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Comparing Historical and Implied Volatility for a Silver Electronically Traded Fund Between Months of High and Low Returns

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COMPARING HISTORICAL AND IMPLIED VOLATILITY FOR A SILVER ELECTRONICALLY TRADED FUND BETWEEN MONTHS OF HIGH AND LOW RETURNS

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Introduction

The Black-Scholes model (Black & Scholes, The Pricing of Options and Corporate Liabilities, 1973)was a major breakthrough in pricing options. The Black- Sholes Model for equities is based on a partial differential equation that uses five parameters to compute the European options price for an equity. Since almost all corporate liabilities can be viewed as combinations of options, the formula and the analysis which led to model are also applicable to corporate liabilities such as common stock, corporate bonds, and warrants. The Black- Sholes model discusses different strategies when dealing with corporate bonds and warrants and how the actual corporation is affected compared to the buyer of the corporations stocks. Black and Scholes performed empirical tests that agree with their theoretical model, and found the price at which buyers actually buy options deviate from the model because of transaction and market cost that occur. It is also a fact that, it is straightforward observation that volatility is the only computed parameter for the partial differential equation, better volatility estimated will ultimately lead to more accurate options pricing (Gatheral, 2006; Stamey, 2011-A).

There are five parameters to the Black-Scholes model. These parameters include stock price, strike price, time, risk-free rate, and volatility. The stock price is the current price of the stock in the market. The strike price is the price at which an option can be exercised. Time is the amount of days from maturity of the option. The risk free rate is the US Treasury bill rate (usually the one-year rate). The volatility, a measure directly related to how much the market expects the underlying asset price to move, is computed in a number of different ways – many proprietary to the organization that actually trades options for its own (proprietary/house) account (Stamey, 2011-B). Investor perception plays a major role in the difference between implied and historical volatility. The two most commonly used measures of equity volatility are historical volatility and implied volatility. Historical volatility is computed from the last 20 to 30 closing price return changes. While its simplicity of computation is advantageous, historical volatility can mask dynamically changing volatility. Implied volatility is the actual volatility that is derived from the market price of options. Researchers continue to work on mathematical models that will predict volatility, as the differences between all models of volatility is many times extreme (Gatheral, 2006).

Silver as a commodity is used in many different industrial applications as well as in jewelry. Silver is five times scarcer than gold (Stamey, Class Notes, 2011) is at this point and is becoming more and more popular with investors. Many investors instead of buying physical silver have looked to invest in the Silver ETF. An ETF is an Exchange Traded Fund, and is a way to trade a commodity like a stock. A price varies in proportion to the commodity, so as Silver moves so does SLV (Silver ETF). There are many different ways to invest in silver. Investors can

- own physical silver, which has storage cost,
- can own interest in bullion, and,
- can also collect rare coins.

There are a number of silver ETFs, including:

- iShares Silver Trust Fund (SLV),
- ETRACS CMCI Silver ETN (USV),
- ETFS Physical Silver Shares ETF(SIVR),
- PowerShares DB Silver Fund (DBS),
- ProShares Ultra Silver ETF (AGQ),
- ProShares UltraShort Silver ETF (ZSL),
- COMEX Silver Bear Plus ETF (HZD-TSX),
- COMEX Silver Bull Plus ETF (HZU-TSX),
- COMEX Silver ETF (HUZ-TSX),
- ETFS Leveraged Silver ETF (LSIL-LSE),
- ETFS Physical Silver ETF (PHAG-LSE),

- ETFS Physical Silver Sterling ETF (PHSP-LSE),
- ETFS Short Silver ETF (SSIL-LSE),
- ETFS Silver ETF (SLVR-LSE).

In this paper, the Silver ETE chosen was iShares Silver Trust Fund (NYSE: ARCA symbol SLV). The objective of the iShares Silver Trust is for the value of the shares of the iShares Silver Trust to reflect, at any given time, the price of silver owned by the iShares Silver Trust at that time, less the iShares Silver Trust's expenses and liabilities. We compare historical and implied volatility of the January 2010 SLV option prices are compared to November 2010 SLV to determine if these volatility measures are similar. In January 2010 silver prices and SLV were lower and there was very little movement. In November 2010, SLV was almost double the price and there were larger daily movements.

