

# How do FED monetary policy announcements impact the U.S. equity market?

Joakim Skaftnes

Dissertation written under the supervision of Professor  
Diptes Chandrakante Prabhudas Bhimjee

Dissertation submitted in partial fulfilment of requirements for the  
MSc in International Finance, at Universidade Católica Portuguesa  
and for the MSc in Business, major in Finance at BI Norwegian  
Business School, May 2023.





# **How do FED monetary policy announcements impact the U.S. equity market?**

**by Joakim Skaftnes**

May 2023

## **Abstract**

The present Dissertation explores the impact of monetary policy announcements on U.S. equity markets, thereby critically analysing its magnitude and persistence. The time window ranges from 2001 until 2023, and the sample analyses the days with Federal Open Market Committee (FOMC) meetings, and the corresponding dates where changes in the Federal Funds target rate are being announced. The Dissertation implements the seminal methodology of Kuttner (2001) to decompose the changes in monetary policy into expected and unexpected components using historical Fed Funds future rates data. The main finding of the Dissertation is a strong relation between monetary policy and equity markets. The returns of the Dow Jones Industrial Average and NASDAQ-100 are negative upon positive surprises in the target rate. Overall, the findings are consistent with the Efficient Market Hypothesis, as the expected changes in the target rate are incorporated in equity prices in advance to its announcement. Through the inclusion of dummy variables, the Dissertation does not find evidence of different market reactions to target rate surprises in recessions, nor in reversal meetings. The Dissertation also finds a longer lasting impact of target rate changes, observed through the implied and realized volatility of the indices. Greater than expected increases in the target rate are associated with increases in both volatility measures. The spread between them is on average positive, leading to the existence of a positive volatility risk premium. Subsequently, the Dissertation employs two robustness checks, affirming the robustness and stability of the findings presented herein.

**Keywords:** Monetary policy announcements, Federal Funds Futures, U.S. stock market

**J.E.L. Classification:** E52, E58, G13, G14

# How do FED monetary policy announcements impact the U.S. equity market?

by Joakim Skaftnes

May 2023

## Resumo

A presente Dissertação analisa criticamente o impacto dos anúncios de política monetária do F.E.D. no mercado acionista norte-americano, descrevendo criticamente a sua magnitude e persistência. A janela temporal decorre de 2001 até 2023, e a amostra inclui os dias/sessões onde existiram reuniões da “*Federal Open Market Committee*” (FOMC), bem como as decisões correspondentes relativas à taxa diretora “*Federal Funds rate*”. A Dissertação implementa a metodologia seminal de Kuttner (2001) para decompor as mudanças na política monetária em componentes esperadas e inesperadas, usando dados históricos de taxas futuras dos “*Fed Funds*”. Conclui-se pela existência de uma forte relação entre a política monetária e os mercados acionistas. Os retornos dos índices Dow Jones Industrial Average e NASDAQ-100 são negativos, face a surpresas positivas na taxa diretora. No geral, os resultados são consistentes com a “*Efficient Market Hypothesis*”, já que as mudanças esperadas na taxa diretora são incorporadas nos preços das ações antes da sua publicitação. Através da inclusão de variáveis *dummy*, a Dissertação não encontra evidências de diferentes reações no mercado para surpresas da taxa diretora em recessões, nem em reuniões de reversão. A Dissertação também encontra um impacto duradouro de mudanças nas taxas diretoras, observado através da volatilidade implícita e realizada dos índices. Aumentos maiores do que o esperado na taxa diretora estão associados a aumentos em ambas as medidas de volatilidade, conduzindo à existência de um “*volatility risk premium*” positivo. Posteriormente, a Dissertação emprega duas verificações de robustez, constatando a robustez e estabilidade das evidências empíricas aqui apresentadas.

**Palavras-chave:** Monetary policy announcements, Federal Funds Futures, U.S. stock market

**Classificação J.E.L.:** E52, E58, G13, G14



**Table of Contents**

- 1. Introduction ..... 1**
- 2. Literature Review ..... 3**
- 3. Contextualization ..... 11**
  - 3.1 FED and FOMC ..... 11
  - 3.2 Federal Funds Futures contracts ..... 11
- 4. Methodology and Data ..... 13**
  - 4.1 Empirical methodology ..... 13
  - 4.2 Data ..... 18
    - 4.2.1. Data description and descriptive statistics ..... 19
- 5. Empirical findings & Discussion ..... 21**
  - 5.1 Empirical findings ..... 21
    - 5.1.1. Impact of monetary policy on interest rates ..... 23
    - 5.1.2. Impact of monetary policy on equity returns ..... 25
    - 5.1.3. Impact of monetary policy on volatility ..... 29
  - 5.2 Robustness checks ..... 32
- 6. Conclusion ..... 36**
- References ..... 39**
- Appendix ..... 42**

**Table of Tables<sup>1</sup>**

Table 1: Event days..... 19

Table 2: Descriptive statistics of Dow Jones Industrial Average..... 19

Table 3: Descriptive statistics of NASDAQ-100 ..... 20

Table 4: Overview of changes in policy rates between 2001 and 2023 ..... 21

Table 5: Impact of target rate changes in interest rates ..... 24

Table 6: Impact of target rate changes on equity returns ..... 25

Table 7: Recession dummy variable ..... 28

Table 8: Impact of target rate changes on the implied volatility ..... 29

Table 9: Impact of target rate changes on the realized volatility ..... 30

Table 10: Impact of target rate changes on the volatility risk premium ..... 30

Table 11: Robustness check (1): Equity returns..... 32

Table 12: Robustness check (1): Implied volatility ..... 32

Table 13: Robustness check (1): Realized volatility ..... 33

Table 14: Robustness check (1): Volatility risk premium..... 33

Table 15: Robustness check (2): Equity returns..... 34

Table 16: Robustness check (2): Implied volatility ..... 34

Table 17: Robustness check (2): Realized volatility ..... 34

Table 18: Robustness check (2): Volatility risk premium..... 34

Table 19A: Reversal dummy variable..... 42

Table 20A: Wald test results ..... 42

Table 21A: Wald test results ..... 42

Table 22A: Wald test results ..... 43

---

<sup>1</sup> Tables denoted with an “A” are found in the Appendix.

**Table of Figures**

Figure 1: Target rate surprises..... 23

Figure 2: Returns in the Dow associated with actual, expected, and unexpected target rate changes..... 26

Figure 3: Implied- and realized volatility, and the volatility risk premium of the NASDAQ-100..... 31

**Table of Equations**

Equation 1: Profit function Fed Funds future contracts ..... 5

Equation 2: No-arbitrage risk-neutral market price of Fed Funds future contracts ..... 5

Equation 3: Gauging market expectations ..... 6

Equation 4: Unexpected change in the target rate ..... 13

Equation 5: Expected change in the target rate ..... 14

Equation 6: Relation between interest rate and target rate changes ..... 14

Equation 7: Relation between interest rate and decomposed target rate changes ..... 14

Equation 8: Equity returns and target rate changes..... 14

Equation 9: Equity returns and decomposed target rate changes..... 15

Equation 10: Realized volatility ..... 15

Equation 11: Implied volatility and target rate changes..... 16

Equation 12: Implied volatility and decomposed target rate changes..... 16

Equation 13: Volatility risk premium..... 16

Equation 14: Volatility risk premium and target rate changes ..... 16

Equation 15: Volatility risk premium and decomposed target rate changes ..... 16

Equation 16: Weighted average cost of capital (WACC) ..... 23

Equation 17: Capital asset pricing model (CAPM)..... 24

## **Glossary**

<b>CAPM</b>	Capital asset pricing model
<b>DJIA</b>	Dow Jones Industrial Average (“The Dow”)
<b>FED</b>	Federal Reserve
<b>FOMC</b>	Federal Open Market Committee
<b>IR</b>	Interest rates
<b>NDX</b>	NASDAQ-100
<b>OMO</b>	Open market operations
<b>WACC</b>	Weighted average cost of capital
<b>“Cut”</b>	Reduction in the target rate of the FED
<b>“Hike”</b>	Increase in the target rate of the FED

## **Acknowledgements**

First and foremost, I would like to thank my Supervisor, Professor Diptes Bhimjee. Through discussions, meetings, and revisions his insights and knowledge have made a significant contribution to the development of the Dissertation.

I would also like to thank my Family who have supported me unconditionally throughout my Master's degree and during the writing of the Dissertation.

Lastly, I would like to thank the Professors at BI Norwegian Business School, and Universidade Católica Portuguesa for their valuable courses.



## 1. Introduction

The Federal Reserve is the central bank of the U.S. and was established through the Federal Reserve Act in 1913, with the purpose of providing the nation with the tools required to implement a safe, stable, and flexible monetary policy (Federal Reserve, 2016). The Federal Reserve uses three main conventional tools to reach its institutional goals, namely (i) open market operations, (ii) the discount rate, and (iii) reserve requirements. The main responsibility of the FOMC is to decide the target rate, known as the Federal Funds rate. Chicago Board Options Exchange (CBOE) provides the opportunity to trade future contracts, whose settlement price is dependent on the effective realized Federal Funds rate. The contracts started trading in 1989 and can be used to gauge market expectations of future changes in the target rate.

The present Dissertation explores the relation between changes in the target rate of the Federal Reserve and the U.S. equity market. This relation is of great importance as the stability of equity markets is crucial for capital raising, liquidity, investing, and overall economic growth. Unforeseen changes in the target rate can have comprehensive implications on equity markets. By exploring the single day returns, and implementing two volatility measures, the Dissertation aims to study the market reaction to monetary policy changes. The Dissertation underlines the importance of accounting for the market expectations of change, and provides insight to how these expectations have evolved during the assessed time window between 2001 and 2023.

