S&P 500 Index Option Pricing Inefficiency Surrounding U.S. Federal Reserve Meetings and Economic Uncertainty

by

Colton F. Evans

Thesis submitted in partial fulfillment of the

requirements for the Degree of

Bachelor of Arts with

Honours in Economics

Acadia University

April, 2019

This thesis by Colton F. Evans

is accepted in its present form by the

Department of Economics

as satisfying the thesis requirements for the degree of

Bachelor of Arts with Honours

Approved by the Thesis Supervisor

Andrew Davis	Date

Approved by the Head of the Department

Burc Kayahan	Date

Approved by the Honours Committee

Joseph Hayes	Date

Acknowledgements

First, I would like to thank my thesis supervisor Dr. Andrew Davis, who helped keep me on track and helped me with any questions I had throughout this thesis process and my four years at Acadia University. Without his guidance and supervision, I would not have been able to complete this project.

Secondly, I would like to thank Dr. Burc Kayahan, without whom I may not even be taking an Economics degree or an Honours degree in the first place. He pulled me away from the School of Business with his interesting and compelling Intro to Microeconomics class. His constant advice over the years has helped me achieve the requirements needed to fulfill my degree and move on into the world of economics.

Thirdly, I would like to thank Dr. Stephen MacLean, who has been a great teacher to me regarding all things finance and beyond. He has helped me with any finance related questions regarding my thesis as well as providing me with access to the data necessary to complete it.

Finally, I would also like to thank all of the professors and administrative support staff in the Economics Department. Each faculty member has provided me with extensive information and guidance over the years to further my understanding of economics and other topics.

Table of Contents

List of Tables

List of Figures

Abstract

Many researchers such as Galai (1977) have showed that option markets experience periods of inefficiency. Other researchers such as Gemmill (1991) have shown that these periods of inefficiency occur surrounding uncertain events like political elections. Federal Reserve policy meetings occur roughly every six weeks and frequently have uncertain outcomes over potential policy changes. This study uses option data between February 11th, 2005 and December 31st, 2011 to conduct multiple OLS regressions and robustness tests to determine if Federal Reserve meetings and economic uncertainty increase pricing inefficiency in option markets. Results show a statistically significant, although not economically significant, positive relationship between option market inefficiency, Federal Reserve meetings and economic uncertainty.

CHAPTER 1: Introduction

As Galai (1977) showed by generating consistent profits by buying and selling options deemed under or overvalued by comparing their Black-Scholes option model price with their market price, option markets are not always efficient. This is despite the general acceptance of Eugene Fama's (1970) efficient market hypothesis (EMH) which is defined as a financial market in which market prices fully incorporate all available information in order to determine securities prices. Assuming this theory is correct should mean that an option should trade at a computable fair value price on its respective exchange.

Besides Galai (1977), other researchers have also shown this to not always be the case, such as Noh, Engle and Kayne (1994) and Capelle-Blancard and Chaudhury (2001). These three studies tested efficiency in several different ways. The question then is not "are option markets efficient?" but what causes these periods of inefficiency and can we predict them. Niederhoffer, Gibbs and Bullock (1970) along with other authors such as Gemmill (1991) have shown that these periods of inefficiency can be somewhat predicted as they provide evidence that markets can be affected by the occurrence of uncertain events such as political elections. Baker, Bloom and Davis (2016) have shown correlations between their Economic Policy Uncertainty (EPU) Index and implied option volatility. The EPU Index also has a strong link with uncertain or unknown policy meetings such as Federal Reserve Policy meetings. Although not entirely political in nature these Federal Reserve meetings still have strong policy implications and semi-uncertain outcomes. The question then becomes can these two factors be used to explain and predict periods of option market inefficiency. The research question that this study will attempt to answer is:

"Does option pricing inefficiency exist within S&P 500 Index options trading on the Chicago Board Options Exchange (CBOE) surrounding U.S. Federal Reserve Policy Meetings that occurred between February 11th, 2005 & December 31st, 2011?"

I will attempt to answer this question by conducting an in-depth literature review, followed by the testing of the following two hypotheses using collected data to perform a regression analysis consisting of approximately 1.6 million observations.

1. *An increase in economic policy uncertainty will increase the level of option pricing inefficiency amongst S&P 500 Index options trading on the CBOE.*
2. *The occurrence of U.S. Federal Reserve Policy Meetings increases the level of option pricing inefficiency amongst S&P 500 Index options trading on the CBOE.*

This research has 5 parts, the first being this introduction. The second is a literature review, including an in-depth analysis of previous literature and theories that shape the current understanding of market efficiency and option pricing. The literature review will discuss topics related to the Black-Scholes option pricing model, Efficient Market Hypothesis, option market efficiency, economic uncertainty and how markets react to uncertain events. Following the literature review will be a chapter outlining the data set, the variables, summary statistics and methodology. Daily data for all variables was collected for a sample period between February 11th, 2005 and December 31st, 2011. Following the data and methodology chapter will be a look at the results and various robustness tests performed to help ensure the validity of the results. Lastly, an overview of the findings, which shows a connection between option inefficiency, economic uncertainty and Federal Reserve policy meetings will be discussed followed by a number of appendices containing additional tables and figures.

CHAPTER 2: Literature Review

It is important to review and take into consideration the previous literature relevant to the current research question before empirically analyzing the effect U.S. Federal Reserve Policy meetings have on option market efficiency. In order to better understand the hypothesis that will be tested five categories of the academic literature have been analyzed. An in-depth analysis will be given on the Black-Scholes Option Pricing Model, the Efficient Market Hypothesis, option market efficiency and economic uncertainty. This will help identify gaps in the literature related to the current research topic and provide the understanding and methodology necessary to make a useful contribution to the academic literature.

2.1 Black-Scholes Option Pricing Model

The first known appearance of option pricing literature was in 1877 in the book "*The Theory of Options in Stocks and Shares*" by Charles Castelli. This book identified how options could be used by investors for hedging and speculation purposes but did not try to provide an analytical valuation model for options. Options are derivative securities that give an investor the right, but not the obligation, to buy or sell an asset under certain conditions, within a certain time period. The first attempt at an analytical valuation model would not come until Louis Balchelier's 1900 PhD thesis titled "*Théorie de la Spéculation*" (Davis & Etheridge, 2006). Balchelier's dissertation first introduced the finance world to the random walk hypothesis. This theory encountered issues as the process allowed negative security prices and option prices that surpassed the price of the underlying asset (Malliaris, 2007). No major new literature focused on option pricing models until Kruizenga (1965) focused on a theoretical analysis of put and call options. This led to the next major contribution to the literature by Fischer Black and Myron Scholes. In their 1973 article titled "*The Pricing of Options and Corporate Liabilities.*" Fischer

Black and Myron Scholes introduced the world to what would become the most used and researched option pricing model throughout derivative security literature. This model is what is now called the Black-Scholes Option Pricing Model. They developed this model as an attempt to accurately price options, which are derivative securities that give an investor the right, but not the obligation, to buy or sell an asset under certain conditions, within a certain time period (Black & Scholes, 1973). Like most models, their model is contingent on several assumptions that create ideal market conditions. The seven assumptions they made are:

1. The short-term interest rate is known and is constant through time.
2. The stock price follows a random walk in continuous time with a variance rate proportional to the square of the stock price. Thus the distribution of possible stock prices at the end of any finite interval is log normal. The variance of the rate of return on the stock is constant.
3. The stock pays no dividends or other distributions.
4. The option is "European", that is it can only be exercised at maturity.
5. There are no transaction costs in buying or selling the stock or the option.
6. It is possible to borrow any fraction of the price of a security to buy it or to hold it at the short-term interest rate.
7. There are no penalties for short selling. A seller who does not own a security will simply accept the price of the security from a buyer and will agree to settle with the buyer on some future date by paying him an amount equal to the price of the security on that date.

These assumptions allow the value of the option to depend only on the price of the underlying security, time, and variables that are known constants (Black & Scholes, 1973).

The formulas used to value the Black-Scholes Option price are provided below, along with their inputs.

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left[r_{RF} + \left(\frac{\sigma^2}{2}\right)\right]t}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

$$C = S[N(d_1)] - Xe^{-r_{RF}t}[N(d_2)]$$

$$P = S[N(d_1) - 1] - Xe^{-r_{RF}t}[N(d_2) - 1]$$

Where,

C = Black-Scholes call option price,

P = Black-Scholes put option price,

S = Value of the underlying security,

X = Exercise price,

r_{RF} = Risk free rate,

t = Time to maturity,

σ^2 = Variance of the underlying securities distribution of rates of return,

$N(\,)$ = Cumulative standard normal distribution.

$S[N(d_1)]$ is the amount that will be received on selling the stock at expiration, while the expression $Xe^{-r_{RF}t}[N(d_2)]$ is the payment that will be made to purchase the stock when the call option is exercised at expiration. The value of the call option depends on the difference between these two values. The Black-Scholes option pricing model also solves the original issues encountered with the random walk hypothesis as $N(d_1)$ and $N(d_2)$ prevent the intrinsic value from falling below zero.

This option pricing theory is widely accepted with far-reaching applications. The model still has limitations identified by the literature. The model assumes that volatility is constant over time. This results in the model being limited to the short-term as Hull (2009) argues that although accurate in the short-term, this assumption fails in the long-term as volatility is never constant long-term due to volatility clustering. Hull (2009) also shows that because volatility measures are negatively correlated with the return on the underlying security, that volatility can't be constant long-term. The next limitation comes in the assumption that interest rates are constant and known. Interest rates can fluctuate greatly during times of increased volatility, for example as volatility rises so would the risk-free interest rate. For most larger countries and scenarios this is still an accurate assumption as risk-free organizations such as central banks are unlikely to fail. The model also assumes that returns of log normally distributed underlying securities are normally distributed. In the short-term, asset returns have finite variances and semi-heavy tail distributions which are contrary to a normal distribution (Clark, 1973).

The Black-Scholes model assumes there are no transaction costs in buying or selling the underlying security or the option. This is false in the real world as investors incur fees when buying and selling options. Black and Scholes (1972) discovered this for themselves when they tested their model on historic option prices and returns. Without transaction costs their model performed well and found that buyers of calls generally received a significantly higher return of 33.3% on average versus sellers of calls who received a return of 8.6% on average. This makes sense as buyers of calls are taking on a riskier position then the writers (Black & Scholes, 1972). Once they added transaction costs though the gap diminished greatly. Call buyers' average return decreased to 8.3% and call writers' average return decreased to 6.3%. This shows how significant of a difference transaction costs can make. The model also can only accurately calculate the price of European options which can only be exercised on the maturity date. It can't account for the possibility of early exercise that American options have.

In spite of the expressed restrictions, the Black-Scholes option valuation model has led to numerous contributions to the literature. It is essential to talk about the positive qualities of the model. Due to its approach and wide range of applicability, the Black-Scholes model is thought of as one of the largest successes in financial literature. The model's main advantage is that it can gauge market volatility of an underlying asset as a function of specific and generally known variables such as expected return (Teneng, 2011). Another advantage of the model comes from the model's capacity to utilize a self-replicating trading strategy to produce a terminal payoff equal to the payoff of an option. This is achieved by buying or selling risk-free bonds and an underlying asset (Teneng, 2011). The vast majority of the Black-Scholes model's constraints are related to fundamental aspects of the market, but this has not stopped researchers from attempting to address factors and assumptions excluded in the original valuation model.

For instance, Merton (1998) was essential in understanding the Black-Scholes model as his contribution helped demonstrate the continuous trading strategy. This is a trading strategy where if one could trade continuously without cost, then following Black and Scholes' dynamic trading strategy using the underlying traded asset and the riskless asset would exactly replicate the payoffs on the option. (Merton 1998). He also continued his previous work, expanding the Black-Scholes model to allow early exercise and variable interest rates on risk-free assets (Merton, 1998). Lately, modifications and progressions of the Black-Scholes model have focused on four main themes. These themes are relaxing assumptions, changing variables, empirical testing and searching for new financial applications for the valuation model. For example, Benoussan and Julien (1999) attempted to relax the assumption of frictionless markets in part by considering frictions related to the cost of holding a portfolio of securities. Khan, Gupta and Siraj (2013) built off Benoussan and Julien by including an altered Black-Scholes model that uses a risk adjusted interest rate. They used three risks to replace the risk-free rate; basic risk, reprising risk and yield curve risk. Peng and Yao (2011) also continued to try and improve on the Black-Scholes model. They modified the model using an uncertain differential equation to price in uncertain markets. Lauterbach and Schultz (1990) attempted a different test of the Black-Scholes model. They attempted an empirical test of Black-Scholes for warrant prices. Their results showed that there is a problem with the constant variance assumption as it causes bias in warrant prices calculated using Black-Scholes and thus, although Black-Scholes can be used for options, it does not work the same for warrants.

Not all new applications of the Black-Scholes Model include financial instruments. Leuhrman (1998) also discussed real options, which are options that have tangible assets as their underlying security. Real options give an investor the right, but not the obligation, to undertake uncertain business activities laid out in the option (Leuhrman, 1998). Examples of this would be if a firm undertook a new project, the real option could give the firm the option to expand the project or abandon it after a certain amount of time, or both.

As the risk management aspect of finance continues to be of more importance to investors, Black-Scholes has become more relevant than it was when it was first formulated. Black-Scholes is still widely accepted despite its limitations as no model can perfectly mimic market conditions or include all variables. Shah (1997) discusses how option pricing research and studies have cleared a path for investors to diversify their holdings and transfer market risks that they may be exposed to. As risk management continues to be a growing source of interest to investors, the importance of Black-Scholes and other derivative security studies will continue to grow.

2.2 Efficient Market Hypothesis

Eugene Fama has made many contributions to the financial literature, including the widely used and well known Fama-French three factor model and the capital asset pricing model (CAPM). As important as these contributions are, Fama's greatest contribution may have come in 1970 with his Efficient Market Hypothesis (EMH). EMH holds in a market in which security prices fully incorporate all available information (Fama, 1970). This means that options and shares trade at their fair value on their respective exchanges. Therefore, the only way for an investor to achieve a higher return is to take on more risk; they cannot profit from over or undervalued securities. Fama showed that it is impossible to outperform a market through transaction timing and security selection. Fama's (1970) research along with Malkiel (1973) and Roberts (1959) resulted in three different levels of market efficiency within the EMH which will be outlined below.

1. **Weak Form Market Efficiency**: Weak form market efficiency states that security prices fully incorporate all historical data including price movements and volume data when determining their price. This means that it is impossible for an investor to use technical analysis, an investment strategy based on past price patterns, to achieve an abnormal return. The random walk hypothesis also discredits technical analysis as it states that stock market price changes are random and unpredictable (Shiller & Perron, 1985). Furthermore, the price of a share is generally calculated as the present value of all future cash flows. This would mean that all the historical data used in technical analysis would have already been priced into the share in the past and the current price is entirely future looking.

2. **Semi-Strong Form Market Efficiency**: The second level of market efficiency is semi-strong form market efficiency. It states that current security prices fully and correctly incorporate all historical price information as well as all relevant publicly available information related to the security. Semi-strong form efficient capital markets would not allow an investor to gain an abnormal return through technical or fundamental analysis investment strategies. Fundamental analysis is a strategy that incorporates analysis of financial statements, company announcements, and any other relevant public information. Theoretically markets should be semi-strong form efficient as all public information is available to every investor and thus, they should not be able to use it to gain an abnormal return. An investor would need insider information not known to the rest of the public to gain an abnormal return under semi-strong form efficiency.
3. **Strong Form Market Efficiency**: The third level of market efficiency is strong form market efficiency. It states that all public and private information known to any market participant is fully incorporated into a security's price. This implies that it is impossible for any investor to gain an abnormal return no matter how much research is conducted or information available. Strong form market efficiency is considered to be part of the random walk theory. There is only a weak presence of strong form market efficiency in the literature as there is evidence that shows abnormal returns can be gained through insider (private) information.

The literature has very different and mixed views on which type of EMH exists. Some studies show support for weak form market efficiency, while other studies show evidence that supports semi-strong form market efficiency, and then there are other studies that show support for markets not being efficient at all. Recent literature and more accurate financial data has shown a number of anomalies relating to EMH. Yen and Lee (2008) have defined a market anomaly as any event that implies market inefficiency or profit opportunities. It is also important to take a look at literature surrounding option market efficiency instead of the entire market as a whole. This will be done in the following section.

2.3 Option Market Efficiency

Option market efficiency is simply the Efficient Market Hypothesis applied to option markets. There are generally considered to be three main types of option market efficiency tests. The first type was outlined by Hull and White (1987). This method compares actual market prices of options to prices calculated using an option pricing model. The second type was outlined by Poon and Pope (1999). This method estimates volatility and uses a trading rule to test whether a profit can be achieved. The third type is used by Capelle-Blancard and Chaudhury (2001). This method uses a no arbitrage price relationship to determine whether inefficiency is present in an option market. Black and Scholes (1972) conducted one of the earliest option market efficiency tests. It was referred to as the ex-post hedging test. Galai (1972) built off the Black and Scholes methodology and used it to test option market efficiency on the Chicago Board of Options Exchange (CBOE). This test held the initial option position until the expiration date and used the daily change in option price, which was calculated as the difference between the actual option price and the Black-Scholes option model price. Hedging was achieved by calculating the change in a stocks position. The gains and losses from the daily hedged position were averaged out over the option’s lifespan. The results from the Generalized Least Squared (GLS) analysis showed that although the model performed well, the market did not seem perfectly efficient (Galai, 1972).

Galai (1977) made another attempt at option market efficiency testing, but this time building off the work of Boness (1962). He took expected daily option prices calculated using the Black-Scholes model and compared them to the daily market prices of specific option contracts. He used this comparison to classify the options into two categories; options that were undervalued compared to their Black-Scholes price, and options that were overvalued compared to their Black-Scholes price. The goal was to test whether it was possible to obtain a profit by buying the undervalued options and selling the overvalued ones. This should only be possible in a market experiencing inefficiency. The model that was used to calculate the excess dollar return for an option is:

$$EDR = (\Delta C - C_V \Delta V) - (C - C_V V) r \Delta t$$

Where,

$EDR =$ Excess dollar return on an option,

$C =$ The model value of the option,

$\Delta C =$ Change in the model value of the option between trading days,

$C_V =$ First derivative of C with respect to V,

$V =$ Value of the underlying stock,

$\Delta V =$ Change in the value of the underlying stock, and

$\Delta t =$ Time interval over which the value changes are calculated.

This EDR equation gives the imputed realized excess return, on what is considered a perfectly hedged position, over and above the normal riskless return on the asset (Galai, 1977). The test resulted in an average return of $1.29 per option per day for overvalued options, and $1.73 per option per day for undervalued options (Galai, 1977). A t-test showed that although the returns are economically small, they were found to be highly significant. Thus, the results showed that it was possible to earn an abnormal return on the CBOE between July 1973 and April 1974.

Galai (1977) showed inefficiency by comparing market prices to calculated Black-Scholes prices. Other researchers have looked at inefficiency using other tests. Researchers often measure efficiency using variance forecasting and volatility spreads. Negative economic shocks such as a market crash can rapidly change market volatility. Stock and option prices are both impacted by significant market volatility changes. Thus, when volatility changes it is difficult to accurately calculate the expected implied volatility of an efficiently priced option (Noh, Engle, and Kane, 1994). Noh et al. (1994) conducted a study that tested the efficiency of the S&P 500 Index option market. They employed a method based off the work of Hull and White (1987). They used two volatility prediction models. The first is a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. This method allows them to capture market volatility tendencies without any option valuation formulas or observed option prices. Noh et al. used a modified version of Black-Scholes that used the calculated volatility forecasts to predict the option price for the next trading day. The GARCH model achieved a 1.62% average daily return over a 1,048 day span using a straddled position and a $0.25 transaction cost per straddle while comparing the models option prices to S&P 500 Index option data (Noh et al., 1994). The second volatility prediction model they used was the Implied Volatility Regression (IVR) model. This volatility forecast estimates implied volatilities through a GLS regression created by Whaley (1982) and which was also cited by Hull and White (1987). Over a smaller period of 655 days this model achieved a smaller average daily return of 1.04%. Due to these positive returns both tests indicate some level of inefficiency for S&P 500 Index options.