The research question to be answered is as follows:

> Is there a difference between the historical and implied volatility for SLV between January 2010 (a period of lower prices and lower returns) and November 2010 (a period of higher prices and higher returns).

To answer this question, the implied volatility had to be computed. The formula used to compute the implied volatility is based on (Brenner & Subrahmanyam, 1988) and required options pricing for each day of the months we examined. The data was purchased from an agency of the New York Stock Exchange, where SLV trades.

Literature Review

In the beginning of this research we researched the Black-Scholes model to create a starting point from the original pricing model. This model gave a better understanding of options pricing, which was used to compute the implied volatility prices on a daily basis for the data.

These articles show a timeline of articles dealing directly with the Black-Scholes model to more recent techniques and models in quantitative finance.

<u>The Black Scholes Options Pricing model</u>

"The Pricing of Options and Corporate Liabilities" by Fischer Black and Myron Scholes is the landmark research article published by Fischer Black and Myron Scholes in 1973. In this article Black and Scholes introduce their finding about options for the market as well as for different corporations concerning bonds and common stock. The authors begin the paper with an overall general introduction to stock options and define the terms that are used when working in the field. The author's argument in the paper is that they have created a theoretical valuation formula for options. Since almost all corporate liabilities can be viewed as combinations of options, the formula and the analysis that led to it are also applicable to corporate liabilities such as common stock, corporate bonds, and warrants (Black & Scholes, The Pricing of Options and Corporate Liabilities, 1973). Because this is the original article talking about the model, all the articles published after this model either adds to the model or they discuss different variations they have come up with when using the model in their own way. As discussed earlier, they used five parameters which included, stock price, strike price, time, risk free rate and volatility.

At the same time Black and Scholes were completing their research, Robert Merton completed research in an almost identical model. The first part of the paper gives an introduction into the theory of warrant and options pricing and the different approaches that have been taken when trying to apply them. The first section concentrates on laying the foundations for a rational theory of options pricing. It talks about trying to derive theorems about the properties of option prices to gain universal support to the extent it is successful (Merton, 1971). From that point, the resulting theorems become necessary conditions to be satisfied by any rational options pricing theory (Merton, 1971). Merton takes the reader through different restrictions on options pricing that will be used when determining different types of options like American or European. Merton goes through many technical complex theories in this section that show almost every possible alternative and restriction. Merton then discusses the effects of dividends and changing exercise price. He gives more theorems and proofs to back these different options. Last, he talks about restrictions on rational put option prices. He gives a small background into put options and explains even though they are less popular there are still benefits they can provide.

The second part of the paper begins to relate the numbers and theorems to the Black-Scholes model. Merton begins to break down some of the theories he has discussed in the first section and list some theorems that are most compatible with the model that Black and Scholes had created at the time. The first section Merton discusses is rational option pricing usint the Black-Scholes. Merton gives the reader some examples and uses numbers discussed in the first section and inputs them into the Black-Scholes model to show the reader the different outputs and results. Merton's next section is an alternative derivation of the Black-Scholes model. Because the American and European calls are different (American calls can be exercised at any time while European options can only be exercised date), there are going to be derivations in the models results (Merton, 1971). Merton discusses the assumptions that must be made about the model and then gives examples of how these assumptions will affect the model and why. Merton then moves into the extension of the model to include dividend payments and exercise price changes. Dividends add complexity to the model because they vary from company to company and even during different time periods from the same company (Merton, 1971). For these reasons, Merton has added different equations that will attempt to account for these different changes. The last section Merton discusses is valuing an American put option. This section is added because in the first part of the paper Merton used mostly European puts and calls as examples and he wanted to add in the difference in calculations and what might have to be added to the model to account for these differences. Merton concludes that the model has the derivation based on a relatively weak condition of avoiding dominance, the final formula is a function of observable variables and the model can be extended in a straightforward fashion to determine the rational price of any type of option (Merton, 1971).

