock price decrease below €16 while avoiding losses if the stock rises above that price. He purchases a call option with a strike price €16 and one month to maturity at a cost (premium) of €0.50. At expiration, the payoffs are as follows:

- On the short forward contract: 50,000 × (€18 − S_T)
- On the long call: 50,000 × {Max[0,(S_T − €16)] − €0.50}
- On the combined position: 50,000 × {(€18 − S_T) + [Max[0,(S_T − €16)] − €0.50]}

If S_T ≤ €16, the call will expire worthless and the profit will amount to 50,000 × (€18 − S_T + 0 − €0.50).
If S_T > €16, the call is exercised and the Generali shares delivered for a maximum profit of 50,000 × (€18 − €16 − €0.50) = €75,000.

In similar fashion, an investor with a long stock position can change his payoff and risk profile into that of a long call by purchasing a put ("protective put" strategy). The long put eliminates the downside risk, whereas the long stock leaves the profit potential unlimited. As shown in Exhibit 5, the strategy has a payoff profile resembling that of a long call. Again, all positions are assumed to expire at the same time. We will have much more to say about the protective put strategy later in this reading. Finally, the payoff profile of a long call can also be achieved by adding a long put to a long forward or futures position, all with the same expiration dates and the same strike and forward (or futures) prices.

Exhibit 5: Synthetic Long Call

Stock price at expiration:	40	50	60
Alternative 1:			
Long stock at 50	−10	0	10
Long 50-strike put payoff	10	0	0
Total value	0	0	10
Alternative 2			
Long 50-strike call payoff	0	0	10
Value	0	0	10

COVERED CALLS AND PROTECTIVE PUTS

3

☐ discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a covered call position

Writing a **covered call** is a very common option strategy used by both individual and institutional investors. In this strategy, a party that already owns shares sells a call option, giving another party the right to buy their shares at the exercise price.[1] The investor owns the shares and has taken on the potential obligation to deliver the shares to the call option buyer and accept the exercise price as the price at which she sells the shares. For her willingness to do this, the investor receives the premium on the option.

When someone simultaneously holds a long position in an asset and a long position in a put option on that asset, the put is often called a **protective put**. The name comes from the fact that the put protects against losses in the value of the underlying asset.

The examples that follow use the convention of identifying an option by the underlying asset, expiration, exercise price, and option type. For example, in Exhibit 6, the PBR October 16 call option sells for 1.42. The underlying asset is Petróleo Brasileiro (PBR) common stock, the expiration is October, the exercise price is 16, the option is a call, and the call premium is 1.42. It is important to note that even though we will refer to this as the October 16 option, it does not expire on 16 October. Rather, 16 reflects the price at which the call owner has the right to buy, otherwise known as the exercise price or strike.

Petróleo Brasileiro (PBR)	October	16	Call
Underlying asset	*Expiration*	*Exercise price*	*Option type*

On some exchanges, certain options may have weekly expirations in addition to a monthly expiration, which means investors need to be careful in specifying the option of interest. For a given underlying asset and exercise price, there may be several weekly and one monthly option expiring in October. The examples that follow all assume a single monthly expiration.

Investment Objectives of Covered Calls

Consider the option data in Exhibit 6. Suppose there is one month until the September expiration. By convention, option listings show data for a single call or put, but in practice, the most common trading unit for an exchange-traded option is one contract covering 100 shares. Besides call and put premiums for various strike (i.e., exercise) prices and monthly expirations, the option data also shows implied volatilities as well as the "Greeks" (variables so named because most of the common ones are denoted by Greek letters). Implied volatility is the value of the unobservable volatility variable that equates the result of an option pricing model—such as the Black–Scholes–Merton (BSM) model—to the market price of an option, using all other required (and observable) input variables, including the option's strike price, the price of the underlying, the time to option expiration, and the risk-free interest. Before proceeding further, we provide a brief review of the Greeks because they will be an integral part of the discussion of the various option strategies to be presented.

- **Delta (Δ)** is the change in an option's price in response to a change in price of the underlying, all else equal. Delta provides a good approximation of how an option's price will change for a small change in the underlying's price. Delta for long calls is always positive; delta for long puts is always negative. *Delta (Δ) ≈ Change in value of option/Change in value of underlying.*

1 When someone creates (writes) a call without owning the underlying asset, it is known as a "naked" call.

- **Gamma (Γ)** is the change in an option's delta for a change in price of the underlying, all else equal. Gamma is a measure of the curvature in the option price in relationship to the underlying price. Gamma for long calls and long puts is always positive. *Gamma (Γ) ≈ Change in delta/Change in value of underlying.*
- **Vega (ν)** is the change in an option's price for a change in volatility of the underlying, all else equal. Vega measures the sensitivity of the underlying to volatility. Vega for long calls and long puts is always positive. *Vega (ν) ≈ Change in value of option/Change in volatility of underlying.*
- **Theta (Θ)** is the daily change in an option's price, all else equal. Theta measures the sensitivity of the option's price to the passage of time, known as time decay. Theta for long calls and long puts is generally negative.

