CME Group

INTEREST RATES

Treasury Options for Fixed Income Asset Managers

DECEMBER 12, 2013

John W. Labuszewski
Managing Director
Research & Product Development
312-466-7469
jlab@cmegroup.com

Michael Kamradt
Executive Director
International Development
312-466-7473
Michael.kamradt@cmegroup.com

David Reif
Senior Director
Interest Rate Products
312-648-3839
David.reif@cmegroup.com

Fixed income asset managers have many strategic alternatives available to them including the use of spot, futures and option markets in their pursuit of investment value (or "alpha') relative to market benchmarks. CME Group offers 2-year, 3-year, 5-year and 10-year Treasury note futures; as well as "classic" and "Ultra" T-bond futures.

In addition to these highly successful futures contracts, CME Group offers options exercisable for these futures contracts. Similar to the underlying futures, these option contracts offer a high degree of liquidity, transparency, price discovery and are accessible through the CME Globex® electronic trading platform.

This document is intended to provide a review of the fundamentals of CME Group Treasury options; and, a discussion of the ways in which these options may be utilized to manage the risks associated with a Treasury security investment portfolio.

What is an Option?

Options provide a very flexible structure that may be tailored to meet the risk management or "alpha" seeking needs of a portfolio manager. Cash and futures markets offer portfolio managers the opportunity to manage risk and opportunity based upon an assessment of price (or yield) movements. But options offer further opportunities to conform the characteristics of a fixed income investment portfolio to take advantage of additional factors including convexity, the passage of time and volatility.

As a first step, let's get the option basics out of the way. There are two basic types of options – call and put options – with two distinct risk/reward scenarios.

Call option buyers pay a price (in the form of a "premium") for the right, but not the obligation, to buy the instrument underlying the option (in the case of our discussion, a Treasury futures contract) at a particular strike or exercise price on or before an expiration date. Call option sellers (*aka,* option "writers" or "grantors") receive a premium and have an obligation to sell futures at the exercise price if the buyer decides to exercise their right.

Put option buyers pay a price for the right, but not the obligation, to sell a Treasury futures contract at a particular strike or exercise price on or before an expiration date. [1] The seller of a put option receives a premium for taking on the obligation to buy futures at the exercise price if the put buyer decides to sell the underlying futures at the exercise price.

Options may be configured as European or American style options. A European style option may only be exercised on its expiration date while an American style option may be exercised at any time up to and including the expiration date. CME Group offers options on Treasury futures configured in the American style as well as flexible or "flex" options which allow the user to specify non-standardized expirations or strike prices and which may be European style.

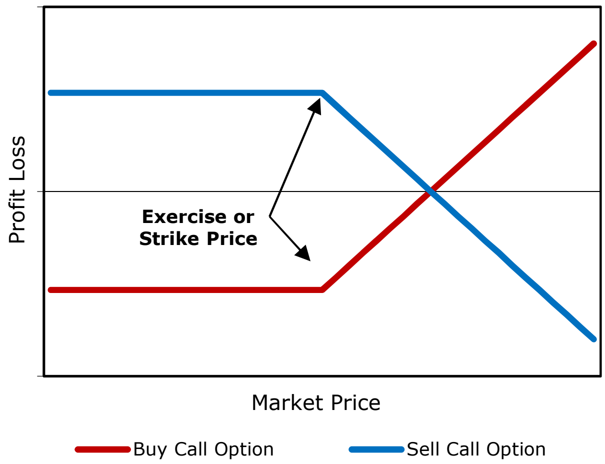
The purchase of a call option is an essentially bullish transaction with limited downside risk. If the market should advance above the strike price, the call is considered "in-the-money" and one may exercise the call by purchasing a Treasury futures contract at the exercise price even when the market rate exceeds the exercise price.

This implies a profit that is diminished only by the premium paid up front to secure the option. If the market should decline below the strike price, the option is considered "out-of-the-money" and may expire, leaving the buyer with a loss limited to the premium.

[1] One must exercise some caution when referring to options on U.S. Treasury futures insofar as these options terminate trading and expire during the month preceding the named month. Specifically, options on Treasury futures terminate trading on the last Friday which precedes by at least 2 business days the last business day of the month preceding the option month. Thus, a "March option" expires in February; a "June option" expires in May; a "September option" expires in August; a "December option" expires in November. The named month is a reference to the delivery period of the futures contract and not to the option expiration month. Note that Treasury futures permit the delivery of Treasury securities on any business day during the contract month at the discretion of the short. By terminating the option prior to the named month, traders are afforded the opportunity to liquidate futures established through an option exercise and avoid the possibility of becoming involved in a delivery of Treasury securities against the futures contract.

The risks and potential rewards which accrue to the call seller or writer are opposite that of the call buyer. If the option should expire out-of-the-money, the writer retains the premium and counts it as profit. If the market should advance, the call writer is faced with the prospect of being forced to sell Treasury futures at the fixed strike price when prices may be much higher, such losses cushioned to the extent of the premium received upon option sale.

Profit/Loss for Call Option



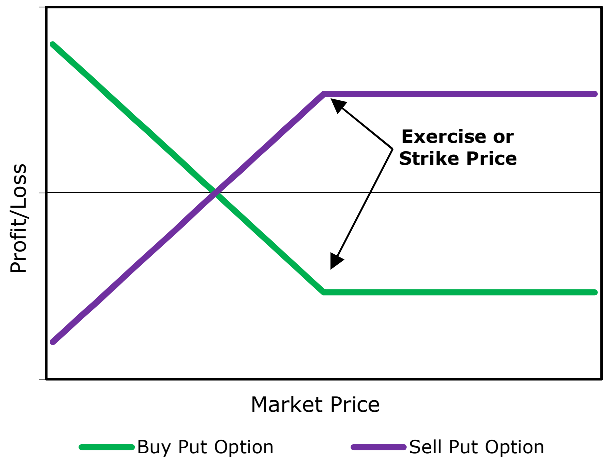
The purchase of a put option is essentially a bearish transaction with limited downside risk. If the market should decline below the strike price, the put is in-the-money and one may exercise the put by selling a Treasury futures contract at the exercise price even when the market price is less the exercise price. If the market should advance above the strike price, the option is out-of-the-money, implying a loss equal to the premium.

The risks and potential rewards which accrue to the put writer are opposite that of the put buyer. If the option should expire out-of-the-money, the writer retains the premium and counts it as profit. If, the market should decline, the put writer is faced with the prospect of being forced to buy Treasury futures at the fixed strike price when prices are much lower, such losses cushioned to the extent of the premium received upon option sale.

While one may dispose of an option through an exercise or abandonment (expiration *sans* exercise), there is also the possibility that one may liquidate a long/short option through a subsequent sale/purchase.

Because of the variety of options which are offered, including puts and calls with varying exercise prices and expiration dates, one may create an almost infinite variety of strategies which may be tailored to suit one's unique needs. Further, one may deploy a combination of options to achieve particular risk management requirements.

Profit/Loss for Put Option



Option Pricing

Option pricing is at once one of the most complicated, but perhaps the most significant, topic which a prospective option trader can consider. The importance of being able to identify the "fair value" of an option is evident when you consider the meaning of the term fair value in the context of this subject.

A fair market value for an option is such that the buyer and seller expect to break even in a statistical sense, *i.e.,* over a large number of trials (without considering the effect of transaction costs, commissions, etc.). Thus, if a trader consistently buys over-priced or sells underpriced options, he can expect, over the long term, to incur a loss. By the same token, an astute trader who consistently buys underpriced and sells over-priced options might expect to realize a profit.

But how can a trader recognize over- or underpriced options? What variables impact upon this assessment? There are a number of mathematical models which may be used to calculate these figures, notably including models introduced by Black-Scholes, Cox-Ross-Rubinstein and Whaley amongst others. Several factors including the relationship between market and exercise price, term until expiration, market volatility and interest rates impact the formula. Frequently, options are quoted in terms of volatility and converted into monetary terms with use of these formulae.

The purpose of this section, however, is not to describe these models but to introduce some of the fundamental variables which impact an option premium and their effect. Fundamentally, an option premium reflects two components: "intrinsic value" and "time value."

Premium = Intrinsic Value + Time Value

The intrinsic value of an option is equal to its in-the- money amount. If the option is out-of-the-money, it has no intrinsic or in-the-money value. The intrinsic value is equivalent, and may be explained, by reference to the option's "terminal value." The terminal value of an option is the price the option would command just as it is about to expire.

When an option is about to expire, an option holder has two available alternatives. On one hand, the holder may elect to exercise the option or, on the other hand, may allow it to expire unexercised. Because the holder cannot continue to hold the option in the hopes that the premium will appreciate and the option may be sold for a profit, the option's value is limited to whatever profit it may generate upon exercise.