Merton believes the model developed by himself and the Black-Scholes mdoel is successful and can be used to further understanding of options, warrants, and interest rates. Before Merton, the Black-Scholes model was generally used for European Options, but after Merton wrote this article, people began to see how to use the Black-Scholes model for American calls and also mold the different inputs of the model to fit each individual research and financial needs.

After Merton published his article (Merton, 1971) about the different ways to use the actual model, Fisher Black (Black, Fact and Fantasy in the Use of Options, 1975) himself wrote an article to clarify the background behind the model and his viewpoints on the uses of the model. In this article Black discusses option trading and the facts and fantasies that go along with it. Black discusses his option formula from the Black-Scholes equation and states the different parts necessary to compute this formula. From there he breaks each variable down and describes the importance of each part. These variables include volatility, standard deviation, interest rates, dividends, and actual prices (Black, Fact and Fantasy in the Use of Options, 1975). Each different variable is described in detail because each variable affects the outcome of the model in a different way. Black then goes on to describe the different external variables that affect the model. These include taxes, transaction costs, and regulations by the SEC. These external variables also affect the decision an investor will make from the outcome of the model. Black argues that the decision to purchase on option has many different variables that affect it, but when computed and analyzed properly and investor will be able to compute whether or not the option is worth buying (Black, Fact and Fantasy in the Use of Options, 1975). With that being said there are some factors in a market that are unforeseeable that will cause different fluxes in the market, but the purpose of the model is to find the value in the option not technically tell the future of the market. Black noted that the model was used to give an output from multiple inputs into the model. He stated that if you did not know what you were putting in, it would be impossible to know what the number meant you were getting out. He was one of the first to admit that there had to be adjustments to the model because the market is changing every day.

Following the work of Black, Scholes and Merton, three financial engineers, John Cox, Stephen Ross, and Mark Rubenstein, published a simplified method which only required simple mathematics, little more than college algebra (Cox, Ross, & Rubienstien, 1979). The paper presents a simple and efficient numerical procedure for valuing options which can have premature exercise dates (Cox, Ross, & Rubienstien, 1979). Cox, Ross, and Rubienstien argue that their model is not only simpler, but is also computationally more efficient than other methods that use partial differential equations, such as Black-Scholes. The evidence that the authors show throughout the paper is there simple mathematical computations compared with more complex variations off the Black-Scholes model. Throughout the paper, the authors discuss different ways their model can be used in options pricing and using the binomial options pricing system. They then address riskless trading strategies and address different special cases where more complicated models might be necessary (Cox, Ross, & Rubienstien, 1979).The authors do agree there are simplified ways to solve basic options computations, but they also agree that many cases do involve more complex formulas for all the extra necessary additions.

A decade later, Robert Geske and Richard Roll (Geske & Roll, 1984) came up with another adjustment to the Black-Scholes model to value American Call options. The purpose of the paper is to explain biases between the market value of stock options and the options computed by the Black Scholes Formula. The Black Scholes Formula is based on the European call option position which has a major difference from the American call option position. The American calls are allowed to be exercised at any time in the life of the option, but European options can only be exercised at maturity (Geske & Roll, 1984). The authors argue that this bias found can be answered by adding an adjustment into the model for this major difference. The authors suggest different add-ons to the module that would account for dividends and variances in the timing of exercising the option that would give a closer number to the actual market value. The authors address strike price bias, time to expiration bias, and variance bias. With each explanation, the author gives charts and data to back the argument for each bias and solutions for the problem. The authors conclude there are conflicting sides to the argument; there is also limited data at the time this article was written to come to a certain conclusion. There is also always variation in the stock market and options market that limits the formula from being 100 percent effective (Geske & Roll, 1984). The authors do conclude that the American option model of the Black-Scholes can explain for the different biases found within the model. The authors of this article try to argue against the Black-Scholes model, but in the end they also do agree that the model works with adjustments, just as any model would need adjustments dealing with different markets and time periods.

