SEEKING OUTSIZED RETURNS USING AMERICAN OPTIONS

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Abstract: This paper attempts to analyze the viability of four investment strategies using a combination of empirical and theoretical methods. Said investment vehicles include the intraday iron condor, multi-year deep-in-the-money calendar spreads, monthly deep-in-the-money calendar spreads, and the 'flying pratish'. The results of the analysis within show above market returns for the monthly deep-in-the-money calendar spread strategy and negative total returns for each of the remaining three strategies analyzed using theoretical option pricing. Further quantitative analysis using empirically gathered option prices is required to understand the full potential of the intraday iron condor and multi-year deep-in-the-money calendar spreads.

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I. Introduction

In 2015, the Chicago Board Option Exchange (CBOE) published its most recent report highlighting the market for option and other derivative securities. This report showed that in 2015 approximately $592B in contract value was transacted across just over 1B option contracts, up from $202B in 2005 (CBOE, 2015). The growth of this industry has led to many questions surrounding the viability of options as an investment vehicle and what role they might play in a diversified portfolio. Classical economic theory implies that outsized risk-adjusted returns are not possible if a market is operating efficiently as perfectly competitive market participants drive up asset prices until any excess return is dissipated. This paper's goal is to explore whether select option strategies might provide an outsized risk-adjusted return relative to holding 'the market' as measured by the historic returns and simulated future returns generated from buying and holding the S&P 500 index.

While prior papers have undergone similar analysis testing a wide breadth of option strategies for profitability, this paper will expand upon that body of research by exploring four independently developed strategies which appear to be largely unexplored by existing academic literature. The remainder of the paper includes a literature review regarding theoretical option pricing, a suggested framework on how a reader not yet familiar with options might view further analysis, an introduction to the strategies being analyzed, a description of the research methodology, and finally results and concluding statements.

II. Literature Review

The widespread use of options as an investment vehicle has led to the development of a significant body of research both theoretical and empirical by academics and industry professionals alike. Given the extent of existing research surrounding option pricing the intent of this literature review is not to provide a comprehensive summary of all options related research. Rather the intent of this section is to give the reader an understanding of the key theoretical models established in the literature that the empirical modeling in later portions of this paper relies on.

The first person recognized to have conducted research on the pricing of options was a young French financier named Louis Bachelier who wrote the Centenary of Theorie De La Speculation (1900) as his graduate thesis project. In the now famous paper, Bachelier conducts empirical research in which he records transactional data from the French futures and options markets. Using this data Bachelier developed several theories about option valuation including the geometric structure of various contract payoff diagrams, the relations of options to other financial derivatives, and the relation of probability theory to option pricing. Bachelier's work also formally defined a variety of complex option strategies (any option portfolio composed of multiple puts/calls designed to work in tandem) which he tested for profitability using the application of his theoretical pricing model.

After Bachelier's paper is published in 1900, little research is done to expand upon his finding until the 1950's when Paul Samuelson rediscovers the work. Samuelson popularized and expanded upon Bachelier's work, ultimately publishing dozens of papers in the pursuit of developing a comprehensive understanding of option markets. Samuelson and other contemporary thinkers on derivative made several attempts at developing option pricing models, but all required inherently unknowable model inputs such as the expected value of a stock's future stock price – until Fischer Black and Myron Scholes develop the now famous BlackScholes model in 1973.

Black and Scholes (1973) demonstrated the first comprehensive model for valuing a European stock option given only known constants, an underlying stock price, and time. After publishing their findings in the '73 paper in the Journal of Political Economy, the mathematical underpinnings laid out by Black and Scholes were adopted almost universally as the standard for option valuation. At the time, empirical discrepancies observed between Black-Scholes valuations and market prices for options were largely thought to be small and non-material due to historically high transactions cost in that period.

With the Black-Scholes model in place researchers across the nation began to theorize ways to relax some of the assumptions implicit within the Black Scholes model. One such paper was Cox, Ross, and Rubinstein (1979) that developed a discrete time model in which options could be valued using decision trees. This breakthrough not only allowed for easier interpretation, but also served to generalize the Black-Scholes model to American style options. The result was a model for option pricing that is more broadly applicable to modern options markets, and more empirically accurate. While this model has undergone minor adjustments by modern finance researchers, this model is still broadly regarded as an accurate way for determining the value of calls and put options and will serve as the foundation for this paper's empirical analysis.

This paper builds upon existing literature by applying the theoretical pricing model established by Cox, Ross, and Rubinstein (1979) to an artificially recreated 'backtesting' of option portfolios using empirically collected stock market prices dating back to 1993.

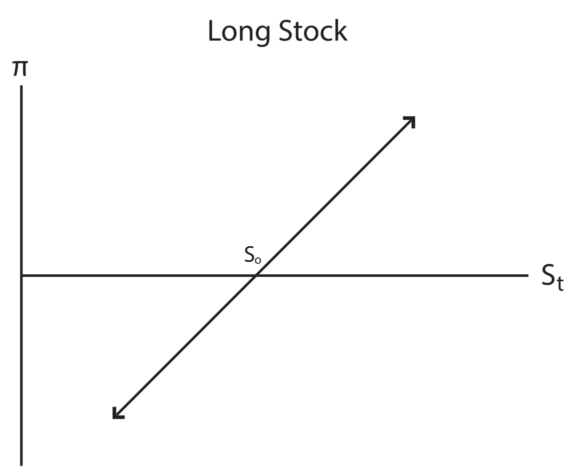
In addition to a backtesting of historic returns, the following analysis will attempt to project expected returns based upon simulated future stock market performance. Again Cox, Ross, and Rubinstein's (1979) model for binomial tree option pricing will be applied in a manner like that described above. However, rather than using empirically collected data, future price levels for the stock market will be generated using simulations. To do so, we will once again return to the literature to find guidance on the simulation process. In Fama (1965), it is theorized and shown empirically that stock market prices tend to fluctuate randomly according to a random walk process. In the following section this paper will seek to build upon this existing body of research by tweaking the approach to more recent empirically tailored model parameters and applying such a simulation process to a theoretical exercise in option markets.

III. Framework for Analyzing Option Strategies

Option contracts are unlike traditional equity investments in that their value is derived not from an asset's earnings, but rather the price of another financial instrument. Additionally, option contracts have other traits that make them fundamentally different from more ubiquitous investment vehicles both in their payoff structures and in the way investors think about them. Thus, for the benefit of the reader, this report will attempt to provide a cursory briefing on how one might approach thinking of options more generally before diving into further analysis.