The academic literature has mainly focused on the reactions of the S&P500 upon changes in the target rates, as well as determining model accuracy in gauging market expectations of policy changes. The present Dissertation employs the methodology of Kuttner (2001) to gauge market expectations of changes in the target rate, using Federal Funds future contracts. Subsequently, the Dissertation explores the reactions of the Dow Jones Industrial Average and NASDAQ-100 indices to monetary policy announcements.

The main finding of the Dissertation argues in favor of a strong relation between conventional monetary policy<sup>2</sup> and equity markets. Both equity indices react negatively to positive surprises in the FED target rate. By incorporating dummy variables, the Dissertation does not find

---

<sup>2</sup> The target rate of the FED is an integral component of conventional monetary policy. In more recent years unconventional tools, such as Quantitative Easing (QE) have emerged, which are nevertheless beyond the scope of the present Dissertation.

evidence of different reactions to target rate changes in different stages of the business cycle (e.g., recessions), nor of reversal decisions. Positive surprises are also accompanied by increases in the implied and realized volatility.

The Dissertation is structured as follows: Section 2 presents the most relevant literature related to the academic research question, and the development of the methodology employed to gauge market expectations. Section 3 provides insight to the dynamics of Federal Funds Futures contracts, as this contract is a fundamental component of the Dissertation. Section 4 describes the methodology applied, and the dataset used herein. Section 5 presents and critically discusses the empirical findings of the Dissertation, including the robustness checks used to examine the stability of the findings. Lastly, Section 6 concludes.

## 2. Literature Review

Due to its significance, the Federal Funds rate and its impact constitutes a nuclear field of economic research. However, there are still unexplored areas, which this Dissertation seeks to fill in. The present section reviews the state-of-the-art academic literature related to the academic research question herein addressed, namely the relation between changes in U.S. monetary policy and the performance of equity markets.

A fundamental component in asset pricing models is the risk-free interest rate. This rate is typically strongly correlated with conventional monetary policy through central bank interest rates. Therefore, central bank interest rate decisions normally create a strong relation between the equity markets and monetary policy. *Ex ante*, this relationship should be present in the short-to medium-term, even if the view of money neutrality were to hold<sup>3</sup>. Cook and Hahn (1989) innovatively addressed the impact of the Federal Funds rate on interest rates. Their research focused on the one-day response in Treasury yields to changes in the target rate and was conducted using a dataset between 1974 and 1979. The authors find that changes in the target rate had a greater impact on short term maturity yields than longer ones, but were significant for all treasuries assessed (3-month to 20-year bonds). In addition, they also observe a significant and positive response the day after the policy change takes place. This can be accounted for by the FED actions, as the FED did not publicly announce its policy changes before 1994. Thus, changes in monetary policy did not become fully known by market participants until the day after the change took place.

Roley and Sellon (1995) applied Cook and Hahn (1989)'s empirical methodology but do not observe a significant relation between the changes in the target rate and long-term Treasury yields. These authors use a dataset ranging from 1987 until 1995. Likewise, Radechi and Reinhart (1994) also observe a weak relation with a dataset of target rate changes encompassing the time interval between 1989 and 1992.

Similar research has been performed subsequently, and the seminal work of Kuttner (2001) conducts the same analysis with a sample consisting of 42 FOMC meetings between 1989 and 2000. Kuttner (2001) further highlights a flaw in the approach pursued by Cook and Hahn

---

<sup>3</sup> The theory of money neutrality implies that equity values should be independent of monetary policy in a long-term perspective (Bernanke and Kuttner, 2005).

(1989), as their regression did not account for market expectations, but simply regressed the change in yields on the change in the target rate of the FED. The failure to decompose the change in the target rate into expected and unexpected components led to an errors-in-variables problem. This also accounts for the failure to observe a significant relation between changes in monetary policy and interest rates in the 80's and 90's.

Kuttner (2001) addresses this issue by gauging market expectations of changes in the target rate using Federal Funds Future contracts. With the forward-looking nature of the futures market, the price of the spot-month contract at any given moment is equal to 100.00 minus the market expectations of the weighted-average effective Federal Funds rate for the remaining days of the month in basis-points. Hence, price changes must be driven by changes in expectations of future Federal Funds rates. When replicating the work of Cook and Hahn (1989) on data between 1989 and 2000, Kuttner (2001) obtains a smaller impact on interest rates and only statistically significant coefficients for maturities of five years or shorter. The findings led this author to conclude that the diminishing impact could be driven by different sample sizes, increased transparency by the FED, or more likely, that the markets to a greater extent anticipate future changes in Fed Fund rates. The author proceeds by implementing an approach similar to Cook and Hahn (1989), while accounting for both the expected and unexpected change components. The results reveal that the expected changes of the market, and the target rate change in itself are not accompanied by a significant response in Treasury yields. The unexpected changes on the other hand are significant for all maturities, including for 30-year bonds. In addition to the statistical significance, the economic impact is also more evident, as the coefficients of the unexpected changes are considerably greater than the ones obtained when not controlling for market expectations. A hypothetical one percentage point surprise change in the target rate is associated with a 71.6 basis-points move in the 1-year Treasury bills. A similar shock generates a 19.8 basis-points move when not controlling for market expectations. The author follows a line of argumentation which states that bond yields should react differently to expected and unexpected changes in target rate. As market participants to a greater extent manage to anticipate changes in monetary policy, the effect of the actual change should have a diminishing impact on bond yields. This leads to the need of gauging the market expectations when assessing the impact of changes in the target rate on other variables.

The innovative approach of Kuttner (2001) in using the Federal Funds Future contracts as a market-based proxy had previously been partially explored and examined by Krueger and

Kuttner (1996). They found that the Fed Funds Future contracts are “efficient” forecasts of the future funds rate, in the sense that their residuals are not significantly correlated with other publicly known variables at the time of the “forecast”. In their research, the authors use data on one- and two-month Fed Funds Future contracts. To explore the rationality of the expected future changes in target rates, the authors derive the profit function of the Fed Funds Future contracts, in which the profit of month  $s$ , with  $D$  days, is equal to the difference between the Fed Funds Future rate and the weighted average of the Fed Funds rate:

$$\pi_t^s = f_t^s - \frac{1}{D} \cdot \sum_{i \in s} r_i \quad (1)$$

Which further leads to the no-arbitrage risk-neutral condition of the market price at time  $t$ :

$$0 = f_t^s - \frac{1}{D} \cdot E_t \left( \sum_{i \in s} r_i \right) \quad (2)$$

From this procedure, Krueger and Kuttner (1996) finds that the futures markets contain a small, positive premium term, and that the market incorporates substantially all available information of future changes in target rate at time  $t$ .

Kuttner (2001) identifies numerous advantages of using the futures data to derive the expected and unexpected changes in the Federal Funds rate, instead of using other statistical procedures. These advantages include: (i) the benefit of not having to select a model (which may generate a model bias); (ii) historical data selection used in the statistical models; and (iii) no generated regressor problems. On the other hand, the author also finds two hurdles associated with using these contracts. Firstly, as changes in target rates only have an impact on the remaining days of the month, there is a need to scale the shocks into its actual sizes. Secondly, the premium term identified by Krueger and Kuttner (1996) serves as a violation of the risk-neutral no-arbitrage condition. However, the presence of a premium term does not serve as an inherent issue, but rather the corresponding potential fluctuations associated with this term. Hence, the approach of Kuttner (2001) relies on the assumption of no significant day-to-day changes in the premium term of the contracts, as this would lead to misleading proxies of market expectations. With the developed approach any premium term that does not exhibit day-to-day changes will be

cancelled out, as it is based on the change in the future contract rate between day  $t$  ( $f_{s,t}^0$ ) and day  $t-1$  ( $f_{s,t-1}^0$ ). Hence, the method developed by Kuttner (2001) to estimate unexpected changes in target rate at day  $t$  in a month with  $d$  days may be expressed as:

$$\Delta r_t^u = \frac{d}{d-t} \cdot (f_{s,t}^0 - f_{s,t-1}^0) \quad (3)$$

Given that a single change in target rate is expected for a given month,  $\Delta r_t^u$  is an effective gauge of market expectations<sup>4</sup>. Having estimated the unexpected change in the target rate, the author obtains the expected change from the difference between the actual and unexpected change. After the research performed by Kuttner (2001), the equivalent approach of gauging market expectations to changes in target rates has been broadly applied (See Chuliá et al. (2010), Hausman and Wongswan (2006), among others). Later, Gürkaynak et al. (2002) finds that the approach of Kuttner (2001) outperforms all other forecast techniques of future changes in FED target rates for maturities up to 6 months, thereby strengthening the validity of Kuttner (2001).

Bernanke and Kuttner (2005) further implements the methods developed by Kuttner (2001) to examine the reaction of the stock market to changes in FED target rates, and to identify reasons for the observed reactions. They find that a 25 basis-point unexpected decrease in the target rate leads to an approximately 1% increase in U.S. stock market indices. They also find that the actual rate change, and its expected component are not associated with significant reactions, which is aligned with the Efficient Market Hypothesis<sup>5</sup>. Further, they discover that the impact of changes in target rates on stock prices comes through the expected future excess returns or the expected future dividends, depending on sample selection. The authors also reveal that while unexpected cuts in rates lead to a positive response in equity returns, they are followed by prolonged periods with below-average excess returns. This finding may be attributed to the signaling effect of unexpected cuts in target rates. The article observes a greater reaction to policy changes that are perceived to be more permanent, and less of a response to unexpected inaction upon FOMC meetings (that is, a meeting in which the market has expectations of a

---

<sup>4</sup> In October 2008 the sample herein used contains two changes in target rates. The same goes for March 2020, but these observations are omitted as they serve as outliers in the sample. This is further commented upon in the Methodology and Data section.