Poon and Pope (1999) expanded on the literature when they published a study that traded volatility spreads as a test of market efficiency. Before this, studies did not take into account information on common components of volatility in the returns of similar assets and their option values (Poon and Pope, 1999). Poon and Pope's study focused on the relative pricing of options on closely related assets with large common volatility components. If returns on two assets share common volatility components, the prices of options on the assets should be interdependent and the implied volatility spread should revert to the mean (Poon and Pope, 1999). They created an option market efficiency test centered around trading the volatility spreads of two options that have imperfectly related underlying securities. Poon and Pope believed their trading strategy is based on a vega neutral hedge position and is "designed to exploit disequilibrium in the relative implied volatilities between two option markets" (Poon and Pope, 1999). The strategy used both S&P 100 and 500 Index options on the CBOE from June 1989 to December 1993 and the results showed that the option markets are not jointly efficient (Poon and Pope, 1999). Periods of market inefficiency were observed in both options markets as the strategy achieved consistent profits.

Capelle-Blancard and Chaudhury (2001) used a no arbitrage price relationship to determine whether inefficiency was present in the CAC 40 French Index option market. They believed that a benefit of their study is that the method used does not depend on an option pricing model and instead on the validity of theoretical arbitrage pricing relationships such as Put-Call Parity. (Capelle-Blancard and Chaudhury, 2001). Hans Stoll (1969) created Put-Call Parity (PCP). PCP states that "the premium of a call option implies a certain fair price for the corresponding put option having the same strike price and expiration date, vice versa" (Stoll, 1969, p. 215). The PCP condition that assumes no transaction costs or dividend payments is:

$$\mathrm{C} + K^{-r_t} = P + S$$

Where,

$C =$ Price of a European call option,

$P =$ Price of a European put option,

$K =$ Exercise price,

$r_t =$ Risk-free rate, and

$S =$ Price of the underlying asset.

This equation states the price of a European call option plus the present value of the exercise price discounted from the value on the expiration date at the risk free rate is equal to the price of its corresponding European put option plus the price of the underlying asset.

Capelle-Blancard and Chaudhury suggest that if the PCP condition is violated then an investor is able to achieve a risk-free arbitrage profit using a long or short investment strategy. In a long strategy an investor would buy the underlying security and a put option, while selling a call option and borrowing at the risk-free rate. For a short strategy an investor would sell a put option and the underlying security, while buying a call option and lending at the risk-free rate (Capelle-Blancard and Chaudhury, 2001). The results were reported as a percentage of PCP violations over time. They showed that the CAC 40 Index violated the long PCP condition 42% of the time and violated the short condition 58% of the time (Capelle-Blancard and Chaudhury, 2001). In comparisons to tests run on U.S. Index options, the frequency of violations shows an improvement in the rate of market efficiency. Chance (1987) ran a test on the S&P 500 Index and found that the short PCP condition is violated 28% of the time while the long PCP condition is violated 43% of the time. Evnine and Rudd (1985) delved into the frequency of PCP violations for S&P 100 Index options. They found that the short PCP condition was violated 52% of the time while the long PCP condition was violated 22% of the time. Karma and Miller (1995) offered an explanation for the variation in PCP violations. They believed that the number of PCP violations is greater if open interest and index volume are low. Their theory explains why a smaller, more volatile index like the CAC 40 would exhibit a higher frequency of violations.

Another way that the literature has shown option market efficiency can be tested is index option portfolios. Constantinides, Czerwonko, and Perrakis (2016) considered two investors who purchase and sell European style options based on three different time intervals that range from 7 to 28 days. One investor holds an optimal portfolio of the S&P 500 Index and cash. The other investor holds the same portfolio and the zero net cost portfolio with a payoff at maturity. Constantinides et al. used second-order stochastic dominance to determine if option market inefficiency existed. Stochastic dominance is a type of partial ordering that occurs in decision making processes where one wager can be ranked as superior in comparison to another. Market inefficiency would exist if the zero net cost portfolio exhibits stochastic dominance over the optimal market portfolio. Constantinides et al. asserted that "an intuitive interpretation of stochastic dominance is that the investor increases her expected utility by shifting income from the states where the index level is high to states where the index level is low at zero net cost, while maintaining the same or higher expected portfolio return" (p. 1). The authors built off Constantinide's previous work from 1979 to develop the following stochastic dominance relationship:

$$E_t[A(S_{t+1})V_y(x_{t+1}, y_{t+1}, t+1)] > 0$$

Where,

$A(S_t) =$ Payoff of zero net cost portfolio,

$V(x, y, t) =$ Indirect utility, and

$E_t =$ Conditional expectation.

S&P 500 zero net cost portfolios that imply stochastic dominance on a monthly basis were able to be identified between 1990 and 2013. The zero net cost portfolio outperformed the optimal portfolio return by 0.5% for the 28 day trading period. Both the 7 and 14 day trading period portfolios outperformed the optimal portfolio by more than 1%. The authors also determined that stochastic dominance is more frequent when at the money implied volatility is high. They also discovered it was more frequent when right skewness was low (Constantinides et al., 2016). This provides significant evidence that some S&P 500 Index options are greatly mispriced in relation to the S&P 500 Index. This study was reproduced using option data from the CAC 40 and the DAX (German index). The 7 day trading period produced a statistically significant excess return of over 5% while the 14 and 28 day trading periods were insignificant. These results agree with the results of Chance (1987) and Evnine and Rudd (1985) showing that rates of market inefficiency are less in the United States.

There are many theories as to why option market inefficiency exists. With respect to index option inefficiency, one theory is that investors' credit and liquidity constraints may distort index option prices (Constantinides et al., 2016). Another theory is that index funds tend to minimize their tracking error and holding options would negatively impact this minimization attempt and result in a larger tracking error. Lots of active funds undertake alternative investment strategies and therefore may not hold a market portfolio. Although just theories, credit and liquidity constraints, different funds' optimization rules and alternative investment strategies are some of the potential reasons as to why funds with the research and capital necessary to take advantage of these periods of market inefficiencies do not do so.

2.4 Economic Policy Uncertainty Index

In 2016 Baker, Bloom and Davis developed an index called the Economic Policy Uncertainty (EPU) Index. The EPU uses newspaper coverage frequency as a proxy for movements in policy related economic uncertainty. The index reflects the frequency of articles in 10 leading U.S. newspapers for the human generated monthly index and 1,500 U.S.

newspapers from the Newsbank news aggregator for the computer-generated daily index. This allows a sufficient number of articles to generate a useful daily index (Baker et al., 2016). The daily EPU has a 0.85 correlation with the monthly 10 paper index. Although this is not perfect it provides a high frequency substitute for the monthly index. The index uses three underlying variables to calculate the EPU number. The first variable quantifies newspaper coverage data. The index searches newspapers for articles that contain a word or words from each of the three word categories. The three categories are: the economic category, with words such as "economic" and "economy"; the uncertain category, with words such as "uncertain" and "uncertainty"; and the policy category, with words such as "legislation", "Federal Reserve" and "White House". The second variable examines lists of U.S. federal tax provisions released by the Congressional Budget Office. Finally, the levels of dispersion amongst forecasted macroeconomic variables are investigated to discover any potential impact on economic policy. Each variable is normalized using standard deviation and then the average value of each variable is computed using weights of 50% for newspaper coverage and 16.67% for the other remaining variables (Baker et al., 2016).

The authors also analyzed the relationship between implied stock price volatility of 30-day equity options traded on the CBOE and the EPU Index. Their regression showed a significant relationship between the EPU Index and implied option volatility. For every 1% increase in the EPU Index, option implied volatility rose by 0.4% on average (Baker et al., 2016). This shows that both implied option volatility and option prices rise in regards to an increasing EPU Index. Because of how the EPU is constructed and computed it will be altered by news about Federal Reserve Meetings. This means the EPU should give some insight into the changes of option prices surrounding these meetings.

2.5 Market Reaction to Uncertain Events

Most of the literature on market reaction to uncertain events surrounds political events such as elections. Niederhoffer, Gibbs, and Bullock (1970) released a study of eighteen US presidential elections titled *"Presidential Elections and the Stock Market."* The study showed some tendencies occurring in financial markets surrounding presidential elections and their results. The study outlined the tendency that financial markets exhibit a higher return one week prior to a presidential election. If a Democratic Party candidate won financial markets would slump, while if a Republican Party candidate won the rise in financial markets would continue. Trading strategies were developed throughout future literature to profit from US presidential elections based of the findings of Niederhoffer et al. (1970). One of these strategies was created by Riley and Luksetich (1979). Their strategy consisted of short selling securities when a Democrat candidate was victorious and purchasing securities when a Republican candidate won. This shows the possibility of exploiting periods of inefficiency because if markets were efficient then the victory would be immediately priced into the market instead of lagging behind.

The next major study to note in this area was done by Gemmill (1991). He followed up on the previous theory by investigating the impact of an uncertain event on not just stock markets but option markets as well. Gemmill (1991) tested whether stock and option prices were consistent with opinion poll information surrounding the 1987 British election. According to the opinion polls, the Conservative party had an approximate 12.4% lead over their opposing party throughout the campaign. Based off the findings of Niederhoffer et al (1970) a market would prefer a Conservative victory. Semi-strong form market efficiency would then require a positive relationship between the chosen index and the probability of a Conservative party win (Gemmill, 1991). To test for differentiation between option pricing on the FTSE Index and election opinion polls, two separate daily option prices were calculated throughout the campaign using the assumption of risk-neutrality. Gemmill (1991) used a jump-diffusion model to derive the following option pricing formulas:

$$OPC_{t-n} = f\{g(1-\alpha), PF_{t-n}, r, \sigma, X, T\}$$

$$OPL_{t-n} = f\{-\alpha g, PF_{t-n}, r, \sigma, X, T\}$$

Where

$OPC =$ Option price contingent on a Conservative win in t days,

$OPL =$ Option price contingent on an opposition win in t days,

$\alpha =$ Probability of a Conservative win,

$PF =$ FTSE futures price,

$r =$ Risk free rate,

$\sigma =$ Volatility,

$X =$ Exercise price,

$T =$ Time to maturity, and

$n =$ Number of days until election date.

These equations were used to calculate the daily value of an index option during the campaign, contingent on the victorious candidate. The fair value of the equivalent FTSE Index options were then compared to the values from these equations. This revealed two important findings regarding market efficiency surrounding uncertain events. The first finding was that an index option's implied volatility significantly increases as the number of days until the election decreases. The second finding was that levels of market inefficiency also increase as the number of days until the election decreases. The probability of a loss inferred from index options differed from the opinion polls. The polls showed the Conservative Party had a low chance of losing the election, approximately 44% of the predicted votes with the other two parties splitting the remainder, while the probability of a loss inferred from index options was approximately 20% (Gemmill, 1991). Gemmill blamed a large inflow of ill-informed investors into the market looking to profit from the election's outcome as one of the largest contributors to the high level of inefficiency. These ill-informed investors purchased and/or sold index options but were unaware that the probability of a Conservative win was already priced into the underlying FTSE Index. Gemmill (1991) was one of the first researchers to explore the effect of an uncertain event on option market efficiency. He provided a basic theoretical framework for future researchers to expand on this underrepresented topic.

Kelly, Pastor, and Veronesi (2016) combined the work of Gemmill (1991) and Baker et al.'s 2016 study that created the EPU Index in an attempt to isolate political uncertainty from economic policy uncertainty. They attempted to do this by only assessing national elections and global summits. They analyzed 216 global summits and 64 elections from 20 different countries. They showed that political uncertainty has increased in recent years. Kelly et al (2016) interpreted the catalyst behind this increase to be an increased frequency of negative events requiring changes to government policies. The US exhibited larger levels of political uncertainty following the 2008 financial crisis. This was caused by the fear of new government administrations threatening to reform the finance industry to prevent future financial crises from occurring. This fear was partially brought on by the 2008 Emergency Economic Stabilization Act.

Kelly et al (2016) used S&P 500 Index options to conduct an empirical analysis to determine whether or not political uncertainty is priced into option markets. They captured the price, variance, and tail risk of a political event by using the differences in an index option's implied volatility, variance risk premium, and implied volatility slope. They drew conclusions from differences in these variables between two groups of index options. One group of options had lives spanning global summits or political elections while the other group, the control group, had lives that did not span these events. The results confirmed the hypothesis that political uncertainty is priced into option markets (Kelly et al., 2016). They found that the market price for a S&P 500 Index option was 8% more expensive if a political event occurs during the option's life. These results show that larger levels of political uncertainty increases the value of option protection against uncertain political event outcomes (Kelly et al., 2016). Investors are willing to pay higher prices for options that provide protection against negative market shocks linked to political events. Despite these findings it is still unclear if the occurrence of Federal Reserve meetings would show similar results. To the best of my knowledge, no literature has examined if the occurrence of Federal Reserve meetings is priced into option markets.

Gettleman, Julio, and Risik (2012) believe there is evidence in the literature that shows investors misreact in the option market. They disagreed with previous findings originally discussed by Poteshman (2001) that showed that investors who conduct option trading tend to overreact to large shifts in the price of the underlying asset in the long-term and underreact in the short-term. Gettleman et al. (2012) believed that investors overreact immediately to declines in the price of the underlying asset. They predicted that due to demand pressures, declines in the price of the underlying asset would cause out of the money puts to become overpriced. They tested this by looking at the difference between the Black-Scholes option pricing model's implied volatility and underlying asset realized volatility following price movements larger than 10%. Bollen and Whaley (2004) showed that this is an effective measure of how expensive an option is. Gettleman, Julio, and Risik (2012) conducted empirical tests using stock options from each of the constituents making up the S&P 100 Index. They used a five day event period surrounding asset price changes. The authors discovered that following a stock price decline of greater than 10%, the implied volatility of a stock option was 25.3% larger than the underlying asset's realized volatility. If the stock price decreased by more than 20%, the difference increases to 27.5% (Gettleman et al., 2012). These results showed that the greater the magnitude of a stock price decrease will cause put options to exhibit higher levels of overpricing, a form of market inefficiency.

Gettleman et al. (2012) provide evidence similar to the evidence provided by Gemmill (1991), that option inefficiency is a result of ill-informed investors panicking after a negative market shock, which leads them to buy out of the money puts as protection for their investments. This large inflow of investors into the option market cause the implied volatility to increase beyond the realized volatility by the underlying asset. This creates market inefficiency as put prices rise too high. Knowledgeable investors will take advantage of the ill-informed investors by selling them out of money put options. Using a delta hedging strategy the knowledgeable investor will achieve significant profits (Gettleman et al., 2012). The opposite will also occur during large stock price increases. Ill-informed investors will become over-excited and expect further price increases. These investors will purchase call options to attempt to take advantage of this. This increase in demand will cause call options to become overpriced and create market inefficiency if supply is inelastic. The theory that demand for an option significantly contributes to option inefficiency began with Bollen and Whaley (2004). They used S&P 500 Index options to show that demand for an option affects the implied volatility. Gettleman et al's. (2012) study contributed to the literature by providing continued evidence for Gemmill's (1991) theories as well as for Bollen and Whaley's (2004) theories on demand affecting option inefficiency.

2.6 Conclusion

As the risk management aspect of finance continues to become more and more important to investors, Black-Scholes and option market efficiency become more and more prevalent in the world of finance. Option market efficiency has been researched by many people, from Galai's 1977 test showing it was possible to buy and sell under and overvalued options to generate a profit of $1.29 per option per day for undervalued options and $1.73 per option per day for overvalued options to Capelle-Blancard and Chaudhury's 2001 test of PCP violations which showed the short PCP condition of the CAC 40 was violated 58% of the time and the long was violated 42% of the time; all the way to Noh, Engle and Kayne's 1994 test showing that abnormal returns were able to be achieved using two volatility models. Their IVR model produced an average daily return of 1.04% over 655 days and their GARCH model produced an average daily return of 1.62% over 1,048 days. These are multiple examples of studies showing that option markets experience varying periods of inefficiency. The question then becomes what causes these periods of inefficiency and are they predictable. Niederhofer et al. (1970) showed that tendencies exist in financial markets surrounding presidential elections. Gemmill (1991) provided evidence of inefficiency in option markets surrounding the 1987 British election. Can these windows of inefficiency be predicted by using an index such as the EPU Index? Or do they surround important policy events such as Federal Reserve meetings?

After analyzing the previous literature, it has become clear that there is a gap regarding the predictability of these periods of inefficiency when it comes to indexes like the EPU and important policy meetings like the Federal Reserve ones. Federal Reserve meetings fall into an interesting category as it is not quite a political event and occurs much more frequently than the previously studied political events but does have potential policy implications and effects on financial markets. The current study will attempt to uncover the relationship between Federal Reserve policy meetings and option market pricing inefficiencies.

Chapter 3: Data and Methodology

3.1 Data

The data used in the current study is European style US index call and put options trading on the CBOE. Thomson Reuters Eikon DataStream was used to retrieve all option data. It was also used to retrieve data on the S&P 500 Index, CBOE Volatility Index, federal funds futures and the federal funds target rate. The EPU Index was retrieved from the Economic Policy Uncertainty database. The sample period ranges from February 11th, 2005 to December 31st, 2011 and the frequency of each variable is daily. The Federal Reserve historical database was cross referenced to confirm the dates of past Federal Reserve meetings. All 56 Federal Reserve meeting dates that occurred from 2005 to 2011 were used. Only one US index was used, the Standard and Poor's 500 (S&P 500) Index. The sample consists of 1,644,010 observations. A group of control variables including a mix of numeric and dummy variables were picked to help empirically test the impact of Federal Reserve meetings on S&P 500 Index option market efficiency. The reasoning behind the inclusion of each variable as well as a definition of each variable is provided.

As mentioned in the option market efficiency literature, the market price of an option and the theoretical price (aka fair value) of an option can be used to determine whether inefficiency is present in the option price. Market price (MP) is the price for which an option is offered for sale or purchase on an option market exchange. The fair value (FV) of an option is calculated using the Black-Scholes option pricing model discussed in section 2.1. The following formula was used to analyze the value of option inefficiency within S&P 500 Index options as a percentage of the theoretical price.

$$ABSIFF_{t,i} = \left| \frac{MP_{t,i} - FV_{t,i}}{FV_{t,i}} \right|$$

ABSIFF represents the daily level of inefficiency for each individual index option. The absolute value of this measure is taken as the direction of inefficiency is irrelevant for this study as it only aims to see if inefficiency exists. If no inefficiency exists then, theoretically, the market price should be equal to the fair value. Where the market price is:

$$MP_{t,i} = FV_{t,i}\left(S_{t,i}, X_{t,i}, \sigma^2_{t,i}, r_{t,i}, T_{t,i}\right).$$

The market price, measured as the closing price, and fair value were both retrieved from Thomson Reuters Eikon DataStream. These values were then used to calculate ABSIFF through EViews.

The implied volatility (IV) of an option estimates the future volatility of its price by taking both its current and future values into consideration. IV does not aim to predict the direction of price change just the probability of an overall price fluctuation which can be either a depreciation or appreciation in value. Calculating IV uses both the market price of an option and an option pricing model such as Black-Scholes to infer volatility (McDonald, 2008). IV is estimated by taking the market price of the option and solving back through the option model for the volatility input. IV will increase as the probability of a significant price change increases. Large levels of IV lead to higher option premiums which effect option efficiency. Gettleman et al. (2012) indicated that a spike in IV can lead to options being overvalued. This means that IV influences option inefficiency and thus was included as a control variable. The IV of each index option was retrieved from Thomson Reuters Eikon DataStream and is backed out of the Black-Scholes option pricing model using the market price.

The CBOE Volatility Index (VIX) was used as a secondary measure of volatility. This index was created to measure the market's expectation of near-term volatility of S&P 500 Index options. The VIX is considered one of the best predictors of market volatility as it is based on the expectations of future volatility. During periods of higher expected volatility, investors are more likely to use low risk investment strategies. Future expectations of high volatility periods would result in larger VIX returns. The VIX is quoted in percentage points and represents the expected range of movement in the S&P 500 Index over the next year at a 68% confidence interval. For example, if the VIX is quoted at 12 then the market expects an annualized change of less than 12% up or down in the S&P500 at a 68% confidence interval. The CBOE Volatility Index was retrieved from Thomson Reuters Eikon DataStream.