In the Forecasting Chapter of "*Applied Management Science: Modeling, Spreadsheet Analysis, and Communication for Decision Making*", Lawrence and Pasternak examined the process of generating a forecast. They focused on how, based on time series data, the appropriate forecasting model to use, and discussed techniques that can be applied to the different models in order to create different forecasts (Lawerence & Pasternack, 2002). One important idea the author's addressed was the ability of the forecast model to respond quickly to changes so that future forecast errors are not too severe (Lawerence & Pasternack, 2002). When forecasting different subjects the person conducting the test must choose the appropriate technique to fit the data they are analyzing. The writers address different ways to choose the correct technique when looking at different types or quantity of data. The authors address different time series models including, stationary, and trend, models that include trend, seasonal, and cyclical components. Within these models there are different techniques that are appropriate. The authors list the pros and cons of the different techniques which gives the reader a good summary of which technique to choose for their specific project. This paper is useful to the overall project because it introduces forecasting and different methods to use for specific data. Forecasting will be very important in project so having an article with examples of simple and complex forecasting is vital.

Lawrence and Pasternak gave a general background into different methods of smoothing. James Taylor is more specific in his article "Volatility Forecasting with Smooth Transition Exponential Smoothing.", focusing exclusively on exponential smoothing. Exponential smoothing allows smoothing parameters to change over time, in order to adapt for changes in characteristics of the time series (Taylor, 2004). The paper presents a new adaptive method for predicting the volatility in financial returns. It enables the smoothing parameter to vary as a logistic function of the user-specified variables (Taylor, 2004). Throughout the paper, the author introduced a new smooth transition exponential smoothing method that uses a logistic function as adaptive smoothing parameter. He also estimated the parameters for weekly volatility forecasting using realized weekly volatility calculated from daily data. Because of the increased data available daily, the author believes that intra-day data can be used to calculate realized daily volatility for use in the estimation of parameters for daily volatility forecasting (Taylor, 2004). The Black-Scholes model is a start to try to calculate correction options pricing, but there are some adjustments that need to be made for the specific stock or area of the market that is being analyzed. In this paper Taylor gives a new smoothing method that can be used to calculate daily volatility. Volatility is one of the inputs used in calculating the Black-Scholes model. As of now, volatility is usually calculated over a longer range of data. The smaller the time period of volatility aka days or weeks, the more accurate each calculation has the probability to be. Taylor addresses these "1-step ahead forecasting methods" which gives samples and examples of how to go about doing it for SLV.

Financial Asset Pricing Model

There are many different ways to invest in the market. Options are just one area of the market that can be studied to make profits. Harry Markowitz created the first Modern Portfolio Theory which attempts to maximize portfolio expected return for a given amount of portfolio risk, or equivalently minimize risk for a given level of expected return, by carefully choosing the proportions of various assets (Markowitz, 1952). MPT is a mathematical formulation of the concept of diversification in investing, with the aim of selecting a collection of investment assets that has collectively lower risk than any individual asset (Markowitz, 1952). Markowitz shows different formulas throughout the paper that explain how these risks can be altered. That this is possible can be seen intuitively because different types of assets often change in value in opposite ways (Markowitz, 1952). Prices in the stock market tend to move independently from prices in the bond market, a collection of both types of assets can therefore have lower overall risk than either individually. This paper is relative to options pricing because it talks about the need to diversify investments to stay protected from specific market crashes.