Assume the current PBR share price is 15.84 and the risk-free rate is 4%. Now let us consider three different market participants who might logically use covered calls.

Exhibit 6: PBR Option Prices, Implied Volatilities, and Greeks

Call Prices			Exercise Price	Put Prices		
SEP	OCT	NOV		SEP	OCT	NOV
1.64	1.95	2.44	15	0.65	0.99	1.46
0.97	1.42	1.90	16	1.14	1.48	1.96
0.51	1.02	1.44	17	1.76	2.09	2.59

Call Implied Volatility				Put Implied Volatility		
SEP	OCT	NOV		SEP	OCT	NOV
64.42%	57.33%	62.50%	15	58.44%	56.48%	62.81%
55.92%	56.11%	60.37%	16	59.40%	56.35%	62.27%
51.07%	55.87%	58.36%	17	59.59%	56.77%	63.40%

Delta: change in option price per change of +1 in stock price, all else equal

Call Deltas				Put Deltas		
SEP	OCT	NOV		SEP	OCT	NOV
0.657	0.647	0.642	15	−0.335	−0.352	−0.359
0.516	0.540	0.560	16	−0.481	−0.460	−0.438
0.351	0.434	0.475	17	−0.620	−0.564	−0.513

Gamma: change in delta per change of +1 in stock price, all else equal

Call Gammas				Put Gammas		
SEP	OCT	NOV		SEP	OCT	NOV
0.125	0.100	0.075	15	0.136	0.102	0.075
0.156	0.109	0.082	16	0.147	0.109	0.080
0.159	0.109	0.086	17	0.140	0.107	0.079

Theta: daily change in option price, all else equal

Call Thetas (daily)				Put Thetas (daily)		
SEP	OCT	NOV		SEP	OCT	NOV
−0.019	−0.012	−0.011	15	−0.015	−0.010	−0.009
−0.018	−0.013	−0.011	16	−0.017	−0.011	−0.010
−0.015	−0.012	−0.011	17	−0.016	−0.011	−0.010

Vega: change in option price per 1% increase in volatility, all else equal

Call Vegas (per %)				Put Vegas (per %)		
SEP	OCT	NOV		SEP	OCT	NOV
0.017	0.024	0.030	15	0.017	0.024	0.030
0.018	0.026	0.031	16	0.018	0.026	0.031
0.017	0.025	0.032	17	0.017	0.025	0.032

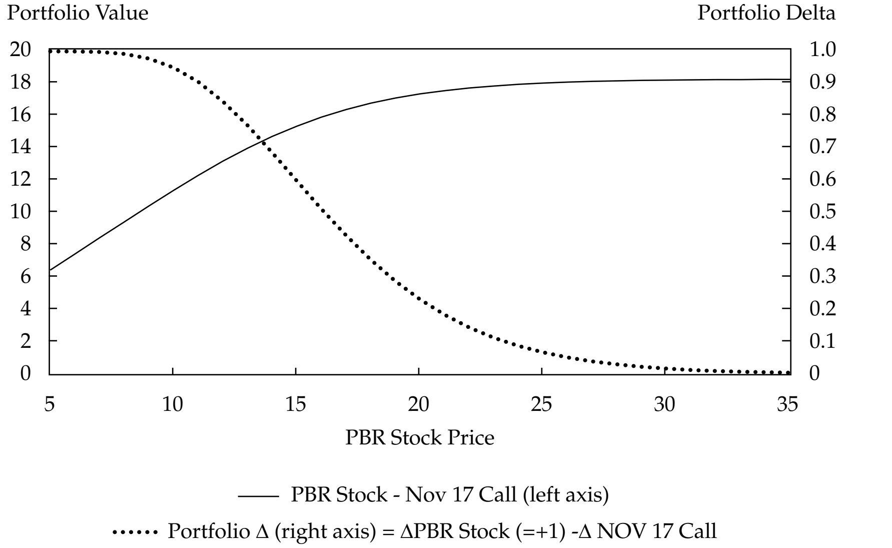
Market Participant #1: Yield Enhancement

The most common motivation for writing covered calls is cash generation in anticipation of limited upside moves in the underlying. The call option writer keeps the premium regardless of what happens in the future. Some covered call writers view the premium they receive as an additional source of income in the same way they view cash dividends. For a covered call, a long position in 100 shares of the underlying is required for each short call contract. No additional cash margin is needed if the long position in the underlying is maintained. If the stock price exceeds the strike price at expiry, the underlying shares will be "called away" from the covered call writer and then delivered to satisfy the option holder's right to buy shares at the strike price. It is important to recognize, however, that when someone writes a call option, he is essentially giving up the returns above the strike price to the call holder.