<sup>5</sup> The Efficient Market Hypothesis states that all available information should be reflected in asset prices (Fama, 1970). Expected changes should therefore be incorporated in the prevailing asset prices, and not be associated with significant price reactions.

change, and the FED does not move their target rate). Furthermore, the authors decompose the observed returns into industry portfolios, and estimate the market betas of each portfolio. From these regressions, Bernanke and Kuttner (2005) finds that high-techs and telecoms are the most sensitive to surprises in the target rates. On the other end of the scale, they find sectors such as nondurables, energy, and utilities to be least sensitive. Their findings reveal that the returns of the industry portfolios are to a great extent consistent with the reactions predicted by the Capital Asset Pricing Model (CAPM).

Wongswan (2009) finds a significant relation between changes in FED target rates and foreign equity markets using high-frequency data, emphasizing the importance and span of the FED's monetary policy actions on the global economy. The author conducts the study on 15 foreign equity indices, covering both developed and emerging economies between 1998 and 2004. The article finds that an unexpected 25 basis point increase in the target rate is associated with a 0.5% to 2.5% reduction in foreign equity indices, where the impact is caused by altered discount rates. The findings demonstrate that U.S. monetary policy changes does not only serve as a risk factor in the U.S., but also in foreign equity markets.

Chuliá et al. (2010) addresses asymmetric effects of changes in the target rate on S&P100 individual stock returns, volatilities, and correlations. The authors gauge market expectations similarly to Kuttner (2001). To explore market reactions, they estimate 5-minute returns surrounding FOMC announcements, with a sample size consisting of 77 scheduled meetings between 1997 and 2006. They find that expected changes in the target rate are insignificant both when using a 5-minute interval, daily data, and when controlling for reversal decisions<sup>6</sup>. Furthermore, they find that an unexpected increase of 10 basis-points is associated with a 46 basis-points negative stock return. The short-term (5-minute interval) impact of reversal decisions are of greater magnitude than a regular change in the target rate. The volatility and correlation between stocks are also significantly influenced, where a 10 basis-points unexpected increase in the target rate on average relates to a 48 basis-point increase in volatility, and average correlations move from 0.2 to 0.41. Another relevant finding is that positive unexpected changes (greater hikes, or smaller cuts than expected) have a stronger impact on stock returns than negative unexpected changes. This finding contradicts those of Bernanke and Kuttner (2005) who do not observe such asymmetries; but these asymmetries might occur due to the

---

<sup>6</sup> Reversal decisions occur when the Federal Reserve changes the direction of their target rate.

use of intraday data. Lastly, the authors also document a bias in the sense that for positive unexpected changes the surprise in itself is more important than the magnitude component, but for negative unexpected changes the magnitude component is more important than the news.

Stotz (2019) uses information embedded in options to decompose the equity returns upon monetary policy decisions into: (i) cash-flow news, (ii) interest rate news, and (iii) equity risk premium news. Cash-flow news are defined as revisions in expectations of the future generated cash-flows of firms. The other two factors jointly create the discount rate at which the future cash-flows are discounted at when estimating their present value<sup>7</sup>. Further, Stotz (2019) proposes a new methodology, as the prevailing methods were not appropriate for the decomposition of stock returns required to conduct the research, namely the “Option-implied return” (OIS). This approach uses option data to obtain a risk-neutral probability density function, which are converted into a risk-adjusted probability density function. In this transition the author assumes an investor with power utility, to attain the implied equity return. The author finds that the market reaction is contingent on the state of the economy. In economic expansions the cash-flow channel explains the majority of the returns, whereas in recessions changes in the equity risk premium generate the greatest impact. In an economic expansion, an unexpected decrease of 25 basis-points target rate is accompanied by an increase of 225 basis- points in stock prices, in which 268 basis-points can be accounted for by altered cash-flow expectations by investors. A similar unexpected decrease of 25 basis-points in a contraction is associated with a decrease in stock prices of 42 basis-points, where 86 basis-points can be attributed to a higher equity risk premium.

The impact of a monetary policy surprise may influence the equity markets to a greater extent than what is captured using intraday or daily data. Gospodinov and Jamali (2012) addresses the impact in volatility, proxied by both the implied volatility and the realized volatility, upon FOMC meetings or unscheduled policy changes. As a proxy for the implied volatility, the authors use the VIX index, which is built from of out-of-the-money European put and call options on the S&P500 with 23 to 37 days until maturity. The VIX index is a measure of the 30-day forward volatility of the S&P500 (CBOE, n.d.). Furthermore, the realized volatility is calculated using the daily squared returns over the subsequent 22 trading days. Using these two measures of volatility the authors can extract the volatility risk premium (VRP), which is the

---

<sup>7</sup> In this article, the discount rate is defined as the risk-free rate plus the equity risk premium.

difference between the implied volatility and the realized volatility. The surprises, or unanticipated changes, are estimated using the spot month, one-month-ahead, and the two-month-ahead future contracts. The authors conclude that the expected changes in the target rate does not seem to influence either the implied or realized volatility. Furthermore, an unexpected positive change of one percentage point in the target rate is associated with an increase in the VIX in the range of 2.8 to 8.04 percentage points, and an increase in the realized volatility of 1.48 to 7.08 percentage points, both depending on the type of contract used. An unexpected change of similar proportion leads to a decrease of 8.28 percentage points in S&P500 returns using the spot-month future contract. The spot and one-month-ahead future contract exhibit significantly greater responses to the policy changes relative to the two-month future. Lastly, they find that the volatility risk premium is on average positive and that a positive surprise of 25 basis-points leads to a reduction within the range of 1.1 to 3.7 percentage points depending on the type of futures contract considered.

Bomfim (2003) finds that surprises in the target rate are accompanied by significant increases in short-term volatility in the S&P500 index, like Gospodinov and Jamali (2012). Furthermore, higher than expected levels in target rates (a positive surprise in the target rate) is associated with greater changes in volatility, than a similar negative unexpected change. Hence, the markets exhibit an asymmetric reaction in terms of volatility upon surprises in the target rates.

As the majority of research in market expectations of policy changes have been conducted using pre-2008 data, a significant proportion of data remains relatively unexplored. After the “Subprime” financial crisis of 2008 until 2015, the Federal Reserve effectively implemented a near zero-interest rate policy. Furthermore, the market communication of the FED has quite significantly improved over time. In 1994 they started to publicly announce policy rates. The FED minutes, which are released after the FOMC meetings, provide extensive insight to market participants on the reasoning of the decisions undertaken by the committee. Such measures help reduce the impact of monetary policy changes on the financial markets, as greater communication and transparency are introduced.

By using the innovative approach by Kuttner (2001) to gauge market expectations of target rate changes, the present Dissertation seeks to add to the existing literature. The Dissertation uses an extended sample from 2001 until 2023, leading to a significantly greater sample size than the relevant literature presented. Research addressing volatility and equity returns in U.S.

typically use the VIX and S&P500. The dissertation takes advantage of similar volatility measures as the VIX but derived from the options of the Dow Jones Industrial Average and the NASDAQ-100, which is an uncommon practice. By using these time series, the Dissertation will be able to compare the market reactions both internally, but also externally with the prevailing research performed on the S&P500. Thus, the Dissertation greatly broadens the existing academic literature by exploring different indices over an extended time interval, enhancing the validity of the inferences and conclusions drawn.

### **3. Contextualization**

The Federal Reserve (FED) is the U.S. central bank. Its mandate is defined in the Federal Reserve Act, and states that their main objectives are “to promote effectively the goals of maximum employment, stable prices and moderate long-term interest rates” (Federal Reserve, n.d.). The Federal Open Market Committee (FOMC) consists of 12 members, and the committee are responsible for the implementation of the open market operations (OMO) of the FED. The two other tools available at its disposal are the discount rate and the use of reserve requirements, which are the responsibility of the Board of Governors. The three tools serve as the fundamental mechanisms through which the FED pursues its main institutional goals.

#### **3.1 FED and FOMC**

The target rates determined by the FED are one of the most central components of both the U.S. and the global economy. Effectively, increased target rates increase the cost of credit across the globe as a significant proportion of loans are denominated in USD (Goldberg et al., 2022). The Federal Funds rate is the overnight rate according to which financial institutions borrow or lend excess liquidity at the Federal Reserve to each other. The FOMC has eight scheduled meetings each year. At the end of their two-day meetings, they announce changes (if any) to the target rate, which will become effective from the next day onwards.

#### **3.2 Federal Funds Futures contracts**

Beginning in 1989 the Chicago Board of Exchange started to act as a market-maker of Federal Funds Futures (ZQ) contracts, allowing market participants to buy and sell futures contracts related to the Federal Funds rate. This provided an opportunity to hedge against future changes in the target rate, but also a chance to speculate on future decisions of the FED. In their present format, the contracts are presently quoted on a monthly basis, for up to 60 months (5 years) into the future. As the present target rate of the FED is always known to market participants<sup>8</sup>, the only uncertainty related to its pricing is connected to any future changes in the rate occurring at the scheduled FOMC meetings or through “surprise” meetings. Such meetings only occur

---

<sup>8</sup> Since 1994. Before this date, the Federal Reserve did not publicly announce their monetary policy changes, which created an information delay to market participants.

when there is an immediate and urgent requirement to adjust the policies of the FED, as seen during the Global Financial Crisis and during the outburst of the covid-19 pandemic.