An index option's underlying security is the index value on which the option contract is based. Due to the fact that this underlying value directly affects the price of the option, it is important to control for fluctuations in this value. Significant changes in the underlying index's value can influence the efficiency of index options. The current study only uses S&P 500 Index options and thus the control variable will be the index price of the S&P 500 Index. This value will be used to control for fluctuations in the underlying indexes value. The end of day closing price of the S&P 500 Index was retrieved from Thomson Reuters Eikon DataStream.

It is important to identify any potential differences in option inefficiency relating to the type of option an investor has selected. A call option gives an investor the right, but not the obligation, to purchase an underlying security, at a given price, within a certain period of time. A put option is the opposite of a call option. It gives an investor the right, but not the obligation, to sell a specified amount of an underlying security, at a given price, within a certain period of time. A dummy variable was created to identify the variation in option inefficiency between call and put options. Each option is assigned a value of 1 if it is a call option and a value of 0 if it is a put option. Each of the options used in this study are European-style options, which means the option can only be exercised on its expiry date. Another important distinction to make between different types of options is whether the option is in the money or out of the money. An option is in the money if it has intrinsic value. A call option is in the money if its exercise price is less than the price of its underlying security and out of the money if its exercise price is greater than the price of its underlying security. A put option is the opposite. It is in the money if its exercise price is greater than the price of its underlying security and it is out of the money if its exercise price is less than the price of its underlying security. Two variables were created to capture this difference. The first variable is the distance or dollar amount that an option is in the money (DITM). If the option was in the money, then the variable was calculated as the absolute value of the option's exercise price minus the price of its underlying security. If the option was out of the money then the variable took a value of zero. The second variable is the distance or dollar amount that an option is out of the money (DOTM). If the option was in the money, then the variable would take a value of zero. If the option was out of the money, then the variable was calculated as the absolute value of the option's exercise price minus the price of its underlying security.

Some significant events occurred during the sample period used including the 2008 financial crisis. In order to attempt to control for this, 6 dummy variables were created. One for each year except 2011 which will be used as the base case. For example, if an observation takes place in the year 2008 then the dummy variable for 2008 (Y08) will be equal to 1, if it does not take place in 2008 then this variable will take a value of zero. The same goes for the dummy variables for 2005, 2006, 2007, 2009 and 2010.

Over the course of the sample period there were two different chairs of the Federal Reserve, Alan Greenspan and Ben Bernanke. These two chairs had different approaches to monetary policy and on what information to share with the public. Alan Greenspan came from a professional background on Wall Street. He was not as open with the information released to the public as Bernanke. He also liked to make his decisions based off his "reads" on the economy (Smith, 2007). Greenspan was also mostly against setting a target level of inflation. Bernanke on the other hand came from a background as an academic. Bernanke preferred to base his monetary policy off models and projections and liked the idea of setting an inflation target. The difference between these two chairs has an impact on what information was available to the public and how decisions were made. This difference has the potential to affect the level of option inefficiency and thus another dummy variable was created in an attempt to control for this. The variable will take a value of 1 if the observation takes place under Ben Bernanke's time as chair of the Federal Reserve and zero otherwise.

Two more variables were used to help indicate uncertainty, the first of which is a variable created as a proxy for Federal Funds Uncertainty (FFU). The FFU variable was created using the federal funds target rate (FFTR) and the 30-day federal funds futures composite (FFF), which were both retrieved from Thomson Reuters Eikon DataStream. The 30-day federal funds futures composite takes a value between 0 and 100 and is a measure of the markets expectation of what the federal funds target rate will be in 30 days' time. If the value of the 30-day federal funds composite is 97.8 then that means investors expect the federal funds target rate to be 2.2% in 30 days. If the Federal Reserve decides to change the target rate then it is generally raised or lowered by a multiple of 0.25%. Therefore, it can be argued that markets expectation of the federal funds target rate is more uncertain when the federal funds futures composite is a value between multiples of 0.25 such as 97.625 versus a value that is a multiple of 0.25 such as 97.50. This is because if the current target rate was 2% and everyone expected the rate to increase by 0.25% then the federal funds futures composite should take a value of 97.75. If investors were equally undecided if it would increase by 0.25 or stay the same, then the federal funds futures composite would take a value of 97.875. Therefore, the Federal Funds Uncertainty variable (FFU) is calculated as follows:

$$FFU_{t,i} = \min\{\left|\left[\left(1 - FFF_{t,i}\right) - FFTR_{t,i}\right] mod\ 0.25\right|, 0.25 - \left|\left[\left(1 - FFF_{t,i}\right) - FFTR_{t,i}\right] mod\ 0.25\right|\}$$

Where,

$FFU_{t,i}$ = Federal Funds Uncertainty,

$FFF_{t,i}$ = 30-day Federal Funds Futures Composite, and

$FFTR_{t,i}$ = Federal Funds Target Rate.

The second variable used to control for uncertainty and one of the main variables of interest for this study is the EPU Index. The EPU Index captures fluctuations in economic policy uncertainty and was retrieved from the Economic Policy Uncertainty database. This variable is expected to have a positive correlation with inefficiency.

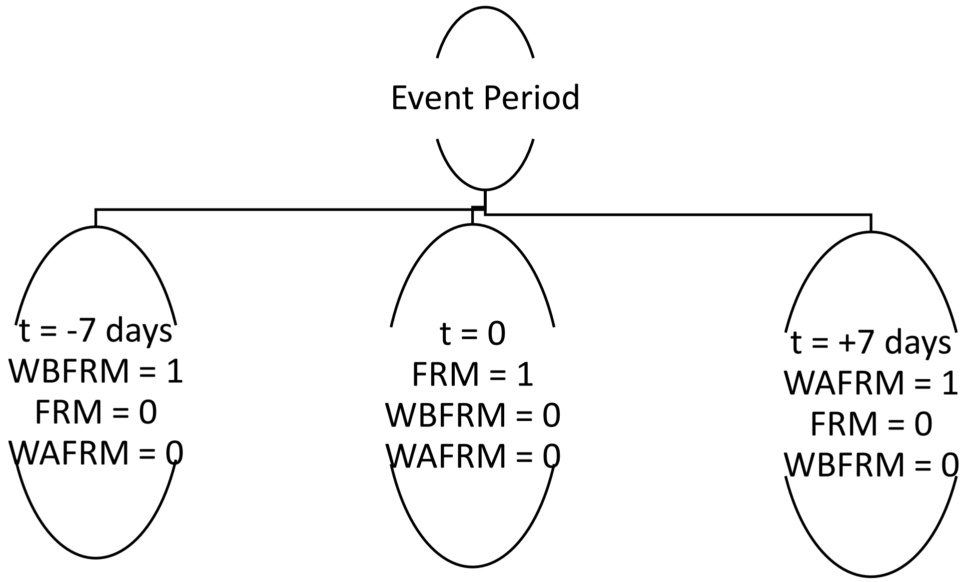
The final set of variables are dummy variables created to control for a 15-day event period surrounding Federal Reserve meetings. The first variable (WBFRM) takes a value of 1 if the observation occurs on a date within the week before a Federal Reserve meeting and a zero otherwise. The second variable (FRM) takes a value of 1 if the observation occurs on the date of a Federal Reserve meeting and a zero otherwise. The third and final variable (WAFRM) takes a value of 1 if the observation occurs on a date within the week after a federal reserve meeting and a zero otherwise. Fifty-six Federal Reserve meeting dates that occurred between 2005 and 2011 are used for this study. These meetings occur roughly every 6 weeks. Table 1 outlines the dates used. Figure 1 also outlines the structure of the event period. Table 2 provides the abbreviations for each variable as well as a short description.

Table 1 – Federal Reserve Meeting Dates

Federal Reserve Meeting Dates			
2005			
February 2nd	March 22nd	May 3rd	June 30th
August 9th	September 20th	November 1st	December 13th
2006			
January 31st	March 28th	May 10th	June 29th
August 8th	September 20th	October 25th	December 12th
2007			
January 31st	March 20th	May 9th	June 28th
August 7th	September 18th	October 31st	December 11th
2008			
January 30th	March 18th	April 30th	June 25th
August 5th	September 16th	October 29th	December 16th
2009			
January 28th	March 18th	April 29th	June 24th
August 12th	September 23rd	November 4th	December 16th
2010			
January 27th	March 16th	April 28th	June 23rd
August 10th	September 21st	November 3rd	December 14th
2011			
January 26th	March 15th	April 27th	June 22nd
August 9th	September 21st	November 2nd	December 13th

Notes: All dates were retrieved from the Federal Reserve historical database.

Figure 1 – Fifteen Day Event Period



Notes: A Fifteen-day event period is used to measure the difference in index option inefficiency surrounding the 56 Federal Reserve meetings.

Table 2 – Variable Description

Variable Name	Abbreviation	Description
Option Inefficiency	ABSIFF	Measure of option inefficiency
Implied Volatility	IV	Estimated volatility of a security's price backed out of Black-Scholes
S&P 500 Index Price	SP500	S&P 500 daily index price
CBOE Volatility Index	VIX	Market expectation of near-term volatility
Economic Policy Uncertainty Index	EPU	Measure of economic policy uncertainty
Federal Funds Uncertainty	FFU	Measure of federal funds uncertainty
Dollars In the Money	DITM	Dollar amount by which an option is in the money
Dollars Out of the Money	DOTM	Dollar amount by which an option is out of the money
Call Option Dummy	CALL	Option is a call option
Ben Bernanke Dummy	BB	Observation occurs while Ben Bernanke was chair of the Federal Reserve
Week Before Federal Reserve Meeting	WBFRM	Dummy variable for the week before a Federal Reserve meeting
Day of Federal Reserve Meeting	FRM	Dummy variable for the day of a Federal Reserve meeting
Week After Federal Reserve Meeting	WAFRM	Dummy variable for the week after a Federal Reserve meeting
Year 2005	Y05	Dummy variable for an observation occurring in 2005
Year 2006	Y06	Dummy variable for an observation occurring in 2006
Year 2007	Y07	Dummy variable for an observation occurring in 2007
Year 2008	Y08	Dummy variable for an observation occurring in 2008
Year 2009	Y09	Dummy variable for an observation occurring in 2009
Year 2010	Y10	Dummy variable for an observation occurring in 2010

Notes: All data was retrieved from Thomson Reuters Eikon DataStream, the Economic Policy Uncertainty database and the Federal Reserve historical database.

3.2 Summary Statistics

Table 3A – Summary Statistics Unrestricted

Variable: Average	ABSIFF	IV	SP500	VIX	EPU	FFU	DITM	DOTM
2005 (27,396)	0.055010	0.1764	1217.88	12.68	60.14	0.042	119.03	117.03
2006 (131,818)	0.006353	0.2061	1316.43	12.87	56.84	0.029	88.24	96.19
2007 (182,973)	0.005673	0.2468	1480.22	18.37	64.19	0.036	101.47	102.12
2008 (282,105)	0.088447	0.3802	1194.21	34.77	145.59	0.050	123.58	122.94
2009 (364,409)	0.274142	0.4124	955.14	30.90	130.18	0.066	146.07	145.93
2010 (377,372)	0.649704	0.3735	1137.97	22.65	148.66	0.066	149.92	150.18
2011 (277,937)	0.016172	0.4151	1276.01	23.14	145.06	0.095	152.71	153.68
Overall Average (1,644,010)	0.229782	0.3595	1184.17	25.21	125.18	0.061	134.17	134.92
Minimum	0.000000	0.0088	676.53	9.89	3.38	0.000	0.00	0.00
Maximum	58734.29	9.9255	1565.15	80.86	626.03	0.125	1900.77	1900.77
Standard Deviation	49.14769	0.361849	191.0109	11.64820	75.96441	0.035347	215.9277	216.1376

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. Numbers in parentheses are the number of observations in the given year. The data covers a sample period of February 11th, 2005 to December 31st, 2011.

Table 3A above displays moments of a data set of 1,644,010 observations of options with varying maturity periods and exercise prices. 49.96% of the observations are call options while the other 50.04% are put options. This results in 821,328 call option observations and 822,682 put option observations. Exercise prices ranged from a minimum of $100 to a maximum of $3000, which resulted in an average exercise price of $1104 over the sample period. In the sample 50.12% of the observations are options that are out of the money while 49.88% are in the money and the remaining less than 0.01% are options at the money. This results in 823,937 observations out of the money, 820,061 observations in the money and 12 observations at the money.

During the sample period, S&P 500 Index options trading on the CBOE experienced an average daily level of option inefficiency of 22.9782%. The most inefficient year according to Table 3A was 2010 with an average option inefficiency of 64.9704%. If absolute values of inefficiency were not used, then the overall average of inefficiency would show that the options in the sample period are overpriced on average. These values seem quite large. A closer look at the sample reveals some large outliers, the largest of which is a 5,873,429% level of inefficiency. The next highest level of inefficiency is 1,073,556%. Going back to the raw sample data it appeared there was some values that were recorded incorrectly. There were 55 observations with a level of inefficiency greater than 100,000%. There were 486 observations with a level of inefficiency greater than 10,000%, 945 observations with a level of inefficiency greater than 1,000% and 2419 observations with a level of inefficiency greater than 100%. Compared to the sample size of 1,644,010 observations these are relatively low numbers with only 0.15% of the observations experiencing a level of inefficiency greater than 100%. A call option with an expiration date in December 2011 and an exercise price of $2000 accounted for 42 out of the 55 observations with an efficiency greater than 100,000%. It is hypothesized that the data for this option was skewed by a low volume of options traded. Data on volume was not available for all options. Due to these outliers many robustness tests were performed to determine an appropriate cutoff for ABSIFF. These robustness tests will be discussed in greater detail, but they resulted in a cutoff of an inefficiency level of 100%. Due to this sample restriction a second table of summary statistics is presented. Table 3B shows the summary statistics for the restricted sample.

Table 3B – Summary Statistics Restricted (ABSIFF < 1)

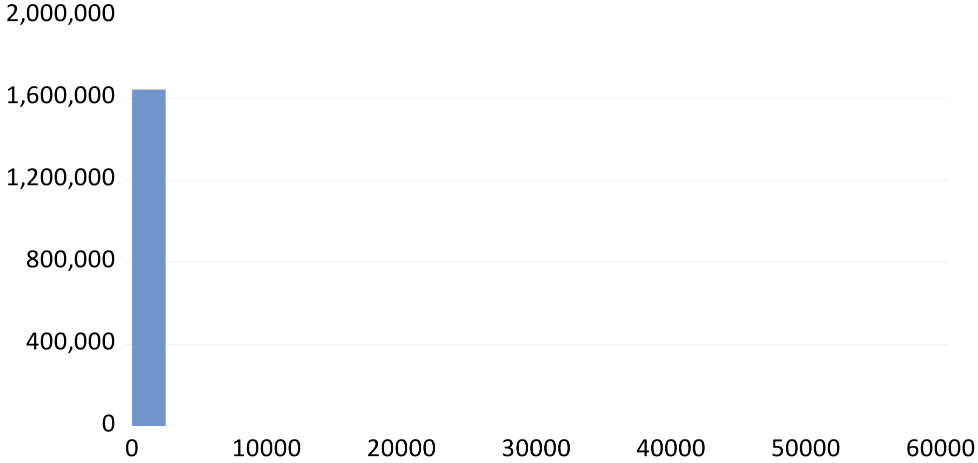
Variable: Average	ABSIFF	IV	SP500	VIX	EPU	FFU	DITM	DOTM
2005 (27,347)	0.003370	0.1764	1217.87	12.68	60.13	0.042	119.24	116.51
2006 (131,737)	0.002693	0.2061	1316.45	12.87	56.85	0.029	88.29	95.94
2007 (182,950)	0.004255	0.2468	1480.22	18.37	64.19	0.036	101.48	102.12
2008 (281,769)	0.005917	0.3801	1194.28	34.76	145.54	0.050	123.70	122.73
2009 (364,031)	0.003224	0.4123	955.04	30.91	130.20	0.066	146.18	145.72
2010 (375,208)	0.008174	0.3737	1138.02	22.65	148.63	0.066	150.64	148.80
2011 (277,790)	0.011467	0.4147	1276.02	23.13	145.04	0.095	152.79	153.50
Overall Average (1,640,832)	0.006289	0.3594	1184.26	25.21	125.14	0.061	134.38	134.45
Minimum	0.000000	0.0088	676.53	9.89	3.38	0.000	0.00	0.00
Maximum	0.999941	9.9255	1565.15	80.86	626.03	0.125	1900.77	1900.77
Standard Deviation	0.048360	0.360666	191.1101	11.65098	75.95838	0.035358	216.0698	215.6532

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. Numbers in parentheses are the number of observations in the given year. The data covers a sample period of February 11th, 2005 to December 31st, 2011.

As can be seen above in Table 3B, all the variables except for ABSIFF stay at relatively the same levels with this cutoff implemented. This provides some evidence for the hypothesis that these outliers were caused by measurement error. Figure 2A shows a histogram analysis of ABSIFF without restrictions, while Figure 2B shows a histogram analysis of ABSIFF with the chosen restriction. These histograms show the distribution of ABSIFF and shows that the restriction is eliminating massive outliers that likely resulted from measurement error. Table 3B consists of a data set of 1,640,832 observations of options with varying maturity periods and exercise prices. This constitutes a reduction in sample size of 3,178 observations or 0.19%. Of the observations 49.95% are call options while the other 50.05% are put options. This results in 819,632 call option observations and 821,200 put option observations. This restriction very slightly altered the call to put balance by 0.01%. Exercise prices ranged from a minimum of $100 to a maximum of $3000, which resulted in an average exercise price of $1104 over the sample period. This did not change with the restriction. In the sample 50.06% of the observations are options that are out of the money while 49.94% are in the money and the remaining less than 0.01% are options at the money. This results in 821,437 observations out of the money, 819,383 observations in the money and 12 observations at the money. The balance of out of the money observations vs in the money observations also shifted slightly with the restriction but only by 0.06%. During the sample period with restrictions, S&P 500 Index options trading on the CBOE experienced an average daily level of option inefficiency of 0.6289%. The most inefficient year according to Table 3B was 2011 with an average option inefficiency of 1.1467%. The average values for ABSIFF have decreased significantly with the restriction to the sample and show just how much the 0.19% of observations that were cut were skewing the sample.

If absolute values of inefficiency were not used, then the overall average of inefficiency would show that the options in the sample period are underpriced. This shows that an index options market price is less than the theoretical price derived from the Black-Scholes option pricing model. These new findings are consistent with the work of Galai (1977), who showed evidence of option underpricing being more frequent than overpricing for index options. It is important that these statistics show that option inefficiency exists as it allows the current study to empirically test the effect of Federal Reserve meetings on option inefficiency.

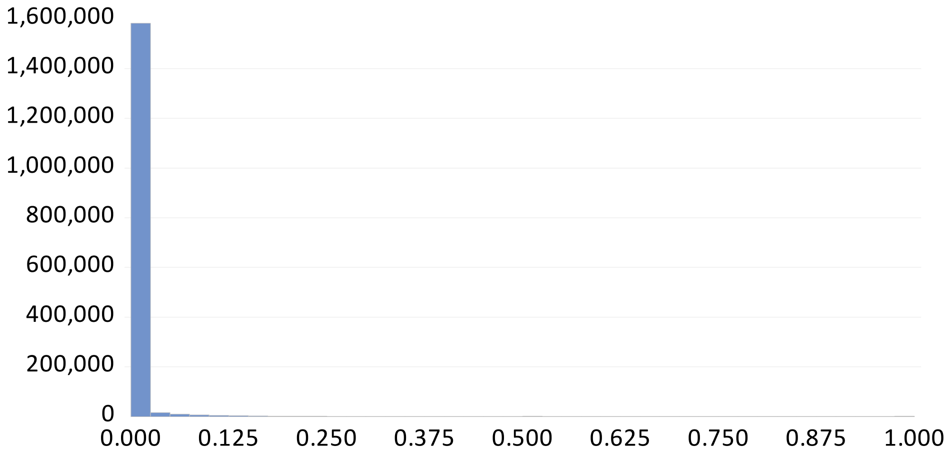
Figure 2A – ABSIFF Histogram (No Restrictions)



Series: ABSIFF
Sample 1 1644010
Observations 1643545

Mean	0.229837
Median	0.000000
Maximum	58734.29
Minimum	0.000000
Std. Dev.	49.14595
Skewness	1052.397
Kurtosis	1243499.
Jarque-Bera	1.06e+17
Probability	0.000000

Figure 2B – ABSIFF Histogram (ABSIFF < 1)



Series: ABSIFF
Sample 1 1644010 IF FV<>0
AND MP<>0 AND ABSIFF<1
Observations 1640832

Mean	0.006289
Median	0.000000
Maximum	0.999941
Minimum	0.000000
Std. Dev.	0.048360
Skewness	13.88417
Kurtosis	236.5220
Jarque-Bera	3.78e+09
Probability	0.000000

Table 4 – Variable Correlation Matrix

	IV	SP500	VIX	EPU	FFU	DITM	DOTM
IV	1.000						
SP500	-0.2020	1.000					
VIX	0.2393	-0.6952	1.000				
EPU	0.1500	-0.3924	0.4886	1.000			
FFU	0.0996	-0.0931	0.0560	0.2063	1.000		
DITM	0.1388	-0.0611	0.0386	0.0449	0.0586	1.000	
DOTM	0.2276	-0.0609	0.0379	0.0452	0.0515	-0.3878	1.000

Notes: Correlation matrix figures were taken from EViews 10 University Edition. Correlation coefficients were used to determine if and how strongly pairs of control variables were related. A coefficient of 0.0 indicates that there is no relationship between the two variables.