Consider an individual investor who owns PBR and believes the stock price is likely to remain relatively flat over the next few months. With the stock currently trading at just under 16, the investor might think it unlikely that the stock will rise above 17. Exhibit 6 shows that the premium for a call option expiring in September with an exercise price of 17, referred to as the SEP 17 call, is 0.51. She could write that call and receive this premium. Alternatively, she could write a different call, say the NOV 17 call, and receive 1.44. There is a clear trade-off between the size of the option premium and the likelihood of option exercise. The option writer would get more cash from writing the longer-term option (because of a larger time premium), but there is a greater chance that the option would move in the money, resulting in the option being exercised by the buyer and, therefore, the stock being called away from the writer. The view of the covered call writer can be understood in terms of the call option's implied volatility. Essentially, writing the call expresses the view that the volatility of the underlying asset will be lower than the pricing of the option suggests. As shown in Exhibit 6, the implied volatility of the NOV 17 options is 58.36%. By writing the NOV 17 call for 1.44, the covered call investor believes that the volatility of the underlying asset will be less than the option's implied volatility of 58.36%. The call buyer believes the stock will move far enough above the strike price of 17 to provide a payoff greater than the 1.44 cost of the call.

Although it may be acceptable to think of the option premium as income, it is important to remember that the call writer has given up an important benefit of stock ownership: capital gains above the strike price. This dynamic can be seen in Exhibit 7. Consider an investor with a long position in PBR stock (with delta of +1) and a short position in a PBR NOV 17 call. The investor enjoys the benefit of the call premium of 1.44. This cushions the value of the position (Stock – Call, or S – C) as the PBR share price drops. If the PBR stock price drops to 5, the call option will drop to essentially 0. The portfolio will be worth about 6.44, as shown in Exhibit 7. As the stock price increases, however, the short call position begins to limit portfolio gains. If the price of PBR shares rises to 30, the call option delta approaches 1, so the delta of the portfolio (S – C) approaches 0. The portfolio gains from the long PBR stock position will be reduced by losses on the short call position. As the in-the-money option expires, the maximum value of the portfolio will approach 18.44, the exercise price of 17 plus the 1.44 premium, as in Exhibit 7.

Exhibit 7: Covered Call Portfolio Value: Long PBR Stock—NOV 17 Call



Market Participant #2: Reducing a Position at a Favorable Price

Next, consider Sofia Porto, a retail portfolio manager with a portfolio that has become overweighted in energy companies. She wants to reduce this imbalance. Porto holds 5,000 shares of PBR, an energy company, and she expects the price of this stock to remain relatively stable over the next month. She may decide to sell 1,000 shares for 15.84 each. As an alternative, Porto might decide to write 10 exchange-traded PBR SEP 15 call contracts. This means she is creating 10 option contracts, each of which covers 100 shares. In exchange for this contingent claim, she receives the option premium of 1.64/call × 100 calls/contract × 10 contracts = 1,640. Because the current PBR stock price (15.84) is above the exercise price of 15, the options she writes are in the money. Given her expectation that the stock price will be stable over the next month, it is likely that the option will be exercised. Because Porto wants to reduce the overweighting in energy stocks, this outcome is desirable. If the option is exercised, she has effectively sold the stock at 16.64. She receives 1.64 when she writes the option, and she receives 15 when the option is exercised. Porto could have simply sold the shares at their original price of 15.84, but in this specific situation, the option strategy resulted in a price improvement of 0.80 ([15 + 1.64] – 15.84) per share, or 5.05% (0.80/15.84), in a month's time.[2] By maintaining the stock position and selling a 15 call, she still risks the possibility of a stock price decline during the coming month resulting in a realized price lower than the current market price of 15.84. For example, if the PBR share price declined to 10 over the next month, Porto would realize only 10 + 1.64 =11.64 on her covered call position.

An American option premium can be viewed as having two parts: exercise value (also called intrinsic value) and time value.[3]

$$\text{Call Premium} = \text{Time Value} + \text{Intrinsic Value} = \text{Time Value} + \text{Max}(0, S - X)$$

2 Porto's effective selling price of 16.64 is 0.80 higher than the original price of 15.84: 0.80/15.84 = 5.05%.

3 In addition to exercise value, some use the term "economic value" for intrinsic value because it is the value of the option if the investor were to exercise it at this very moment and trade out of the stock position.

In this case, the right to buy at 15 when the stock price is 15.84 has an exercise (or intrinsic) value of 0.84. The option premium is 1.64, which is 0.80 more than the exercise value. This difference of 0.80 is called time value.

1.64 = Time Value + (15.84 − 15)

Someone who writes covered calls to improve on the market is capturing the time value, which augments the stock selling price. Remember, though, that giving up part of the return distribution would result in an opportunity loss if the underlying goes up.