As such, the issue revolves entirely on whether the option lies in-the-money or out-of-the-money as expiration draws nigh. If the option is out-of-the-money then, of course, it will be unprofitable to exercise and the holder will allow it to expire unexercised or "abandon" the option.

An abandoned option is worthless and, therefore, the terminal value of an out-of-the- money option is zero. If the option is in-the-money, the holder will profit upon exercise by the in-the-money amount and, therefore, the terminal value of an in-the-money option equals the in-the-money amount.

An option should (theoretically) never trade below its intrinsic value. If it did, then arbitrageurs would immediately buy all the options they could for less than the in-the-money amount, exercise the option and realize a profit equal to the difference between the in-the-money amount and the premium paid for the option.

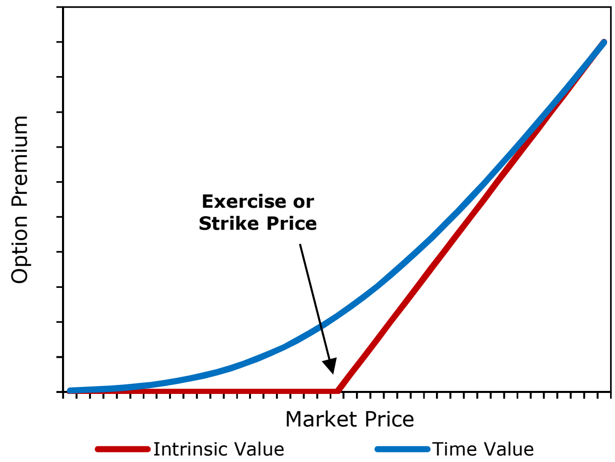
Time Value

An option contract often trades at a level in excess of its intrinsic value. This excess is referred to as the option's "time value" or sometimes as its "extrinsic value." When an option is about to expire, its premium is reflective solely of intrinsic value.

But when there is some time until option expiration, there exists some probability that market conditions will change such that the option may become profitable (or more profitable) to exercise. Thus, time value reflects the probability of a favorable development in terms of prevailing market conditions which might permit a profitable exercise.

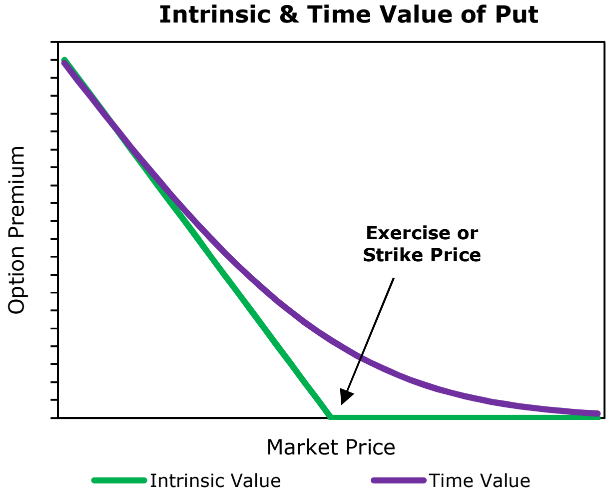
Generally, an option's time value will be greatest when the option is at-the-money. In order to understand this point, consider options which are deep in- or out-of-the-money. When an option is deep out-of-the-money, the probability that the option will ever trade in-the-money becomes remote. Thus, the option's time value becomes negligible or even zero.

Intrinsic & Time Value of Call



When an option trends deep in-the-money, the leverage associated with the option declines. Leverage is the ability to control a large amount of resources with a relatively modest investment.

Consider the extraordinary case where a call option has a strike price of zero. Under these circumstances, the option's intrinsic value equals the outright purchase price of the instrument. There is no leverage associated with this option and, therefore, the option trader might as well simply buy the underlying instrument outright. Thus, there is no time value associated with the option.

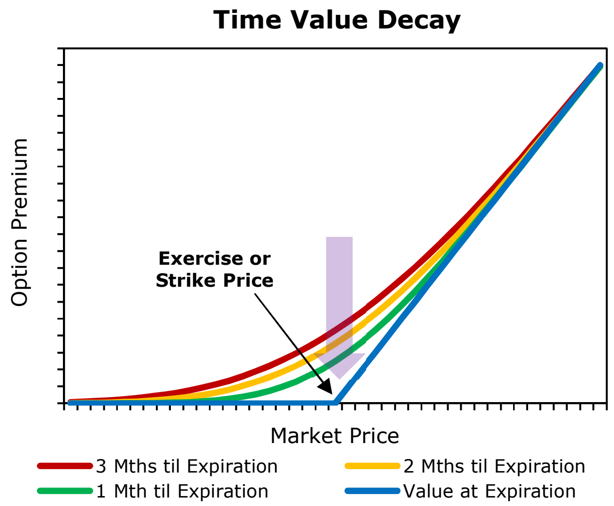


A number of different factors impact on an option on futures' time value in addition to the in- or out-of-the-money amount. These include - (i) term until option expiration; (ii) market volatility; and (iii) short-term interest rates. Options exercisable for actual commodities or actual financial instruments (*i.e.,* not futures or forwards) are also affected by any other cash flows such as dividends (in the case of stock), coupon payments (bonds), etc.

Term until Expiration

An option's extrinsic value is most often referred to as time value for the simple reason that the term until option expiration has perhaps the most significant and dramatic effect upon the option premium. All other things being equal, premiums will always diminish over time until option expiration. In order to understand this phenomenon, consider that options perform two basic functions - (i) they permit commercial interests to hedge or offset the risk of adverse price movement; and (ii) they permit traders to speculate on anticipated price movements.

The first function suggests that options represent a form of price insurance. The longer the term of any insurance policy, the more it costs. The probability that adverse events may occur is increased as a function of the term of the option. Hence, the value of this insurance is greater. Likewise, when there is more time left until expiration, there is more time during which the option could potentially move in-the-money. Therefore, speculators will pay more for an option with a longer life.



Not only will the time value of an option decline over time, but that time value "decay" or "erosion" may accelerate as the option approaches expiration. But be aware that accelerating time value decay is a phenomenon that is characteristic of at- or near-the-money options only. Deep in- or out-of-the-money options tend to exhibit a linear pattern of time value decay.

Volatility

Option holders can profit when options trend into-the-money. If market prices have a chance, or probability, to move upwards by 10%, option traders may become inclined to buy call options. Moreover, if market prices were expected to advance by 20% over the same time period, traders would become even more anxious to buy calls, bidding the premium up in the process.

It is not always easy to predict the direction in which prices will move, but it may nonetheless be possible to measure volatility. Market volatility is often thought of as price movement in either direction, either up or down. In this sense, it is the magnitude, not the direction, of the movement that counts.

Standard deviation is a statistic that is often employed to measure volatility. These standard deviations are typically expressed on an annualized basis. *E.g.,* you may see a volatility quoted at 10%, 15%, 20%, etc. The use of this statistic implies that underlying futures price movements may be modeled by the "normal price distribution." The popular Black Scholes and Black option pricing models are, in fact, based on the assumption that movements in the instrument underlying an option may be described by reference to the normal pricing distribution. The normal distribution is represented by the familiar "bell shaped curve."

To interpret a volatility of 6%, for example, you can say with an approximate 68% degree of confidence that the price of the underlying instrument will be within plus or minus 6% (=1 standard deviation) of where it is now at the conclusion of one year. Or, with a 95% degree of confidence that the price of the underlying instrument will be within plus or minus 12% (=2 x 6% or 2 standard deviations) of where the price lies now at the conclusion of a year. A good rule of thumb is that the greater the price volatility, the more the option will be worth.

One may readily calculate an historic or realized volatility by taking the standard deviation of day-to-day returns in the market of interest. One may sample these returns over the past 30, 60, 90, 180 days or some other period of interest and express the resulting number of an annualized basis. The implicit assumption is that movements over the past X number of days may be reflective of future market movements.

But the aggregate expectations of market participants with respect to future volatility may be at odds with past volatility. Thus, traders often reference "implied volatilities" or the volatility that is implicit in the level of an option premium as traded in the market.