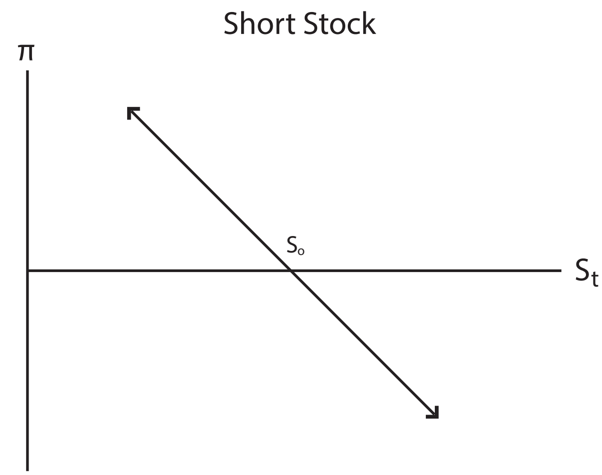
To begin understanding option contracts, one must first learn to conceptualize the underlying financial instruments through the lens of a payoff diagram. At its core a corporation's stock is a right bestowed upon the shareholder to a pro-rata share of all future dividends distributed by the underlying business. This right, like most goods, trades in the market for some price agreed upon by buyers and sellers. Regardless of the price of entry or the underlying business a person purchasing (going "long") this right is effectively purchasing an asset that behaves in such a manner that the owner earns one dollar when the market value of the right appreciates one dollar and loses a dollar for the converse. Formalizing this behavior, one may begin to picture stock ownership as a profit function (π) with market share price at time t (St) as an independent variable. For every non-dividend paying stock (assuming leverage is zero) this profitability function can be generalized to look like a linear function with slope one and an x-intercept of the purchase price (So) as can be seen below in Figure 3.1:

Figure 3.1: Payoff Curve of a Long Stock



When shorting a stock, the shorting party gains one dollar for each dollar the underlying depreciates in value and loses a dollar for the converse. Thus, shorting a stock produces a profit function identical to that of a stock, only multiplied by negative one. This can be seen graphically in Figure 3.2 below:

Figure 3.2: Payoff Curve of a Shorted Stock



Any investment vehicle can be thought of using this kind of graphical analysis, where going long a security gives the investor a defined payoff function and shorting that same instrument gives the negative of that defined function. Crafting a portfolio of investments with the same underlying is the graphical equivalent to vertically summing all the payoff curves owned/shorted within the portfolio. For example, simultaneously going long a stock and shorting the same stock will give an investor a portfolio whose payoff curve is the line $\pi = 0$ since the vertical sum of a long and short stock with identical So is zero (net of transaction costs).

Unlike a stock which is a direct ownership right to an entity's future dividends, an option contract is a right to purchase or sell a stock. There are two fundamental kinds of options that make up all option based strategies – call contracts and put contracts. A call contract is the right, but not the obligation, to purchase an underlying (typically a stock) at a certain price (called the strike price, K) for a certain amount of time (until the "expiration date" when the option expires). A put contract is the same as a call only it is the right to sell rather than buy the underlying security. The value of any option contract is composed of intrinsic value (the value of the option if it is exercised today) and some time value that is positive for all 'American' style contracts (an

‘American’ style contract is one in which the option may be exercised by the option owner at any time before expiration. There are other styles such as ‘European’ style contracts that may only be exercised at the time of expiration, but this paper will only address American style options). The sum of these two values is the price that an option will trade for in the marketplace and what the Black-Scholes and Binomial Tree methodologies discussed in Section II are designed to approximate.

Ultimately, the price of an option will approach intrinsic value as time left to expiration approaches zero. A call option’s intrinsic value is given by the function max(0, St – K). To see why this is the case, imagine an owner of a call option with strike price $10. If the price of the underlying is below $10 then a profit maximizing individual seeking to acquire shares would choose to pay the market price of lower than $10 rather than exercising their option and buying the stock for $10, implying the intrinsic value of the option is zero. Conversely, if the underlying’s price is above $10, then a profit maximizing individual may choose to exercise their option and buy the underlying for $10 rather than acquire shares on the open market for a price greater than $10. In this case, the difference between today’s stock price and the strike price of the option is its intrinsic value.

Like a call, a put option’s intrinsic value can be derived using an equation. However, a put’s value increases as the stock price falls below the strike price rather than above like a call option. To formalize, the intrinsic value of a put contract is equal to max(0,K-St). Given that an American option contract has some non-zero probability of being profitable prior to expiration if there is time left to expiration, a positive time premium is paid by the buyer to incentivize the sale of the contract. To see this generalized for both put and call options, see Figures 3.3 and 3.4 below.

Figure 3.3: Payoff Curve of a Call Option

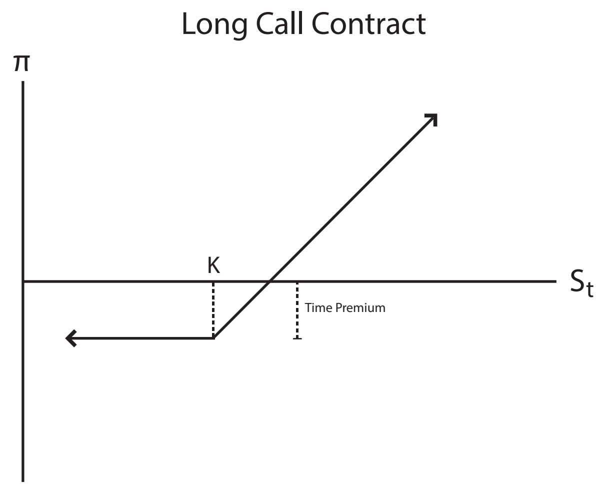
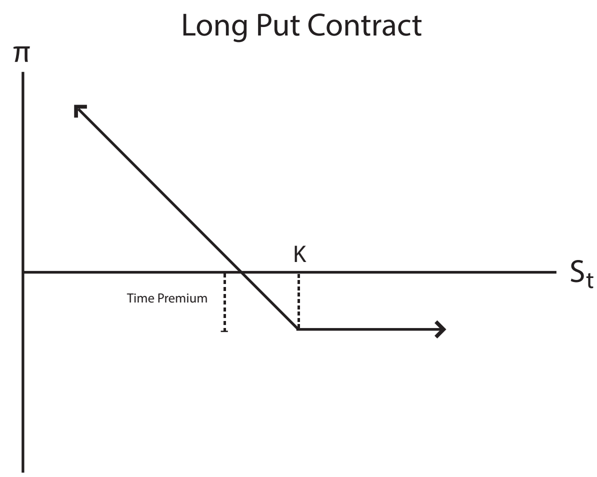


Figure 3.4: Payoff Curve of a Put Option



Note: The payoff curve for a long option is the intrinsic value function shifted downward by the time premium paid at time of purchase.

Most option based strategies can be thought of as portfolios (vertical sums) of these foundational payoff curves acquired/shorted in varying amounts to match the investor's market outlook. While this kind of graphical analysis is not comprehensive, it is helpful to keep in mind when trying to ascertain the market sentiment imbedded within the individual strategies described in the following section.

IV. Conceptual Groundings for Individual Strategy Analysis

With a basic framework for analyzing the conceptual merit of an option strategy established, this section will now describe each of the four strategies empirically tested later in the paper. Starting first with the intraday iron condor, followed by multi-year and monthly deep-in-the-money calendar spreads, and finishing with the flying pratish; each strategy briefing will include an introduction aimed at informing the reader of the investor's sentiment when taking said position, a general description of the strategy's payoff curve, and some key investment risks associated with the strategy.