Before the levels of daily option inefficiency can be empirically analyzed, it is worthwhile to test for any hidden correlations between control variables that will be used in the regression model specifications. This is because an extremely high correlation (0.90 and above) between two variables can inflate the variance of the regression coefficients and make it hard to determine their significance. The correlation matrix is presented in Table 4. Correlation coefficients range from -1 to +1 and display if and how strongly a pair of variables are linearly related. Values closer to +1 represent stronger positive relationships, while values closer to -1 represent stronger negative relationships. The closer a value is to 0, the weaker the relationship is, with 0 representing no relationship at all. The first pair of variables that were predicted to be highly correlated were EPU and FFU as they are both measures of uncertainty. The correlation coefficient between the two is 0.2063. This shows that although both variables measure uncertainty they are capturing uncertainty in different ways. Although they are correlated it is a weak relationship and should not cause any problems with testing. The next set of variables predicted to be correlated were implied volatility and the CBOE Volatility Index (VIX). This is because both variables measure future expectations of risk. The correlation coefficient between the two is 0.2393. This shows that although they both measure future expectations of risk they are measuring different expectations. This is probably because implied volatility is option specific and calculated through a model, whereas the CBOE Volatility Index is the market's expectation of near-term volatility based off of what market participants think. Although there is a relationship present, it is once again a weak one and thus should not cause any problems with the regressions. The third set of variables predicted to be highly correlated were the SP500 variable and the VIX variable. This is because the VIX measures the markets expectation of near-term volatility of the S&P 500 Index and the SP500 variable is the index price of the S&P 500. These variables have a correlation coefficient of -0.6952. This is a moderately strong negative relationship. It is weak enough though that it should not cause any problems with testing. A look at the other values in Table 4 shows weak to moderately strong relationships between variables but nothing that should cause significant issues while testing.

3.3 Methodology

To determine the effect Federal Reserve meetings have on the level of option inefficiency, the absolute value of the percentage of theoretical price (ABSIFF) will be used. ABSIFF is calculated as the absolute value of the market price minus the fair value price divided by the fair value price and was chosen because it measures the level of inefficiency for a given option.

$$ABSIFF_{t,i} = \left| \frac{MP_{t,i} - FV_{t,i}}{FV_{t,i}} \right|$$

The two hypotheses that this study aims to test are as follows:

1. *An increase in economic policy uncertainty will increase the level of option inefficiency amongst S&P 500 Index options trading on the CBOE.*
2. *The occurrence of U.S. Federal Reserve policy meetings increases the level of option inefficiency amongst S&P 500 Index options trading on the CBOE.*

These two hypotheses are based off Niederhoffer (1970), Gemmill (1991) and Kelly et al. (2016), who all identified tendencies and/or periods of market inefficiency surrounding uncertain events such as significant political events. Federal Reserve meetings are not exactly political events, but they are policy related and have an uncertain outcome. This study aims to test if the findings by these authors extend to Federal Reserve meetings as well. If EPU has a positive statistically significant coefficient then the first hypothesis stating that an increase in EPU will increase the level of inefficiency of S&P 500 Index options is accepted. If the dummy variables for the event period surrounding the Federal Reserve meetings have a positive statistically significant coefficient then the second hypothesis stating that the occurrence of Federal Reserve policy meetings increases the level of inefficiency of S&P 500 Index options can be accepted.

Relevant literature such as Noh et al. (1994) and Galai (1977), has provided evidence that periods of inefficiency exist within option markets. This is why ABSIFF was chosen as the dependent variable. It encompasses the total level of inefficiency for a given option and thus using it as the dependent variable will seek to provide an explanation as to why these periods of inefficiency occur.

The first of the two main independent variables of interest are the set of three dummy variables for the event period surrounding the Federal Reserve meetings; WBFRM, FRM, and AFRM. These variables represent the week before the meeting, the day of the meeting, and the week after the meeting. The second main variable of interest is EPU. EPU is measured using the Economic Policy Uncertainty Index and measures the level of economic policy uncertainty present on a given day. Each independent variable will be deemed statistically significant if it is significant with a minimum cutoff less than 1%. This level of significance was chosen due to the large number of observations. Depending on the results of the regression, either a positive or negative coefficient will support the stated hypotheses or other theories found in the literature as to why options markets experience periods of inefficiency.

The regression that will be conducted is outlined below:

$$(1) \quad ABSIFF_{t,i} = \alpha + \beta_{IV} * IV_{t,i} + \beta_{SP500} * \log(SP500_{t,i}) + \beta_{VIX} * VIX_{t,i}$$
$$+ \beta_{EPU} * \log(EPU_{t,i}) + \beta_{FFU} * FFU_{t,i} + \beta_{CALL} * CALL_{t,i} + \beta_{DITM} * DITM_{t,i}$$
$$+ \beta_{DOTM} * DOTM_{t,i} + \beta_{BB} * BB_{t,i} + \beta_{WBFRM} * WBFRM_{t,i} + \beta_{FRM} * FRM_{t,i}$$
$$+ \beta_{WAFRM} * WAFRM_{t,i} + \beta_{Y05} * Y05_{t,i} + \beta_{Y06} * Y06_{t,i} + \beta_{Y07} * Y07_{t,i}$$
$$+ \beta_{Y08} * Y08_{t,i} + \beta_{Y09} * Y09_{t,i} + \beta_{Y10} * Y10_{t,i} + \varepsilon_{t,i}$$

A log relationship was chosen with respect to the S&P 500 and EPU indices. This is because the percentage change of these variables matters much more than a one unit increase and logging them allows for this percentage change to be addressed. An Ordinary Least Squares (OLS) regression following the format above will be run. The regression will be run using ordinary standard errors but robustness tests will be conducted using Huber-White standard errors to ensure the variables are still significant if heteroscedasticity is present.

Chapter 4: Results

Table 5 – Regression 1 Results (ABSIFF < 100%)

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/03/19 Time: 20:27
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<1
Included observations: 1640832

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.153504	0.005880	-26.10571	0.0000
IV	-0.002372	0.000114	-20.72183	0.0000
LOG(SP500)	0.022966	0.000798	28.76924	0.0000
VIX	0.000338	8.64E-06	39.08493	0.0000
LOG(EPU)	0.000977	8.22E-05	11.88868	0.0000
FFU	-0.029386	0.001336	-21.99921	0.0000
CALL	-0.004174	7.73E-05	-54.02450	0.0000
DITM	5.51E-06	1.98E-07	27.76746	0.0000
DOTM	-1.57E-06	2.01E-07	-7.781698	0.0000
BB	-0.006655	0.000645	-10.32246	0.0000
WBFRM	-0.000298	0.000107	-2.791256	0.0053
FRM	0.001175	0.000219	5.358498	0.0000
WAFRM	0.000785	0.000107	7.373180	0.0000
Y05	-0.011224	0.000721	-15.56381	0.0000
Y06	-0.007538	0.000199	-37.82452	0.0000
Y07	-0.010120	0.000202	-50.13167	0.0000
Y08	-0.008868	0.000155	-57.35886	0.0000
Y09	-0.004769	0.000215	-22.22191	0.0000
Y10	-0.001497	0.000152	-9.814813	0.0000

R-squared	0.007671	Mean dependent var	0.006289
Adjusted R-squared	0.007660	S.D. dependent var	0.048360
S.E. of regression	0.048175	Akaike info criterion	-3.227954
Sum squared resid	3808.001	Schwarz criterion	-3.227812
Log likelihood	2648284.	Hannan-Quinn criter.	-3.227916
F-statistic	704.6393	Durbin-Watson stat	0.798931
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables and also due to the restriction of ABSIFF < 100%. Regression output was taken from EViews 10 University edition.

The results of Regression 1 appear in Table 5 above. This regression consisted of 1,640,832 observations. Based off of the adjusted R-squared value, this regression model explains 0.7671% of the variation of S&P 500 Index option pricing inefficiency on the CBOE over the period of February 11th, 2005 to December 31st, 2011, on average. The adjusted R-squared indicates a low amount of variability in the level of index option inefficiency has been accounted for in this regression model. Low to moderate R-squared values are consistent with other results presented throughout the finance related literature.

An F-test was used to test the significance of the specified regression model. The F-test tests the joint statistical significance of the regression slope coefficients. The null and alternative hypotheses tested by the F-test are as follows:

$$H_0: \beta_{IV} = \beta_{SP500} = \beta_{VIX} = \beta_{EPU} = \beta_{FFU} = \beta_{CALL} = \beta_{DITM} = \beta_{DOTM} = \beta_{BB} = \beta_{WBFRM} \\ = \beta_{FRM} = \beta_{WAFRM} = \beta_{Y05} = \beta_{Y06} = \beta_{Y07} = \beta_{Y08} = \beta_{Y09} = \beta_{Y10} = 0$$

$$H_A: \beta_{IV} \neq \beta_{SP500} \neq \beta_{VIX} \neq \beta_{EPU} \neq \beta_{FFU} \neq \beta_{CALL} \neq \beta_{DITM} \neq \beta_{DOTM} \neq \beta_{BB} \neq \beta_{WBFRM} \\ \neq \beta_{FRM} \neq \beta_{WAFRM} \neq \beta_{Y05} \neq \beta_{Y06} \neq \beta_{Y07} \neq \beta_{Y08} \neq \beta_{Y09} \neq \beta_{Y10} \neq 0$$

If the null hypothesis is not rejected, then all the slope coefficients in the regression are not statistically significant from zero. If this were the case, then the conditional expectation of option inefficiency would be a constant value and would not react significantly to changes in the variables contained in the regression such as implied volatility and the option's underlying securities value. A large F-statistic is evidence against the null hypothesis. The F-statistic for Regression 1 is 704.6393, which is much large than zero. The p-value for the F-statistic is 0.00000, which is less than any normal level of significance, therefore the null hypothesis is rejected. In other words, it can be concluded that the regression coefficients are jointly significantly different from zero. This means that the variables used in the regression have an impact on option inefficiency.

The first variable of interest is the Economic Policy Uncertainty Index (EPU). The EPU's p-value is 0.0000 and it is thus its coefficient is significantly different from zero at all standard levels of significance. A 1% increase in the EPU Index is expected to increase the option's daily level of market inefficiency by 0.000977 percentage points on average. This coincides with the first hypothesis that an increase in the EPU Index will increase the level of option market inefficiency of S&P500 Index options traded on the CBOE. This coincides with Gemmill's (1991) results that option markets experience an increased level of inefficiency surrounding uncertain events such as political elections. Although this result provides a link between option inefficiency and the EPU Index, the size of the coefficient is economically insignificant for small changes in the EPU Index. For example, say an option had a fair value of $1000, if the EPU Index increased by 1%, the price difference between the fair value and the market price will increase by $0.98. For reference the average S&P 500 Index price over the sample period is $1184.26. Assuming trading costs do not wipe out this difference, and an investor was able to accurately predict an increase in the EPU Index, roughly $100,000 would need to be spent to make $98. If an investor was able to predict a large increase in the EPU Index, then this would in fact be an economically significant difference and an investor would be able to gain an abnormal profit.

The next variables of interest are the dummy variables surrounding the Federal Reserve meeting dates (FRM, WBFRM, WAFRM). The dummy variable for observations that occur on dates in the week before the scheduled Federal Reserve meeting (WBFRM) returned a p-value of 0.0053 and thus its coefficient is significantly different from zero at the 1% level of significance. Holding everything else constant, on a day within a week of a scheduled Federal Reserve meeting, an option is expected on average to experience a decrease in inefficiency by 0.0298 percentage points compared to an option on a regular day not surrounding a Federal Reserve meeting. The dummy variable for observations that occur on the day of the scheduled

Federal Reserve meeting (FRM) returned a p-value of 0.0000 and thus its coefficient is significantly different from zero at the 1% level of significance. All other variables remaining unchanged, on the day of the Federal Reserve meeting an option is expected to experience a 0.1175 percentage point increase in inefficiency on average compared to an option on a regular day not surrounding a Federal Reserve meeting. The dummy variable for observations that occur on dates in the week following the scheduled Federal Reserve meeting (WAFRM) returned a p-value of 0.0000 and thus its coefficient is significantly different from zero at the 1% level of significance. Holding everything else constant, on a date within the week following a Federal Reserve meeting an option is expected to experience a 0.0785 percentage point increase in inefficiency compared to an option on a regular day not surrounding a Federal Reserve meeting on average. This is consistent with the second hypothesis that the occurrence of Federal Reserve meetings would increase the daily level of option market inefficiency of S&P500 Index options traded on the CBOE. This would also coincide with Gemmill's (1991) evidence that option inefficiency will increase surrounding uncertain events.

The coefficients for FRM and WAFRM are very similar and thus a Wald test was conducted in EViews to determine if their coefficients are significantly different from each other. A Wald test is used to test the possibility of coefficients taking a specified value. The null and alternative hypotheses that were tested are as follows:

$$H_0: \beta_{FRM} = \beta_{WAFRM}$$

$$H_A: \beta_{FRM} \neq \beta_{WAFRM}$$

The resulting p-value for the Wald test is 0.0970. Therefore, the two coefficients are significantly different from each other at a 10% level of significance but not at the 1% level of significance that was set for the current study. A full print out of the Wald test conducted in EViews can be found in Appendix A.

It is interesting to note however that the option market inefficiency decreases in the week prior to the meeting on average before spiking on the day of the meeting and then slightly decreasing but staying elevated for the week following the meeting. It is important to discuss whether or not these deviations are economically significant. In order to determine this, consider a quick example. If an option's fair value is $1000, on the day of the Federal Reserve meeting the difference between the option's market price and fair value will increase by 0.1175% of the options fair value. In this example that would be $1.75. This would mean that the option in question is either underpriced or overpriced by $1.75 on the day of the Federal Reserve meeting. This is an economically insignificant number especially when trading costs are taken into account.

One hypothesis for this would be that leading up to the meeting people think they know what is going to happen at the meeting and thus become falsely more certain. Then once the statement is actually released it may or may not conform to their expectations. This could cause some uncertainty for the market participants who experienced an unexpected result. In the week following the meeting this unexpected shock persists as market participants speculate and wait to see how the market will react to the changes.

All other variables in Regression 1 have coefficients that are significantly different from zero at the 1% level of significance. It is important to briefly discuss these variables as well. Holding everything else constant a 1 point increase in an option's implied volatility is expected to decrease its daily level of market inefficiency by 0.2372 percentage points on average. This is interesting and matches the relationship that was expected between these two variables.

Generally speaking an option with a larger implied volatility will have a higher price than a similar option with a lower implied volatility. One explanation for this relationship would be that the market price of an option is generally lower than the calculated fair value price of the option in the current sample, thus when the implied volatility rises the market price also rises pushing it closer to the fair value and lowering the inefficiency for small changes in implied volatility. This holds true within the sample used for the regression as 366,927 observations have a market price lower than the fair value price whereas only 32,839 observations have a market price greater than the fair value price. This would also imply that the volatility of the underlying asset is greater than the implied volatility of the option on average as the implied volatility is backed out of the Black Scholes equation using the market price whereas the fair value is calculated using the volatility of the underlying asset.

Holding everything else constant, a 1% increase in the price of the S&P 500 Index (the option's underlying asset) is expected to raise the option's daily level of market inefficiency by 0.022966 percentage points. All other variables remaining constant, a 1 percentage point increase in the CBOE Volatility Index (VIX) is expected to raise the option's inefficiency by 0.0338 percentage points on average. Everything else being constant, a 1 percentage point increase in federal funds uncertainty is expected to decrease an option's inefficiency by 2.9386 percentage points on average. Holding everything else constant, a call option is expected to be 0.4174 percentage points less inefficient than a put option on average. All other variables remaining unchanged, for every additional dollar an option moves into the money, the option's inefficiency is expected to increase by 0.000551 percentage points on average. Holding everything else constant, for every additional dollar an option moves out of the money, the option's inefficiency is expected to decrease by 0.000157 percentage points on average.

Everything else remaining constant, an option on the market during the time Ben Bernanke was chair of the Federal Reserve is expected to be 0.6655 percentage points more efficient than options on the market during Alan Greenspan's time as chair of the Federal Reserve on average. This is interesting and most likely has to do with their two different approaches to what information should be released to the public. Ben Bernanke was willing to share much more information with the public than Alan Greenspan. Bernanke also based his decisions on models and projections more than Greenspan did. The following can be hypothesized based of this difference in chairs of the Federal Reserve. The decisions that came from a consistent model would be more predictable by investors. This along with Bernanke releasing more information to the public would make people feel more informed and allow them to better predict the markets reactions. This in turn would cause the options to be less inefficient on average.

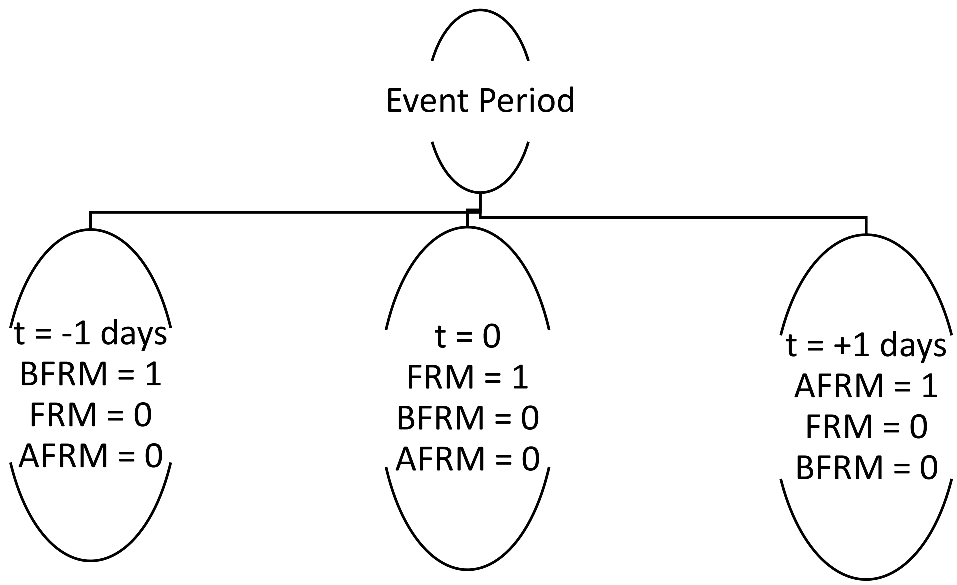
The last set of variables was used to control for structural differences between years. Holding everything else constant, an observation that occurred in 2005 was found to be 1.1224% more efficient than observation that occurred in 2011 on average. All other variables remaining unchanged, an observation that occurred in 2006 was found to be 0.7538% more efficient than observation that occurred in 2011 on average. Holding everything else constant, an observation that occurred in 2007 was found to be 1.0120% more efficient than observation that occurred in 2011 on average. All other variables remaining unchanged, an observation that occurred in 2008 was found to be 0.8868% more efficient than observation that occurred in 2011 on average. Holding everything else constant, an observation that occurred in 2009 was found to be 0.4769% more efficient than observation that occurred in 2011 on average. All other variables remaining unchanged, an observation that occurred in 2010 was found to be 0.1497% more efficient than observation that occurred in 2011 on average. Coefficient tests were conducted between all the yearly dummy variables due to their close magnitudes to determine if they were significantly different from each other. The results showed that all yearly dummy variables are significantly different from each other at all standard levels of significance except for Y05 and Y07. The tests showed that the difference between 2005 and 2007 was not significantly different from zero as the test resulted in a p-value of 0.1345. The full printouts of the coefficient tests can be found in Appendices B through P.