As suggested above, there are various mathematical pricing models available which may be used to calculate the fair value of the option premium as a function of the underlying futures price (U), strike price (S), term until expiration (t), volatility (v) and short-term interest rates (r).

$$Premium = f(U,S,t,v,r)$$

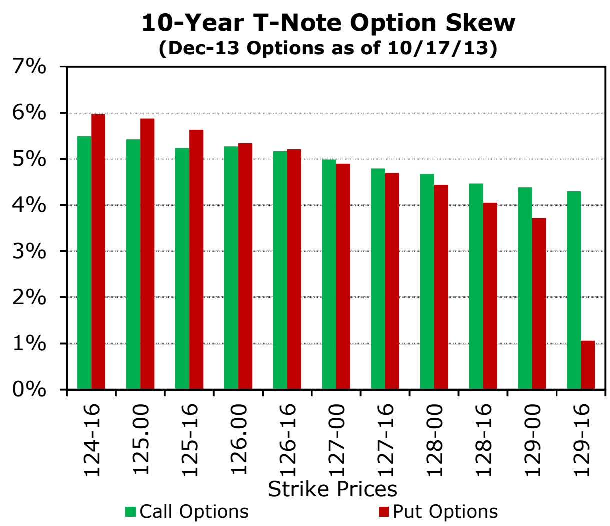
The underlying market price, strike price, term and short-term rates are readily observable. Further, the option premium trading in the marketplace may also be readily observable. This leaves volatility as the least readily observable and most abstract of the necessary variables. But one may solve the mathematical pricing model to find volatility or "implied volatility" as a function of the observed premium and the other variables.

$$v = f(Premium, U, S, t, r)$$

Referring to the table in the appendix below, we note that the implied volatilities (IVs) may be quite different amongst options that share a common underlying instrument and expire on the same date. *E.g.,* the near-the-money 127 December 2013 put had an IV=4.89% while the out-of-the-money 126 put had an IV=5.34%.

Traders frequently impute different values to options based on their subtly different investment attributes. Options on Treasury futures are most heavily utilized by institutional traders who often deploy these options for risk management purposes. They tend to value less expensive out-of-the-money puts as a means of buying price protection as discussed in more detail above. Thus, they may bid up the value of less expensive out-of-the-money puts, particularly where they perceive a high risk of rising rates and falling Treasury prices.

This may create a pattern known as the option skew or "smile" by reference to the fact that the graphic display of this information sometimes resembles a smile.



Treasury rates had been generally drifting higher as of October 2013 with much anticipation that the Treasury might begin to "taper" its quantitative easing programs, leading to higher rates and lower prices.

This is reflected in the skew such that low-struck puts were generally bid up, resulting in higher implied volatilities. Calls with the same strike likewise displayed progressively higher IVs as a result of "put-call parity" phenomenon. [2]

Short-Term Rates

When someone invests in a business venture of any sort, some positive return typically is expected. Accordingly, when an option exercisable for a futures contract is purchased there is an investment equal to the premium. To the extent that the option is paid for up front and in cash, a return is expected on the investment.

This implies that premiums must be discounted to reflect the lost opportunity represented by an investment in options. When the opportunity cost rises, as reflected in the rate at which funds may alternately be invested on a short-term basis, the price of an option is discounted accordingly. When the opportunity cost decreases, the premium appreciates.

These remarks must be qualified by the following considerations. First, the effect described is applicable only to options on futures and not to options exercisable for actual instruments. In fact, rising short-term rates will tend to increase call premiums and decrease put premiums for options exercisable for actual instruments.

Secondly, these remarks apply holding all other considerations equal. But of course, we know that all else is never held equal. For example, if short-term rates are rising or falling, this suggests that bond futures prices will be affected. Of course, this consideration will also have an impact, often much greater in magnitude, than the impact of fluctuating short- term rates.

Delta

When the price of the underlying instrument rises, call premiums rise and put premiums fall. But by how much? The change in the premium relative to the change in the underlying commodity price is measured by a common option statistic known as "delta."

Delta is generally expressed as a number from zero to 1.0. Deep in-the-money deltas will approach 1.0. Deep out-of-the- money deltas will approach zero. Finally at- or near-the-money deltas will run at about 0.50.

It is easy to understand why a deep in- or out-of-the-money option may have a delta equal to 1.0 or zero, respectively. A deep in-the-money premium is reflective solely of intrinsic or in-the-money value. If the option moves slightly more or less in-the-money, its time value may be unaffected. Its intrinsic value, however, reflects the relationship between the market price and the fixed strike price, hence, a delta of 1.0.

Delta
Deep In-the-Money → 1.00
At-the-Money → 0.50
Deep Out-of-the-Money → 0.00

At the other extreme, a deep out-of-the-money option has no value and is completely unaffected by slightly fluctuating market prices. Hence, a delta of zero.

A call delta of 0.50 suggests that if the value of the underlying instrument advances by $1, the premium will advance by 50 cents. A put delta of 0.50 suggests that if the value of the underlying

[2] Put-call parity suggests that if puts and calls of the same strike did not trade with approximately equal IVs, an arbitrage opportunity would arise. The execution of such an arbitrage would cause these IVs to align in equilibrium. Specifically, if a call were to trade significantly "richer" than a put with identical strikes, as measured by their respective IVs, one might pursue a "conversion" strategy. This entails the sale of the call and purchase of the put, creating a "synthetic short futures" position. This is hedged by the simultaneous purchase of futures, effectively locking in an arbitrage profit. A "reverse conversion" or "reversal may be pursued if the put were trading richer than the call with the same strike. This entails the sale of the put and purchase of the call, creating a "synthetic long futures" position. One hedges with the simultaneous sale of futures, locking in an arbitrage profit. Trader will continue to execute these traders until they have restored a market equilibrium and it becomes unprofitable to continue placing these strategies, after considering the attendant transaction costs.

instrument advances by $1, the premium will fall by 50 cents.

Note that the delta of a bullish option, *i.e.*, a long call or short put, is often assigned a positive value. On the other hand, an essentially bearish option, *i.e.*, a long put or short call, is often assigned a negative value. This convention facilitates summation of the deltas of all options in a complex position (based upon the same or similar underlying instrument) to identify the net risk exposure to price or yield fluctuations.

Delta is a dynamic concept. It will change as the market price moves upwards or downwards. Hence, if an at-the-money call starts trending into-the-money, its delta will start to climb. Or, if the market starts falling, the call delta will likewise fall.

The table in our appendix below provides the delta as well as other statistics for a wide variety of options exercisable for 10-Year U.S. Treasury note futures contracts. This data represents intra-day values sampled as of October 17, 2013 in the December 2013 options. [3]

E.g., the at- or nearest-to-the-money December 2013 call option was struck at 127-00/32nds while December 2013 futures was quoted at 126-26+/32nds. It was bid at a premium of 0-45/64ths with a delta of 0.47. This suggests that if the market were to advance (decline) by one point (*i.e.,* 1 percent of par) the premium would be expected to advance (decline) by approximately one-half of a point (holding all else constant).

Thus, delta advances as the option moves in-the-money and declines as the option moves out-of-the-money. This underscores the dynamic nature of delta.

"Greek" Statistics

In addition to movement in the underlying market price (as measured by delta), other factors impact significantly upon the option premium, notably including time until expiration and marketplace volatility.

A number of exotic "Greek" statistics including delta, gamma, vega and theta are often referenced to measure the impact of these factors upon the option premium. Underlying price movement stands out as perhaps the most obvious factor impact option premiums and we have already discussed delta as the measure of such impact. Let's consider other statistics including gamma, vega and theta.

"Greek" Option Statistics

Delta	Measures expected change in premium given change in PRICE of instrument underlying option
Gamma	Measures change in DELTA given change in PRICE of instrument underlying option, *i.e.,* "delta of the delta" measuring CONVEXITY
Vega	Measures expected change in option premium given change in VOLATILITY of instrument underlying option
Theta	Measures expected change in option premium given forward movement of TIME

Gamma may be thought of as the "delta of the delta." Gamma measures the expected change in the delta given a change in the underlying market price. Gamma is said to measure a phenomenon known as "convexity." Convexity refers to the shape of the curve which depicts the total value of an option premium over a range in possible underlying market values. The curvature of that line is said to be convex, hence the term convexity.

Convexity is a concept which promises to benefit traders who purchase options to the detriment of those who sell or write options. Consider that as the market rallies, the premium advances at an ever increasing rate as the delta itself advances. Thus, the holder of a call is making money at an increasing or accelerating rate. But if the market should fall, the call holder is losing money but at a decelerating rate.

[3] Note that 10-year Treasury note futures contracts are based upon a $100,000 face value contract size. They are quoted in percent of par and 32nds of 1% of par with a minimum price increment or "tick" of 1/64th or $15.625 (=1/64th of 1% of $100,000). Thus, a quote of 128-16 represents 128 + 16/32nds or 128.50% of par. A futures quote of 128-165 means 128 + 16/32nds + ½ of 1/32nd. This equates to 128.515625% or par. Options on 10-year Treasury note futures contracts call for the delivery upon exercise of one $100,000 face value 10-year T-note futures contract. They are quoted in percent of par in increments of 1/64th of 1% of par or $15.625 (=1/64th of 1% of $100,000). Thus, one might see a quote of 1-61/64ths which equates to 1.953125% of par.