When doing research that requires storing and analyzing data, it is much more efficient to be able to create programs that will assist the researcher in doing so. Chokri Dridi discusses in his article, "A Short Note on the Numerical Approximation of the Standard Normal Cumulative Distribution and Its Inverse", the benefits of creating specific programs to fix the research being completed. The paper explains how more researchers in economics and other business industries have started doing in depth research for different problems. Popular integration methods range from very simple inaccurate methods like rectangular rules to more complex approaches like the Gaussian quadratures (Dridi, 2003). In the article the author introduces and evaluates the results of the rational fraction approximation approach and the composite Gauss- Legendre quadrature. The author compares the results provided by computer programs written in Python against built-in functions in Excel. Using more complex programming in the end will save the researcher valuable time by organizing and analyzing the data more efficiently than excel or spreadsheets.

When researching, it is valuable to have databases that share common ideas and new relevant research. Wiley wrote “ISO 20022” because they believed the financial services industry had a unique opportunity to identify and promote interoperable business processes that contain risk, reduce cost and deliver effective products and solutions. The leveraging process named the ISO 20022 allows this to be possible. We can define and hold the basic foundations of our businesses in a “data dictionary” and analyze the financial messages we are able to gain from these tools (Team, 2010). We can leverage current technical advances and adapt to future technical change. This foresight and flexibility is built into the ISO 20022 standard. The authors believe that it is important to raise the awareness and provide industry participants with the knowledge that they need to improve, grow and sustain their businesses in the long-term. The ISO 20022 Dictionary helps the financial community align and do business by providing concise definitions for common business concepts. ISO 20022 is open to anyone in the industry and uses mostly XML (A technical syntax which gets support from software platforms and tools). The ISO 20022 web query tool allows anyone to explore the ISO 20022 dictionary with no software required (Team, 2010). The ISO 20022 provides common language for machines and people to exchange information about financial business. All of these attributes about ISO 20022 allows users to access information in a common business forum free of cost. Many different ideas are passed around through this application free of cost which is beneficial to anybody conducting research and studies.

The limitations of the research read seemed to lead to adjustments having to be made because of changes in the market and changes in investment strategies. Some of the research is based on high profile/high technology companies who are able to used massive amounts of money to store a database of historical prices and analysis and run them every second of the day, as seen in high profile trading. My research was limited in this aspect because there was little capital put into this research. Also, some of the techniques involve creating portfolios of many different options and stocks to limit risk and market correlation. Our research also did not follow this technique because of the time limitation and limited capital. Our research was however able to focus on one specific commodity and was able to follow and analyze Silver and use different quantitative techniques to come to a conclusion of our hypothesis.

Large Companies

Large companies have almost unlimited resources when it comes to investing. They have the largest databases to store data, they have the best technology to analyze this data, and they have the fastest servers to compete on high frequency trading markets to make profits on market volatility. For the average individual investor it is not possible or feasible to have these resources or capabilities. There is however still opportunities to make a profit in the market. This research aimed to show investors that with the use of new Finance 2.0 techniques it is feasible to follow a limited number of ETF's and make profits when there are market changes.

Portfolios

Our research focused on a single ETF of SLV, because of this we were not able to create a portfolio such as a hedge fund discussed in the research. However, we do agree with the principals of hedge funds, and believe that this research is credible and could be used to create a profitable portfolio. Instead of comparing months within the same ETF, regression and correlation can also be used to create a portfolio to protect capital and generate a positive return with a low volatility and market correlation. Additionally, we have found Silver to be interesting as a hedge fund because it is a stock, option, as well as a commodity. It is possible to create a portfolio of strictly silver and still be protected against shifts in the market.