The futures contracts and its prices provide information related to the market expectations of what the future rate will be. The settlement price of the contract is equal to 100.00 minus the weighted average realized in the effective Federal Funds rate of the month in basis-points. To further understand this pricing dynamics, the Dissertation presents two different but common market situations:

1. In a month where the target rate is 2.5% and there are no scheduled FOMC meetings, the futures contract should trade at  $100.00 - 2.50 = 97.50$  during the entire month.
2. In a month where the target rate is 2.5% and there is one scheduled FOMC meeting on the 15<sup>th</sup> in a month of 30 days in which they decide to hike 50 bps, the contract should have a settlement price of 97.25. The settlement price is derived from the average federal funds rate of the month. In the scenario we have 15 days where the rate is 2.5% and 15 days where the rate is 3.00%, which provides a monthly average of 2.75%. The implied settlement price (which is also where the contract should trade immediately after the announcement) is  $100.00 - 2.75 = 97.25$ .

Through these pricing dynamics it is possible to obtain the market expectations of future target rate changes from the FED in advance of each meeting. In the Dissertation this is done by observing the price change of the Federal Funds future contracts. Based on this, it is possible to decompose what part of the actual target rate changes are in effect expected and unexpected by the market. Such decomposition is further discussed and explained in the following sections. The Dissertation will exploit this information from the futures contracts to explore the relationship between changes in monetary policy and the U.S. equity markets.

## 4. Methodology and Data

The present section of the Dissertation presents the set of empirical methods employed to assess the impact of monetary policy on the equity market. The research design herein adopted involves the following steps: (i) gauging the unexpected change in the target rate through the Federal Funds future contracts; (ii) using this estimation to control for the expected changes of the market; (iii) using the actual, expected, and unexpected change components to examine the market reaction and its persistence to monetary policy announcements. Hence, when employing the empirical methods, the Dissertation assesses both the reaction to the actual target rate change, and the change decomposed into expected and unexpected components, in which Eq. (4) and Eq. (5) serve as the fundamental framework. Further, the dataset is also discussed, and the corresponding descriptive statistics are provided.

### 4.1 Empirical methodology

To explore the relation between monetary policy and equity market, the assessment of market expectations becomes crucial. As previously considered, lack of, or improper estimation of market expectations may lead to an errors-in-variables problem. To gauge for both the expected and unexpected components of changes in policy rates, this Dissertation follows the methodology proposed by Kuttner (2001):

$$\Delta r_t^u = \frac{d}{d-t} \cdot (f_{s,t}^0 - f_{s,t-1}^0) \quad (4)$$

Where  $\Delta r_t^u$  is the unexpected change in the target rate of the FED,  $d$  is the number of days in the month in which the policy change occurs,  $t$  is the day in the month of announcement, and  $f_{s,t}^0$  and  $f_{s,t-1}^0$  are the Fed Funds Future rates derived from the spot-month future contracts at the day of announcement and the day before, respectively. As the change in the target rate only influences the remaining part of the month after the announcement, the first term of the equation scales the “shock” into its actual proportion. Policy changes occurring within the last three days of the month may be significantly impacted by the targeting error (deviation between the effective federal funds rate and the target rate). This issue is addressed by using the one-month futures contract instead of the spot-month contract. As the one-month future contract is not susceptible to this targeting error, the potential distortion is circumvented. For changes in the

target rate happening at the first day of the month there are no spot-month contract for the current month trading at the previous day, as these contracts only trade within the present month. By replacing the  $f_{s,t-1}^0$  term in Eq. (4) with the one-month future contract rate ( $f_{s-1,m}^1$ ) this problem is also solved. Hence, the spot-month future rate is replaced by the one-month future rate of the last day in the previous month. The expected change,  $\Delta r_t^e$ , is the residual between the actual policy change and its unexpected component:

$$\Delta r_t^e = \Delta r_t^a - \Delta r_t^u \quad (5)$$

Where the unexpected change ( $\Delta r_t^u$ ) is estimated in Eq. (4), and  $\Delta r_t^a$  represents the actual change in target rate. The Dissertation seeks to explore the impact of the actions (explicit or implicit) of the Federal Reserve. To establish a potential channel through which monetary policy may influence the equity market, the impact on interest rates (IR), proxied by Treasury yields, is assessed. Following the methodology developed by Cook and Hahn (1989), this Dissertation examines the relation between the change in interest rates and the change in the target rate of the FED.

$$\Delta IR_t = \alpha + \beta_1 \cdot \Delta r_t^a + \varepsilon_t \quad (6)$$

Using the findings of an errors-in-variables problem by Kuttner (2001), the target rate change is decomposed into its expected and unexpected components. Thereby, the present Dissertation can assess the relation between monetary policy, controlling for the expectations of the market, and the interest rates, linking Eq. (4) and Eq. (5).

$$\Delta IR_t = \alpha + \beta_1 \cdot \Delta r_t^e + \beta_2 \cdot \Delta r_t^u + \varepsilon_t \quad (7)$$

The equivalent methodology is also applied to equity returns, to examine the relationship between monetary policy and equity markets. The returns of the equity market are estimated as  $R_t = \ln(P_t) - \ln(P_{t-1})$ , which takes the impact of continuous compounding into account. The present Dissertation uses both the Dow Jones Industrial Average and the NASDAQ-100 as proxies when assessing this relation:

$$R_t = \alpha + \beta_1 \cdot \Delta r_t^a + \varepsilon_t \quad (8)$$

$$R_t = \alpha + \beta_1 \cdot \Delta r_t^e + \beta_2 \cdot \Delta r_t^u + \varepsilon_t \quad (9)$$

The regressions explore both the market return to the actual changes in the target rate in Eq. (8), and how the reaction is contingent on the expectations of the market in Eq. (9).

The actions of the Federal Reserve may have greater impacts on the financial markets than what the single day returns of the equity market may capture immediately after the event took place. To assess the persistence and magnitude of monetary policy shocks in the market, the Dissertation introduces two volatility measures, namely the implied- and the realized volatility. The implied volatility (IV) measure is built through the same methods as the VIX of the S&P500, but for the Dow Jones Industrial Average and NASDAQ-100. First differences of the implied and realized volatility (RV) are implemented following Gospodinov and Jamali (2012), Chuliá et al (2010) and others. Thus, the change in implied volatility is estimated as  $\Delta IV = IV_t - IV_{t-1}$ , and the equivalent for the realized volatility. The realized volatility is estimated as a rolling sample of realized squared returns of the Dow Jones Industrial Average and the NASDAQ-100. Each estimate of the realized volatility contains 22 trading days and are annualized by multiplication with the root of 252, similar to Gospodinov and Jamali (2012). The approach has the benefit of allowing for direct comparison with the implied volatility metric<sup>9</sup>. The annualized realized volatility in the rolling sample may then be expressed as:

$$RV_{i,\gamma} = \sqrt{\frac{1}{\gamma} \cdot \sum_{t=i+1}^{\gamma} r_t^2} \cdot \sqrt{252} \quad (10)$$

In which  $\gamma$  is equal to 22. Having computed estimates of the implied and realized volatility, the Dissertation assesses the impact of monetary policy announcements on these. Eq. (11) and Eq. (12) are only expressed for the implied volatility (IV) but are conducted equivalently for the realized volatility (RV) metric. Employing a similar framework as in Eq. (8) and Eq. (9), the Dissertation explores the reaction to the actual change in the target rate, and how the change decomposed into expected and unexpected components may provide additional insight.

---

<sup>9</sup> The VIX indices have a monthly unit, not taking the actual trading days into account. As there are on average 22 trading days in a month, this approach makes the measures comparable. See Gospodinov et al. (2006) for further clarification.

$$\Delta IV_t = \alpha + \beta_1 \cdot \Delta r_t^a + \varepsilon_t \quad (11)$$

$$\Delta IV_t = \alpha + \beta_1 \cdot \Delta r_t^e + \beta_2 \cdot \Delta r_t^u + \varepsilon_t \quad (12)$$

Bollerslev et al. (2009) define the volatility risk premium (VRP) as the spread between the implied volatility and the realized one. Having both the implied and realized volatility estimated, the volatility risk premium is easily extracted:

$$VRP_t = IV_t - RV_t \quad (13)$$

The relation between monetary policy and the volatility risk premium is explored implementing the same methodology as in Eq. (8) and Eq. (9).

$$VRP_t = \alpha + \beta_1 \cdot \Delta r_t^a + \varepsilon_t \quad (14)$$

$$VRP_t = \alpha + \beta_1 \cdot \Delta r_t^e + \beta_2 \cdot \Delta r_t^u + \varepsilon_t \quad (15)$$

To obtain further insight into how the economic environment may elicit distinctive market reactions, the regressions concerning equity returns and volatility are also conducted with dummy variables. These variables address the business cycle (hereby denoted as a recession variable) and the stage in the interest rate cycle (hereby denoted as a reversal variable). To define the observations in economic contractions and expansions, data from the National Bureau of Economic Research (NBER) have been retrieved. The contractions start at the peak of a business cycle and end at the trough (NBER, n.d.). Furthermore, the reversal variable is included to observe whether the first change in direction<sup>10</sup> of the target rate is associated with greater reactions, than the ones intra-cycle.