E.g., on October 17, 2013, the delta for a December 2013 call option on 10-Year T-note futures, struck at 127-00/32nds (essentially at-the-money with December futures trading at 126-26+/32nds) was 0.47. It had a gamma of 0.2535 suggesting that if the underlying futures price were to move upwards (downwards) by 1 percent of par, the value of delta would move upwards (downwards) by about 0.2535.

If the call buyer is making money at an accelerating rate and losing money at a decelerating rate, the call writer is experiencing the opposite results. Gamma tends to be highest when an option is at- or near-to-the-money. But gamma declines as an option trends in- or out-of-the-money.

Theta and vega are likewise greatest when the market is at or reasonably near to the money. These values decline when the option goes in- or out-of-the-money as discussed below. Thus, convexity as measured by gamma works to the maximum benefit of the holder of at-the-money options.

Theta measures time value decay or the expected decline in the option premium given a forward movement in time towards the ultimate expiration date of the option, holding all other variables (such as price, volatility, short-term rates) constant. Time value decay and the degree to which this decay or erosion might accelerate as the option approaches expiration may be identified by examining the change in the theta.

E.g., our December 2013 127-00 call had a theta of -0.0107. This suggests that over the course of one (1) day, holding all else equal, the value of this call option may fall 0.0107 percent of par. This equates to 0.685/64ths (=0.0107 x 64) or about $10.70 per $100,000 face value unit. Thus, the premium is expected to decline from the current value of 0-45/64ths to approximately 44/64ths over the course of a single day, rounding quotes to the nearest integral multiple of the tick size.

Note that we are quoting a theta in percent of par over the course of 1 calendar day. It is also common to quote a theta over the course of seven (7) calendar days. One must be cognizant of the references that are being made in this regard.

Theta is a dynamic concept and may change dramatically as option expiration draws nigh. At- or near-to-the-money options experience rapidly accelerating time value decay when expiration is close. Away-from-the-money options experience less time value decay as in-and out-of-the-money options have less time value than do comparable at- or near-the-money options.

Thetas associated with moderately in- or out-of-the-money options may be relatively constant as expiration approaches signifying linear decay characteristics. Deep in- or out-of-the-money options will have very little or perhaps no time value. Thus, the theta associated with an option whose strike is very much away from the money may "bottom-out" or reach zero well before expiration.

Time value decay works to the benefit of the short but to the detriment of the long. The same options which have high thetas also have high gammas. Convexity as measured by gamma works to the detriment of the short and to the benefit of the long. Near-the-money options will have high thetas and high gammas. As expiration approaches, both theta (measuring time value decay) and gamma (measuring convexity) increase.

Thus, it becomes apparent that you "can't have your cake and eat it too." In other words, it is difficult, if not impossible, to benefit from both time value decay and convexity simultaneously.

Vega measures the expected change in the premium given a change in marketplace volatility. Normally, vega is expressed as the change in the premium given a one percent (1.0%) movement in volatility.

E.g., our December 2013 127 call had a vega of 0.1579. This suggests that its premium of 45/64ths might fluctuate by approximately 10/64ths (=0.1579 x 64) or about $157.90 per $100,000 face value unit, if volatility were to move by 1% from the current implied volatility of 4.99%.

Vega tends to be greatest when the option is at- or reasonably near-to-the-money. In- and out-of-the-money options have generally lower vegas. However, this effect is not terribly great. Note that vega tends to fall, rather than rise, as a near-to-the-money option approaches expiration. This is unlike the movement of theta and gamma which rise as expiration draws near.

Volatility and convexity are highly related properties. This can be understood when one considers that it is only when the market is moving, or when the market is volatile, that the effects of convexity are observed.

Remember that when you buy an option, convexity works to your benefit no matter whether underlying price movements are favorable or not. If the market moves against you, you lose money at a decelerating rate. If the market moves with you, you make money at an accelerating rate. Thus, the prospect of rising volatility is generally accompanied by beneficial effects from convexity (at least from the long's standpoint).

Earlier we suggested that it is generally impossible to enter an option strategy in which both time value decay and convexity worked to your benefit simultaneously. Paradoxically, it may be possible to find option strategies where the prospect of rising volatility and time value decay work for you simultaneously (although convexity will work against you).

This is possible because vega falls as expiration approaches while theta and gamma rise. *E.g.,* one might buy a long-term option experiencing the ill effects of time value decay while selling a shorter-term option which benefits from time value decay. The benefits associated with the short-term option will outweigh the disadvantages associated with the longer-term option. And, the strategy will generally benefit from the prospect of rising volatility as the long-term option will have a higher vega than will the short-term option.

Putting It All Together

Options are strongly affected by the forces of price, time and volatility/convexity. (We often consider convexity and volatility to be one in the same property for reasons discussed above.) "Exotic" option statistics such as delta, gamma, theta and vega are quite useful in measuring the effects of these variables.

As a general rule, when you buy an option or enter into a strategy using multiple options where you generally buy more than you sell, convexity and the prospect of rising volatility work to your benefit. Time value decay generally works against you in those situations. When you sell options or enter into strategies where you are generally selling more options than you buy, convexity and the prospect of rising volatility will work against you although time value decay will work to your benefit.

Earlier we had suggested that essentially bullish options including long calls and short puts are frequently assigned positive deltas. Essentially bearish options including long puts and short calls are likewise often assigned negative values. This facilitates summation of the "net delta" associated with a complex option position (based upon the same or similar underlying instruments).

Likewise, we often attach positive or negative values to gamma, theta and vega. To the extent that rising gammas and vegas benefit long option holders, we assign positive gammas and vegas to long calls and puts; and, negative gammas and vegas to short calls and puts. On the other hand, rising thetas benefit shorts to the detriment of longs. Thus, long puts and calls are frequently assigned negative thetas while shorts are assigned positive thetas.

The key point is that these variables - price, time and volatility - do not operate independently one from the other. Price may generally be considered the most important of these variables and will tend to dictate whether time value decay is more or less important than convexity and rising volatility. One can use this information to good effect when formulating a hedging strategy using options.

Measuring Portfolio Risk

Now that we have established a foundation for understanding the pricing of options, let's explore how options may be used to hedge the risks associated with fixed income investment portfolios. But, just as we measure the risks uniquely associated with options by reference to the "Greeks," we must likewise establish a framework for measuring risks associated with fixed income securities. In the fixed income markets, one generally measures portfolio risk by reference to duration or "basis point value" (BPV).

Duration is a concept that was originated by the British actuary Frederick Macauley. Mathematically, it is a reference to the weighted average present value of all the cash flows associated with a fixed income security, including coupon income as well as the receipt of the principal or face value upon maturity.

E.g., the most recently issued or "on-the-run" 10-year Treasury note as of September 30, 2013 was the 2-½% security maturing August 15, 2023. Its duration was equal to 8.662 years. This suggests that if yields were to advance by 100 basis points (or "bps"), the price of the security should decline by approximately 8.662%.

Basis point value (BPV) is a concept that is closely related to modified duration. The BPV measures the expected change in the price of a security given a 1 basis point (0.01%) change in yield. It may be measured in dollars and cents based upon a particular face value security, commonly $1 million face value. It is sometimes also referred to as the "dollar value of an 01" or simply "DV of an 01."

On-the-Run Treasury Notes & Bonds
(9/30/13)

Tenor	Coupon	Maturity	Modified Duration	BPV (per million)
2-Year	¼%	9/30/15	1.990	$199
3-Year	7/8%	9/15/16	2.915	$294
5-Year	1-3/8%	9/30/18	4.813	$481
7-Year	2%	9/30/20	6.499	$650
10-Year	2-½%	8/15/23	8.662	$861
30-Year	3-5/8%	8/15/43	17.999	$1,789

E.g., the on-the-run 10-year T-note had a basis point value of $861 per $1 million face value unit, as of September 30, 2013. This implies that if yields were to advance by 1 basis point, the price of a $1 million face value unit of the security might decline by $861.

In particular, we compare how futures, puts and calls may be used to hedge a fixed income investment exposure. In the process, we might ask: what hedging strategy is best under what kind of market conditions? In other words, can we select an option strategy which may be well matched to prospective market conditions?

Futures Hedge

In order to provide a comparison of various hedging strategies with the use of options, let us review the efficacy of a short futures hedge against a long Treasury portfolio. This is intended to serve as a "baseline" against which the effect of option strategies may be compared.