Market Participant #3: Target Price Realization

A third popular use of options is really a hybrid of the first two objectives. This strategy involves writing calls with an exercise price near the target price for the stock. Suppose a bank trust department holds PBR in many of its accounts and that its research team believes the stock would be properly priced at 16 per share, which is only slightly higher than its current price. In those accounts for which the investment policy statement permits option activity, the manager might choose to write near-term calls with an exercise price near the target price, 16 in this case. Suppose an account holds 500 shares of PBR. Writing 5 SEP 16 call contracts at 0.97 brings in 485 in cash. If the stock is above 16 in a month, the stock will be called away at the strike price (target price), with the option premium adding an additional 6% positive return to the account.[4] If PBR fails to rise to 16, the manager might write a new OCT expiration call with the same objective in mind.

Although this strategy is popular, the investor should not view it as a source of free money. The stock is currently very close to the target price, and the manager could simply sell it and be satisfied. Although the covered call writing program potentially adds to the return, there is also the chance that the stock could experience bad news or the overall market might pull back, resulting in an opportunity loss relative to the outright sale of the stock. The investor also would have an opportunity loss if the stock rose sharply above the exercise price and it was called away at a lower-than-market price.

The exposure from the short position in the PBR SEP 16 call can be understood in terms of the Greeks in Exhibit 6. Delta measures how the option price changes as the underlying asset price changes, and gamma measures the rate of change in delta.[5] A PBR SEP 16 call has a delta = 0.516 and a gamma of 0.156. A short call will reduce the delta of the portfolio (S – C) from +1 to +0.484 (= +1[Share] – 0.516[Short Call]). The lower portfolio delta will reduce the upside opportunity. A share price increase of 1 will result in a portfolio gain of approximately 0.484.[6] The delta of the portfolio is not constant. By selling the PBR 16 call, the portfolio is now "short gamma". Remember, gamma is the rate of change of delta. Although the underlying PBR share has a gamma of 0, the short call will make the gamma of the portfolio –0.156. As the price of PBR shares increases above 16, the delta of the PBR call position will change, at a rate of gamma. Gamma is greatest for a near-the-money option and becomes progressively smaller as the option moves either into or out of the money (as seen in Exhibit 8).

Gamma of an ATM option can increase dramatically as the time to expiration approaches. Traders with large gamma exposure (especially large negative gamma) should be aware of the speed with which the position values can change. The change in portfolio delta and gamma for a PBR SEP 16 covered call as a function of share price can be seen in Exhibit 8. As the price of PBR shares increase, the portfolio delta

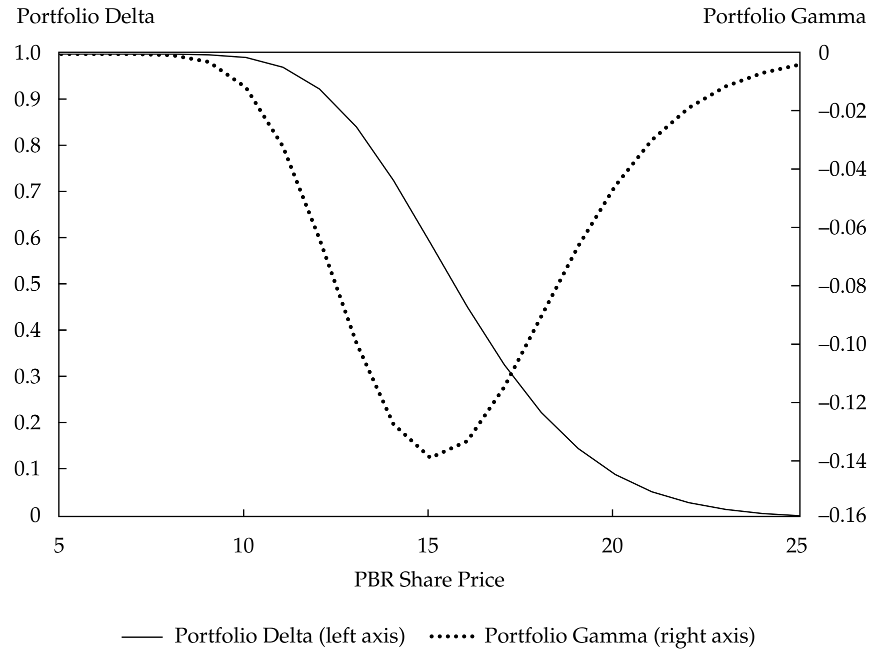
4 Relative to a stock price of 16, the option premium of 0.97 is 0.97/16 = 6.06%.

5 Delta is the calculus first derivative of the option price with respect to the underlying asset price. Gamma is the second derivative of the option price with respect to the underlying asset price.