The academic literature has established other more comprehensive measures which may be employed to gauge for market expectations. The advantages and disadvantages identified by Kuttner (2001) have been thoroughly described in the Literature Review section. Of these, it is evident that the advantages of the approach are much greater than the disadvantages, as these are addressed through relatively uncomplicated methods. Gürkaynak et al. (2002) infer that the

---

<sup>10</sup> Often referred to as a “pivot” in the financial markets.

methods of Kuttner (2001), herein used, are superior forecasts of market expectations for horizons inferior to 6 months. Hence, the forecasting abilities of other statistical procedures could have been more appropriate for longer horizons than those of the Dissertation. A disadvantage of the methodology is the use of daily data over higher frequency data. High frequency data is proven to better capture the market reactions to unanticipated change in target rates, which also allows for exploration of more in-depth relations between monetary policy and other variables<sup>11</sup>. However, the duration and accessibility of such data is limited, and therefore contradicts the main goal of the Dissertation, namely to observe the market over an extended time window. Operating with a marked-based proxy also provides insight into how the expectations may differ over time, in different environments and at different stages of the interest-rate cycles. Gauging market expectations with statistical models could to a great extent remove the influence of the prevailing market psychology, which the Federal Funds future contracts contain. On the other hand, the markets can be irrational for prolonged periods, but these contracts are less susceptible to such irrationality due to their short time horizons, large trading volume and interest from institutional investors (CME Group, n.d.). Accordingly, the methods of Kuttner (2001) are implemented to gauge market expectations of changes in the target rate of the Federal Reserve.

The Dissertation uses first differences of the employed volatility measures for comparability with the prevailing literature. By performing the Augmented Dickey-Fuller (ADF) and KPSS test, the Dissertation do not obtain conclusive results concerning the presence of a unit root in the volatility measures of the indices. First differencing of these series may then introduce a moving average structure into the error terms (Brooks, 2019, pp. 437–452). To address this issue, Newey-West heteroscedastic- and autocorrelation-consistent standard errors are thus implemented. This is a common practice in the academic literature, as entire samples, or subsamples may suffer from non-stationarity. To determine the optimal lag length the Schwarz's (1978) Bayesian information criterion (SBIC) is used. From the information criterion implemented herein, the Dissertation obtains an optimal lag length of 1, whereas the common practice in similar research is the inclusion of 4 lags. This deviation is further discussed and explored in the Robustness tests section of the Dissertation.

---

<sup>11</sup> As observed by Chuliá et al. (2009), Gürkaynak et al. (2004), Lunde and Zebedee (2009), among others.

## 4.2 Data

The present subsection of the Dissertation presents the data herein used, and thoroughly describes the variables. The corresponding descriptive statistics table is also provided.

Information concerning monetary policy, including announcement dates and the target rates, are obtained from the historical archives in the Federal Reserve database<sup>12</sup>. The time window for this research ranges from 2001 to 2023, which provides an initial sample size of 180 observations. Out of these, four observations are omitted from the sample as they serve as outliers. The first omitted observation is the 22<sup>nd</sup> of January 2008, where the Federal Reserve unexpectedly cut their target rates by 75 basis-points. Out of the 75, 74 were unexpected by the market, thereby serving extreme outliers in the sample. Another observation omitted from the sample is the 18<sup>th</sup> of March 2008. During the preceding weekend (15<sup>th</sup> of March), the FED held an unscheduled meeting, where they slashed the discount rate by 75 basis-points. This propelled market expectations (derived from the Federal Funds Future contracts) of cuts from 49 to 91 basis-points. Furthermore, the announcement of the JP Morgan Chase & Co bid on Bear Stearns boosted the equity markets. The two other omitted observations are related to the Covid-19 pandemic. Both are unscheduled changes and occurred on the 3<sup>rd</sup> of March and 15<sup>th</sup> of March in 2020. The 3<sup>rd</sup> of March meeting represents the first unscheduled cut in target rates during the Covid-19 pandemic. The markets were plunging, irrespectively of any action of the FED. The unscheduled weekend meeting on the 15<sup>th</sup> of March was followed by unprecedented declines in equity markets. Monday the 16<sup>th</sup> of March witnessed declines of 13.84% and 13% in the Dow Jones Industrial Average and NASDAQ-100, respectively. By removing these four meetings, the issue of more than one target rate change in a month is also discarded. The remaining 176 observations consisting of the union of days with FOMC meetings or unscheduled target rate changes serves as the basis for the final sample herein used.

The historical data of the Federal Funds Futures have been retrieved from Bloomberg. These are accessible as the spot-month future contracts. As mentioned in the Methodology subsection, for expectations of observations occurring at the first or last three days in the month, these contracts are not appropriate. For such observations, market expectations are gauged using the one-month ahead futures which are more cumbersome to retrieve as each contract needs to be manually extracted from the database.

---

<sup>12</sup> [https://www.federalreserve.gov/monetarypolicy/fomc\\_historical\\_year.htm](https://www.federalreserve.gov/monetarypolicy/fomc_historical_year.htm)

Bloomberg is also the source for the index prices of the Dow Jones Industrial Average and the NASDAQ-100. The Treasury yields for all maturities are from the FRED database. Data on the VIX of the DJIA and NASDAQ-100, which in the Dissertation serves as a measure of implied volatility, are also from FRED. The availability of these served as a limiting factor in the timeframe of the Dissertation, as the data only started in 2001 (the beginning point of the adopted time window). This leads to a timeframe from 2001 until 2023, generating a significant sample size, while also allowing the Dissertation to analyze market reactions over an extended interval, providing insight into how market expectations may deviate over time, and in within different economic stages of different business cycles.

#### 4.2.1. Data description and descriptive statistics

The present section of the Dissertation presents the descriptive statistics of the data used herein. Table 1 considers the sample consisting of FOMC meetings and unscheduled target rate changes. The number of observations without a target rate change are of considerable size due to the low interest environment that prevailed in the aftermath of the Global Financial Crisis. However, this does not stand as a challenge, as the *ex-ante* expectations of the markets are not affected by the final decision of the FOMC.

Meetings	Observations	Mean change
Event days	176	1.42
Scheduled	174	2.01
With target rate change	53	6.60
Positive target rate change	34	32.35
Negative target rate change	19	-39.47
Without target rate change	121	0
Unscheduled	2	-50

**Table 1:** Event days consisting of all days with either a scheduled FOMC meeting or unscheduled target rate changes. The table also provides the mean target rate change in basis-points for the different event days.

Tables 2 and 3 provide the descriptive statistics for the variables herein used.

Dow Jones Industrial Average		Mean	Median	Max	Min	SD	Skew
Return (%)	Event days	0.23	0.15	4.11	-2.52	1.13	0.42
	Non-event days	0.02	0.05	10.76	-10.52	1.17	-0.11
Implied volatility	Event days	18.76	16.59	62.95	7.58	7.98	2.03
	Non- event days	18.88	16.69	74.6	9.28*	8.10	2.13
Realized volatility	Event days	15.75	12.56	77.96	4.81	10.45	3.03
	Non-event days	15.64	12.87	100.54	4.07	10.39	3.47

**Table 2:** Descriptive statistics of Dow Jones Industrial Average, considering the event days and non-event days separately. (\*): One observation of 2.12 in the sample, which is likely due to data error.

NASDAQ-100		Mean	Median	Max	Min	SD	Skew
Return (%)	Event days	0.46	0.36	9.10	-6.94	1.66	0.43
	Non-event days	0.04	0.11	11.85	-11.11	1.45	-0.21
Implied volatility	Event days	25.15	21.02	69.13	11.28	11.97	1.62
	Non- event days	25.01	21.36	80.64	10.31	11.51	1.57
Realized volatility	Event days	22.17	18.02	84.18	6.39	13.65	2.07
	Non-event days	21.83	17.90	91.20	5.09	13.06	2.04

**Table 3:** Descriptive statistics of NASDAQ-100, considering the event days and non-event days separately.

## 5. Empirical findings & Discussion

The present section of the Dissertation presents and critically examines the findings obtained through the application of the aforementioned methodology and data. Section 5.1.1 presents the impact of monetary policy on interest rates. This relation is explored using Treasury yields with maturities between 3 months and 30 years as a proxy for interest rates. Section 5.1.2 assesses the impact of monetary policy actions (or inactions as there may be expectations of changes in target rates upon FOMC meetings with no change) by the FED on the financial markets, before the persistence of the target rate surprises is assessed in Section 5.1.3. Furthermore, robustness tests are also conducted to investigate the stability of the findings. The outcomes of these tests are discussed and presented in Section 5.1.4.