Interest rate futures are frequently utilized to hedge, or more specifically, to adjust the average weighted duration of fixed income investment portfolio. In particular, one might increase risk exposure as measured by duration in anticipation of rate declines (price advances); or, decrease duration when rate increases (price decline) are forecast. One may buy futures to extend duration; or, sell futures to reduce duration.

E.g., consider a hypothetical fixed income portfolio valued at $100 million with a weighted average duration of 8 years. In anticipation of increasing rates and declining prices, the asset manager decides to execute a temporary tactical shortening of portfolio duration from 8 years to 6 years.

This may be executed by selling CME Group Treasury note futures. While Treasury futures are available based upon all the major tenures extended out on the yield curve, 10-year Treasury note futures will have an effective duration closest to the current portfolio duration of 8 years. The appropriate number of futures to sell, or the "hedge ratio" (HR), may be calculated using the following formula.

$$HR = \left(\frac{D_{target} - D_{current}}{D_{current}}\right) x \left[BPV_{portfolio} \div \left(\frac{BPV_{ctd}}{CF_{ctd}}\right)\right]$$

Where D_{target} is the target duration; $D_{current}$ is the current duration. CF_{ctd} is the conversion factor of the security that is cheapest-to-deliver against the particular futures contract that is being used. $BPV_{portfolio}$ represents the basis point value of the portfolio. Finally, BPV_{ctd} is the basis point value of the cheapest-to-deliver security. [4]

[4] Treasury note and bond futures contracts permit the delivery of a variety of Treasury securities within a certain maturity window, at the discretion of the short. *E.g.,* the 10-year T-note futures contract permits the delivery of T-notes with a remaining maturity between 6-1/2 to 10 years. This includes a rather wide variety of

E.g., assume that the $100 million portfolio had a BPV equal to $80,000. As of October 17, 2013, the cheapest-to-deliver (CTD) security vs. December 2013 10-year T-note futures was the 2-1/8% coupon security maturing in August 31, 2020. This note had a conversion factor (CF) of 0.7939 with a BPV of $64.40 per a $100,000 face value unit, corresponding to the deliverable quantity against a single futures contract.[5] Using these inputs, the appropriate hedge ratio may be calculated as short 248 futures contracts.

$$HR = \left(\frac{6-8}{8}\right) x \left[\$80{,}000 \div \left(\frac{\$64.40}{0.7939}\right)\right]$$
$$= -247 \; or \; Sell \; 247 \; futures$$

By selling 247 Ten-Year T-note futures against the portfolio, the asset manager may be successful in pushing his risk exposure as measured by duration from 8 to 6 years.

Sell futures → Reduce portfolio risk as measured by duration

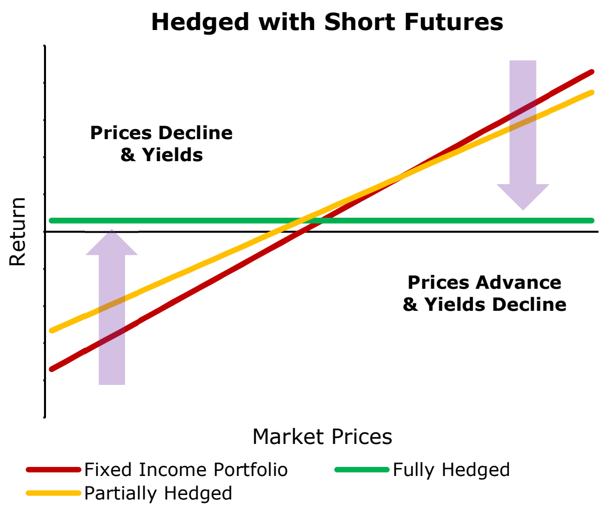
securities with varying coupons and terms until maturity. Because these securities may be valued at various levels, the contract utilized a Conversion Factor (CF) invoicing system to determine the price paid by long to compensate the short for the delivery of the specific security. Specifically, the principal invoice amount paid from long to short upon delivery of securities is calculated as a function of the futures price multiplied by the CF. Technically, CFs are calculated as the price of the particular security as if they were yielding the "futures contract standard" of 6%. The system is intended to render equally economic the delivery of any eligible for delivery security. However, the mathematics of the CF system is such that a single security tends to stand out as most economic or cheapest-to-deliver (CTD) in light of the relationship between the invoice price of the security vs. the current market price of the security. Typically, long duration securities are CTD when prevailing yields are in excess of the 6% futures market standard; while short duration securities are CTD when prevailing yields are less than 6%. It is important to identify the CTD security because futures will tend to price or track or correlate most closely with the CTD.

[5] These relationships are dynamic and subject to constant change. In particular, the BPV associated with any portfolio or security will change of its own accord in response to fluctuating yield levels. As a rule, an asset manager might wish to review the structure of a hedge transaction upon a 20 basis point movement in prevailing yields. Further, the CTD will change as a function of changing yield levels, particularly when prevailing yields are in the vicinity of the 6% futures contract standard which may be regarded as an inflection point of sorts. However, this information may be found at www.cmegroup.com.

If yields advance by 100 bps, the value of the adjusted portfolio may decline by approximately 6% or $6 million. But this is preferable to a possible $8 million decline in value if the asset manager maintained the portfolio duration at the original benchmark duration of 8 years. Thus, the asset manager preserved $2 million in portfolio value.

Of course, the asset manager may readily accomplish the same objective simply by selling off a portion of the portfolio holdings in favor of cash. But Treasury futures tend to be more liquid than the cash markets. Moreover, the futures hedge allows the asset manager to maintain his current holdings while adjusting duration exposures quickly and at minimal costs.

In this example, we assume that the asset manager hedges only a portion of his risk (a "partial hedge"). This assumption is realistic to the extent that the performance of fixed income portfolio managers is often assessed relative to a "benchmark" index. *E.g.,* while there are many suitable fixed income indexes, the Barcap U.S. Aggregate Bond Index stands out as a popular example. Thus, a fixed income portfolio manager may generally conform the characteristics of his portfolio to the benchmark ("core" or "beta" returns) but attempt to enhance returns (or add "alpha") above those benchmark returns.



But the manager may have limited discretion to alter the composition of the portfolio. *E.g.*, assume our portfolio manager has discretion to decrease duration from 8 years to 6 years in anticipation of rising rates; or, to increase duration from 8 years to 10 years in anticipation of falling rates. While the prospect of increasing duration and accepting more risk seems to run contrary to the classic concept of a "hedge," it is nonetheless consistent with the concept of "managing risks" in pursuit of enhanced returns.

In the interest of establishing a "baseline" example, however, consider the possibility of a hedge that reduces portfolio risk to an absolute minimum.

E.g., if the hedging objective was to push duration from 8 to 0 years, *i.e.,* to be "fully hedged," our portfolio manager might have sold 992 futures.

$$HR = \left(\frac{0-8}{8}\right) x \left[\$80{,}000 \div \left(\frac{\$64.40}{0.7939}\right)\right]$$
$$= -986 \; or \; Sell \; 986 \; futures$$

While perhaps not typical in practice, this fully hedged strategy could have been used effectively to push duration to essentially zero. This is analogous to liquidating the longer term securities in the portfolio and replacing them with very short-term money market instruments. As such, the portfolio manager might expect to earn a return that approximates short-term yields.

Buying Protection with Puts

The idea behind the purchase of puts is to compensate loss associated with the potentially declining value of bond prices (rising yields) with the rising intrinsic value of the puts. As market prices decline, puts will go deeper and deeper in-the-money, permitting the put holder to exercise the options for a profit.

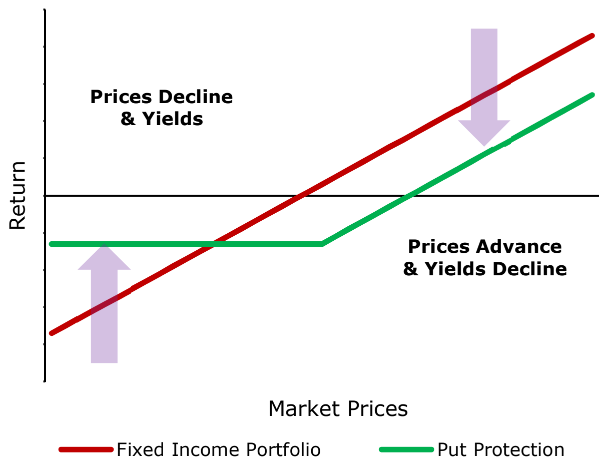
If the market should rally instead, the puts go out-of-the-money. Having paid the option premium up front, however, the put holder's loss is limited to that premium. Any advance in the underlying market price (decline in yields) would represent a profit in the value of the fixed income portfolio, limited only to the extent of the premium forfeit up front to purchase the puts.