4.1 Robustness Testing

4.1.1 Three Day Event Period

The first robustness test conducted uses a smaller event period to see if similar results are present during a three-day event period surrounding Federal Reserve meetings. BFRM was used to control for the day before a Federal Reserve meeting. It takes a value of 1 on the day before a Federal Reserve meeting and a zero otherwise. AFRM was used to control for the day before a Federal Reserve meeting. It takes a value of 1 on the day after a Federal Reserve meeting. Figure 3 shows the 3-day event period.

Figure 3 – Three Day Event Period



Notes: Fifteen-day event period is used to measure the change of index option inefficiency surrounding the 56 Federal Reserve meetings.

Both AFRM and BFRM will be added into Regression 1 in place of WBFRM and WAFRM. The sample has the same restrictions as Regression 1 and the same time period of February 11th, 2005 to December 31st, 2011. This new regression will be referred to as Regression 2.

$$\begin{aligned}(2)\quad ABSIFF_{t,i} = {} & \alpha + \beta_{IV} * IV_{t,i} + \beta_{SP500} * \log(SP500_{t,i}) + \beta_{VIX} * VIX_{t,i} \\ & + \beta_{EPU} * \log(EPU_{t,i}) + \beta_{FFU} * FFU_{t,i} + \beta_{CALL} * CALL_{t,i} + \beta_{DITM} * DITM_{t,i} \\ & + \beta_{DOTM} * DOTM_{t,i} + \beta_{BB} * BB_{t,i} + \beta_{BFRM} * BFRM_{t,i} + \beta_{FRM} * FRM_{t,i} \\ & + \beta_{AFRM} * AFRM_{t,i} + \beta_{Y05} * Y05_{t,i} + \beta_{Y06} * Y06_{t,i} + \beta_{Y07} * Y07_{t,i} \\ & + \beta_{Y08} * Y08_{t,i} + \beta_{Y09} * Y09_{t,i} + \beta_{Y10} * Y10_{t,i} + \varepsilon_{t,i}\end{aligned}$$

Table 6 – Regression 2 Results (ABSIFF < 100%)

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 02:35
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<1
Included observations: 1640832

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.153754	0.005878	-26.15697	0.0000
IV	-0.002368	0.000114	-20.68494	0.0000
LOG(SP500)	0.022994	0.000798	28.81839	0.0000
VIX	0.000338	8.63E-06	39.11122	0.0000
LOG(EPU)	0.000956	8.23E-05	11.62099	0.0000
FFU	-0.029338	0.001336	-21.96703	0.0000
CALL	-0.004174	7.73E-05	-54.03535	0.0000
DITM	5.50E-06	1.98E-07	27.75145	0.0000
DOTM	-1.57E-06	2.01E-07	-7.802666	0.0000
BB	-0.006450	0.000645	-10.00598	0.0000
BFRM	0.001265	0.000218	5.807410	0.0000
FRM	0.001107	0.000218	5.084417	0.0000
AFRM	-0.001046	0.000217	-4.817268	0.0000
Y05	-0.011015	0.000721	-15.27767	0.0000
Y06	-0.007543	0.000199	-37.83304	0.0000
Y07	-0.010126	0.000202	-50.15474	0.0000
Y08	-0.008862	0.000155	-57.31638	0.0000
Y09	-0.004753	0.000215	-22.15830	0.0000
Y10	-0.001485	0.000152	-9.741566	0.0000

R-squared	0.007662	Mean dependent var	0.006289
Adjusted R-squared	0.007652	S.D. dependent var	0.048360
S.E. of regression	0.048175	Akaike info criterion	-3.227946
Sum squared resid	3808.032	Schwarz criterion	-3.227803
Log likelihood	2648277.	Hannan-Quinn criter.	-3.227907
F-statistic	703.8784	Durbin-Watson stat	0.798747
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables and also due to the restriction of ABSIFF < 100%. Regression output was taken from EViews 10 University edition.

Similar to Regression 1, Regression 2 contained 1,640,832 observations. Its adjusted R-squared is slightly lower than Regression 1, coming in at 0.7652%. The results for Regression 2 appear in Table 6 above. It is important to note that all variables are still statistically significant at the 1% level of significance. The F-statistic is almost the same as Regression 1 and the p-value is still 0.000000. All coefficients are similar to the coefficients in Regression 1 which gives support to the validity of Regression 1's results.

4.1.2 Restriction Testing

Due to the presence of extreme outliers, restrictions were imposed on the sample to get more accurate coefficients, standard deviations and p-values. Regression 1 was estimated with 20 different restrictions on ABSIFF to determine an acceptable restriction to use. This is a fairly subjective test. The intervals for the 20 restrictions shown were chosen subjectively as the next most logical cutoff value. A restriction was chosen at a point where the coefficients seemed stable. Tables 7A and 7B show the various regression coefficients with various ABSIFF restrictions. Tables 8A and 8B show the p-values of the regression coefficients.

Table 7A – Regression Coefficients with Various Restrictions Part 1

Variable	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0
Co-Efficeients		ABSIFF<50000	ABSIFF<1000	ABSIFF<500	ABSIFF<200	ABSIFF<100	ABSIFF<50	ABSIFF<10	ABSIFF<5	ABSIFF<2.5
C	-2.76154	-2.632182	-1.470303	-1.932754	-0.296313	-0.883435	-0.601284	-0.191361	-0.22868	-0.171086
IV	-0.59734	-0.577042	-0.291638	-0.140887	-0.035907	-0.001846	0.007792	-0.000622	-0.0026	-0.002214
Log(SP500)	0.32498	0.280832	0.173967	0.251038	0.042114	1.30E-01	9.04E-02	3.16E-02	3.51E-02	2.60E-02
VIX	0.006686	0.007704	0.001486	0.002805	0.000749	0.001191	0.000825	4.40E-04	4.59E-04	3.72E-04
Log(EPU)	-0.01939	0.018687	-0.009547	0.00382	0.006767	2.73E-03	3.22E-03	1.54E-03	8.86E-04	1.26E-03
FFU	-1.63062	-1.043579	0.270406	0.215585	0.104925	0.010686	0.013982	-0.02469	-0.02627	-0.034316
CALL	0.398379	0.316255	0.166474	0.084639	0.037993	0.013286	0.004952	-0.000994	-0.0023	-0.004282
DITM	0.000413	0.000551	0.000289	0.000112	-1.83E-05	-1.51E-05	-1.09E-05	-2.99E-06	9.56E-07	4.57E-06
DOTM	0.002913	0.002902	0.001652	0.000802	0.000206	7.95E-05	3.32E-05	-2.32E-06	-1.61E-06	2.36E-07
BB	0.035686	0.006044	-0.045655	-0.075711	-0.087626	-0.092123	-0.077653	-0.036448	-0.02027	-0.01247
WBFRM	0.195296	-0.039571	0.007272	-0.01184	-0.000372	-0.001345	-0.001325	-0.000836	-0.00048	-0.000573
FRM	0.076646	0.070286	0.113224	0.018569	0.015357	0.012368	0.011148	0.002834	0.001436	0.001162
WAFRM	0.136381	0.136489	0.069756	0.018446	0.020451	0.010475	0.008342	0.002136	0.001406	0.000997
Y05	0.025636	0.082257	0.019815	-0.003734	-0.048331	-0.056367	-0.057851	-0.036062	-0.02264	-0.016448
Y06	-0.00492	0.096144	0.059856	0.050685	0.012314	0.003271	0.001034	-0.006962	-0.00754	-0.007701
Y07	-0.07188	0.018556	0.02792	0.004814	0.004653	-0.016045	-0.011775	-0.010908	-0.01196	-0.010791
Y08	0.024939	0.04353	0.080709	0.026958	0.005614	-0.002736	-0.003267	-0.00883	-0.00915	-0.009227
Y09	0.271666	0.112887	0.150432	0.126063	0.016886	0.033883	0.021637	-0.001705	-0.0009	-0.004578
Y10	0.61225	0.625367	0.381706	0.218945	0.108868	0.054921	0.026665	0.009022	0.00544	-0.000206
Included Obs	1643428	1643427	1643373	1643269	1643111	1642942	1642792	1642482	1642149	1641509
Adj R-Squared	0.000159	0.001223	0.002206	0.001935	0.000493	0.000994	0.000862	0.002329	0.002666	0.00649

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables.

Table 7B – Regression Coefficients with Various Restrictions Part 2

Variable	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0
Co-Efficeients	ABSIFF<2	ABSIFF<1.5	ABSIFF<1	ABSIFF<0.5	ABSIFF<0.25	ABSIFF<0.15	ABSIFF<0.10	ABSIFF<0.05	ABSIFF<0.025	ABSIFF<0.01
C	-0.166483	-0.155163	-0.1535	-0.137448	-0.074535	-0.036823	-0.013831	0.000543	0.003427	2.96E-03
IV	-0.002146	-0.002091	-0.00237	-0.000149	-0.000167	-0.000264	-0.000302	-0.000394	-0.000461	-0.000375
Log(SP500)	2.54E-02	2.39E-02	2.30E-02	2.07E-02	1.16E-02	5.87E-03	2.38E-03	8.02E-05	-4.13E-04	-3.56E-04
VIX	3.63E-04	3.48E-04	3.38E-04	2.70E-04	1.68E-04	8.88E-05	4.12E-05	1.05E-05	3.48E-06	-2.02E-06
Log(EPU)	1.23E-03	1.12E-03	9.77E-04	8.12E-04	4.69E-04	3.50E-04	2.37E-04	8.76E-05	-8.07E-06	-3.71E-05
FFU	-0.034031	-0.032289	-0.02939	-0.025019	-0.013041	-0.006283	-0.002767	-0.000136	0.00053	0.000682
CALL	-0.004257	-0.004219	-0.00417	-0.001821	-0.001373	-0.000934	-0.000615	-0.000271	-0.000113	4.60E-05
DITM	4.67E-06	4.94E-06	5.51E-06	-6.26E-06	-4.18E-06	-1.97E-06	-3.67E-07	1.48E-06	2.09E-06	1.80E-06
DOTM	-8.56E-08	-5.83E-07	-1.57E-06	-6.53E-06	-6.50E-06	-5.03E-06	-3.52E-06	-1.33E-06	-2.47E-07	1.20E-07
BB	-0.012437	-0.012093	-0.00666	-0.006117	-0.003498	-1.43E-03	-4.25E-04	1.94E-04	3.00E-04	8.62E-05
WBFRM	-0.000535	-0.000487	-0.0003	-0.000187	-6.14E-05	-1.42E-05	3.94E-05	5.57E-05	3.96E-05	3.14E-05
FRM	0.001162	0.001244	0.001175	0.000809	1.24E-04	-0.000174	-0.000221	-0.000205	-0.00013	-9.59E-06
WAFRM	0.000913	0.000766	0.000785	0.000512	0.00026	6.38E-05	3.00E-05	5.93E-05	2.62E-05	2.00E-05
Y05	-0.016476	-0.016506	-0.01122	-0.01094	-0.008193	-4.95E-03	-2.98E-03	-9.45E-04	-2.88E-04	-3.18E-04
Y06	-0.007716	-0.007707	-0.00754	-0.006906	-0.005305	-3.43E-03	-2.05E-03	-5.23E-04	-9.76E-05	-1.98E-04
Y07	-0.010696	-0.010445	-0.01012	-0.009048	-0.006485	-4.01E-03	-2.30E-03	-6.10E-04	-1.64E-04	-1.91E-04
Y08	-0.009173	-0.009102	-0.00887	-0.007951	-0.006208	-4.02E-03	-2.47E-03	-8.41E-04	-3.17E-04	-2.15E-04
Y09	-0.004635	-0.00484	-0.00477	-0.004954	-0.004818	-3.70E-03	-2.70E-03	-1.27E-03	-6.15E-04	-2.93E-04
Y10	-0.000482	-0.000947	-0.0015	-0.003925	-0.003617	-2.62E-03	-1.85E-03	-8.41E-04	-4.06E-04	-2.00E-04
Included Obs	1641440	1641274	1640832	1635951	1630919	1623709	1615727	1599585	1583042	1553880
Adj R-Squared	0.006733	0.007133	0.00766	0.018504	0.024368	0.024313	0.021845	0.022011	0.041977	0.11043

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables.

Table 8A – Regression P-Values with Various Restrictions Part 1

Variable	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0
P-Values		ABSIFF<50000	ABSIFF<1000	ABSIFF<500	ABSIFF<200	ABSIFF<100	ABSIFF<50	ABSIFF<10	ABSIFF<5	ABSIFF<2.5
C	0.645	0.2247	0.1089	**0.0001**	0.1687	**0**	**0**	**0**	**0**	**0**
IV	**0**	**0**	**0**	**0**	**0**	0.3591	**0**	**0.0471**	**0**	**0**
Log(SP500)	0.6896	0.3401	0.1623	**0.0001**	0.1496	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**
VIX	0.4476	**0.0155**	0.2698	**0.0001**	**0.0178**	**0**	**0**	**0.00E+00**	**0.00E+00**	**0.00E+00**
Log(EPU)	0.8169	0.5373	0.4562	0.574	**0.0245**	**5.98E-02**	**1.00E-04**	**0.00E+00**	**0.00E+00**	**0.00E+00**
FFU	0.2312	**0.0341**	0.1944	**0.0511**	**0.032**	0.6504	0.2945	**0**	**0**	**0**
CALL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ITM	**0.0412**	**0**	**0**	**0**	**0.0116**	**0**	**0**	**0**	**0.0172**	**0**
OTM	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0001**	0.3176
BB	0.9565	0.9796	0.6485	0.1541	**0.0002**	**0**	**0**	**0**	**0**	**0**
WBFRM	**0.0723**	0.3141	0.6619	0.1794	0.924	0.4748	0.2131	**0.0042**	**0.0264**	**0**
FRM	0.7315	0.3843	**0.0009**	0.3057	**0.0556**	**0.0014**	**0**	**0**	**0.0012**	**0**
WAFRM	0.2089	**0.0005**	**0**	**0.0362**	**0**	**0**	**0**	**0**	**0**	**0**
Y05	0.9721	0.7563	0.8597	0.9499	**0.0663**	**0**	**0**	**0**	**0**	**0**
Y06	0.9807	0.191	**0.0543**	**0.0021**	**0.0917**	0.3526	0.6035	**0**	**0**	**0**
Y07	0.7269	0.8032	0.3753	0.7732	0.5291	**0**	**0**	**0**	**0**	**0**
Y08	0.8743	0.4452	**0.0008**	**0.0351**	0.3215	0.316	**0.0343**	**0**	**0**	**0**
Y09	0.2143	0.1537	**0**	**0**	**0.0316**	**0**	**0**	**0.0038**	**0.0372**	**0**
Y10	**0.0001**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0.2491
Included Obs	1643428	1643427	1643373	1643269	1643111	1642942	1642792	1642482	1642149	1641509
Adj R-Squared	0.000159	0.001223	0.002206	0.001935	0.000493	0.000994	0.000862	0.002329	0.002666	0.00649

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Green means the variable is significant at the 1% level of significance, yellow the 5% level and blue the 10% level.

Table 8B – Regression P-Values with Various Restrictions Part2

Variable	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0	FV<>0
P-Values	ABSIFF<2	ABSIFF<1.5	ABSIFF<1	ABSIFF<0.5	ABSIFF<0.25	ABSIFF<0.15	ABSIFF<0.10	ABSIFF<0.05	ABSIFF<0.025	ABSIFF<0.01
C	0	0	0	0	0	0	0	0.3133	0	0
IV	0	0	0	0.0144	0	0	0	0	0	0
Log(SP500)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.73E-01	0.00E+00	0.00E+00
VIX	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Log(EPU)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.64E-02	0.00E+00
FFU	0	0	0	0	0	0	0	0.2652	0	0
CALL	0	0	0	0	0	0	0	0	0	0
ITM	0	0	0	0	0	0	0	0	0	0
OTM	0.7074	0.0069	0	0	0	0	0	0	0	0
BB	0	0	0	0	0	0	0.0002	0.0011	0	0
WBFRM	0	0	0.0053	0.001	0.1075	0.588	0.0339	0	0	0
FRM	0	0	0	0	0.114	0.0013	0	0	0	0.0728
WAFRM	0	0	0	0	0	0.0151	0.1069	0	0	0
Y05	0	0	0	0	0	0	0	0	0	0
Y06	0	0	0	0	0	0	0	0	0	0
Y07	0	0	0	0	0	0	0	0	0	0
Y08	0	0	0	0	0	0	0	0	0	0
Y09	0	0	0	0	0	0	0	0	0	0
Y10	0.0052	0	0	0	0	0	0	0	0	0
Included Obs	1641440	1641274	1640832	1635951	1630919	1623709	1615727	1599585	1583042	1553880
Adj R-Squared	0.006733	0.007133	0.00766	0.018504	0.024368	0.024313	0.021845	0.022011	0.041977	0.11043

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Green means the variable is significant at the 1% level of significance, yellow the 5% level and blue the 10% level.

Tables 7 and 8 clearly show that the coefficients begin to stabilize as the outliers are restricted out of the sample. In the end a cutoff of 100% option inefficiency was chosen. Looking at Table 7 it is possible to see that the coefficients stabilize around this cutoff. It is also important to note that most of the variables are significant at the 1% level of significance in the majority of regressions. Tables 7 and 8 provide more support for the sample restrictions chosen for Regression 1 and also give support to the findings of Regression 1. The full regression output from EViews for all the above regressions can be found in Appendices Q through AJ.

4.1.3 Heteroskedasticity Tests

If the error terms are heteroscedastic then the variances of the regression coefficients will be calculated incorrectly. The coefficients will still be unbiased, but they will no longer have the smallest variance. This means that it will be difficult to tell if the coefficients in the regression are statistically significant from zero. A White heteroskedasticity test was conducted to determine if heteroskedasticity was present. The full test output can be found in Appendix AK. The null hypothesis for a White test is that the error terms are homoscedastic. The results of this test showed that heteroskedasticity was present as the p-value of the F-statistic is 0.000000. However, the adjusted R-squared value of this test was only 0.012168, therefore only 1.2168% of the variance in Regression 1's squared residuals can be explained using the variables in the regression. A large number of the variables had p-values less than 1% and thus it is impossible to tell exactly which variables are causing the heteroskedasticity. Fortunately, the significance of the variables can still be determined.

Table 9 – Regression 1 with Huber-White Variances

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/12/19 Time: 01:38
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<1
Included observations: 1640832
Huber-White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.153504	0.006804	-22.56011	0.0000
IV	-0.002372	0.000101	-23.53091	0.0000
LOG(SP500)	0.022966	0.000929	24.72319	0.0000
VIX	0.000338	1.02E-05	33.11008	0.0000
LOG(EPU)	0.000977	8.03E-05	12.16226	0.0000
FFU	-0.029386	0.001313	-22.38697	0.0000
CALL	-0.004174	8.21E-05	-50.82926	0.0000
DITM	5.51E-06	4.00E-07	13.75146	0.0000
DOTM	-1.57E-06	1.91E-07	-8.187655	0.0000
BB	-0.006655	0.000672	-9.907455	0.0000
WBFRM	-0.000298	0.000103	-2.883172	0.0039
FRM	0.001175	0.000240	4.894908	0.0000
WAFRM	0.000785	0.000110	7.115806	0.0000
Y05	-0.011224	0.000724	-15.51128	0.0000
Y06	-0.007538	0.000147	-51.20769	0.0000
Y07	-0.010120	0.000210	-48.12184	0.0000
Y08	-0.008868	0.000176	-50.35028	0.0000
Y09	-0.004769	0.000231	-20.67910	0.0000
Y10	-0.001497	0.000171	-8.741383	0.0000

R-squared	0.007671	Mean dependent var	0.006289
Adjusted R-squared	0.007660	S.D. dependent var	0.048360
S.E. of regression	0.048175	Akaike info criterion	-3.227954
Sum squared resid	3808.001	Schwarz criterion	-3.227812
Log likelihood	2648284.	Hannan-Quinn criter.	-3.227916
F-statistic	704.6393	Durbin-Watson stat	0.798931
Prob(F-statistic)	0.000000	Wald F-statistic	587.5554
Prob(Wald F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables and also due to the restriction of ABSIFF < 100%. Regression output was taken from EViews 10 University edition.