1. Intraday Iron Condor

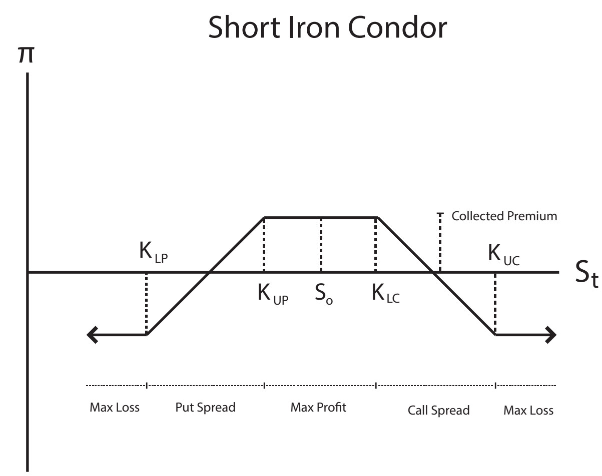
   a. *Strategy Introduction*

      This strategy relies on a perceived market overpricing of near-the-money contracts (an option whose strike price is close to the current market price of the underlying) with less than one day to expiration. The fundamental concept underlying this strategy is that most volatility that occurs in an underlying occurs between trading sessions rather than within them, and that the marketplace has not properly adjusted premiums on contracts with same-day expirations to account for this difference. To capitalize on this hypothesized mispricing, the investor short sells near-the-money contracts that expire on the same day hoping that the contracts will expire out-of-the-money and collected premiums can be retained without further obligation.

   b. *The Payoff Curve*

      By shorting very near-the-money call and put contracts with expirations at the end of the trading day the investor collects premiums with relatively high levels of time decay (called "theta" or the rate at which an option contract's time value is approaching zero), while minimizing the amount of time the underlying has to move beyond the shorted contracts' strike prices. The investor then goes long a slightly further out-of-the-money call and put contract to serve as insurance in the event of against sharp market movements, limiting losses to the level the investor is comfortable with. This hedging effort costs lowers the total amount of premium collected, but provides slightly more stable returns in periods of unexpected volatility. The payoff curve for the intraday iron condor can be seen below in Figure 4.1:

Figure 4.1: Payoff Curve of a Short Iron Condor



Note: The shorted near-the-money contracts are indicated above as K_{UP} and K_{LC}, whereas the longed contracts serving as insurance have strikes of K_{LP} and K_{UC}. In addition to the traditional P/C indicating whether the contract is a put or a call contract, a subsequent subscript designation of "L" is given to the contract with a lower strike price and "U" to the higher strike price for ease of reference.

c. *Investment Risks*

1. The intraday iron condor strategy is "delta" negative, meaning that losses can be occurred if relatively small movements (typically <1%) in

the underlying price occur. This risk is compounded if the trade is entered on a day where macroeconomic news may unexpectedly impact market pricing, or if large market participants decide to enter or exit a trade involving the underlying causing movements in the underlying's price. Taking the following measures can help to mitigate this risk:

- Choosing short contract strikes that are further out-of-the-money when entering the trade will provide a larger safety buffer against intraday stock movements, minimizing the negative impacts of negative delta exposure at the cost of some collected premiums.
- Exiting the strategy prior to the last thirty-to-forty minutes of the trading day may help avoid losses from spikes in volatility which often occur at the end of the trading day. This will eliminate additional exposure to negative delta and lock in any unrealized gains for the day, but will also reduce net premiums and increase transaction costs (relative to holding till expiration).
- Choosing underlying securities that tend to be exposed to fewer intraday swings such as an ETF or an index option may lower the likelihood that contract strikes will be breached. Note that index options are traded as "European" style contracts, so additional analysis may be required.
- Rolling contracts that have been breached (simultaneously purchasing back the iron condor you shorted and short selling another iron condor further out in the future) may allow for

additional premiums to be collected and add time for the investment to move back out-of-the-money prior to expiration.

2. The intraday iron condor is only a partially hedged position and is highly volatile, meaning that when losses are incurred they oftentimes are incurred quickly and are significant. Continual reinvestment of cash flows from successful iterations of this strategy may ultimately hurt total portfolio returns as losses incurred in one period may fully wipe out investor capital. This risk may be partially mitigated by leaving a portion of the portfolio value uninvested to continue strategy operation in the event of a significant loss.

2. Multi-Year Deep-in-the-Money Calendar Spread

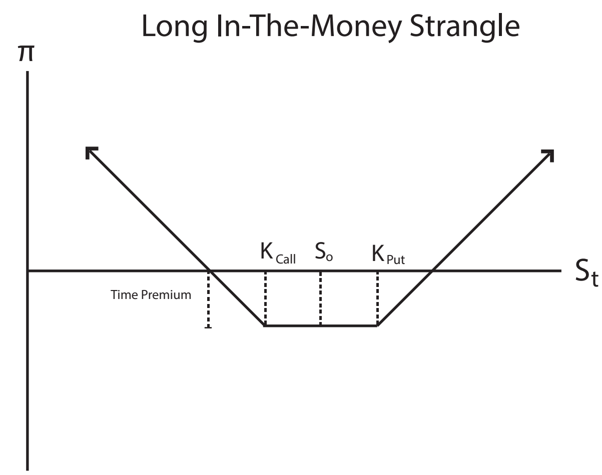
a. *Strategy Introduction*

The fundamental concept underlying this tactic is that time decay of short-term options is much greater than that of long-term options, and that this discrepancy can be exploited by purchasing long term contracts and shorting short term contracts of the same style. As part of the strategy the investor goes long a deep-in-the-money 'strangle' contract whose expiration is far out into the future and periodically shorts an out-of-the-money 'strangle' whose expiration is relatively close (~15-45 days). Each strangle contract is composed of one call and one put contract which are either purchased or short-sold together to create the following payoff curve.

b. The Payoff Curve

Typically, a long strangle contract is acquired by purchasing one out-of-the-money call and one out-of-the-money put. Time premium aside, this investment gives the owner of the strangle positive profits should the underlying's value depreciates below the strike of the put contract or if it appreciates above the long call strike. The payoff curve for a long deep-in-the-money straddle operates similarly, however both purchased contracts are in-the-money and thus positive profits will not be achieved until the underlying's price appreciates above the put strike or conversely below the call strike (the reverse of an out-of-the-money strangle). This can be observed below in Figure 4.2.

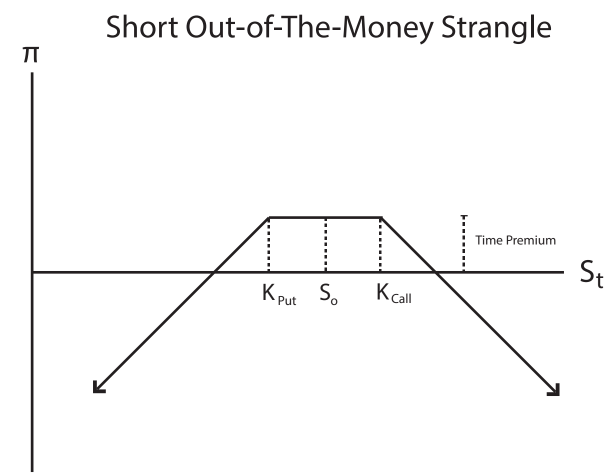
Figure 4.2: Payoff Curve of a Long Deep-in-the-Money Strangle



Note: The long call strikes (Kcall) lie below the current market price (So) while put strikes (Kput) are above implying that the contracts purchased are in-the-money.