E.g., our fixed income asset manager holding a $100 million Treasury portfolio with a duration of 8 years might elect to purchase 986 at-the-money put options. Note that this example assumes that our asset manager buys puts using the "fully hedged" ratio as described above.

If market prices should decline as yields advance, the portfolio suffers a loss. However, that loss is offset to the extent that the long put options are going in-the-money and will permit a profitable exercise at or before expiration. The long puts are exercised by selling futures at the put strike despite the fact that the market has declined below the strike price. If the hedge was ratioed as described above, it is as if the asset manager locked in a "floor price" for his portfolio.

If, on the other hand, the market should advance above the put strike price as yields decline, the options will go out-of-the-money and eventually expire worthless. As such, the asset manager has forfeit the premium paid up front to secure the options. However, this payment may be offset and more by an advance in the portfolio value.

Buying Put Protection



As such, the long put hedge allows one to lock-in a floor return while still retaining a great deal of the upside potential associated with a possibly favorable market swing, limited to the extent that you pay the premium associated with the purchase of the put options up front.

Buy put options → **Lock in "floor return" & retain upside potential**

Option premiums are, of course, impacted by a variety of factors including the movement of price, time and volatility. So while the purchase of put options in the context of a hedging application reduces price risks, it also entails the acceptance of other types of risk uniquely applicable to options. Still, price impact is the foremost of these factors.

The degree to which you immediately reduce price risk may be found by reference to the put delta. In our example above, we assumed that our asset manager buys at- or near-the-money put options with a delta of approximately 0.50. As such, we effectively reduce the immediate or near-term price risk by a factor of about one-half (using the appropriate futures hedge ratio).

But delta is a dynamic concept. If the market falls and the put option goes in-the-money, the delta will get closer to 1.0. If the market rises and the put option goes out-of-the-money, the delta gets closer to zero. An in-the-money put with a delta of 0.60 suggests an effective 60% reduction in price risk while the use of an out-of-the-money option with a delta of 0.40 suggests a 40% reduction in price risk.

The dynamic nature of delta represents convexity. Convexity, or the change in delta quantified by gamma, benefits the holder of a put insofar as it promises more protection in a bear market when you need more protection; and, less protection in a bull market when you would prefer less protection. Unfortunately, you pay for convexity by accepting negative time value decay.

As expiration approaches, a near-to-the-money option will exhibit more and more time value decay or "accelerating" time value decay or erosion. It is interesting that the same options which experience high and rising convexity (near-term, near-the-moneys) also experience high and rising thetas. Barring a mispricing, it is impossible to experience both a positive gamma and theta (change in the premium given the elapse of time) when trading options.

Thus, you must ask yourself whether market conditions are likely to be volatile and, therefore, you should take advantage of convexity by buying options. Or, will market conditions remain essentially stable, recommending a strategy of taking advantage of time value decay by selling options?

Yield Enhancement with Calls

If you believe that the market is basically stable, you might pursue a "yield enhancement" or "income augmentation" strategy by selling call options against a long cash or spot position. This is also known as "covered call writing" in the sense that your obligation to deliver the instrument underlying the option as a result of writing a call is "covered" by the fact that you may already be long the instrument or similar instruments.

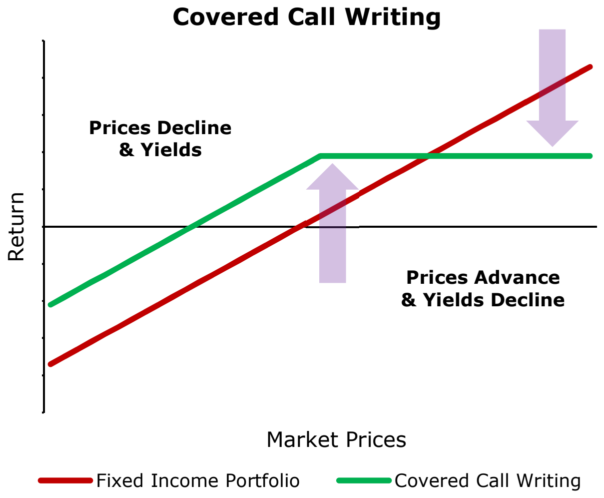
In these examples, of course, we assume that our portfolio manager owns Treasury securities and trades options exercisable for Treasury futures. While Treasury futures call for the delivery of Treasury securities, the two instruments are, of course, different. But to the extent that Treasury securities and futures perform similarly in response to dynamic market conditions, one may be a reasonable proxy for the other. Hence, the term "covered" call writing remains appropriate.

E.g., let's revisit our example of the asset manager who holds $100 million of Treasury securities with an average weighted duration of 8 years. Assume that our manager sells 986 at-the-money call options (using the "fully hedged" futures hedge ratio).

If the market remains stable or declines (on advancing yields) below the strike price, then the short calls fall out-of-the-money and eventually expire worthless. As such, the asset manager retains the full value of the option premium received up front upon sale. The receipt of this premium serves to enhance portfolio returns in a neutral or bear market.

But if the market should advance above the call strike price, the options will go in-the-money. As such, they may be exercised, compelling the asset manager to sell futures at the fixed strike price even though market prices may be trading at higher levels. This implies a loss which offsets the advancing value of the Treasury portfolio.

Still, the initial receipt of the option premium ensures that a positive return is realized nonetheless. Thus, the covered call strategy implies that you lock-in a ceiling return, limiting your ability to participate in any upside potential. The covered call writer is compensated, however, to the extent that he receives the option premium which at least partially offsets downside losses.



While a long put hedge enables you to take advantage of convexity albeit while suffering the ill effects of time value decay. The short call hedge is just the opposite insofar as it allows you to capitalize on time value decay while suffering from the potentially ill effects of convexity.

Sell call options ➔ **Enhances income in neutral market & lock-in ceiling return**

Convexity and volatility are closely related concepts. It is only when the market is volatile, when it is moving either up or down, that the effects of convexity are actually observed. If the market is moving and volatility is rising, the short calls may rise in value, resulting in loss.

If the market should advance, the calls will go in-the-money, the delta approaching 1.0. The growing intrinsic value of the calls presumably offsets profit in the rising value of the cash security resulting in an offset.

Fortunately, this return is positive by virtue of the initial receipt of the option premium. If the market should decline, the calls go out-of-the-money, eventually expiring worthless as the delta approaches zero. Still, the hedger is better off having hedged by virtue of the receipt of the premium up front.

The short call hedge works best when the market remains basically stable. In this case, time value decay results in a gradual decline in the premium. Thus, you "capture" the premium, enhancing yield.

Matching Strategy with Forecast

Note that by buying puts against a long cash portfolio, the risk/reward profile associated with the entire position strongly resembles that of an outright long call. As such, this strategy is sometimes referred to as a "synthetic long call." Likewise, the combination of selling calls against a long cash currency portfolio will strongly resemble the outright sale of a put. Thus, we sometimes refer to this strategy as a "synthetic short put."

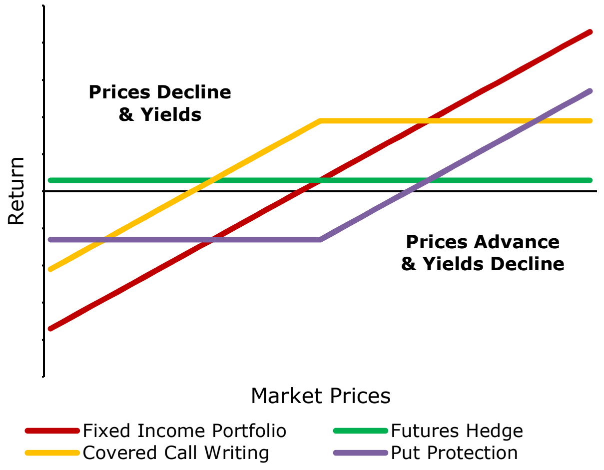
Many textbooks draw a strong distinction between hedging or risk-management and speculative activity. We are not so sure that this distinction is warranted in the context of fixed income portfolio management when the portfolio manager’s objective is to seek enhanced returns over that of some “benchmark” or “bogey,” as opposed to an objective of simply matching the returns on the benchmark on a passive basis.

The same factors which might motivate a speculator to buy calls might motivate a hedger to buy puts against a cash portfolio to generate alpha as yields rise. Likewise, the same factors which might motivate a speculator to sell puts might motivate a hedger to sell calls against his cash portfolio to enhance yield or “alpha” in a stable or low volatility market environment.