Table 9 above shows Regression 1 calculated with Huber-White variances. Huber-White variances are used to correctly calculate the variance of the regression coefficients when heteroskedasticity is present. Table 9 shows that all variables are still significant at the 1% level of significance and the thus the previous statements made concerning Regression 1 still hold true.

4.2 Limitations

Limitations are present in the data set and empirical model used. All the options used have the S&P 500 Index as the underlying asset. This was done due to the sheer amount of options traded on the CBOE and limitations in the software used as only 4 million observations can be used in EViews 10 University Edition. Other index options such as those for the Dow Jones Industrial Average and the NASDAQ are also traded on the CBOE but including these observations would push the data set over 4 million observations.

A large limitation of the model is that it makes the assumption that the calculated Black-Scholes Option Pricing Model price is correct. This calculated price was used as the fair value price when calculating inefficiency. In order for this to be the case all seven of the Black-Scholes model's assumptions would have to be true. Previous literature such as Galai (1972 & 1977) used Black-Scholes as the fair value price for options and were able to generate abnormal profits by comparing the fair value with the market price. This research ultimately hinges on the Black-Scholes price being a valid comparison to the market price like previous literature.

Other limitations that are present in the model include the exclusion of a variable that proxies liquidity such as volume traded and a variable for bid-ask spread. This was due to the data not being available for all observations. Both these variables would have helped to determine the cause and presence of outliers. A variable for bid-ask spread would have also helped determine a cutoff for ABSIFF as well as if the level of inefficiency was economically significant.

Closing prices were also used for the market price and S&P 500 Index. The statements from the Federal Reserve meetings are generally released mid-day. This means that tick prices would be better as they update from trade to trade. Theses prices would be able to better capture the effect that occurs immediately surrounding the statements release. Tick prices were not used because tick price data was not available from Thomson Reuters Eikon for the selected options.

Another limitation of the data set is the number of years used. Data from 2005 to 2011 was used in this study. Data is available all the way through to 2019. A larger time period would provide a larger sample and would minimize the effects that the 2008 financial crisis could have on the regression. Once again this was not possible at the time due to the observation limit in EViews 10 University Edition.

The model is also limited due to the presence of heteroskedasticity. This presence means that although the coefficients are still unbiased, OLS no longer provides the smallest coefficient variance. Under the right conditions, this is able to be corrected using weighted least squares (WLS). In order to do this though, the cause of the heteroskedasticity must be easily discernable. In this case it is extremely hard to discern the cause of the heteroskedasticity and therefore the only way to account for it is to use Huber-White variances. This results in the correct variances being calculated for the regression, so the coefficient's significance can be determined. The coefficient's variances are not the smallest, in comparison to other estimation methods such as WLS. Thus, it is possible that variables will appear insignificant while they are significant in the population. Since all variable in Regression 1 and 2 were deemed significant, this does not pose a problem. Despite the limitations discussed in this section, it is still possible to make some conclusions on the relationships present.

Chapter 5: Conclusion

Although there is a large body of research regarding the impact of political events on option market inefficiency, literature focusing on the impact Federal Reserve meetings have on option market inefficiency is not represented. Over the past 50 years the role central banks have in the economy and financial markets has drastically changed. Until this study no researcher has provided a connection between Federal Reserve meetings and option market inefficiency.

During the sample period of February 11th, 2005 to December 31st, 2011, S&P 500 Index options trading on the CBOE had an average level of daily inefficiency of 0.6289% given sample restrictions. This research investigated whether or not the daily level of option inefficiency increases due to the occurrence of Federal Reserve Policy Meetings or an increase in economic uncertainty. The current study used 56 Federal Reserve meetings over 7 years to further investigate the relationship between these variables and option market inefficiency.

The absolute value of the percentage of theoretical price (ABSIFF) was used as the measure of an index option's level of inefficiency to test two hypotheses. The impact of economic uncertainty was measured using the Economic Policy Uncertainty Index (EPU) created by Baker, Bloom and Davis (2016). A fifteen-day event period was created for each Federal Reserve meeting to determine if these meetings influence option market inefficiency and, if so, how long does the influence last. The predicted relationship was that an increase in the EPU Index and the occurrence of Federal Reserve Policy meetings would increase the level of option market inefficiency. The evidence in this research supported this predicted relationship as well as the findings of Gemmill (1991) regarding the effect of uncertain events on option market inefficiency. The empirical analysis conducted in Regression 1 demonstrated that in a model with an adjusted R-squared of approximately 0.766%, a 1% increase in the Economic Policy

Uncertainty Index is expected to increase the daily level of option inefficiency by 0.000977% on average. The analysis of the fifteen-day event period showed that on average, options experienced a 0.0298% decrease in the level of daily option inefficiency the week prior to a Federal Reserve Policy meeting, followed by a 0.1175% increase in the level of daily option inefficiency on the day of the meeting, and a 0.0785% increase in the level of daily option inefficiency compared to a regular day on average. These findings meant that neither of the two tested hypotheses were rejected. Because neither hypothesis was rejected, semi-strong market efficiency does not hold. These findings agree with the previous literature by authors such as Gemmill (1991) pertaining to uncertainty and the effects of uncertain events on option market inefficiency.

Robustness tests were conducted to determine the validity of the coefficients and the sample restrictions. A shorter event period was used over the sample period, but it did not appear to alter the significance of the other variables or the magnitude of their effect. Twenty different restrictions on ABSIFF were also imposed on Regression 1 to determine an appropriate sample restriction. These 20 regressions showed that as the outliers were removed the coefficients and their p-values stabilized. Based on the distribution of ABSIFF and the various restricted regressions, a restriction of ABSIFF less than 100% was concluded to be an appropriate restriction for the sample. This resulted in a loss of approximately 0.19% of the observations which is a small fraction.

Due to the limitations discussed such as the data set and omitted variables, the next step for this study would be to obtain data on the liquidity of the options and the bid-ask spread as well as the tick prices for the options. This would allow for a better understanding of the connection between option market inefficiency, Federal Reserve meetings and economic uncertainty. Another future step for this study would be to extend the sample period to the present (2019). This would allow for the effect of other chairs of the Federal Reserve beyond Greenspan and Bernanke to be estimated.

In conclusion, the current study has found semi-strong support for the hypothesized relationship that the occurrence of Federal Reserve Policy meetings and an increase in economic policy uncertainty would increase the daily level of option inefficiency of S&P 500 Index options. However, the observed increase in option market inefficiency was not economically significant when trading costs were considered and thus could not be used to obtain an abnormal profit. Option markets appear to do a fairly good but not perfect job of capturing economic uncertainty and outcome of uncertain events such as Federal Reserve Policy meetings and pricing them into S&P 500 Index options.

Appendix A – Wald Coefficient Test Regression 1 FRM=WAFRM

Appendix A provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(12) is the coefficient for FRM and C(13) is the coefficient for WAFRM.

$$H_0: \beta_{FRM} = \beta_{WAFRM}$$

$$H_A: \beta_{FRM} \neq \beta_{WAFRM}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	1.659518	1640813	0.0970
F-statistic	2.753999	(1, 1640813)	0.0970
Chi-square	2.753999	1	0.0970

Null Hypothesis: C(12)=C(13)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(12) - C(13)	0.000389	0.000235

Restrictions are linear in coefficients.

Appendix B – Wald Coefficient Test Regression 1 Y05=Y06

Appendix B provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(14) is the coefficient for Y05 and C(15) is the coefficient for Y06.

$$H_0: \beta_{Y05} = \beta_{Y06}$$

$$H_A: \beta_{Y05} \neq \beta_{Y06}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-5.296369	1640813	0.0000
F-statistic	28.05153	(1, 1640813)	0.0000
Chi-square	28.05153	1	0.0000

Null Hypothesis: C(14)=C(15)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14) - C(15)	-0.003686	0.000696

Restrictions are linear in coefficients.

Appendix C – Wald Coefficient Test Regression 1 Y05=Y07

Appendix C provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(14) is the coefficient for Y05 and C(16) is the coefficient for Y07.

$$H_0: \beta_{Y05} = \beta_{Y07}$$

$$H_A: \beta_{Y05} \neq \beta_{Y07}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-1.496771	1640813	0.1345
F-statistic	2.240325	(1, 1640813)	0.1345
Chi-square	2.240325	1	0.1345

Null Hypothesis: C(14)=C(16)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14) - C(16)	-0.001104	0.000738

Restrictions are linear in coefficients.

Appendix D – Wald Coefficient Test Regression 1 Y05=Y08

Appendix D provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(14) is the coefficient for Y05 and C(17) is the coefficient for Y08.

$$H_0: \beta_{Y05} = \beta_{Y08}$$

$$H_A: \beta_{Y05} \neq \beta_{Y08}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-3.241600	1640813	0.0012
F-statistic	10.50797	(1, 1640813)	0.0012
Chi-square	10.50797	1	0.0012

Null Hypothesis: C(14)=C(17)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14) - C(17)	-0.002356	0.000727

Restrictions are linear in coefficients.

Appendix E – Wald Coefficient Test Regression 1 Y05=Y09

Appendix E provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(14) is the coefficient for Y05 and C(18) is the coefficient for Y09.

$$H_0: \beta_{Y05} = \beta_{Y09}$$

$$H_A: \beta_{Y05} \neq \beta_{Y09}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-8.943576	1640813	0.0000
F-statistic	79.98756	(1, 1640813)	0.0000
Chi-square	79.98756	1	0.0000

Null Hypothesis: C(14)=C(18)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14) - C(18)	-0.006456	0.000722

Restrictions are linear in coefficients.

Appendix F – Wald Coefficient Test Regression 1 Y05=Y10

Appendix F provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(14) is the coefficient for Y05 and C(19) is the coefficient for Y10.

$$H_0: \beta_{Y05} = \beta_{Y10}$$

$$H_A: \beta_{Y05} \neq \beta_{Y10}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-13.60232	1640813	0.0000
F-statistic	185.0231	(1, 1640813)	0.0000
Chi-square	185.0231	1	0.0000

Null Hypothesis: C(14)=C(19)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14) - C(19)	-0.009728	0.000715

Restrictions are linear in coefficients.

Appendix G – Wald Coefficient Test Regression 1 Y06=Y07

Appendix G provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(15) is the coefficient for Y06 and C(16) is the coefficient for Y07.

$$H_0: \beta_{Y06} = \beta_{Y07}$$

$$H_A: \beta_{Y06} \neq \beta_{Y07}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	11.66826	1640813	0.0000
F-statistic	136.1484	(1, 1640813)	0.0000
Chi-square	136.1484	1	0.0000

Null Hypothesis: C(15)=C(16)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(15) - C(16)	0.002582	0.000221

Restrictions are linear in coefficients.

Appendix H – Wald Coefficient Test Regression 1 Y06=Y08

Appendix H provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(15) is the coefficient for Y06 and C(17) is the coefficient for Y08.

$$H_0: \beta_{Y06} = \beta_{Y08}$$

$$H_A: \beta_{Y06} \neq \beta_{Y08}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	6.606489	1640813	0.0000
F-statistic	43.64570	(1, 1640813)	0.0000
Chi-square	43.64570	1	0.0000

Null Hypothesis: C(15)=C(17)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(15) - C(17)	0.001330	0.000201

Restrictions are linear in coefficients.

Appendix I – Wald Coefficient Test Regression 1 Y06=Y09

Appendix I provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(15) is the coefficient for Y06 and C(18) is the coefficient for Y09.

$$H_0: \beta_{Y06} = \beta_{Y09}$$

$$H_A: \beta_{Y06} \neq \beta_{Y09}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-12.03178	1640813	0.0000
F-statistic	144.7636	(1, 1640813)	0.0000
Chi-square	144.7636	1	0.0000

Null Hypothesis: C(15)=C(18)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(15) - C(18)	-0.002770	0.000230

Restrictions are linear in coefficients.

Appendix J – Wald Coefficient Test Regression 1 Y06=Y10

Appendix J provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(15) is the coefficient for Y06 and C(19) is the coefficient for Y10.

$$H_0: \beta_{Y06} = \beta_{Y10}$$

$$H_A: \beta_{Y06} \neq \beta_{Y10}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-32.00799	1640813	0.0000
F-statistic	1024.511	(1, 1640813)	0.0000
Chi-square	1024.511	1	0.0000

Null Hypothesis: C(15)=C(19)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(15) - C(19)	-0.006042	0.000189

Restrictions are linear in coefficients.

Appendix K – Wald Coefficient Test Regression 1 Y07=Y08

Appendix K provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(16) is the coefficient for Y07 and C(17) is the coefficient for Y08.

$$H_0: \beta_{Y07} = \beta_{Y08}$$

$$H_A: \beta_{Y07} \neq \beta_{Y08}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-7.118949	1640813	0.0000
F-statistic	50.67943	(1, 1640813)	0.0000
Chi-square	50.67943	1	0.0000

Null Hypothesis: C(16)=C(17)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(16) - C(17)	-0.001252	0.000176

Restrictions are linear in coefficients.

Appendix L – Wald Coefficient Test Regression 1 Y07=Y09

Appendix L provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(16) is the coefficient for Y07 and C(18) is the coefficient for Y09.

$$H_0 : \beta_{Y07} = \beta_{Y09}$$

$$H_A : \beta_{Y07} \neq \beta_{Y09}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-17.11188	1640813	0.0000
F-statistic	292.8164	(1, 1640813)	0.0000
Chi-square	292.8164	1	0.0000

Null Hypothesis: C(16)=C(18)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(16) - C(18)	-0.005351	0.000313

Restrictions are linear in coefficients.

Appendix M – Wald Coefficient Test Regression 1 Y07=Y10

Appendix M provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(16) is the coefficient for Y07 and C(19) is the coefficient for Y10.

$$H_0: \beta_{Y07} = \beta_{Y10}$$

$$H_A: \beta_{Y07} \neq \beta_{Y10}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-35.31363	1640813	0.0000
F-statistic	1247.052	(1, 1640813)	0.0000
Chi-square	1247.052	1	0.0000

Null Hypothesis: C(16)=C(19)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(16) - C(19)	-0.008623	0.000244

Restrictions are linear in coefficients.

Appendix N – Wald Coefficient Test Regression 1 Y08=Y09

Appendix N provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(17) is the coefficient for Y08 and C(18) is the coefficient for Y09.

$$H_0: \beta_{Y08} = \beta_{Y09}$$

$$H_A: \beta_{Y08} \neq \beta_{Y09}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-17.07004	1640813	0.0000
F-statistic	291.3863	(1, 1640813)	0.0000
Chi-square	291.3863	1	0.0000

Null Hypothesis: C(17)=C(18)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(17) - C(18)	-0.004100	0.000240

Restrictions are linear in coefficients.

Appendix O – Wald Coefficient Test Regression 1 Y08=Y10

Appendix O provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(17) is the coefficient for Y08 and C(19) is the coefficient for Y10.

$$H_0: \beta_{Y08} = \beta_{Y10}$$

$$H_A: \beta_{Y08} \neq \beta_{Y10}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-40.71638	1640813	0.0000
F-statistic	1657.824	(1, 1640813)	0.0000
Chi-square	1657.824	1	0.0000

Null Hypothesis: C(17)=C(19)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(17) - C(19)	-0.007372	0.000181

Restrictions are linear in coefficients.

Appendix P – Wald Coefficient Test Regression 1 Y09=Y10

Appendix P provides the Wald test conducted in EViews 10 University edition to test the following hypotheses. In the test print out C(18) is the coefficient for Y09 and C(19) is the coefficient for Y10.

$$H_0: \beta_{Y09} = \beta_{Y10}$$

$$H_A: \beta_{Y09} \neq \beta_{Y10}$$

Wald Test:
Equation: EQ01

Test Statistic	Value	df	Probability
t-statistic	-22.27224	1640813	0.0000
F-statistic	496.0525	(1, 1640813)	0.0000
Chi-square	496.0525	1	0.0000

Null Hypothesis: C(18)=C(19)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(18) - C(19)	-0.003272	0.000147

Restrictions are linear in coefficients.

Appendix Q – Regression 1 Results No ABSIFF Restrictions

Appendix Q provides the full EViews regression output for Regression 1 with restrictions on ABSIFF.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:31
Sample: 1 1644010 IF FV<>0 AND MP<>0
Included observations: 1643428

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.761543	5.993793	-0.460734	0.6450
IV	-0.597341	0.116245	-5.138629	0.0000
LOG(SP500)	0.324980	0.813744	0.399364	0.6896
VIX	0.006686	0.008803	0.759471	0.4476
LOG(EPU)	-0.019391	0.083744	-0.231554	0.8169
FFU	-1.630623	1.361867	-1.197343	0.2312
CALL	0.398379	0.078742	5.059264	0.0000
DITM	0.000413	0.000202	2.041852	0.0412
DOTM	0.002913	0.000205	14.22191	0.0000
BB	0.035686	0.654549	0.054520	0.9565
WBFRM	0.195296	0.108672	1.797116	0.0723
FRM	0.076646	0.223353	0.343163	0.7315
WAFRM	0.136381	0.108533	1.256591	0.2089
Y05	0.025636	0.732731	0.034987	0.9721
Y06	-0.004916	0.203265	-0.024185	0.9807
Y07	-0.071881	0.205833	-0.349218	0.7269
Y08	0.024939	0.157640	0.158200	0.8743
Y09	0.271666	0.218764	1.241826	0.2143
Y10	0.612250	0.155405	3.939701	0.0001

R-squared	0.000170	Mean dependent var	0.229782
Adjusted R-squared	0.000159	S.D. dependent var	49.14769
S.E. of regression	49.14378	Akaike info criterion	10.62739
Sum squared resid	3.97E+09	Schwarz criterion	10.62753
Log likelihood	-8732655.	Hannan-Quinn criter.	10.62743
F-statistic	15.56133	Durbin-Watson stat	1.897256
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix R – Regression 1 Results ABSIFF < 5,000,000%

Appendix R provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 5,000,000%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:34
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<50000
Included observations: 1643427

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.632182	2.168172	-1.214010	0.2247
IV	-0.577042	0.042050	-13.72273	0.0000
LOG(SP500)	0.280832	0.294361	0.954041	0.3401
VIX	0.007704	0.003184	2.419421	0.0155
LOG(EPU)	0.018687	0.030293	0.616880	0.5373
FFU	-1.043579	0.492637	-2.118354	0.0341
CALL	0.316255	0.028484	11.10292	0.0000
DITM	0.000551	7.32E-05	7.526162	0.0000
DOTM	0.002902	7.41E-05	39.16655	0.0000
BB	0.006044	0.236774	0.025525	0.9796
WBFRM	-0.039571	0.039311	-1.006614	0.3141
FRM	0.070286	0.080795	0.869927	0.3843
WAFRM	0.136489	0.039260	3.476532	0.0005
Y05	0.082257	0.265055	0.310338	0.7563
Y06	0.096144	0.073528	1.307572	0.1910
Y07	0.018556	0.074457	0.249214	0.8032
Y08	0.043530	0.057024	0.763363	0.4452
Y09	0.112887	0.079135	1.426512	0.1537
Y10	0.625367	0.056216	11.12442	0.0000

R-squared	0.001233	Mean dependent var	0.194043
Adjusted R-squared	0.001223	S.D. dependent var	17.78796
S.E. of regression	17.77708	Akaike info criterion	8.593709
Sum squared resid	5.19E+08	Schwarz criterion	8.593851
Log likelihood	-7061547.	Hannan-Quinn criter.	8.593747
F-statistic	112.7531	Durbin-Watson stat	1.213353
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix S – Regression 1 Results ABSIFF < 100,000%

Appendix S provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 100,000%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:36
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<1000
Included observations: 1643373