Since the investor is going long deep-in-the-money contracts (the actual "depth" varies by contract expiration and volatility of the underlying asset, but is generally considered 20% or greater in-the-money), the time premium costs associated acquiring these contracts are low relative to going long an out-of-the-money strangle. While these long contracts have potential for future positive gains if the underlying stock happens to move far beyond market expectations in one direction or the other, the strategy's intent in owning this payoff curve is not to make positive returns. Rather the intent is to have these contracts serve as protection against large, sudden movements in the underlying's price while the investor short-sells out-of-the-money strangles every 15-45 days. This allows the investor to collect high time premiums from shorting out-of-the-money strangles while minimizing the cost associated with other methods of hedging. To see the payoff curve for the shorted out-of-the-money strangle, see Figure 4.3 below:

Figure 4.3: Payoff Curve of a Short Out-of-the-Money Strangle



Note: The short call strike (Kcall) are above the current market price while put strikes (Kput) are below implying that the contracts shorted are out-of-the-money.

c. Investment Risks

1. The largest risk for this strategy is that it is "gamma" negative. This means the strategy is subject to losses in the event of large, short-term, price jumps. This is particularly true if executing this strategy on individual corporate securities. Taking the following measures can mitigate this risk:
    - Operating the strategy exclusively on ETF options that are not prone to significant price jumps, or, if execution on individual stocks is desired, then not short selling during periods of high volatility such as earnings. Index

options would provide a tax-advantaged way of reducing gamma exposure, but require large amounts of starting capital relative to ETF options.

- Bringing long-term contract strikes closer to one another. Although this will come at additional time value costs, it will add positive gamma into the portfolio. It is important to note, however, that the magnitude of this positive gamma shift will be lessened the further out the contract expiration is.
- Moving short sale contract strikes further out from the underlying's current market price. Since further out-of-the-money contracts have lower gamma levels, moving shorted positions further out will reduce the magnitude of the portfolio's negative gamma component. This will reduce gamma exposure, but will come at the cost of decreasing theta (profits collected from the time decay of options).
- Instead of utilizing a 'naked' short sale strategy, sell call/put spreads (purchase puts/calls that are slightly further out-of-the-money in addition to shorting near-the-money puts/calls) against the hedged position. While this will eliminate most of this strategy's exposure to gamma it comes at the cost of decreased premium collections, increased transaction costs, and decreased ease of rolling contracts.

2. This strategy is theta negative, meaning that this set of contracts benefits from time decay. Theta is positively related to implied volatility and as such significant decreases in implied volatility will decrease the ability of this strategy to capitalize on time decay, lowering expected return.

3. Deep-in-the-money contracts are typically much less liquid than options near or out-of-the-money. Since this strategy relies on deep-in-the-money contracts, immediate liquidation in the case of an investor wanting to withdraw capital may be difficult. While liquidity risk is mostly mitigated by the fact that American-style options can be exercised at any time, losses from liquidation may be incurred in the following scenario: 1) liquidation is desired soon after initial capital deployment 2) liquidity in the market for deep-in-the-money options has seized up and 3) the investor has positive time value imbedded in the initial purchase of long-term contracts.

3. Monthly Deep-in-the-Money Calendar Spread

a. *Strategy Introduction*

This strategy is identical in nature to the multi-year deep-in-the-money calendar spread strategy, with the exception that the long strangle contracts are purchased monthly rather than every few years and shorted contracts are sold every two or three days rather than every fifteen to forty-five days. The intent behind this alteration is to minimize total capital expenditure required to acquire the long strangle contracts as shorter duration in-the-money contracts do not have to be as "deep" as longer term contracts to have time premiums approach zero. This allows the investor to either improve strategy level profits by acquiring more long contracts to serve as collateral against additional shorted strangles or to diversify their portfolio by allocating non-expended capital in another investment strategy.

b. *The Payoff Curve*

The payoff curves associated with this strategy are structurally similar as the multi-year deep in-the-money calendar spread, although it is important to note that given the shorter-term duration of the contracts both the call strike and the put strike will be closer in absolute difference to the current stock price.

c. *Investment Risks*

1. The investment risk associated with this strategy again follows the multi-year deep in-the-money calendar spread strategy, with one additional risk factor. Given the shorter timeframe of the investment strategy, rolling in the event of a contract strike breach is made more difficult. This is because less time value can be accrued when rolling a close-to-expiration contract to a short-term contract (2-3 days out) than a close-to-expiration contract to an intermediate term contract (15-45 days out). This inability to roll is further worsened once a contract has been breached since time premiums on short duration in-the-money options approach zero much faster than intermediate term options, further reducing premiums when rolling.

4. Flying Pratish

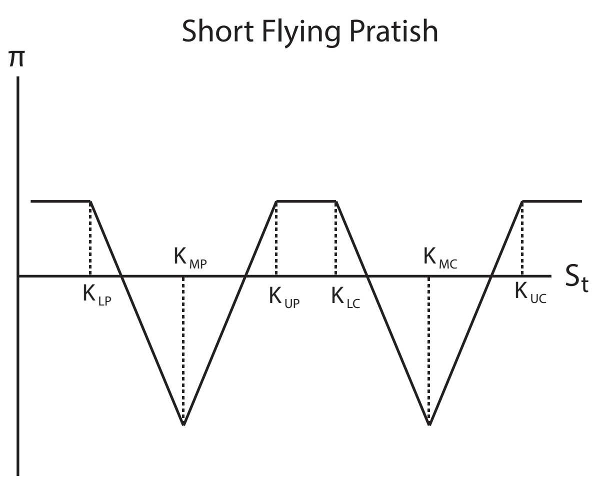
a. *Strategy Introduction*

The flying pratish allows an investor to profit from the idea that underlying stock prices tend to be stable in most periods, and that if prices are unstable they tend to be highly (as opposed to moderately) volatile. The investor attempts to capitalize on this belief by shorting two ‘butterfly’ contracts which are composed of a combination of six total option contracts.

b. *The Payoff Curve*

The flying pratish is composed of two short butterflies crafted from out-of-the-money calls and out-of-the-money puts. The call butterfly contract is created by shorting one near-the-money call, purchasing two slightly further out-of-the-money calls, and finally shorting one last out-of-the-money call. The same is done for the put butterfly using out-of-the money put contracts. The resulting payoff curve is one that earns positive profits if the underlying stays close to the current share price or if the underlying moves far from the current price, but returns negative earnings if the option contract expires with the underlying share price between those two end states. This payoff curve can be seen below in Figure 4.4:

Figure 4.4: Payoff Curve of a Short Flying Pratish



Note: Similarly to the iron condor trade, additional subscript designations of "L", "M", and "U" are given to each call/put contract for ease of depiction. "L" and "U" again represent the lowest and the highest strike price within that individual contract type, while the additional "M" designation represents the contracts whose strike price lies between the "L" and "U" designated strikes.

c. *Investment Risks*

1. Like the iron condor the flying pratish is delta negative, meaning that it is exposed to losses if the stock price moves moderately. This may be partially mitigated by minimizing the distance between the lower, middle, and upper strikes on either the call or the put butterfly, however this will come with lower collected premiums.
2. The flying pratish is difficult to roll in the event of a loss without infusing the strategy with additional capital. This increases the probability that losses incurred on an unrealized basis will ultimately be realized. Like the iron condor, this risk may be partially mitigated by keeping additional capital on hand to continue the investment in the event of a loss period.