6 The delta approximates the portfolio price change for very small changes in the underlying price. The delta itself is changing at a rate of gamma. For a change as large as 1%, the actual portfolio value will increase at a rate of less than 0.484 because it is short gamma.

changes at a rate of gamma. As the share price moves above the exercise price of 16, the portfolio (S − C) delta drops at a rate gamma towards its eventual limit of 0, effectively eliminating any remaining upside in the position.

Exhibit 8: Delta vs. Gamma for PBR 16 Covered Call Portfolio



Profit and Loss at Expiration

In the process of learning option strategies, it is always helpful to look at a graphical display of the profit and loss possibilities at the option expiration. Suppose an investor owns PBR, currently trading at 15.84. The investor believes gains may be limited above a price of 17 and decides to write a call against the long share position. The 17 strike calls will have no intrinsic value because the share price is currently 15.84. The investor must now consider the available option maturities (SEP, OCT, and NOV) as shown in Exhibit 6. In deciding which option to write, the investor may consider the option premiums and implied volatilities. Based on the investor's view that volatility will remain low over the next three months, the investor chooses to write the NOV call. At 58.36%, the NOV 17 call has highest implied volatility of the available 17 strike options, so it would be the most overvalued assuming low volatility. The option premium of 1.44 is completely explained by the time value of the NOV option, because the NOV 17 option has no exercise value (Option premium = Time value + Intrinsic value; 1.44 = Time value + Max[0,15.84 − 17]). If the stock is above 17 at expiration, the option holder will exercise the call option and the investor will deliver the shares in exchange for the exercise price of 17. The maximum gain with a covered call is the appreciation to the exercise price plus the option premium.[7]

7 If someone writes an in-the-money covered call, there is "depreciation" to the exercise price, so the difference would be subtracted. For instance, if the stock price is 50 and a 45 call sells for 7, the maximum gain is −(50 − 45) + 7 = 2.

Some symbols will be helpful in learning these relationships:

S_0 = Stock price when option position opened

S_T = Stock price at option expiration

X = Option exercise price

c_0 = Call premium received or paid

The maximum gain is $(X - S_0) + c_0$. With a starting price of 15.84, a sale price of 17 results in 1.16 of price appreciation. The option writer would keep the option premium of 1.44 for a total gain of 1.16 + 1.44 = 2.60. This is the maximum gain from this strategy because all price appreciation above 17 belongs to the call holder. The call writer keeps the option premium regardless of what the stock does, so if it were to drop, the overall loss is reduced by the option premium received. Exhibit 9 shows the situation. The breakeven price for a covered call is the stock price minus the premium, or $S_0 - c_0$. In other words, the breakeven point occurs when the stock falls by the premium received—in this example, 15.84 − 1.44 = 14.40. The maximum loss would occur if the stock became worthless; it equals the original stock price minus the option premium received, or $S_0 - c_0$.[8] In this single unlikely scenario, the investor would lose 15.84 on the stock position but still keep the premium of 1.44, for a total loss of 14.40.

At option expiration, the *value* of the covered call position is the stock price minus the exercise value of the call. Any appreciation beyond the exercise price belongs to the option buyer, so the covered call writer does not earn any gains beyond that point. Symbolically,

$$\text{Covered Call Expiration Value} = S_T - \text{Max}[(S_T - X),0]. \quad (1)$$

The *profit* at option expiration is the covered call value plus the option premium received minus the original price of the stock:

$$\text{Covered Call Profit at Expiration} = S_T - \text{Max}[(S_T - X),0] + c_0 - S_0. \quad (2)$$

In summary:

$$\text{Maximum gain} = (X - S_0) + c_0$$

$$\text{Maximum loss} = S_0 - c_0$$

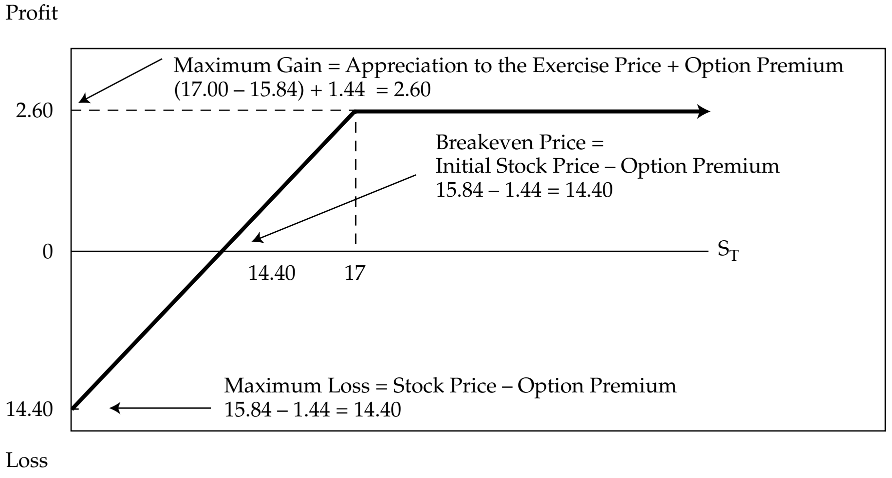
$$\text{Breakeven price} = S_0 - c_0$$

$$\text{Expiration value} = S_T - \text{Max}[(S_T - X),0]$$

$$\text{Profit at expiration} = S_T - \text{Max}[(S_T - X),0] + c_0 - S_0$$

8 Note that with a covered call, the breakeven price and the maximum loss are the same value.

Exhibit 9: Covered Call P&L Diagram: Stock at 15.84, Write 17 Call at 1.44



It is important to remember that these profit and loss diagrams depict the situation only at the end of the option's life.[9] Most equity covered call writing occurs with exchange-traded options, so the call writer always has the ability to buy back the option before expiration. If, for instance, the PBR stock price were to decline by 1 shortly after writing the covered call, the call value would most likely also decline. If this investor correctly believed the decline was temporary, he might buy the call back at the new lower option premium, making a profit on that trade, and then write the option again after the share price recovered.

EXAMPLE 3

Characteristics of Covered Calls

S_0 = Stock price when option position opened = 25.00

X = Option exercise price = 30.00

S_T = Stock price at option expiration = 31.33

c_0 = Call premium received = 1.55

1. Which of the following correctly calculates the maximum gain from writing a covered call?

   A. $(S_T - X) + c_0 = 31.33 - 30.00 + 1.55 = 2.88$

   B. $(S_T - S_0) - c_0 = 31.33 - 25.00 - 1.55 = 4.78$

   C. $(X - S_0) + c_0 = 30.00 - 25.00 + 1.55 = 6.55$

Solution:

C is correct. The covered call writer participates in gains up to the exercise price, after which further appreciation is lost to the call buyer. That is, $X - S_0$ = 30.00 – 25.00 = 5.00. The call writer also keeps c_0, the option premium, which is 1.55. So, the total maximum gain is 5.00 + 1.55 = 6.55.

9 It is also important to note that the general shape of the profit and loss diagram for a covered call is the same as that of writing a put. Covered call writing is the most common use of options by individual investors, whereas writing puts is the least common.

2. Which of the following correctly calculates the breakeven stock price from writing a covered call?

   A. $S_0 - c_0$ = 25.00 − 1.55 = 23.45

   B. $S_T - c_0$ = 31.33 − 1.55 = 29.78

   C. $X + c_0$ = 30.00 + 1.55 = 31.55

Solution:

A is correct. The call premium of 1.55 offsets a decline in the stock price by the amount of the premium received: 25.00 − 1.55 = 23.45.

3. Which of the following correctly calculates the maximum loss from writing a covered call?

   A. $S_0 - c_0$ = 25.00 − 1.55 = 23.45

   B. $S_T - c_0$ = 31.33 − 1.55 = 29.78

   C. $S_T - X + c_0$ = 31.33 − 30.00 + 1.55 = 2.88

Solution:

A is correct. The stock price can fall to zero, causing a loss of the entire investment, but the option writer still keeps the option premium received: 25.00 − 1.55 = 23.45

INVESTMENT OBJECTIVES OF PROTECTIVE PUTS

4

☐ discuss the investment objective(s), structure, payoff, risk(s), value at expiration, profit, maximum profit, maximum loss, and breakeven underlying price at expiration of a protective put position

The protective put is often viewed as a classic example of buying insurance. The investor holds a risky asset and wants protection against a loss in value. He then buys insurance in the form of the put, paying a premium to the seller of the insurance, the put writer. The exercise price of the put is similar to the coverage amount for an insurance policy. The insurance policy deductible is similar to the difference between the current asset price and the strike price of the put. A protective put with a low exercise price is like an insurance policy with a high deductible. Although less expensive, a low strike put involves greater price exposure before the payoff function goes into the money. For an insurance policy, a higher deductible is less expensive and reflects the increased risk borne by the insured party. For a protective put, a lower exercise price is less costly and has a greater risk of loss in the position.

Like traditional term insurance, this form of insurance provides coverage for a period of time. At the end of the period, the insurance expires and either pays off or not. The buyer of the insurance may or may not choose to renew the insurance by buying another put. A protective put can appear to be a great transaction with no drawbacks, because it provides downside protection with upside potential, but let us take a closer look.

Loss Protection/Upside Preservation

Suppose a portfolio manager has a client with a 50,000 share position in PBR. Her research suggests there may be a negative shock to the stock price in the next four to six weeks, and he wants to guard against a price decline. Consider the put prices shown in Exhibit 6; the purchase of a protective put presents the manager with some choices. Puts represent a right to sell at the strike price, so higher-strike puts will be more expensive. For this reason, the put buyer may select the 15-strike PBR put. Longer-term American puts are more expensive than their equivalent (same strike price) shorter-maturity puts. The put buyer must be sure the put will not expire before the expected price shock has occurred. The portfolio manager could buy a one-month (SEP) 15-strike put for 0.65. This put insures against the portion of the underlying return distribution that is below 15, but it will not protect against a price shock occurring after the SEP expiration.