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.470303	0.917102	-1.603206	0.1089
IV	-0.291638	0.017787	-16.39624	0.0000
LOG(SP500)	0.173967	0.124510	1.397214	0.1623
VIX	0.001486	0.001347	1.103555	0.2698
LOG(EPU)	-0.009547	0.012814	-0.745067	0.4562
FFU	0.270406	0.208377	1.297678	0.1944
CALL	0.166474	0.012049	13.81694	0.0000
DITM	0.000289	3.09E-05	9.352368	0.0000
DOTM	0.001652	3.13E-05	52.70354	0.0000
BB	-0.045655	0.100151	-0.455864	0.6485
WBFRM	0.007272	0.016628	0.437325	0.6619
FRM	0.113224	0.034175	3.313078	0.0009
WAFRM	0.069756	0.016607	4.200498	0.0000
Y05	0.019815	0.112113	0.176741	0.8597
Y06	0.059856	0.031101	1.924556	0.0543
Y07	0.027920	0.031494	0.886501	0.3753
Y08	0.080709	0.024120	3.346135	0.0008
Y09	0.150432	0.033473	4.494187	0.0000
Y10	0.381706	0.023779	16.05255	0.0000

R-squared	0.002217	Mean dependent var	0.121588
Adjusted R-squared	0.002206	S.D. dependent var	7.527640
S.E. of regression	7.519333	Akaike info criterion	6.872843
Sum squared resid	92915832	Schwarz criterion	6.872986
Log likelihood	-5647304.	Hannan-Quinn criter.	6.872882
F-statistic	202.8369	Durbin-Watson stat	0.541673
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix T – Regression 1 Results ABSIFF < 50,000%

Appendix T provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 50,000%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:37
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<500
Included observations: 1643269

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.932754	0.486427	-3.973369	0.0001
IV	-0.140887	0.009434	-14.93360	0.0000
LOG(SP500)	0.251038	0.066040	3.801319	0.0001
VIX	0.002805	0.000714	3.926140	0.0001
LOG(EPU)	0.003820	0.006796	0.562130	0.5740
FFU	0.215585	0.110522	1.950597	0.0511
CALL	0.084639	0.006391	13.24429	0.0000
DITM	0.000112	1.64E-05	6.852886	0.0000
DOTM	0.000802	1.66E-05	48.22559	0.0000
BB	-0.075711	0.053118	-1.425331	0.1541
WBFRM	-0.011840	0.008819	-1.342462	0.1794
FRM	0.018569	0.018127	1.024363	0.3057
WAFRM	0.018446	0.008808	2.094132	0.0362
Y05	-0.003734	0.059463	-0.062797	0.9499
Y06	0.050685	0.016496	3.072634	0.0021
Y07	0.004814	0.016704	0.288219	0.7732
Y08	0.026958	0.012793	2.107231	0.0351
Y09	0.126063	0.017754	7.100684	0.0000
Y10	0.218945	0.012612	17.35994	0.0000

R-squared	0.001946	Mean dependent var	0.071569
Adjusted R-squared	0.001935	S.D. dependent var	3.991979
S.E. of regression	3.988115	Akaike info criterion	5.604526
Sum squared resid	26135993	Schwarz criterion	5.604668
Log likelihood	-4604853.	Hannan-Quinn criter.	5.604564
F-statistic	177.9725	Durbin-Watson stat	0.555141
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix U – Regression 1 Results ABSIFF < 20,000%

Appendix U provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 20,000%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:39
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<200
Included observations: 1643111

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.296313	0.215299	-1.376287	0.1687
IV	-0.035907	0.004176	-8.598727	0.0000
LOG(SP500)	0.042114	0.029230	1.440777	0.1496
VIX	0.000749	0.000316	2.369706	0.0178
LOG(EPU)	0.006767	0.003008	2.249664	0.0245
FFU	0.104925	0.048918	2.144904	0.0320
CALL	0.037993	0.002829	13.43166	0.0000
DITM	-1.83E-05	7.26E-06	-2.522874	0.0116
DOTM	0.000206	7.37E-06	28.03666	0.0000
BB	-0.087626	0.023510	-3.727222	0.0002
WBFRM	-0.000372	0.003904	-0.095334	0.9240
FRM	0.015357	0.008023	1.914062	0.0556
WAFRM	0.020451	0.003899	5.245604	0.0000
Y05	-0.048331	0.026318	-1.836451	0.0663
Y06	0.012314	0.007301	1.686599	0.0917
Y07	0.004653	0.007393	0.629319	0.5291
Y08	0.005614	0.005662	0.991440	0.3215
Y09	0.016886	0.007858	2.148865	0.0316
Y10	0.108868	0.005582	19.50223	0.0000

R-squared	0.001301	Mean dependent var	0.037443
Adjusted R-squared	0.001290	S.D. dependent var	1.766250
S.E. of regression	1.765110	Akaike info criterion	3.974315
Sum squared resid	5119241.	Schwarz criterion	3.974457
Log likelihood	-3265101.	Hannan-Quinn criter.	3.974353
F-statistic	118.8879	Durbin-Watson stat	0.386558
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix V – Regression 1 Results ABSIFF < 10,000%

Appendix V provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 10,000%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:40
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<100
Included observations: 1642942

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.883435	0.103778	-8.512720	0.0000
IV	-0.001846	0.002013	-0.917036	0.3591
LOG(SP500)	0.130078	0.014089	9.232312	0.0000
VIX	0.001191	0.000152	7.814626	0.0000
LOG(EPU)	0.002729	0.001450	1.882265	0.0598
FFU	0.010686	0.023580	0.453194	0.6504
CALL	0.013286	0.001364	9.743980	0.0000
DITM	-1.51E-05	3.50E-06	-4.313190	0.0000
DOTM	7.95E-05	3.55E-06	22.39711	0.0000
BB	-0.092123	0.011332	-8.129604	0.0000
WBFRM	-0.001345	0.001882	-0.714685	0.4748
FRM	0.012368	0.003867	3.197817	0.0014
WAFRM	0.010475	0.001879	5.573819	0.0000
Y05	-0.056367	0.012685	-4.443451	0.0000
Y06	0.003271	0.003519	0.929553	0.3526
Y07	-0.016045	0.003564	-4.502377	0.0000
Y08	-0.002736	0.002729	-1.002622	0.3160
Y09	0.033883	0.003788	8.945547	0.0000
Y10	0.054921	0.002691	20.41042	0.0000

R-squared	0.001005	Mean dependent var	0.022030
Adjusted R-squared	0.000994	S.D. dependent var	0.851216
S.E. of regression	0.850793	Akaike info criterion	2.514715
Sum squared resid	1189227.	Schwarz criterion	2.514857
Log likelihood	-2065746.	Hannan-Quinn criter.	2.514753
F-statistic	91.80498	Durbin-Watson stat	0.487582
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix W – Regression 1 Results ABSIFF < 5,000%

Appendix W provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 5,000%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:41
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<50
Included observations: 1642792

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.601284	0.058702	-10.24302	0.0000
IV	0.007792	0.001139	6.842760	0.0000
LOG(SP500)	0.090380	0.007970	11.34057	0.0000
VIX	0.000825	8.62E-05	9.566724	0.0000
LOG(EPU)	0.003215	0.000820	3.920154	0.0001
FFU	0.013982	0.013338	1.048288	0.2945
CALL	0.004952	0.000771	6.420803	0.0000
DITM	-1.09E-05	1.98E-06	-5.525282	0.0000
DOTM	3.32E-05	2.01E-06	16.53907	0.0000
BB	-0.077653	0.006410	-12.11428	0.0000
WBFRM	-0.001325	0.001064	-1.245068	0.2131
FRM	0.011148	0.002188	5.095874	0.0000
WAFRM	0.008342	0.001063	7.847402	0.0000
Y05	-0.057851	0.007176	-8.062016	0.0000
Y06	0.001034	0.001991	0.519306	0.6035
Y07	-0.011775	0.002016	-5.841459	0.0000
Y08	-0.003267	0.001544	-2.116280	0.0343
Y09	0.021637	0.002142	10.09900	0.0000
Y10	0.026665	0.001522	17.51888	0.0000

R-squared	0.000873	Mean dependent var	0.015449
Adjusted R-squared	0.000862	S.D. dependent var	0.481438
S.E. of regression	0.481230	Akaike info criterion	1.375071
Sum squared resid	380437.9	Schwarz criterion	1.375213
Log likelihood	-1129459.	Hannan-Quinn criter.	1.375109
F-statistic	79.71845	Durbin-Watson stat	0.647293
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix X – Regression 1 Results ABSIFF < 1,000%

Appendix X provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 1,000%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:42
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<10
Included observations: 1642482

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.191361	0.016121	-11.87012	0.0000
IV	-0.000622	0.000313	-1.985412	0.0471
LOG(SP500)	0.031620	0.002189	14.44714	0.0000
VIX	0.000440	2.37E-05	18.57207	0.0000
LOG(EPU)	0.001544	0.000225	6.856353	0.0000
FFU	-0.024690	0.003663	-6.740431	0.0000
CALL	-0.000994	0.000212	-4.691578	0.0000
DITM	-2.99E-06	5.44E-07	-5.500999	0.0000
DOTM	-2.32E-06	5.52E-07	-4.211256	0.0000
BB	-0.036448	0.001761	-20.69607	0.0000
WBFRM	-0.000836	0.000292	-2.860688	0.0042
FRM	0.002834	0.000601	4.716958	0.0000
WAFRM	0.002136	0.000292	7.316821	0.0000
Y05	-0.036062	0.001971	-18.29316	0.0000
Y06	-0.006962	0.000547	-12.73567	0.0000
Y07	-0.010908	0.000554	-19.70391	0.0000
Y08	-0.008830	0.000424	-20.82722	0.0000
Y09	-0.001705	0.000588	-2.897062	0.0038
Y10	0.009022	0.000418	21.58257	0.0000

R-squared	0.002340	Mean dependent var	0.009664
Adjusted R-squared	0.002329	S.D. dependent var	0.132305
S.E. of regression	0.132150	Akaike info criterion	-1.209740
Sum squared resid	28683.55	Schwarz criterion	-1.209598
Log likelihood	993507.0	Hannan-Quinn criter.	-1.209702
F-statistic	214.0554	Durbin-Watson stat	0.621968
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix Y – Regression 1 Results ABSIFF < 500%

Appendix Y provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 500%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:44
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<5
Included observations: 1642149

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.228677	0.011887	-19.23766	0.0000
IV	-0.002603	0.000231	-11.25212	0.0000
LOG(SP500)	0.035069	0.001614	21.73070	0.0000
VIX	0.000459	1.75E-05	26.29437	0.0000
LOG(EPU)	0.000886	0.000166	5.335105	0.0000
FFU	-0.026273	0.002701	-9.727718	0.0000
CALL	-0.002297	0.000156	-14.70654	0.0000
DITM	9.56E-07	4.01E-07	2.382405	0.0172
DOTM	-1.61E-06	4.07E-07	-3.948750	0.0001
BB	-0.020267	0.001300	-15.59096	0.0000
WBFRM	-0.000479	0.000216	-2.221001	0.0264
FRM	0.001436	0.000443	3.241311	0.0012
WAFRM	0.001406	0.000215	6.528607	0.0000
Y05	-0.022640	0.001455	-15.56232	0.0000
Y06	-0.007536	0.000403	-18.69906	0.0000
Y07	-0.011964	0.000408	-29.31134	0.0000
Y08	-0.009146	0.000313	-29.25906	0.0000
Y09	-0.000904	0.000434	-2.083352	0.0372
Y10	0.005440	0.000308	17.64864	0.0000

R-squared	0.002677	Mean dependent var	0.008414
Adjusted R-squared	0.002666	S.D. dependent var	0.097563
S.E. of regression	0.097433	Akaike info criterion	-1.819292
Sum squared resid	15589.04	Schwarz criterion	-1.819150
Log likelihood	1493794.	Hannan-Quinn criter.	-1.819254
F-statistic	244.8523	Durbin-Watson stat	0.559565
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix Z – Regression 1 Results ABSIFF < 250%

Appendix Z provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 250%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:46
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<2.5
Included observations: 1641509

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.171086	0.006896	-24.80846	0.0000
IV	-0.002214	0.000134	-16.49850	0.0000
LOG(SP500)	0.026045	0.000936	27.81879	0.0000
VIX	0.000372	1.01E-05	36.73941	0.0000
LOG(EPU)	0.001262	9.64E-05	13.09572	0.0000
FFU	-0.034316	0.001567	-21.90127	0.0000
CALL	-0.004282	9.06E-05	-47.25546	0.0000
DITM	4.57E-06	2.33E-07	19.64284	0.0000
DOTM	2.36E-07	2.36E-07	0.999430	0.3176
BB	-0.012470	0.000755	-16.52078	0.0000
WBFRM	-0.000573	0.000125	-4.580281	0.0000
FRM	0.001162	0.000257	4.520477	0.0000
WAFRM	0.000997	0.000125	7.985570	0.0000
Y05	-0.016448	0.000845	-19.47524	0.0000
Y06	-0.007701	0.000234	-32.93973	0.0000
Y07	-0.010791	0.000237	-45.57305	0.0000
Y08	-0.009227	0.000181	-50.88084	0.0000
Y09	-0.004578	0.000252	-18.18956	0.0000
Y10	-0.000206	0.000179	-1.152657	0.2491

R-squared	0.006501	Mean dependent var	0.006865
Adjusted R-squared	0.006490	S.D. dependent var	0.056699
S.E. of regression	0.056515	Akaike info criterion	-2.908617
Sum squared resid	5242.790	Schwarz criterion	-2.908475
Log likelihood	2387280.	Hannan-Quinn criter.	-2.908579
F-statistic	596.7052	Durbin-Watson stat	0.961553
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AA – Regression 1 Results ABSIFF < 200%

Appendix AA provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 200%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:46
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<2
Included observations: 1641440

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.166483	0.006662	-24.99037	0.0000
IV	-0.002146	0.000130	-16.55286	0.0000
LOG(SP500)	0.025433	0.000904	28.12088	0.0000
VIX	0.000363	9.78E-06	37.08371	0.0000
LOG(EPU)	0.001233	9.31E-05	13.24745	0.0000
FFU	-0.034031	0.001514	-22.48378	0.0000
CALL	-0.004257	8.75E-05	-48.63236	0.0000
DITM	4.67E-06	2.25E-07	20.79289	0.0000
DOTM	-8.56E-08	2.28E-07	-0.375397	0.7074
BB	-0.012437	0.000729	-17.05745	0.0000
WBFRM	-0.000535	0.000121	-4.432635	0.0000
FRM	0.001162	0.000248	4.680556	0.0000
WAFRM	0.000913	0.000121	7.568257	0.0000
Y05	-0.016476	0.000816	-20.19518	0.0000
Y06	-0.007716	0.000226	-34.16607	0.0000
Y07	-0.010696	0.000229	-46.76258	0.0000
Y08	-0.009173	0.000175	-52.36454	0.0000
Y09	-0.004635	0.000243	-19.06050	0.0000
Y10	-0.000482	0.000173	-2.791776	0.0052

R-squared	0.006744	Mean dependent var	0.006771
Adjusted R-squared	0.006733	S.D. dependent var	0.054777
S.E. of regression	0.054592	Akaike info criterion	-2.977832
Sum squared resid	4891.979	Schwarz criterion	-2.977690
Log likelihood	2443985.	Hannan-Quinn criter.	-2.977794
F-statistic	619.1654	Durbin-Watson stat	0.927880
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AB – Regression 1 Results ABSIFF < 150%

Appendix AB provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 150%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:48
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<1.5
Included observations: 1641274

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.155163	0.006314	-24.57470	0.0000
IV	-0.002091	0.000123	-17.02194	0.0000
LOG(SP500)	0.023886	0.000857	27.86471	0.0000
VIX	0.000348	9.27E-06	37.49069	0.0000
LOG(EPU)	0.001124	8.82E-05	12.74238	0.0000
FFU	-0.032289	0.001435	-22.50856	0.0000
CALL	-0.004219	8.30E-05	-50.85358	0.0000
DITM	4.94E-06	2.13E-07	23.21196	0.0000
DOTM	-5.83E-07	2.16E-07	-2.699340	0.0069
BB	-0.012093	0.000691	-17.49933	0.0000
WBFRM	-0.000487	0.000114	-4.256386	0.0000
FRM	0.001244	0.000235	5.285513	0.0000
WAFRM	0.000766	0.000114	6.697164	0.0000
Y05	-0.016506	0.000773	-21.34651	0.0000
Y06	-0.007707	0.000214	-36.00895	0.0000
Y07	-0.010445	0.000217	-48.18238	0.0000
Y08	-0.009102	0.000166	-54.82478	0.0000
Y09	-0.004840	0.000230	-21.00319	0.0000
Y10	-0.000947	0.000164	-5.785348	0.0000

R-squared	0.007144	Mean dependent var	0.006596
Adjusted R-squared	0.007133	S.D. dependent var	0.051923
S.E. of regression	0.051738	Akaike info criterion	-3.085247
Sum squared resid	4393.299	Schwarz criterion	-3.085105
Log likelihood	2531887.	Hannan-Quinn criter.	-3.085209
F-statistic	656.1101	Durbin-Watson stat	0.878802
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AC – Regression 1 Results ABSIFF < 100%

Appendix AC provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 100%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:48
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<1
Included observations: 1640832

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.153504	0.005880	-26.10571	0.0000
IV	-0.002372	0.000114	-20.72183	0.0000
LOG(SP500)	0.022966	0.000798	28.76924	0.0000
VIX	0.000338	8.64E-06	39.08493	0.0000
LOG(EPU)	0.000977	8.22E-05	11.88868	0.0000
FFU	-0.029386	0.001336	-21.99921	0.0000
CALL	-0.004174	7.73E-05	-54.02450	0.0000
DITM	5.51E-06	1.98E-07	27.76746	0.0000
DOTM	-1.57E-06	2.01E-07	-7.781698	0.0000
BB	-0.006655	0.000645	-10.32246	0.0000
WBFRM	-0.000298	0.000107	-2.791256	0.0053
FRM	0.001175	0.000219	5.358498	0.0000
WAFRM	0.000785	0.000107	7.373180	0.0000
Y05	-0.011224	0.000721	-15.56381	0.0000
Y06	-0.007538	0.000199	-37.82452	0.0000
Y07	-0.010120	0.000202	-50.13167	0.0000
Y08	-0.008868	0.000155	-57.35886	0.0000
Y09	-0.004769	0.000215	-22.22191	0.0000
Y10	-0.001497	0.000152	-9.814813	0.0000

R-squared	0.007671	Mean dependent var	0.006289
Adjusted R-squared	0.007660	S.D. dependent var	0.048360
S.E. of regression	0.048175	Akaike info criterion	-3.227954
Sum squared resid	3808.001	Schwarz criterion	-3.227812
Log likelihood	2648284.	Hannan-Quinn criter.	-3.227916
F-statistic	704.6393	Durbin-Watson stat	0.798931
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AD – Regression 1 Results ABSIFF < 50%

Appendix AD provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 50%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:50
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<0.5
Included observations: 1635951

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.137448	0.003139	-43.78910	0.0000
IV	-0.000149	6.10E-05	-2.447883	0.0144
LOG(SP500)	0.020708	0.000426	48.59256	0.0000
VIX	0.000270	4.61E-06	58.57132	0.0000
LOG(EPU)	0.000812	4.38E-05	18.53452	0.0000
FFU	-0.025019	0.000713	-35.10164	0.0000
CALL	-0.001821	4.12E-05	-44.17240	0.0000
DITM	-6.26E-06	1.06E-07	-58.84694	0.0000
DOTM	-6.53E-06	1.07E-07	-60.79333	0.0000
BB	-0.006117	0.000344	-17.79375	0.0000
WBFRM	-0.000187	5.69E-05	-3.294933	0.0010
FRM	0.000809	0.000117	6.911548	0.0000
WAFRM	0.000512	5.68E-05	9.002934	0.0000
Y05	-0.010940	0.000385	-28.44737	0.0000
Y06	-0.006906	0.000106	-64.98836	0.0000
Y07	-0.009048	0.000108	-83.99840	0.0000
Y08	-0.007951	8.25E-05	-96.36150	0.0000
Y09	-0.004954	0.000115	-43.25892	0.0000
Y10	-0.003925	8.14E-05	-48.22464	0.0000

R-squared	0.018515	Mean dependent var	0.004150
Adjusted R-squared	0.018504	S.D. dependent var	0.025909
S.E. of regression	0.025668	Akaike info criterion	-4.487142
Sum squared resid	1077.817	Schwarz criterion	-4.486999
Log likelihood	3670391.	Hannan-Quinn criter.	-4.487103
F-statistic	1714.444	Durbin-Watson stat	1.574491
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AE – Regression 1 Results ABSIFF < 25%