Uniqueness of Silver

Throughout the paper we have concentrated on the financial aspect of silver. There are many different reasons why silver was picked to be analyzed. The first reason financially is SLV is one of the most volatile options in the world. At an average of 30% volatility, there are many price changes throughout the day that make it possible for investors to trade SLV frequently and make a profit. Silver also has grown significantly over the past two years on the options market. In January of 2010 SLV was at 14.00-17.00 and by the end of the year SLV had skyrocketed to over 40.00 at some points. This growing market made it appealing to research to try to see what was actually behind all of these numbers. We began researching silver and watching SLV over all of 2010 and 2011 and saw some very interesting movements and decided to analyze these numbers using quantitative finance. We wanted to see how the volatility of SLV would was affected in the prices of the option. As we were doing research we also began researching Silver Coins and how they were viewed in the market. An ounce of silver doubled in price in 2010 also doubling the price of silver bullion. This means anyone that held any silver coins doubled in price in just the worth of actual silver bullion. Also, through research we discovered there was an extremely large market for silver coins. Each year, countries produce limited number of silver coins. Some countries produce many coins in one year and few in others, and some countries only produce limited amounts of silver coins every year. As we read about portfolios we began to realize there was a possibility of creating a hedge fund using only silver. If we were able to hedge our option calls with actual silver then regardless of the market we would be profitable whichever way the market move whether it was up or down. Additionally, the rarity factor of Silver means that even if the price of silver goes down, the coins we would hold would increase in value every year just because they were becoming rarer.

Purchasing Options

When purchasing options you can either buy a call or put. Simply stated a call means that you are guessing the price of the option is going to increase, and a put means you are guessing the price of the option is going to increase. Therefore, if you buy a call option you make a profit as the price of the option increases and if you buy a put option you make a profit as the price of the option decreases. In this example we are going to follow a normal hedge fund and protect our self against the price of silver dropping. So we purchase some put options on SLV(the silver option).

Buying Silver Coins

At the same time we are buying these put options, we decide to invest in some rare silver coins. These coins will gradually increase in value because of the rarity factor, but the actual value of silver bullion in the coin will fluctuate with the price determined by the market

Result of this example

The possible results of this example is silver could either increase in value or decrease in value. If silver increases in value, our silver coins will become more valuable in bullion value and we will lose a limited amount of money of the put options. If the price of silver decreases the bullion value in the silver coin goes down, but the rarity factor continues to increase and we will make a profit on our put option because we guessed silver would go down. This example shows how an investor could create a portfolio to be profitable using only silver.

Methodology

In this research, we are testing four Hypotheses:

- H_{01} compares the returns of January and November 2011. Are they statistically significantly different?

- H_{02} compares the implied volatility of January and November 2011. Are they statistically significantly different?
- H_{03} compares the historical volatility of January and November 2011. Are they statistically significantly different?
- H_{04} compares the correlations between the returns of January and November 2011, with the S&P 500 returns on the X axis and the SLV returns on the Y axis, in the same manner as a traditional regression analysis. Are they statistically significantly different?

For hypotheses H_{01}, H_{02} and H_{03}, a two-tailed t-test was used that assumed unequal variances. Computations were made on MS Excel 2007. For hypothesis H_{04} a procedure was used to compare two correlation coefficients using implied volatility and historical volatility to determine is the same relationship existed between the two option prices in January and December (Lhabitant, 2004).The simplest way to do this is to compare the differences of the correlation coefficients. If the difference is zero then the two samples are the same. We then compare the correlation in January 2010 to the November 2010. If they are the same then there is no difference between the implied volatility and the historical volatility of the two months. The procedure measures two correlation coefficients over two distinct periods and calculates to see if there is a difference. The procedure can be summarized as follows:

1. Compute the sample correlation coefficients r_{JAN} and r_{NOV}
2. Convert the correlations r, to z-scores with the following transformation
   $Z_i = .5 * \ln(1+r_i)/(1- r_i)$
3. σ_{z1-z2} = sqrt((1/(N_1 – 3) + 1/(N_2 – 3))
4. Compute the 95% confidence interval of Z_1-Z_2 which is
   $[(Z_1-Z_2) - 1.96\ \sigma_{z1-z2}\ ,\ (Z_1-Z_2) - 1.96\ \sigma_{z1-z2}\ ]$
5. Transform the end points of the Z confidence interval back to r by using the inverse
   Transformation $r = (e^{2Z-1} - 1)/ (e^{2Z-1} + 1)$.

Findings

To calculate and organize these formulas, the research was conducted using Excel 2010 to store the data as well as compute certain computations.