V. Data and Methodology

To estimate historic returns for each of the four identified strategies a hybrid approach consisting of empirically gathered underlying price movements and theoretical option pricing is employed. In order to accomplish this simulation the following data was gathered: historic price movement of the underlying stock every fifteen minutes (for our purposes an exchange traded fund designed to track the S&P 500, SPY, was used), historical standard deviation of the S&P 500 index used to measure volatility of the underlying, historic dividend rate of the underlying, and the historic risk free rate as measured by the yield on the one year United States Treasury Bill. With this information dating back to 1998 (the earliest date for which complete data was available), the research team could synthetically recreate what option pricing may have been in each period using the theoretical binomial tree methodology laid out in Cox, Ross, and Rubinstein (1979).

To do this the following method is applied and repeated for all time periods to generate historic returns. Firstly, historic stock market returns, volatility levels, dividend rates, and treasury yields are collected and stored as vectors. One hundred step CRR binomial trees are then used to determine the theoretical market price of options at time of entry as determined by the strategy undergoing testing. With option pricing at entry determined, the positions are held until an exit trigger occurs and another set of one hundred step CRR binomial trees are used to again value the option portfolio. At the time of an exit event, positions are liquidated or allowed to expire (whichever is applicable in that time period) and portfolio value is recorded. Once all iterations of the backtest are finalized the array of portfolio values generated by the process can then be analyzed to determine key investing metrics such as total portfolio return, risk adjusted returns, etc.

Part of the analysis process involved simulation of future stock returns and evaluation of each individual strategy in differing macroeconomic environments. To accomplish this simulation a version of the 'random walk' process outlined in Fama (1965) was used to simulating randomized underlying (SPY) returns. This process involves taking the underlying's current trading price (assumed to be $240 – approximately the current market price of SPY) and moving the price level up or down through each simulated period based on the value of a independent random variable. Each independent random variable is generated from a uniform distribution bounded contained on the interval [0,1] and then normalized using one of three differing distributional assumptions. All the distributional assumptions are normal in shape with an annualized mean return of 8% (based on the historic return of the S&P 500), but each has a different annualized volatility (a low case with 20% annualized volatility, a mid case with 40%

annualized volatility, and a high case with 80% annualized volatility). To see what one of these randomly generated paths see Figures 5.1, 5.2, and 5.3 below:

Figure 5.1: Sample SPY Simulation Path (Low-Volatility Scenario)

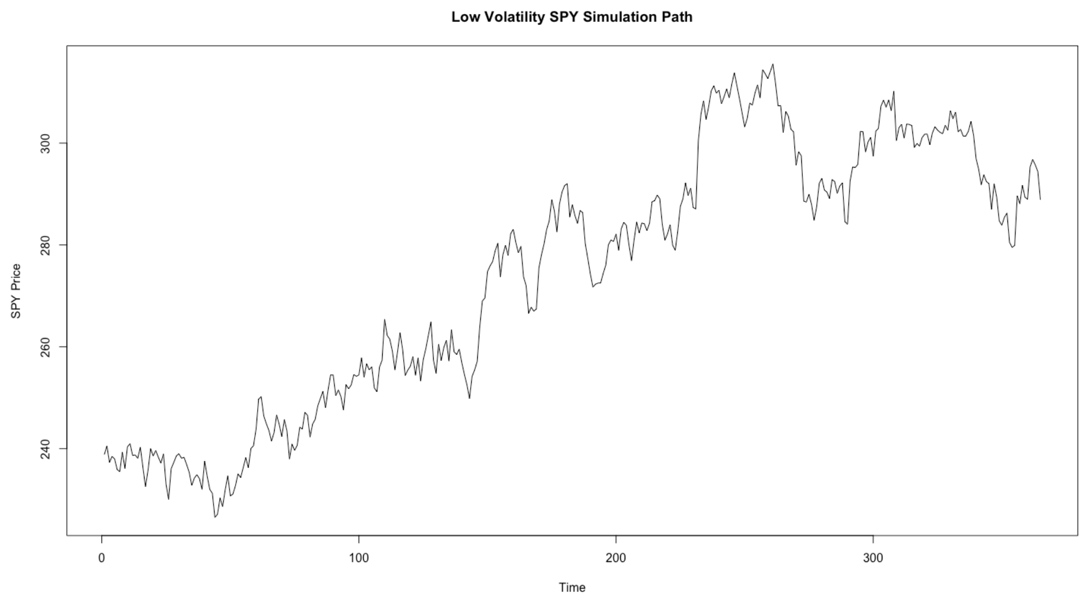


Figure 5.2 Sample SPY Simulation Path (Mid-Volatility Scenario)

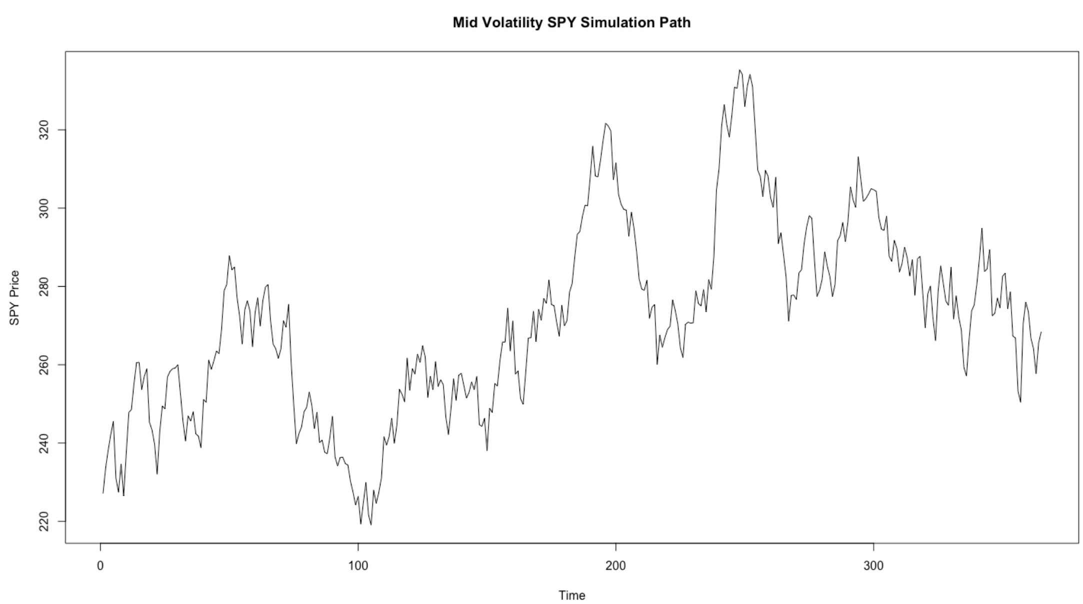
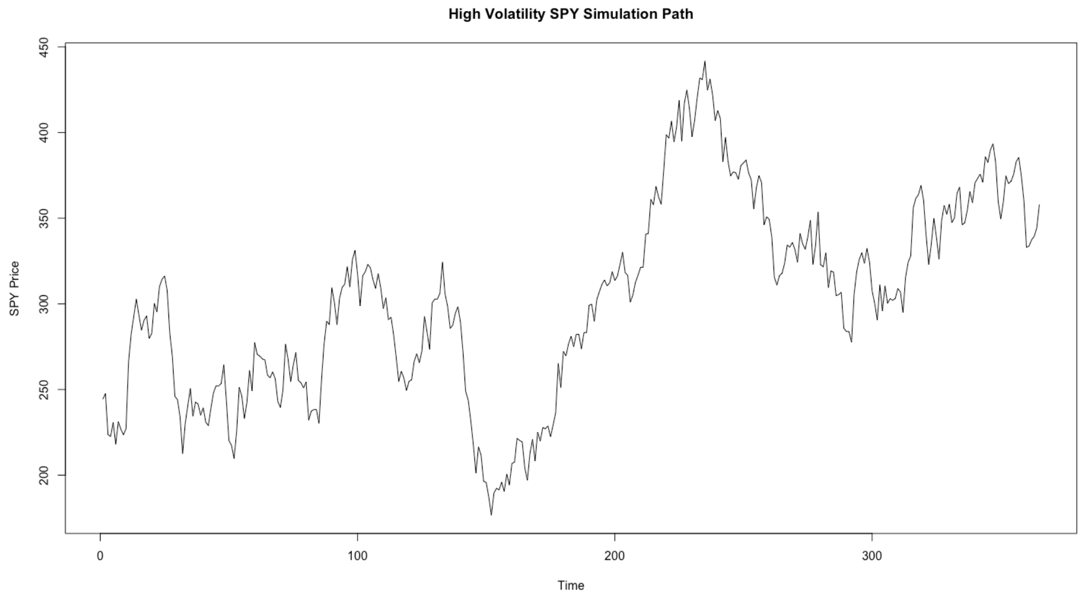