How might we define hedging versus speculative activity? Clearly a speculator is someone who might use futures and options in an attempt to make money. A hedger is someone who might use futures and options selectively in an attempt to add alpha and who already holds a cash position. Perhaps this distinction does not conform with the textbooks but it is nonetheless a thoroughly practical distinction.

The conclusion which might be reached from this discussion is that the necessity of making a yield or price forecast is just as relevant from the hedger's viewpoint as it is from the speculator's viewpoint. Which one of our three basic hedge strategies … sell futures, buy puts or sell calls … is best? Clearly, that depends upon the market circumstances.

Hedging Alternatives



In a bearish environment, where the holder of a cash portfolio needs to hedge the most, the alternative of selling futures is clearly superior to that of buying puts or selling calls. In a neutral environment, the sale of calls is superior, followed by the sale of futures and the purchase of puts. The best alternative in a bull market is simply not to hedge. However, if one must attempt to manage risk and generate alpha, the best hedge alternative is to purchase of puts, followed by the sale of calls and the sale of futures.

Matching Hedging Strategy with Forecast

	Bearish	Neutral	Bullish
1	Sell Futures	Sell Calls	Buy Puts
2	Buy Puts	Sell Futures	Sell Calls
3	Sell Calls	Buy Puts	Sell Futures

Note that no single strategy is systematically or inherently superior to any other. Each achieves a number 1, 2 and 3 ranking, underscoring the "alpha generating objective" element in portfolio management and hedging.

In- and Out-of-the-Money Options

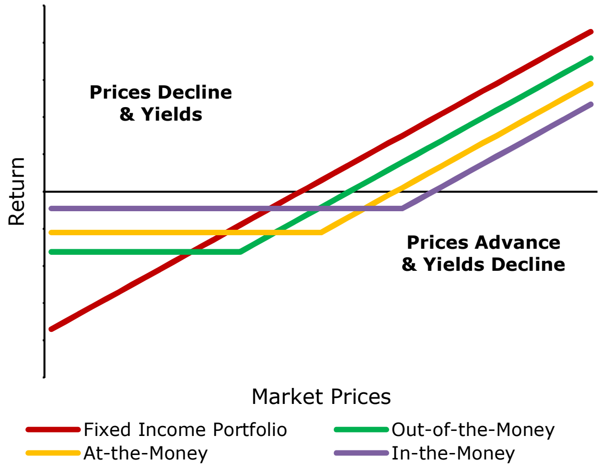
Thus far, we have focused on the use of at- or near-to-the-money options in the context of our hedging strategies. But let us consider the use of in- and out-of-the-money long puts or short calls as an alternative.

As a general rule, you tend to "get what you pay for." The purchase of the expensive in-the-money puts entails a much larger up-front investment but you buy more protection in the event of a market downturn. Thus, rather than buying at-the-money puts, one might have purchased cheaper out-of-the-money puts at a lower strike price; or, more expensive in-the-money puts at a higher strike price.

The purchase of cheap out-of-the-moneys entails a smaller up-front debit to your account. But, you receive less protection in a downturn. The purchase of more expensive in-the-money puts entails a greater up-front debit to the account. But it also provides greater price protection in the event of a market decline.

Long puts allow you to "lock-in" a floor or minimum return. But that floor is only realized at prices at or below the strike price. High-struck in-the-moneys provide protection from higher strike price levels while low-struck out-of-the-moneys provide protection from relatively lower strike price levels.

In-, At-, Out-Money Long Puts

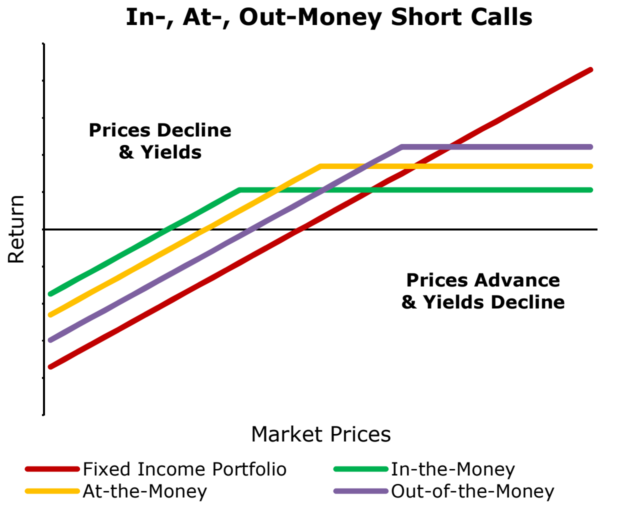


On the other hand, cheap out-of-the-money puts allow you to retain greater ability to participate in possible upward price advances than do the expensive at- or in-the-moneys. Remember that at all prices at or above the strike price, one's returns are restrained by the initial forfeiture of the option premium. The purchase of the expensive in-the-money puts place a greater burden on one's portfolio than do the cheap out-of-the-moneys.

The same general principles may be said to apply to the sale of expensive in-the-money calls vs. the sale of cheap out-of-the-money calls. One receives protection from downside risk by selling calls through the initial receipt of the option premium.

Thus, the sale of more costly low-struck calls implies a greater the degree of protection in a declining market. If market prices should advance above (*i.e.,* yields decline below) the option strike price, short calls go into-the-money and generate losses which offset the increase in the value of the cash securities.

The sale of call options against a long cash portfolio generally is considered appropriate in a low volatility environment. One may sell options to capitalize on time value decay in a stagnant market environment. Clearly, the sale of the at-the-moneys generates the most attractive return when yields remain stable. This makes sense as the at-the-moneys have the greatest amount of time value to begin and experience the greatest degree of time value decay as evidenced by their generally high thetas.



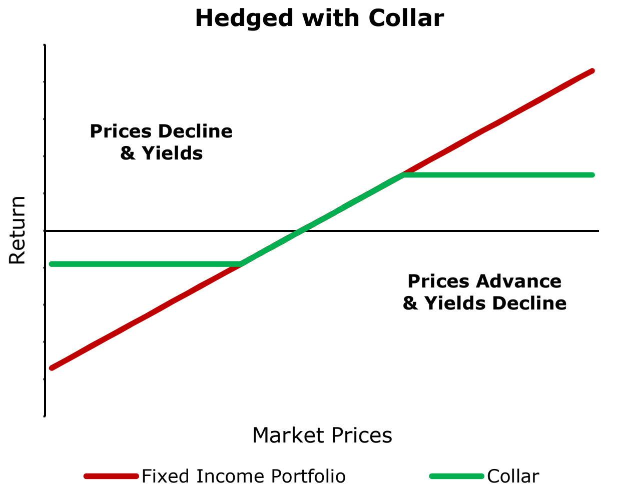
Clearly, the availability of options with different strike prices provides more flexibility, allowing the asset manager very closely to tailor his risk/reward profile with current market forecasts. In particular, one may look for areas of market support or resistance and attempt to structure a hedge which might, for example, provide suitable protection if a market support levels fails to hold.

Collar Strategy

The concept of a long put hedge is very appealing to the extent that it provides limited downside risk while retaining at least a partial ability to participate in potential upside price movement. The problem with buying put options is, of course, the necessity to actually pay for the premium! Thus, some strategists have looked to strategies which might at least partially offset the cost associated with the purchase of put options.

One might, for example, combine the purchase of put options with the sale of call options. If one were to buy puts and sell calls at the same strike price, the resulting risks and returns would strongly resemble that of a short futures position.

As a result, the combination of long puts and short calls at the same strike price is often referred to a "synthetic short futures position." Barring a market mispricing, however, there is no apparent advantage to assuming a synthetic as opposed to an actual futures position as part of a hedging strategy.



But if one were to sell near-to-the money calls and purchase lower struck and somewhat out-of-the-money puts, one could create an altogether different type of risk exposure. This position might allow you to capture some premium in a neutral market as a result of the accelerated time value decay associated with the short calls while enjoying the floor return associated with the long put hedge in the event of a market decline.

On the downside, this strategy limits one's ability to participate in potential market advances. In other words, this strategy entails the elements of both a long put hedge and a short call hedge, *i.e.,* you lock in both a floor and a ceiling return.

Sell calls & buy puts to create collar	→	Locks in floor and ceiling return

A collar is most highly recommended when one has a generally neutral to negative market outlook. There are many variations on this theme including the possibility of buying higher struck puts and selling lower struck calls or a "reverse collar." This strategy might enhance one's returns in a bear market but comes at the risk of reducing one's ability to participate in a possibly upside market move even more severely.