For the first three hypotheses, the following results were obtained:

Hypothesis	Mean	Variance	p-value
H_{01}	JAN: -.0022 NOV: .0050	JAN: .0016 NOV: .0008	.5238
H_{02}	JAN: .1065 NOV: .1121	JAN: .0019 NOV: .0001	.5880
H_{03}	JAN: .3206 NOV: .4121	JAN: .0004 NOV: .0018	<.001

For this data, the historical volatilities were not found to be statistically significantly different at $\alpha = .05$. However, the returns and the implied volatilities were found to be statistically significantly different at $\alpha = .05$. For the test of H_{04} the following results were obtained:

	JANUARY 2011	NOVEMBER 2011
Correlation	.65596	.57306
Number of returns	19	20
Z_i	0.878231	0.610987
$Z_1 - Z_2$	0.08290	
σ_{z1-z2}	.348315	
Conf. Interval of $Z_1 - Z_2$	[0.19592,1.56008]	
Conf. Interval of $r_1 - r_2$	[0.1959, 0.9154]	

Because the confidence interval does not contain 0, we can conclude there is a difference in the correlation coefficient coefficients of January and November, hence there is a difference between the implied volatility and historical volatility.

To summarize the results of our hypothesis tests:

- H_{01}: There is a significant difference between SLV returns in January 2010 versus November 2010.

- H_{02}: There is a significant difference between SLV implied volatility in January 2010 versus November 2010.

- H_{03}: There is no significant difference between SLV historical volatility in January 2010 versus November 2010.

- H_{04}: SLV returns and implied volatility and returns for SLV do not seem to be correlated between January 2010 and November 2010.

Conclusion

The research question to be answered was:

> Is there a difference between the historical and implied volatility for SLV between January 2010 (a period of lower prices and lower returns) and November 2010 (a period of higher prices and higher returns).

Based on options data from the NYSE it was found there is a difference between implied volatility and returns in these months, and there is no difference between historical volatility in these months. Further work can be done to track this change on a monthly basis.

Appendix A: January 2010 Options Data

RETURNS	HISTORICAL VOLATILITY	IMPLIED VOLATILITY
0.000580383	0.069254378	
0.039406054	0.082143365	0.329
0.015677492	0.081252973	0.3298
0.019564002	0.082077464	0.3286
0.001652893	0.076330074	0.3222
0.014277869	0.076574528	0.3109
0.003350084	0.076310104	0.3168
-0.01642036	0.07714263	0.3125
0.019661387	0.078393057	0.3103
0.002216066	0.078355288	0.3086
-0.01409214	0.079211084	0.3005
0.022766079	0.072726288	0.2813
-0.05155243	0.090746075	0.2998
-0.02665245	0.093482089	0.3147
0.100415924	0.132847582	0.3228
-0.11746805	0.176836024	0.3056
-0.02460025	0.176987241	0.355
-0.01067839	0.17707776	0.3462
-0.02138365	0.176682559	0.3506
-0.00118624	0.176077558	0.3456

Appendix B: November 2010 Options Data

RETURNS	HISTORICAL VOLATILITY	IMPLIED VOLATILITY
0.030743664	0.101346508	0.3181
-0.004113534	0.101083091	0.3668
0.009896907	0.095395053	0.3642
-0.002341007	0.094831606	0.3607
0.052671756	0.099871273	0.376
0.020994475	0.097628883	0.3848
0.036287242	0.101622693	0.4228
-0.036302395	0.110737667	0.4723
0.019918849	0.109337032	0.4758
0.015282132	0.108385622	0.4577
-0.06377858	0.126731402	0.4641
-0.023666266	0.129302157	0.4653
0	0.118842857	0.4284
0.002656546	0.117417241	0.4124
0.050486163	0.119952852	0.4194
0.014354067	0.120163864	0.4085
0.016002977	0.120256308	0.4306
-0.011135857	0.121688913	0.4179
0.002678913	0.120678697	0.3836
-0.030508475	0.125925189	0.4127

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