Appendix AE provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 25%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:51
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<0.25
Included observations: 1630919

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.074535	0.002107	-35.37357	0.0000
IV	-0.000167	4.10E-05	-4.071052	0.0000
LOG(SP500)	0.011589	0.000286	40.51105	0.0000
VIX	0.000168	3.10E-06	54.26886	0.0000
LOG(EPU)	0.000469	2.94E-05	15.92746	0.0000
FFU	-0.013041	0.000478	-27.27244	0.0000
CALL	-0.001373	2.77E-05	-49.65633	0.0000
DITM	-4.18E-06	7.14E-08	-58.54819	0.0000
DOTM	-6.50E-06	7.20E-08	-90.15294	0.0000
BB	-0.003498	0.000231	-15.13630	0.0000
WBFRM	-6.14E-05	3.82E-05	-1.609697	0.1075
FRM	0.000124	7.86E-05	1.580632	0.1140
WAFRM	0.000260	3.81E-05	6.821617	0.0000
Y05	-0.008193	0.000258	-31.70333	0.0000
Y06	-0.005305	7.13E-05	-74.44140	0.0000
Y07	-0.006485	7.23E-05	-89.65883	0.0000
Y08	-0.006208	5.54E-05	-111.9548	0.0000
Y09	-0.004818	7.68E-05	-62.71278	0.0000
Y10	-0.003617	5.46E-05	-66.20589	0.0000

R-squared	0.024379	Mean dependent var	0.003104
Adjusted R-squared	0.024368	S.D. dependent var	0.017411
S.E. of regression	0.017197	Akaike info criterion	-5.288143
Sum squared resid	482.3213	Schwarz criterion	-5.288000
Log likelihood	4312286.	Hannan-Quinn criter.	-5.288105
F-statistic	2264.048	Durbin-Watson stat	1.606710
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AF – Regression 1 Results ABSIFF < 15%

Appendix AF provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 15%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:52
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<0.15
Included observations: 1623709

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.036823	0.001450	-25.39890	0.0000
IV	-0.000264	2.82E-05	-9.367178	0.0000
LOG(SP500)	0.005867	0.000197	29.80985	0.0000
VIX	8.88E-05	2.13E-06	41.61420	0.0000
LOG(EPU)	0.000350	2.02E-05	17.29593	0.0000
FFU	-0.006283	0.000329	-19.11199	0.0000
CALL	-0.000934	1.90E-05	-49.08663	0.0000
DITM	-1.97E-06	4.90E-08	-40.20842	0.0000
DOTM	-5.03E-06	4.95E-08	-101.4797	0.0000
BB	-0.001432	0.000159	-8.981265	0.0000
WBFRM	-1.42E-05	2.63E-05	-0.541763	0.5880
FRM	-0.000174	5.41E-05	-3.208782	0.0013
WAFRM	6.38E-05	2.63E-05	2.430213	0.0151
Y05	-0.004953	0.000178	-27.79950	0.0000
Y06	-0.003425	4.90E-05	-69.87499	0.0000
Y07	-0.004005	4.98E-05	-80.40487	0.0000
Y08	-0.004015	3.82E-05	-104.9838	0.0000
Y09	-0.003701	5.28E-05	-70.05678	0.0000
Y10	-0.002623	3.76E-05	-69.73245	0.0000

R-squared	0.024324	Mean dependent var	0.002268
Adjusted R-squared	0.024313	S.D. dependent var	0.011951
S.E. of regression	0.011805	Akaike info criterion	-6.040600
Sum squared resid	226.2686	Schwarz criterion	-6.040456
Log likelihood	4904107.	Hannan-Quinn criter.	-6.040561
F-statistic	2248.809	Durbin-Watson stat	1.571141
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AG – Regression 1 Results ABSIFF < 10%

Appendix AG provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 10%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:53
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<0.1
Included observations: 1615727

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.013831	0.001026	-13.48017	0.0000
IV	-0.000302	2.00E-05	-15.12692	0.0000
LOG(SP500)	0.002381	0.000139	17.09242	0.0000
VIX	4.12E-05	1.51E-06	27.25623	0.0000
LOG(EPU)	0.000237	1.43E-05	16.56543	0.0000
FFU	-0.002767	0.000233	-11.89840	0.0000
CALL	-0.000615	1.35E-05	-45.65222	0.0000
DITM	-3.67E-07	3.47E-08	-10.57324	0.0000
DOTM	-3.52E-06	3.51E-08	-100.4499	0.0000
BB	-0.000425	0.000113	-3.763535	0.0002
WBFRM	3.94E-05	1.86E-05	2.121546	0.0339
FRM	-0.000221	3.83E-05	-5.759423	0.0000
WAFRM	3.00E-05	1.86E-05	1.612473	0.1069
Y05	-0.002981	0.000126	-23.61599	0.0000
Y06	-0.002052	3.47E-05	-59.14545	0.0000
Y07	-0.002296	3.53E-05	-65.03200	0.0000
Y08	-0.002469	2.71E-05	-90.96019	0.0000
Y09	-0.002704	3.74E-05	-72.34152	0.0000
Y10	-0.001850	2.66E-05	-69.42532	0.0000

R-squared	0.021856	Mean dependent var	0.001675
Adjusted R-squared	0.021845	S.D. dependent var	0.008428
S.E. of regression	0.008335	Akaike info criterion	-6.736583
Sum squared resid	112.2594	Schwarz criterion	-6.736438
Log likelihood	5442259.	Hannan-Quinn criter.	-6.736544
F-statistic	2005.662	Durbin-Watson stat	1.526621
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AH – Regression 1 Results ABSIFF < 5%

Appendix AH provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 5%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:55
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<0.05
Included observations: 1599585

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000543	0.000539	1.008250	0.3133
IV	-0.000394	1.05E-05	-37.49750	0.0000
LOG(SP500)	8.02E-05	7.31E-05	1.096660	0.2728
VIX	1.05E-05	7.95E-07	13.19405	0.0000
LOG(EPU)	8.76E-05	7.53E-06	11.64533	0.0000
FFU	-0.000136	0.000122	-1.114170	0.2652
CALL	-0.000271	7.08E-06	-38.32413	0.0000
DITM	1.48E-06	1.82E-08	81.52768	0.0000
DOTM	-1.33E-06	1.84E-08	-72.17290	0.0000
BB	0.000194	5.94E-05	3.259034	0.0011
WBFRM	5.57E-05	9.76E-06	5.704074	0.0000
FRM	-0.000205	2.01E-05	-10.18401	0.0000
WAFRM	5.93E-05	9.76E-06	6.072980	0.0000
Y05	-0.000945	6.63E-05	-14.25502	0.0000
Y06	-0.000523	1.82E-05	-28.71211	0.0000
Y07	-0.000610	1.86E-05	-32.85054	0.0000
Y08	-0.000841	1.43E-05	-58.74257	0.0000
Y09	-0.001266	1.96E-05	-64.52805	0.0000
Y10	-0.000841	1.40E-05	-59.92686	0.0000

R-squared	0.022022	Mean dependent var	0.000966
Adjusted R-squared	0.022011	S.D. dependent var	0.004405
S.E. of regression	0.004356	Akaike info criterion	-8.034320
Sum squared resid	30.35721	Schwarz criterion	-8.034174
Log likelihood	6425808.	Hannan-Quinn criter.	-8.034281
F-statistic	2001.012	Durbin-Watson stat	1.428577
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AI – Regression 1 Results ABSIFF < 2.5%

Appendix AI provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 2.5%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:56
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<0.025
Included observations: 1583042

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003427	0.000302	11.33105	0.0000
IV	-0.000461	5.90E-06	-78.12006	0.0000
LOG(SP500)	-0.000413	4.11E-05	-10.06149	0.0000
VIX	3.48E-06	4.47E-07	7.774263	0.0000
LOG(EPU)	-8.07E-06	4.23E-06	-1.908149	0.0564
FFU	0.000530	6.84E-05	7.748437	0.0000
CALL	-0.000113	3.98E-06	-28.43249	0.0000
DITM	2.09E-06	1.02E-08	204.9959	0.0000
DOTM	-2.47E-07	1.03E-08	-23.95405	0.0000
BB	0.000300	3.34E-05	9.000867	0.0000
WBFRM	3.96E-05	5.49E-06	7.220457	0.0000
FRM	-0.000130	1.13E-05	-11.48820	0.0000
WAFRM	2.62E-05	5.49E-06	4.783321	0.0000
Y05	-0.000288	3.72E-05	-7.723691	0.0000
Y06	-9.76E-05	1.03E-05	-9.511318	0.0000
Y07	-0.000164	1.05E-05	-15.66946	0.0000
Y08	-0.000317	8.07E-06	-39.30996	0.0000
Y09	-0.000615	1.10E-05	-55.79236	0.0000
Y10	-0.000406	7.89E-06	-51.37147	0.0000

R-squared	0.041988	Mean dependent var	0.000601
Adjusted R-squared	0.041977	S.D. dependent var	0.002489
S.E. of regression	0.002436	Akaike info criterion	-9.196883
Sum squared resid	9.394031	Schwarz criterion	-9.196736
Log likelihood	7279545.	Hannan-Quinn criter.	-9.196844
F-statistic	3854.542	Durbin-Watson stat	1.364843
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AJ – Regression 1 Results ABSIFF < 1%

Appendix AJ provides the full EViews regression output for Regression 1 with the sample restricted to ABSIFF < 1%.

Dependent Variable: ABSIFF
Method: Least Squares
Date: 03/04/19 Time: 03:57
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<0.01
Included observations: 1553880

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002963	0.000144	20.61904	0.0000
IV	-0.000375	2.81E-06	-133.7396	0.0000
LOG(SP500)	-0.000356	1.95E-05	-18.25443	0.0000
VIX	-2.02E-06	2.13E-07	-9.469819	0.0000
LOG(EPU)	-3.71E-05	2.01E-06	-18.43187	0.0000
FFU	0.000682	3.25E-05	20.97763	0.0000
CALL	4.60E-05	1.89E-06	24.30030	0.0000
DITM	1.80E-06	4.84E-09	372.7241	0.0000
DOTM	1.20E-07	4.90E-09	24.47103	0.0000
BB	8.62E-05	1.58E-05	5.443127	0.0000
WBFRM	3.14E-05	2.61E-06	12.04829	0.0000
FRM	-9.59E-06	5.35E-06	-1.794131	0.0728
WAFRM	2.00E-05	2.61E-06	7.662167	0.0000
Y05	-0.000318	1.77E-05	-18.00278	0.0000
Y06	-0.000198	4.89E-06	-40.45838	0.0000
Y07	-0.000191	4.98E-06	-38.41339	0.0000
Y08	-0.000215	3.85E-06	-55.99083	0.0000
Y09	-0.000293	5.23E-06	-56.06892	0.0000
Y10	-0.000200	3.75E-06	-53.43669	0.0000

R-squared	0.110441	Mean dependent var	0.000313
Adjusted R-squared	0.110430	S.D. dependent var	0.001216
S.E. of regression	0.001147	Akaike info criterion	-10.70360
Sum squared resid	2.043713	Schwarz criterion	-10.70345
Log likelihood	8316071.	Hannan-Quinn criter.	-10.70356
F-statistic	10717.52	Durbin-Watson stat	1.351255
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. Regression output was taken from EViews 10 University edition.

Appendix AK – Regression 1 White Heteroskedasticity Test

Appendix AK shows the full EViews output for the White heteroskedasticity test conducted on Regression 1.

Heteroskedasticity Test: White
Null hypothesis: Homoskedasticity

F-statistic	497.3867	Prob. F(18,1640813)	0.0000
Obs*R-squared	8904.478	Prob. Chi-Square(18)	0.0000
Scaled explained SS	1048155.	Prob. Chi-Square(18)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/12/19 Time: 02:05
Sample: 1 1644010 IF FV<>0 AND MP<>0 AND ABSIFF<1
Included observations: 1640832

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002675	0.002151	1.243558	0.2137
IV^2	-0.000221	1.86E-05	-11.84176	0.0000
LOG(SP500)^2	3.22E-05	4.05E-05	0.793365	0.4276
VIX^2	3.78E-07	7.74E-08	4.891133	0.0000
LOG(EPU)^2	4.83E-05	6.55E-06	7.369272	0.0000
FFU^2	-0.043633	0.007745	-5.633407	0.0000
CALL^2	-0.002464	5.60E-05	-44.03467	0.0000
DITM^2	1.18E-08	1.58E-10	75.10772	0.0000
DOTM^2	3.00E-12	1.58E-10	0.018946	0.9849
BB^2	-0.002067	0.000475	-4.351107	0.0000
WBFRM^2	-0.000168	7.86E-05	-2.137650	0.0325
FRM^2	0.000495	0.000162	3.060933	0.0022
WAFRM^2	0.000327	7.85E-05	4.165298	0.0000
Y05^2	-0.002871	0.000529	-5.422829	0.0000
Y06^2	-0.001740	0.000142	-12.29116	0.0000
Y07^2	-0.001409	0.000149	-9.442692	0.0000
Y08^2	-0.001268	0.000113	-11.21542	0.0000
Y09^2	-0.000987	0.000163	-6.045825	0.0000
Y10^2	0.000847	0.000112	7.536304	0.0000

R-squared	0.005427	Mean dependent var	0.002321
Adjusted R-squared	0.005416	S.D. dependent var	0.035609
S.E. of regression	0.035513	Akaike info criterion	-3.837847
Sum squared resid	2069.301	Schwarz criterion	-3.837705
Log likelihood	3148650.	Hannan-Quinn criter.	-3.837809
F-statistic	497.3867	Durbin-Watson stat	0.407324
Prob(F-statistic)	0.000000		

Notes: All data was retrieved from Thomson Reuters Eikon DataStream and the Economic Policy Uncertainty database. The data covers a daily sample period from February 11th, 2005 to December 31st, 2011. Some observations from the sample were omitted because data was not available for one or more variables. White test output was taken from EViews 10 University edition.

References

Baker, S., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *Quarterly Journal of Economics*, 131(4), 1593-1636.

Bensoussan, A., & Julien, H. (1999). Option pricing in a market with frictions. In W. M. McEneaney, G. G. Yin, & Q. Zhang (Eds.), *Stochastic analysis, control, optimization and applications* (pp. 521-540). Boston, MA: Birkhäuser.

Black, F., & Scholes, M. (1972). The valuation of option contracts and a test of market efficiency. *The Journal of Finance*, 27(2), 399-417.

Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of Political Economy*, 81(3), 637-654.

Bollen, N., & Whaley, R. (2004). Does net buying pressure affect the shape of implied volatility functions?. *The Journal of Finance*, 59(2), 711-753.

Boness, A. J. (1964). Elements of a theory of stock-option value. *Journal of Political Economy*, *72*(2), 163-175.

Boness, J. A. (1962). A theory and measurement of stock-option value (Unpublished doctoral dissertation). Chicago, IL: University of Chicago.

Capelle-Blancard, G., & Chaudhury, M. (2001). Efficiency tests of the French Index (CAC 40) options market. Paris, FR: University of Paris.

Castelli, C. (1877). The theory of options in stocks and shares. London, EL: F.C Mathieson.

Chance, D. (1987). Parity tests of index options. Advances in Futures and Option Research, 2, 46-64.

Clark, P. K. (1973). A subordinated stochastic process model with finite variance for speculative prices. *Econometrica*, 41(1), 135-155.

Constantinides, G. M. (1979). Multiperiod consumption and investment behavior with convex transaction costs. *Management Science*, 25(11), 1127-1137.

Constantinides, G. M., Czerwonko, M., & Perrakis, S. (2016). Mispriced index option portfolios (No. w23708). Chicago, IL: *National Bureau of Economic Research*.

Davis, M., & Etheridge, A. (2006). Facsimile of Bachelier's original thesis. In Louis Bachelier's theory of speculation: the origins of modern finance (pp. 116-182). Princeton, NJ: *Princeton University Press*.

Evnine, J., & Rudd, A. (1985). Index options: the early evidence. *The Journal of Finance*, 40(3), 743-756.

Fama, E. F. (1970). Efficient capital markets: a review of theory and empirical work. *The Journal of Finance*, 25(2), 383-417.

Galai, D. (1972). The option pricing model and the risk factor of stock. *The Journal of Financial Economics*, 3(2), 53-81.

Galai, D. (1977). Tests of market efficiency of the Chicago board options exchange. *The Journal of Business*, 50(2), 97-167.

Gemmill, G. (1991). Political risk and market efficiency: tests based in British stock and options markets in the 1987 election. *Journal of Banking and Finance*, 16, 211- 231.

Gettleman, E., Julio, B., & Risik, E. (2012). Option market overreaction to stock price changes. ACRN *Journal of Finance and Risk Perspectives*, 1(2), 112-129.

Hull, J. (2009). Options, futures and other derivatives (7th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Hull, J., & White, A. (1987). The pricing of options on assets with stochastic volatility. *The Journal of Finance*, 42(2), 281-300.

Kelly, B., Pastor, L., & Veronesi, P. (2016). The price of political uncertainty: theory and evidence from the option market. *The Journal of Finance*, 71(5), 2417-2480.

Khan, M. T., Gupta, A., & Siraj, S. (2013) Empirical testing of modified Black-Scholes option pricing model formula on NSE derivative market in India. *International Journal of Economics and Financial Issues*, 3(1), 87-98.

Kruizenga, R. J. (1965). Put and call options: a theoretical and market analysis (Unpublished doctoral dissertation). Cambridge, MA: M.I.T.

Lauterbach, B., & Schultz, P. (1990). Pricing warrants: an empirical study of the Black-Scholes model and its alternatives. *The Journal of Finance*, 45(4), 1181-1209.

Luehrman, T. (1998). Investment opportunities as real options. *Harvard Business Review*, 76(4), 51-67.

Malkiel, B. G. (1973). A random walk down wall street. New York: W. W. Norton & Co.

Malliaris, A. G. (2007). The Black-Scholes option pricing model. Available at SSRN 1256522.

Merton, R. C. (1998). Applications of option-pricing theory: twenty-five years later. *American Economic Review*, 88(3), 323-349.

Niederhoffer, V., Gibbs, S., & Bullock, J. (1970). Presidential elections and the stock market. *Financial Analyst Journal*, 26(2), 881-889.

Noh, J., Engle R. F., & Kane, A. (1994). A test of efficiency for the S&P 500 Index option market using variance forecasts. *Journal of Derivatives*, 2, 17-30.

Peng, J., & Yao, K. (2011). A new option pricing model for stocks in uncertainty markets. *International Journal of Operations Research*, 8(2), 18-26.

Poon, S. H., & Pope, P. F. (1999). Trading volatility spreads: a test of index option market efficiency. *European Financial Management*, 6(2), 235-260.

Poteshman, A. (2001). Underreaction, overreaction, and increasing misreaction to information in the options market. *The Journal of Finance*, 56(3), 851-876.

Riley W. B., & Luksetich, W. A. (1980). The market prefers republicans: myth or reality. *Journal of Financial and Quantitative Analysis*, 15, 541-560.

Roberts, H. (1959). Stock market 'patterns' and financial analysis: methodological suggestions. *The Journal of Finance*, 14(1), 1-10.

Shah, S. J. (1997). The option clause in free-banking theory and history: a reappraisal. *The Review of Austrian Economics*, 10(2), 1-25.

Shiller, R., & Perron, P. (1985). Testing the random walk hypothesis: Power versus frequency of observation. *Economics Letters*, 18(4), 381-386.

Smith, Yves (2007). The Real Difference Between Greenspan and Bernanke. Retrieved March 6, 2019, from Naked Capitalism: https://www.nakedcapitalism.com/2007/09/real-difference-between-greenspan-and.html

Stoll, H. R. (1969). The relationship between put and call option prices. *The Journal of Finance*, 24(5), 801-824.

Teneng, D. (2011). Limitations of the Black-Scholes model. *International Research Journal of Finance and Economics*, 68, 99-102.

Whaley, R. E. (1982). Valuation of American call options on dividend-paying stocks: empirical test. *The Journal of Finance*, 10(1), 29-58.

Yen, G., & Lee, C. (2008). Efficient market hypothesis (EMH): past, present and future. *Review of Pacific Basin Financial Markets and Policies*, 11(2), 305-329.