Figure 5.3 Sample SPY Simulation Path (High-Volatility Scenario)



Once a single path is created for each of the three distributional scenarios, the process is repeated until 3 sets of 100 randomly simulated SPY paths were developed. Then the backtesting methodology described earlier in this section is applied to the newly generated SPY price paths to generate potential future returns underneath each of the strategies. This is done for each of the strategies being tested, with the exception of the intraday iron condor that was not tested in this manner due to the research team's limited access to computational power*. The results of the quasi-empirical backtesting and subsequent return analysis are described in the following section.

*Due to the high granularity of 15-minute level trading data, there are over 232,000 observations in the dataset required to backtest the intraday iron condor. Given that each observation requires multiple binomial trees to be structured with 1,000s of individual calculations per tree it quickly became impractical to iterate through simulated paths for this particular strategy.

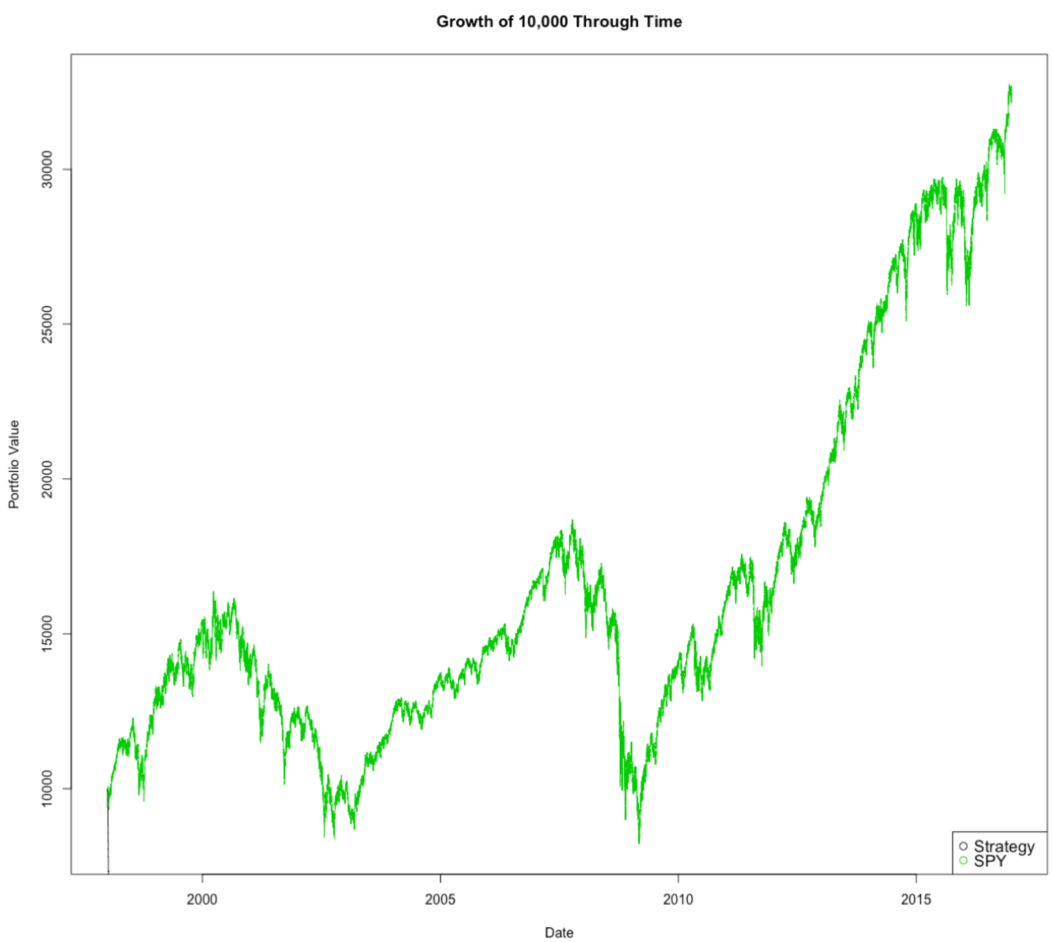
VI. Results

The general results of the historic backtesting process and subsequent portfolio analysis are described below by strategy.

1. Intraday Iron Condor

When backtested using historic underlying data and theoretically generated option prices, the intraday iron condor strategy failed to generate premiums large enough to overcome transaction costs associated with entering into the position. Thus underneath this evaluative model, positive returns are only possible if the investor has access to a marketplace with minimal-to-no transaction fees. To see the estimated returns of $10,000 invested in the iron condor strategy relative to buying-and-holding SPY, please see Figure 6.1 below:

Figure 6.1: Growth of $10,000 – Intraday Iron Condor v. SPY



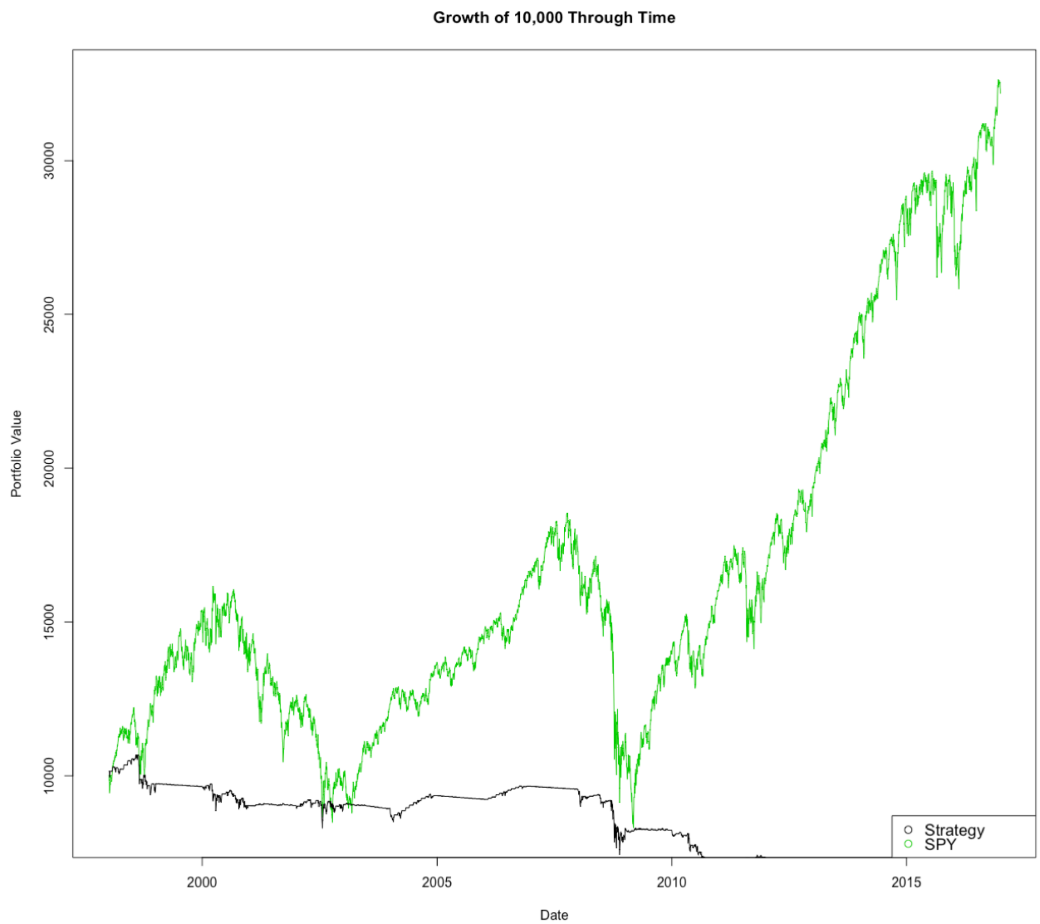
Note: Please note that the intraday iron condor's portfolio value quickly descends to zero as transaction costs overcome collected premiums in each period.

While the model does not produce positive returns due to low calculated premiums, this does not imply that the iron condor strategy itself is incapable of producing outsized returns as the model framework used to evaluate the strategy may have been flawed in approach. In just over 96.4% (7,004/7,626) of periods analyzed the iron condor trade was found to have expired out-of-the-money (within its maximum profit range). Given this large number of periods in which the iron condor strategy out-of-the-money, it may be that the strategy will produce positive returns if theoretical option pricing is underestimating the market clearing price observed empirically. If this is found to be the case, further exploration of the intraday iron condor will be necessary to fully evaluate the strategy's ability to produce outsized returns.

2. Multi-Year Deep In-the-Money Calendar Spread

Unlike the iron condor trade, the multi-year deep in-the-money calendar spread strategy generated positive net premiums after adjusting for empirically observed transaction costs. However, like the iron condor this strategy's portfolio value also provided negative returns. To see the growth of $10,000 invested in the multi-year deep in-the-money calendar spread strategy relative to buying-and-holding SPY please see Figure 6.2 below:

Figure 6.2: Growth of $10,000 – Multi-Year Deep-In-The-Money Calendar Spread v. SPY

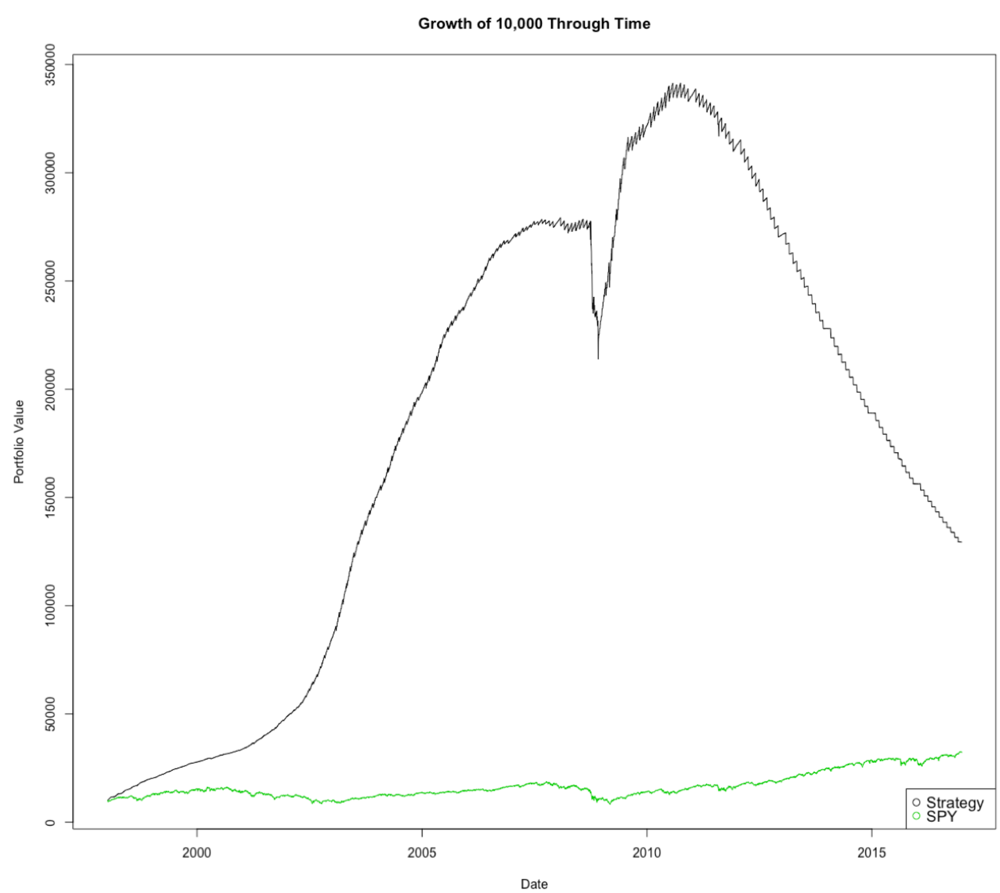


Upon further investigation into the strategy, including analyzing the portfolio's returns underneath simulated future conditions, the strategy was found to underperform largely due to the "inflexibility" of the 1-month shorted contracts. What is meant by the term "inflexibility" in the contracts is that the strategy only allows for adjustment of the shorted contracts' strike prices on a monthly basis (upon expiration), which does not allow the investor to react quickly enough to respond to shifts in the underlying's price. While this inflexibility is somewhat offset by increases in premiums collected, it appears that this increase in collections is not enough to generate positive returns. This problem is further exacerbated in simulated paths with medium-to-high volatilities, when movements in underlying are larger in magnitude and occur more quickly than in low volatility periods. Prior analysis conducted within this paper mentioned potential methods for hedging this "jump" risk (negative gamma risk), and further quantitative analysis is required in order better understand how this strategy might perform when augmented with risk-mitigating measures.