### 5.1 Empirical findings

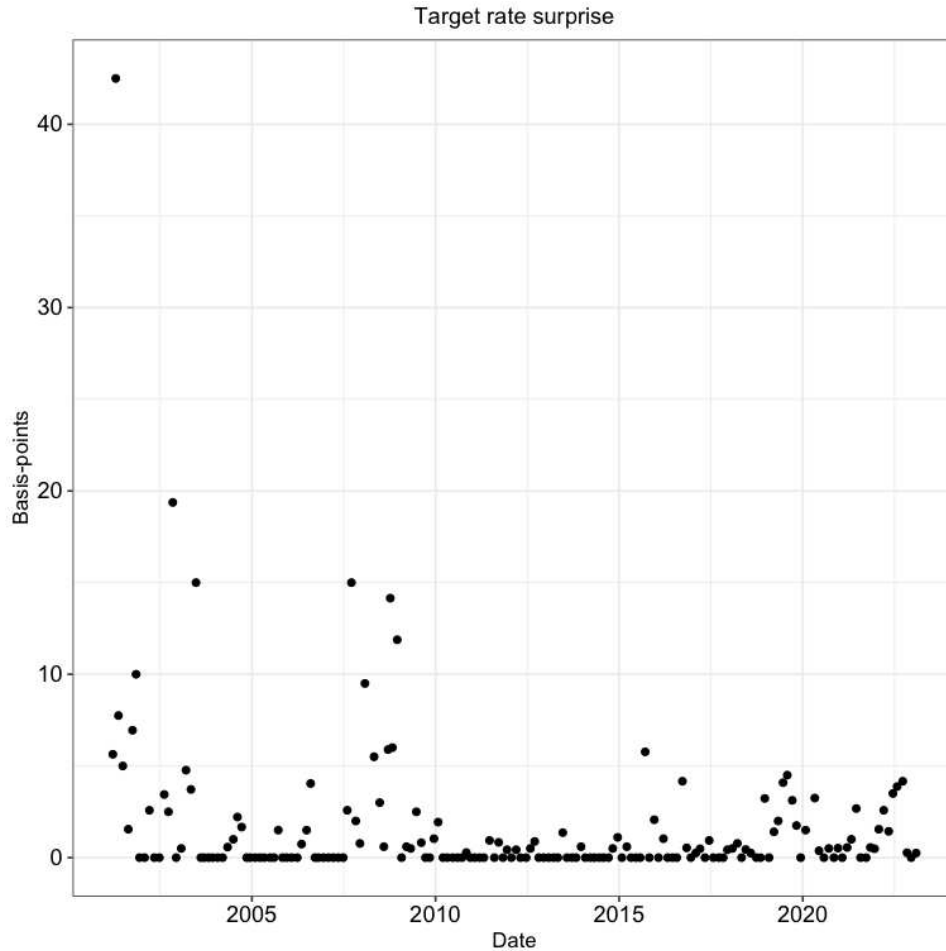
Table 4 consists of all the changes in policy rates, whereas the ones associated with FOMC meetings are denoted accordingly. The actual change in policy rates is decomposed into its expected and unexpected parts, following the methodology previously described in Eq. (4) and Eq. (5), using historical data related to the Federal Funds future contracts.

Date	FOMC	Actual change	Expected	Unexpected	
2001	20/3	✓	-50	-56	+6
	18/4		-50	-8	-42
	15/5	✓	-50	-42	-8
	27/6	✓	-25	-30	+5
	21/8	✓	-25	-27	+2
	2/10	✓	-50	-43	-7
	6/11	✓	-50	-40	-10
	11/12	✓	-25	-25	0
2002	6/11	✓	-50	-31	-19
2003	25/6	✓	-25	-40	+15
2004	30/6*	✓	25	24	+1
	10/8	✓	25	23	+2
	21/9	✓	25	23	+2
	10/11	✓	25	25	0
	14/12	✓	25	25	0
	2005	2/2	✓	25	25
22/3		✓	25	25	0
3/5		✓	25	25	0
30/6		✓	25	25	0
9/8		✓	25	25	0
20/9		✓	25	24	+1
1/11		✓	25	25	0
31/12		✓	25	25	0
2006	31/1	✓	25	25	0

	28/3	✓	25	25	0
	10/5	✓	25	26	-1
	29/6	✓	25	24	+1
2007	18/9*	✓	-50	-35	-15
	31/10	✓	-25	-27	+2
	11/12	✓	-25	-26	+1
2008	22/1		-75	-1	-74
	30/1	✓	-50	-60	+10
	18/3	✓	-75	-92	+17
	30/4	✓	-25	-31	+6
	8/10		-50	-36	-14
	29/10	✓	-50	-56	+6
	16/12	✓	-100	-88	-12
2015	16/12*	✓	25	23	+2
2016	14/12	✓	25	25	0
2017	15/3	✓	25	25	0
	14/6	✓	25	24	+1
	13/12	✓	25	25	0
2018	21/3	✓	25	24	+1
	13/6	✓	25	25	0
	26/9	✓	25	25	0
	19/12	✓	25	22	+3
2019	31/7*	✓	-25	-21	-4
	18/9	✓	-25	-22	-3
	30/10	✓	-25	-27	+2
2020	3/3		-50	-20	-30
	15/3		-100	-87	-13
2022	16/3*	✓	25	28	-3
	4/5	✓	50	51	-1
	15/6	✓	75	72	+3
	27/7	✓	75	79	-4
	21/9	✓	75	79	-4
	2/11	✓	75	75	0
	14/12	✓	50	50	0
2023	1/2	✓	25	25	0

**Table 4:** Overview of changes in policy rates between 2001 and 2023. The actual, expected, and unexpected changes are expressed in basis-points. The table excludes meetings with no change in target rate but emphasizes that there may be expectations of change related to these. Reversal meetings are denoted with asterisks. The near zero-interest rate environment lasted from 2008 until 2015, leading to a lack of observations in this interval.

Analyzing Table 4 it is evident that the magnitude of unexpected changes in policy changes have decreased gradually over time. Figure 1 provides additional insight to this fact. Furthermore, there is an asymmetric distribution between the surprises, depending on the direction of the decision taken by the FED. The increases in the target rate are to a greater extent anticipated (97% of total hikes), whereas decreases contain a greater percentage related to the surprise component (88% anticipated). This is an expected observation as the decreases tend to be implemented to advance a deteriorating economy, in a more urgent fashion than the increases.



**Figure 1:** Target rate surprises upon monetary policy announcements in absolute values. The omitted observations are excluded.

### 5.1.1. Impact of monetary policy on interest rates

The first point to observe is the impact on interest rates, which is assessed using U.S. treasuries with maturities between 3 months and 30 years. The relation is of particular interest as the risk-free rate, often proxied by the yield on 10-year U.S. government bonds, serves as a crucial determinant in the discount rate. Using established facts from conventional finance, the value of a firm is equal to the present value of its future free cash flows. To obtain the present value, the cash flows expected to be generated in the future must be discounted at a proper rate. The discount rate of a firm (not including taxes) may be estimated by the weighted average cost of capital (WACC):

$$WACC = \frac{E}{E + D} \cdot R_E + \frac{D}{E + D} R_D \quad (16)$$

Where the cost of equity ( $R_E$ ) can be estimated with the CAPM:

$$R_E = R_F + \beta_i \cdot (R_M - R_F) \quad (17)$$

From Eq. (16) and Eq. (17) it is evident that the risk-free rate ( $R_F$ ) does not only influence the cost of equity ( $R_E$ ), but also the WACC, the rate at which future cash flows are discounted at when valuing a firm. Hence, when assessing how changes in target rates impacts equity returns, it is crucial to keep this relation in mind.

Maturity	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
3-month	-1.66*** (5.26)	0.07*** (5.00)	0.12	-1.47***	0.04***	0.38***	0.27
6-month	-1.65*** (5.70)	0.06*** (5.00)	0.12	-1.44***	0.04***	0.41***	0.34
1-year	-1.06*** (3.06)	0.03** (2.34)	0.03	-0.86***	0.01	0.39***	0.20
2-year	-0.84 (1.62)	0.02 (0.78)	0.00	-0.65	-0.01	0.33***	0.07
5-year	-1.09* (1.76)	0.01 (0.30)	0.00	-0.9	-0.01	0.33***	0.04
10-year	-0.81 (1.43)	-0.00 (0.05)	0.00	-0.68	-0.02	0.22**	0.02
30-year	-0.43 (0.98)	-0.00 (0.10)	0.00	-0.36	-0.01	0.11	0.01

**Table 5:** Impact of target rate changes on interest rates. Asterisks denote statistical significance at 1% (\*\*\*) , 5% (\*\*) and 10% level (\*).

From Table 5 it is evident that the monetary policy announcements have a significant impact on the interest rates, but at a lesser degree as maturity increases. That is, target changes typically impact shorter maturities. These findings are consistent with Kuttner (2001), but with a weaker magnitude. The Dissertation addresses this finding in more detail in the following sub-section (5.1.2). A one percentage point unexpected increase in the target rate is associated with a 22 basis-points increase in the 10-year Treasury note rate. Furthermore, an interesting observation is the lack of reaction between the actual rate change ( $\beta_{Act}$ ) and its expected component ( $\beta_{Exp}$ ) in the interest rates. The actual change (expected change) provides significant reactions for maturities up until 1 year (6 months). However, the economic significance of this is low, as a one percentage point target rate change is associated with a 3 basis-point move in the 1-year Treasury note rate. On the other hand, the unexpected component ( $\beta_{Unexp}$ ) is accompanied by significant responses in interest rates for maturities up to 10 years. Considering this finding along with Eq. (16) and Eq. (17), unexpected positive changes in the target rate should lead to decreased equity valuations. Having established a relation between monetary policy and the

prevailing risk-free interest rates in the economy and observed how the market reactions are contingent on expectations, the Dissertation proceeds with examining the impact on the equity markets.