Alternatively, the portfolio manager could buy a two-month option, paying 0.99 for an OCT 15 put, or she could buy a three-month option, paying 1.46 for a NOV 15 put. Note that there is not a linear relationship between the put value and its time until expiration. A two-month option does not sell for twice the price of a one-month option, nor does a three-month option sell for three times the price of a one-month option. The portfolio manager can also reduce the cost of insurance by increasing the size of the deductible (i.e., the current stock price minus the put exercise price), perhaps by using a put option with a 14 exercise price. A put option with an exercise price of 14 would have a lower premium but would not protect against losses in the stock until it falls to 14.00 per share. The option price is cheaper, but on a 50,000 share position, the deductible would be 50,000 more than if the exercise price of 15 were selected.[10]

Because of the uncertainty about the timing of the "shock event" she anticipates, the manager might consider the characteristics of the available option maturities. Given our assumptions, three of the BSM model inputs for the available 15 strike options are the same (PBR stock price 15.84, the strike price 15 and the risk-free rate of interest 4%). The difference in the cost of the SEP, OCT, and NOV options will be explained by the differences in time and the term structure of volatility. The BSM model assumes option volatility does not change over time or with strike price. In practice, volatility can vary across time and strike prices. For the 15 puts, the implied volatility is slightly greater for the NOV option, perhaps reflecting other traders' concerns about a shock event before expiration. Because the PBR stock price is 15.84 and the put options are all 15 strike, all three maturities have no intrinsic value.

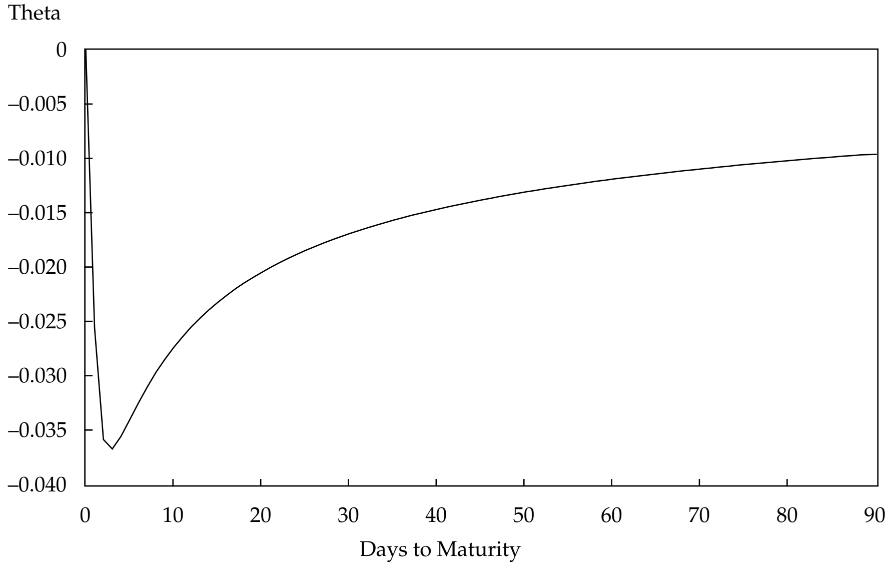
The cost of each PBR 15 strike option is entirely explained by the remaining time value. If the stock price does not fall below 15, the SEP, OCT, and NOV put option values will erode to 0 as they approach their expiration dates. The erosion of the options value with time is approximated by the theta. The daily thetas (Theta/365) for the PBR puts and calls are given in Exhibit 6. Notice, all the theta values in the table are negative. These values approximate the daily losses on the option positions as time passes, all else equal. The NOV 15 put (90 days) has a theta of −0.009 and the SEP 15 put (30 days) has a theta of −0.015. If the NOV 15 option is held for one day, and the price and volatility of the underlying do not change, the put value will decline by approximately 0.009 to approximately 1.45 (= 1.46 − 0.009).