3. Monthly Deep In-the-Money Calendar Spread

While the multi-year deep in-the-money calendar spread strategy struggled to produce positive returns due to jump risk, the monthly version of the same strategy produced positive returns in excess of the buy-and-hold SPY benchmark. To see the growth of $10,000 invested in this strategy, please see Figure 6.3 below:

Figure 6.3: Growth of $10,000 – Monthly Deep-In-The-Money Calendar Spread v. SPY

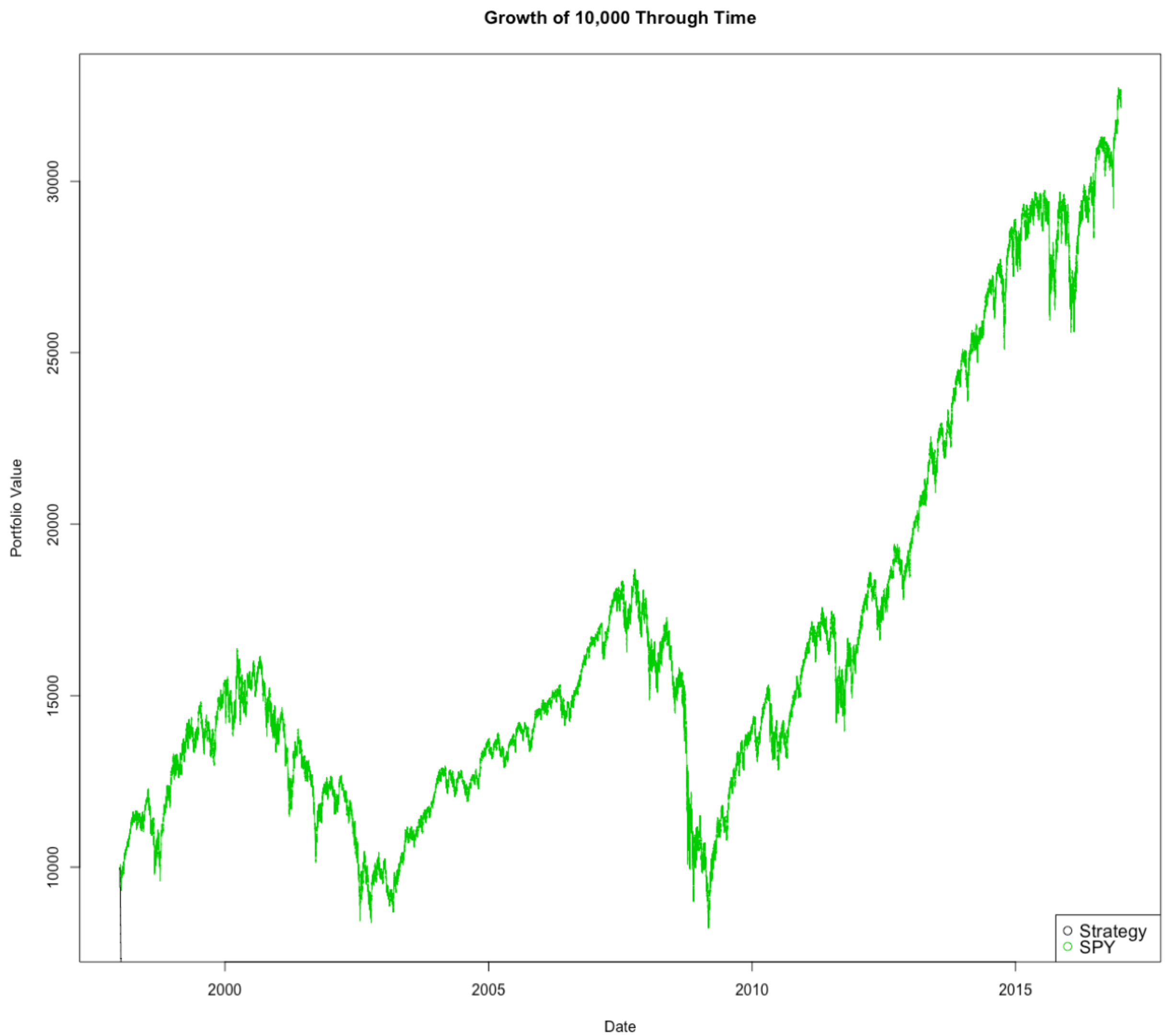


Interesting to note that while this strategy outperformed the market on both an expected total return and a risk-adjusted return basis leading up to the 2008-2009 financial crisis, it produced largely negative realized returns after the recession. This discrepancy in this strategy's return profile is largely due to two key changes in the marketplace post-financial crisis: 1) a long-term decrease in interest rates on treasury bills and 2) a general decrease in overall marketplace volatility during the subsequent market recovery. These changes lower the theoretical pricing of short term out-of-the-money options, and thus inhibit the overall returns of this strategy. Upon subsequently analyzing the strategy's return profile underneath simulated SPY pricing (where interest rates were assumed to be constant), it is also important to note that decreasing volatility alone was not enough to make the strategy non-profitable. Rather the combination of low interest rates and low volatility present in the marketplace post-financial crisis lowered theoretical premiums to the point that transaction costs overtook the strategy's ability to remain profitable.

4. Flying Pratish

Similarly to the intraday iron condor, this strategy's suffered from the short term nature of the trade. This strategy inherently has higher transaction costs than all of the other investment styles analyzed due to it being comprised of eight total contracts per trade cycle and four long contracts that must be purchased as insurance instead of two. These elevated costs in conjunction with smaller premiums collected from a short duration trade, left the strategy's portfolio value to approach zero in the earlier periods. The growth of $10,000 invested in the flying pratish relative to buying-and-holding SPY may be seen below in Figure 6.4:

Figure 6.4: Growth of $10,000 – Flying Pratish v. SPY



Unlike the intraday iron condor, the flying pratish is not likely to produce positive returns even if short term option pricing observed empirically is higher than that theorized by CRR Binomial Trees. This is due to the fact that elevated short term option pricing will be largely offset by the increased cost of acquiring each of the four long contracts required to properly construct the flying pratish strategy.

Section VI: Conclusion

In conclusion, this paper attempted to apply academic research on option markets to empirically gathered data to try and uncover outsized returns with novel adaptations of existing option strategies. Using a hybrid approach of theoretical option pricing and empirically gathered data on underlying price movements produced above market returns for the monthly-year deep in-the-money. Results gathered on the intraday iron condor and the multi-year deep in-the-money calendar spread strategy appear to be negative, but require additional quantitative analysis using empirical option pricing to confirm the inability of each strategy to produce outsized market return. Finally the flying pratish strategy looks to be unlikely to produce positive returns due to high transaction and insurance costs associated with executing that style of trade.

Section VII: References

Bachelier, L. (1900). *The Theory of Speculation.* Annales Scientifques de l'Ecole Normale Superieure. 3(17): 21-86.

Black, F., Scholes, M. (1973) *The Pricing of Options and Corporate Liabilities.* Journal of Political Economy. 81(3): 637-654.

Cox, J., Ross, S., Rubinstein, M. (1979). *Option Pricing: A Simplified Approach.* Journal of Financial Economics. 7: 229-263.

Chicago Board Option Exchange. (2005). *2005 Market Statistics.* Pages 3-4. Retrieved from: http://www.cboe.com/framed/pdfframed?content=/data/marketstats-2005.pdf&section=SEC_MARKET_DATA&title=Market+Statistics-2005

Chicago Board Option Exchange. (2015). *Market Statistics 2015.* Page 4. Retrieved from: http://www.cboe.com/framed/pdfframed?content=/data/market-statistics-2015.pdf&section=SEC_MARKET_DATA&title=Market+Statistics+2015

Fama, E. (1965). *The Behavior of Stock-Market Prices.* Journal of Business. 38(1): 34-105.