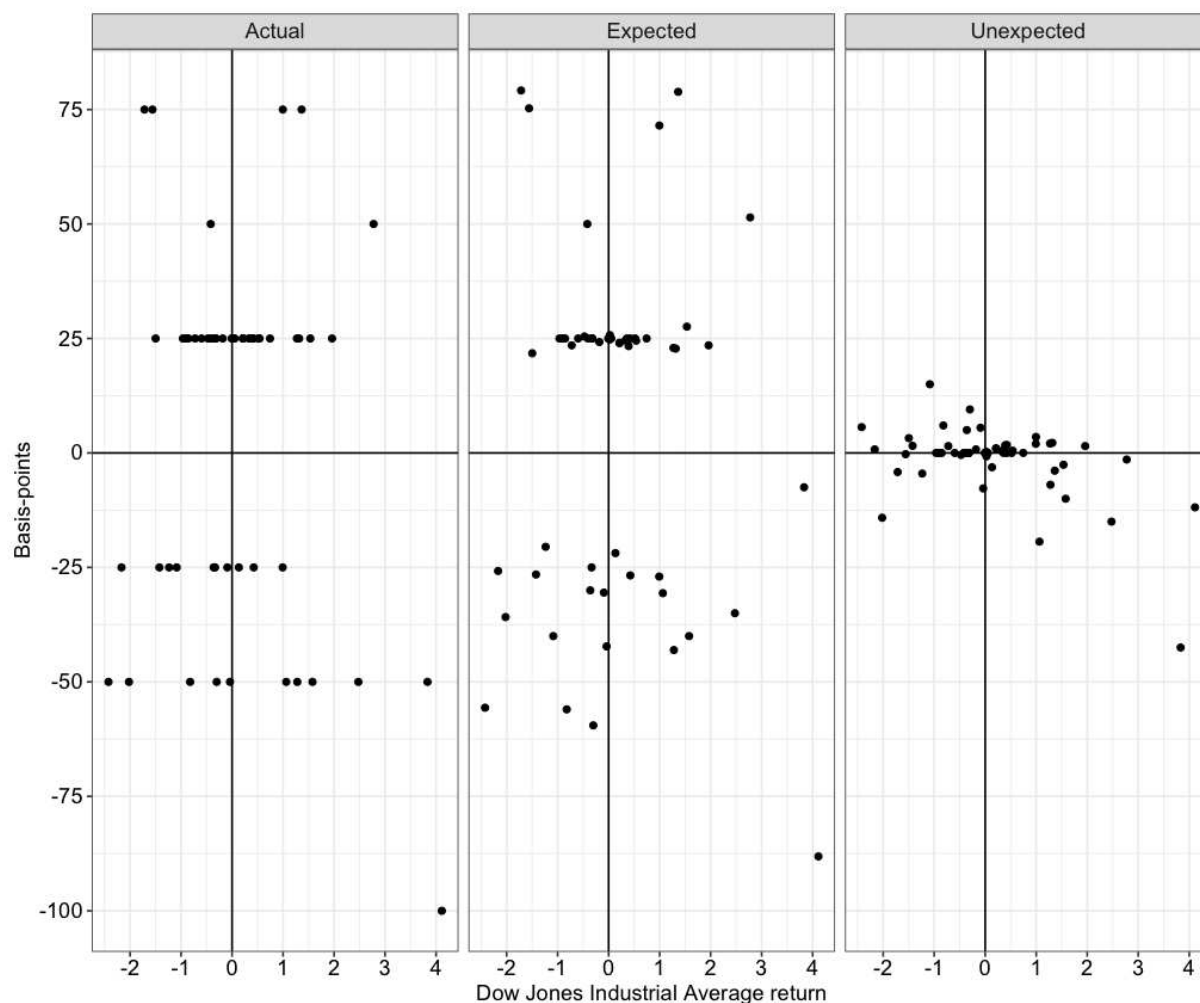
### 5.1.2. Impact of monetary policy on equity returns

The Dissertation uses the findings in Table 4 to explore the relation between monetary policy announcements and the equity market, which is presented in Table 6. In the latter table, Columns 2 to 4 contain the output of regressing the equity returns on the change in the target rate of the FED. Columns 5 to 8 contains the output of regressing the equity returns on the change in the target rate but decomposing the change into expected and unexpected components.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA return	0.24*** (2.89)	-0.01 (0.86)	0.01	0.20** (2.59)	0.00 (0.12)	-0.08*** (4.00)	0.10
NDX return	0.47*** (3.92)	-0.01 (0.67)	0.01	0.40*** (3.42)	0.03 (0.28)	-0.15*** (3.97)	0.18

**Table 6:** Impact of target rate changes (actual, expected, and unexpected) on equity returns. Asterisks denote statistical significance at 1% (\*\*\*) , 5% (\*\*) and 10% level (\*). Significance levels are estimated with Newey-West HAC standard errors. T- statistics are provided in the parenthesis.

At first sight the relation between monetary policy and equity returns may seem trivial. The initial regressions presented in rows 2 and 3 suggest that neither of the indices generate statistically significant responses to changes in the target rate. With an explanatory power measured by the  $R^2$  of 0.01, one may infer that the equity prices are determined irrespectively to changes in the target rate. Such conclusion is nevertheless quite premature due to the previously described errors-in-variables issue that these regressions typically contain when not controlling for the expectations of the market (Brooks, 2019, p. 311).



**Figure 2:** Visualization of how the actual, expected, and unexpected target rate changes in basis-points are associated with returns in the Dow expressed in percentage points. Observations with no change in target rate are excluded. The actual and expected change provides no insight to the returns of the Dow. From the unexpected panel it is evident that there is a negative relation between the unexpected change in basis-points and the returns of the Dow.

When accounting for market expectations of target rate changes the relation is beyond question. Figure 2 visually describes this, and it is evident that there is a negative relation between the unexpected changes in monetary policy and the returns of the Dow (right panel of Figure 2). The NASDAQ-100 provides an equivalent relation. From the regressions controlling for market expectations<sup>13</sup>, the findings yield statistically significant responses in the equity returns due to the unexpected changes. In Table 6, the coefficient of the unexpected change in the Dow (NDX) is equal to -0.08 (-0.15) and is significant at the 1% level. Hence, *ceteris paribus*, a one percentage point surprise cut in target rate is associated with an 8% (15%) increase in the Dow (NDX). Furthermore, the positive intercepts imply that, with no changes in target rate upon

<sup>13</sup> Column 5 to 7 in table 6.

monetary policy announcements, the Dow (NDX) generates a positive return of 0.2% (0.4%). The coefficient of the expected change in both indices is equal to 0, and insignificant. Put into simpler terms, the market does not respond to the expected changes, as these are already incorporated in their valuations, but the market effectively responds quite significantly to unexpected changes.

The Efficient Market Hypothesis (Fama, 1970) states that stock prices should reflect all publicly available market information. Both in the semi-strong and strong forms, this includes not only historical data as in the weak form, but also new, publicly available information and the adjustments made to this. With the findings presented in Table 6, the Dissertation provides results which are aligned with the Efficient Market Hypothesis. As observed, the market reacts quite significantly to the unexpected component of the target rate changes, whereas the actual target rate and the expected component does not exhibit any major significance. Additionally, a Wald test of  $\beta_{Exp} = \beta_{Unexp}$  rejects the null hypothesis of equal reactions to expected and unexpected changes at the 1% level for both indices (Appendix Table 21A & Table 22A). The direction of the market reaction to unexpected changes in the target rate are consistent with conventional financial theories. Greater than expected hikes (equivalent to smaller than expected cuts) are associated with negative equity returns, and smaller than expected hikes (equivalent to greater than expected cuts) are associated with positive equity returns. When controlling for market expectations, the explanatory power of the regressions also drastically increases.

Although the findings presented are aligned with those presented in the Literature Review section, the relation between the target rate changes and equity returns are nevertheless somewhat weaker<sup>14</sup>. There may be several explanations for this, but based on Figure 1 the Dissertation argues that the increased transparency and communication of the FED might have reduced the proportion of monetary policy surprises over time. Accordingly, the explanatory power of the variables has decreased as there are other factors that to a greater extent account for the observed market reactions. As the related literature that has conducted similar studies have been focused on pre-2008 data, which contain a greater proportion of surprise in target rate changes, this is an expected finding. Hence, it is evident that the practices of the FED after

---

<sup>14</sup> The Dissertation obtains a similar relation between monetary policy announcements and interest rates in section 5.1.1.

the Global Financial Crisis have greatly reduced the uncertainty related to their monetary policy actions.

Additionally, the NASDAQ-100 exhibits a greater sensitivity to monetary policy announcements than the Dow Jones Industrial Average. Such finding is expected due to the characteristics of the firms inherent in each index. The selection criteria of the Dow emphasize the importance of reputation, sustained growth, wide investor interest and tend to contain what is known as blue-chip companies (SP Global, n.d.). The NASDAQ-100 on the other hand consists of the 100 largest non-financial firms listed on the NASDAQ stock exchange. These are concentrated on technology, biotechnology, and retail. Such firms tend to have their expected cash-flows further into the future relatively to the more mature firms of the Dow Jones. The more distant cash-flow streams create a greater sensitivity to changes in the discount rate, where the risk-free rate is a central component. With the proven relation between the risk-free rate and changes in the target rate of the FED this finding is expected but reaffirming. The Dissertation explores the differences in reactions to monetary policy announcements for the two indices by employing a Wald test, which reject the null hypothesis (Appendix Table 20A). This implies that the indices generate significantly different responses to unexpected changes in target rate, meaning monetary policy announcements generate different reactions from the referred indices.

Further, the Dissertation explores market reactions in different economic environments (different business cycle stages) by incorporating a recession dummy variable to the regressions. Similarly, the regression is conducted with a reversal decision variable.