The graph of the BSM theta function for the PBR NOV 15 option as it approaches maturity is shown in Exhibit 10. Notice how the rate of decline changes as maturity approaches. If the PBR price does not drop below 15, the NOV 15 put will expire out-of-the-money and the option price will gradually fall to 0. All else equal, the sum of the daily losses approximated by theta will explain the entire loss of 1.46

10 The deductible is 50,000 × (15.84 − 15.00) with a strike price of 15. With a strike price of 14, the deductible would be 50,000 × (15.84 − 14.00), or 50,000 more.

in option value over that time. The complex shape of the theta graph in Exhibit 10 results from the nature of the BSM theta formula, which includes terms to reflect the probability that the stock price will fall below the strike price during the remaining time. Note that if the price of PBR remains at 15.84 for the last 10 days to maturity, the BSM put option value will erode to 0 at varying rates averaging about −0.03/day. Assumptions of the BSM model explain the negative peak in theta around three days prior to maturity as the remaining time value rapidly decays to 0. Theta values might help the investor decide which maturity to choose. If he were to buy the cheaper SEP put, the daily erosion of value (−0.015) would be greater than for the more expensive NOV put (−0.009).

Exhibit 10: PBR 15 Put Theta over Time



Given the four- to six-week time horizon for the shock event anticipated by the portfolio manager, the OCT put seems appropriate, but there is still the potential to lose the premium without realizing any benefit. With a 0.99 premium for the OCT 15 put and 50,000 shares to protect, the cost to the account would be almost 50,000. One advantage of the NOV option is that although it is more expensive, it has the smallest daily loss of value, as captured by theta. This option also has a greater likelihood of not having expired before the news hits. Also, although the portfolio manager could hold onto the put position until its expiration, she might find it preferable to close out the option prior to maturity and recover some of the premium paid.[11]

11 A price shock to the underlying asset might increase the market's expectations of future volatility, thereby likely increasing the put premium. By selling the option early, the investor would capture this increase. Also, once the adverse event occurred, there may be no reason to continue to hold the insurance. If the investor no longer needs it, he should cancel it and get part of the purchase price back. In other words, he should sell the put and recapture some of its cost.

Profit and Loss at Expiration

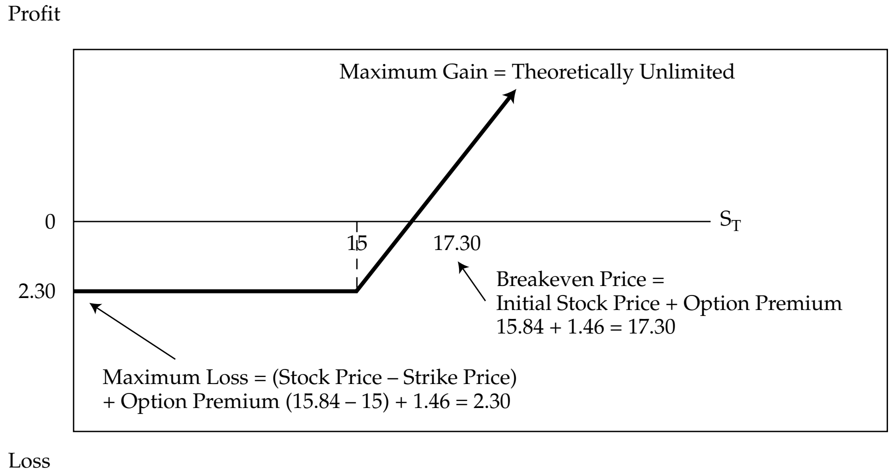
Exhibit 11 shows the profit and loss diagram for the protective put.[12] The stock can rise to any level, and the position would benefit fully from the appreciation; the maximum gain is unlimited. On the downside, losses are "cut off" once the stock price falls to the exercise price. With a protective put, the maximum loss is the depreciation to the exercise price plus the premium paid, or $S_0 - X + p_0$. At the option expiration, the value of the protective put is the greater of the stock price or the exercise price. The reason is because the stock can rise to any level but has a floor value of the put exercise price. In symbols,

$$\text{Value of Protective Put at Expiration} = S_T + \text{Max}[(X - S_T),0]. \quad (3)$$

The profit or loss at expiration is the ending value minus the beginning value. The initial value of the protective put is the starting stock price minus the put premium. In symbols,

$$\text{Profit of Protective Put at Expiration} = S_T + \text{Max}[(X - S_T),0] - S_0 - p_0. \quad (4)$$

Exhibit 11: Protective Put P&L Diagram: Stock at 15.84, Buy 15 Put at 1.46



To break even, the underlying asset must rise by enough to offset the price of the put that was purchased. The breakeven point is the initial stock price plus the option premium. In symbols, Breakeven Price = $S_0 + p_0$.

In summary:

$$\text{Maximum gain} = S_T - S_0 - p_0 = \text{Unlimited}$$

$$\text{Maximum loss} = S_0 - X + p_0$$

$$\text{Breakeven price} = S_0 + p_0$$

$$\text{Expiration value} = S_T + \text{Max}[(X - S_T),0]$$

$$\text{Profit at expiration} = S_T + \text{Max}[(X - S_T),0] - S_0 - p_0$$

12 Note that the profit and loss diagram for a protective put has a shape similar to a long call position, which is the result of put–call parity. Long the asset and long the put is equivalent to long a call plus long a risk-free bond.