Delta Neutral Hedge

Options are extremely versatile instruments and there are many variations on the risk-management theme. In particular, it is always enticing to attempt to find a way to take advantage of the beneficial effects associated with options while minimizing the unfortunate effects that come as part of the package through a system of active management. Many of these systems rely upon the concept of delta as a central measure of risk and are known as "delta neutral" strategies.

E.g., one may buy put options or sell call options against a long exposure with the intention of matching the net deltas. As an illustration, consider our asset manager holding the $100 million Treasury portfolio with an 8 year duration intent on hedging the risk of falling prices and rising yields. He may elect to sell 986 call options on 10-year Treasury note futures by reference to the futures hedge ratio.

Or, the hedge may be weighted by reference to delta. The appropriate "delta neutral hedge ratio" is readily determined by taking the reciprocal of the delta.

$$Delta\ Neutral\ HR = Futures\ HR\ \div Option\ Delta$$

Consider the sale of 986 at-the-money or near-the-money 127 December 2013 call options with a delta of 0.47. Employing a delta weighted strategy; the hedger might elect to utilize 1,945 options.

$$Delta\ Neutral\ HR = 986\ \div 0.47 = 2{,}098\ options$$

But because delta is a dynamic concept, a delta neutral implies some rather active management. When applied with the use of short options, it offers the benefit of yield enhancement in a stable market environment but this comes at the cost of negative convexity in volatile environments.

I.e., as the market rallies and the calls go into-the-money, the call delta will start to increase, resulting in accelerating losses if no action is taken. Thus, our hedger should reduce the size of the short call position as the market advances.

E.g., if the option delta advances from 0.47 to 0.57, this implies that the hedge ratio will decline to 1,730 positions (= 986 ÷ 0.57). Thus, one might buy-back or liquidate some 368 positions as the market advances.

If the market declines, the calls will go out-of-the-money and the call delta will fall. This too will result in accelerating net losses to the extent that the options will provide increasingly less protection as the market breaks. Thus, our hedger might sell more options on the way down.

E.g., if the call delta declines to 0.37, this implies that the hedge ratio will advance to 2,665 positions (= 986 ÷ 0.37). Thus, one might sell an additional 567 calls as the market declines.

The application of a delta hedge strategy with the use of short calls implies an essentially neutral market forecast. This is intuitive to the extent that the sale of call options implies that one wishes to take advantage of time value decay in an essentially sideways trending market environment.

But sometimes the market does not cooperate. In particular, this strategy entails the risk of whipsaw markets, *i.e.,* the possibility that one buys back positions on the way up and sell more on the way down. Thus, whipsaws may have you buying high and selling low as the market reverses from one direction to the other. The perils of a whipsaw market imply that one might couple this strategy with a diligent effort in creating market forecasting tools specifically to avoid the ill effects of whipsaws.

Instead of the use of call options as part of a delta neutral strategy, one might also consider the purchase of put options.

E.g., one might buy the at-the-money 127 struck December 2013 put options with a delta of -0.54.

Our formula suggests that one might utilize 1,826 options to neutralize one's risk exposure as measured by delta.

$$Delta\ Neutral\ HR = 986\ \div 0.54 = 1{,}826\ options$$

As was the case with our delta neutral short call hedge, we know that the put delta will be sensitive to changing market conditions. If, for example, the market were to decline, the puts will go into-the-money and the delta will increase.

This implies that one might liquidate some of the long puts at a profit to maintain a delta neutral stance. Or, if the market advances, this implies that the put options may go out-of-the-money and the delta will decrease. This may suggest that you purchase more puts, or possibly liquidate a portion of the cash portfolio, to maintain a delta neutral stance.

Unlike the short call strategy, the long put strategy benefits from positive convexity and will generally add alpha during volatile market environments. *I.e.,* as market prices decline (yields rise), put options essentially provide more protection just when you need it most by virtue of the advancing delta.

Or, that the put options will provide less protection as the market advances by virtue of a declining delta at a point. This calls the question - why adjust the hedge ratio when the options are "self-adjusting" in a beneficial way?

Of course, the risk of this strategy is that the market might simply remain stagnant and the hedger is subject to the ill effects of time value decay. As such, the use of long options is a hedging strategy most aptly recommended in a volatile market environment.

Conclusion

While futures contracts represent efficient and effective risk management tools for the fixed income asset managers, options provide additional depth and flexibility.

In particular, options may be integrated into a risk management program, allowing the portfolio manager closely to tailor his risks and rewards to match current market forecasts. As such, options have become an indispensable addition to the risk management repertoires of many of the most astute and successful fixed income portfolio managers.

To learn more about CME Group interest rate products, please visit our website at www.cmegroup.com/trading/interest-rates.

Appendix: Options on 10-Year Treasury Note Futures
(As of 10/17/13)

Month	Put/ Call	Strike	Futures Price	Premium	Implied Volatility	Delta	Gamma	1-Day Theta	Vega
Dec-13	Call	124-16	126-26+	2-31	5.49%	0.86	0.1287	-0.0070	0.0088
Dec-13	Call	125.00	126-26+	2-04	5.42%	0.81	0.1617	-0.0084	0.1097
Dec-13	Call	125-16	126-26+	1-42	5.24%	0.74	0.1964	-0.0096	0.1288
Dec-13	Call	126.00	126-26+	1-20	5.27%	0.66	0.2222	-0.0108	0.1461
Dec-13	Call	126-16	126-26+	0-63	5.16%	0.56	0.2430	-0.0106	0.1570
Dec-13	Call	127-00	126-26+	0-45	4.99%	0.47	0.2535	-0.0107	0.1579
Dec-13	Call	127-16	126-26+	0-30	4.79%	0.36	0.2490	-0.0095	0.1486
Dec-13	Call	128-00	126-26+	0-19	4.67%	0.26	0.2234	-0.0084	0.1304
Dec-13	Call	128-16	126-26+	0-11	4.47%	0.18	0.1866	-0.0059	0.1049
Dec-13	Call	129-00	126-26+	0-06	4.38%	0.11	0.1380	-0.0042	0.0759
Dec-13	Call	129-16	126-26+	0-03	4.30%	0.06	0.0919	-0.0030	0.0496
Dec-13	Put	124-16	126-26+	0-13	5.97%	-0.16	0.1302	-0.0077	0.0972
Dec-13	Put	125.00	126-26+	0-18	5.87%	-0.21	0.1567	-0.0097	0.1150
Dec-13	Put	125-16	126-26+	0-24	5.63%	-0.27	0.1871	-0.0106	0.1318
Dec-13	Put	126.00	126-26+	0-32	5.34%	-0.35	0.2205	-0.0110	0.1475
Dec-13	Put	126-16	126-26+	0-43	5.20%	-0.43	0.2407	-0.0106	0.1562
Dec-13	Put	127-00	126-26+	0-56	4.89%	-0.54	0.2586	-0.0104	0.1587
Dec-13	Put	127-16	126-26+	1-09	4.69%	-0.64	0.2538	-0.0092	0.1489
Dec-13	Put	128-00	126-26+	1-29	4.43%	-0.75	0.2302	-0.0080	0.1275
Dec-13	Put	128-16	126-26+	1-52	4.05%	-0.85	0.1839	-0.0049	0.0931
Dec-13	Put	129-00	126-26+	2-15	3.72%	-0.93	0.1178	-0.0028	0.0547
Dec-13	Put	129-16	126-26+	2-44	1.06%	-1.00	Na	Na	Na
Mar-14	Call	124-16	125-16+	2-09	5.35%	0.61	0.1216	-0.0055	0.2837
Mar-14	Call	125-00	125-16+	1-52	5.23%	0.56	0.1278	-0.0060	0.2915
Mar-14	Call	125-16	125-16+	1-33	5.08%	0.51	0.1330	-0.0051	0.2951
Mar-14	Call	126-00	125-16+	1-15	4.95%	0.45	0.1356	-0.0057	0.2934
Mar-14	Call	126-16	125-16+	0-63	4.78%	0.40	0.1368	-0.0052	0.2855
Mar-14	Put	124-16	125-16+	1-09	5.43%	-0.39	0.1200	-0.0055	0.2841
Mar-14	Put	125-00	125-16+	1-20	5.25%	-0.44	0.1272	-0.0061	0.2923
Mar-14	Put	125-16	125-16+	1-33	5.16%	-0.49	0.1309	-0.0058	0.2944
Mar-14	Put	126-00	125-16+	1-47	5.00%	-0.55	0.1342	-0.0057	0.2934
Mar-14	Put	126-16	125-16+	2-01	5.00%	-0.60	0.1325	-0.0054	0.2925