	Expected and unexpected target rate changes, and recession variable				
	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$\delta_{Rec}$	$R^2$
DJIA return	0.16** (2.22)	0.00 (0.23)	-0.07*** (3.84)	0.30 (0.73)	0.10
NDX return	0.34*** (3.26)	0.01 (0.57)	-0.15*** (3.88)	0.48 (0.84)	0.19

**Table 7:** Impact of target rate changes on equity returns, controlling for market expectations, with a recession dummy variable ( $\delta$ ) which takes the value of 1 for the observations when the economy is in a recession. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). Significance levels are estimated with Newey-West HAC standard errors. T- statistics are provided in the parenthesis.

From Table 7 the statistical significance of the unexpected target rate changes is maintained. By including a dummy variable concerning the observations obtained in a recession, the Dissertation does not find evidence of significantly different reactions contingent on the state

of the economy. Similarly, the Dissertation does not find evidence of greater market reactions to reversal decisions contrary to Chuliá et al., 2010<sup>15</sup>, Bernanke and Kuttner (2005) and others (Appendix Table 19A). However, such findings are remarkably dependent on sample composition due to the infrequency of reversals. Furthermore, the enhanced transparency and forward guidance by the FED (Nelson, 2021) are likely to contribute to a diminishing effect of the reversal variable.

### 5.1.3. Impact of monetary policy on volatility

The present sub-section examines the results concerning the implied volatility, realized volatility and the volatility risk premium. From the initial regression of target rate changes in Table 8, there is no relation between implied volatility and the target rate changes for either index. The implied volatility Dow does not react significantly when accounting for market expectations. On the other hand, a one percentage point unexpected move in the target rate is associated with an increase of 6% in the implied volatility of the NASDAQ-100. With the negative intercept the implied volatility of the Dow (NDX) decreases by 0.48% (0.51%) when no change in the target rate is announced.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA IV	-0.50*** (4.27)	0.00 (0.45)	0	-0.48*** (4.32)	-0.01 (0.85)	0.04 (1.53)	0.02
NDX IV	-0.54*** (3.93)	0.00 (0.18)	0	-0.51*** (3.93)	0.00 (0.27)	0.06* (1.95)	0.02

**Table 8:** Impact of monetary policy announcements on the implied volatility (IV) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*), and 10% level (\*). Significance levels are estimated with Newey-West HAC standard errors. T- statistics are provided in the parenthesis.

From Table 9 it is evident that monetary policy announcements are not only associated with daily fluctuations in equity prices, but also with greater persistence, observed through the realized volatility. An unexpected hike of a percentage point in the target rate is associated with a 6% (10%) increase in realized volatility for the Dow (NDX). Hence, changes in the target rate which are not anticipated by the market increases the realized volatility in these indices.

<sup>15</sup> Chuliá et al. (2010) does only observe this using high-frequency data. With daily observations their findings are similar to those of the Dissertation.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA RV	0.01 (0.11)	0.00 (0.73)	0.01	0.04 (0.50)	0.00 (0.08)	0.06** (2.41)	0.08
NDX RV	-0.06 (0.54)	0.00 (0.07)	0	-0.01 (0.11)	-0.01 (0.82)	0.10* (1.72)	0.12

**Table 9:** Impact of monetary policy announcements on the realized (RV) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). Significance levels are estimated with Newey-West HAC standard errors. T- statistics are provided in the parenthesis.

The Dissertation observes the explanatory power of the regressions concerning the volatility measures (Table 8 and 9). The magnitude and significance of the coefficients are comparable with Gospodinov and Jamali (2012), however these authors do not provide their  $R^2$ . For transparency and future comparability, the Dissertation provides its  $R^2$ . Seemingly the coefficient is low, but it is important to consider that these are measures of volatilities over the next month, which are quite subject to an endless set of influencing factors over the said period.

Greater than expected hikes reduces the volatility risk premium of the NASDAQ-100 (Table 10). Although puzzling, it is aligned with Gospodinov and Jamali (2012). A 25 basis-points surprise in the target rate is associated with a 5 percentage points reduction in the volatility spread. For the Dow, neither the actual, expected, or unexpected change provide significant results. The intercept of both indices is positive and significant at the 1% level, implying that the spread between the implied- and realized volatility on average is positive, creating the foundation for the volatility risk premium harvesting strategy<sup>16</sup>.

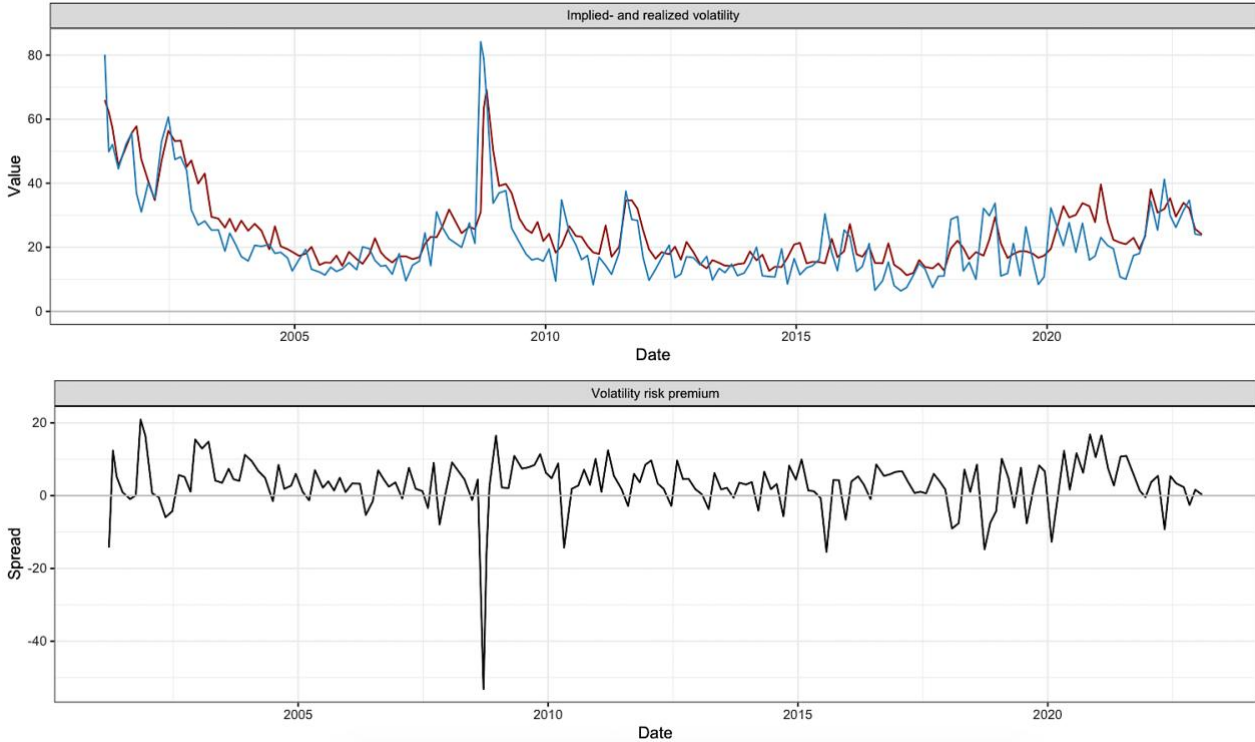
	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA VRP	3.06*** (5.26)	-0.03 (1.09)	0.01	3.00*** (5.15)	-0.02 (0.92)	-0.15 (1.27)	0.02
NDX VRP	3.04*** (4.87)	-0.04 (1.58)	0.01	2.96*** (4.55)	-0.03 (1.11)	-0.20* (1.71)	0.02

**Table 10:** Impact of monetary policy announcements on the volatility risk premium (VRP) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). Significance levels are estimated with Newey-West heteroskedasticity- and autocorrelation consistent standard errors. T- statistics are provided in the parenthesis.

The relation is of great importance as it is: (i) the premium at which market participants must pay to buy insurance; and (ii) the price at which market participants are willing to provide insurance. The spread may be interpreted as a risk aversion indicator, or to what extent the

<sup>16</sup> See The Hedge Fund Journal (2017) for more information on the strategy.

market overreacts to monetary policy announcements. Positive spreads indicates that the market was willing to “pay” a higher implied volatility than what was to follow, thereby overestimating the extent of great market fluctuations, or simply reluctance to bear the risk. In more volatile periods, such as 2008, 2018, and 2020, the spread is negative, implying that the realized volatility is greater than the implied one (Figure 3). As the spread is negative, it is possible to infer that market participants tend to underestimate the future volatility in turbulent environments.



**Figure 3:** Separate figures of the implied (in red)- and realized volatility (in blue), and the volatility risk premium of the NASDAQ-100. The volatility risk premium displays the spread and is on average positive.

## 5.2 Robustness checks

To test the stability of the baseline empirical findings, two robustness checks are conducted. The first robustness check is conducted by considering only the meetings to which the unexpected change is unequal to zero, thereby containing a surprise component. The second robustness check considers the lag length in the Newey-West heteroscedasticity- and autocorrelation consistent standard errors.

Within the sample there are several meetings which did not provide any surprise to the market. These are usually associated with meetings in which the FED did not make any actual changes. Hence, the outcome of the meeting was entirely priced in by the markets in advance. However, the markets are dynamical by nature, and movements will be fully accounted for by the expected variable in the regressions. Inclusion of these observations may have a non-trivial impact on the findings of the Dissertation. The first robustness check removes these observations, whose outcomes are presented in Table 11 to 14.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA return	0.23*	0.00	0.01	0.17	0.00	-0.08***	0.14
	(1.68)	(0.58)		(1.37)	(0.18)	(4.04)	
NDX return	0.58***	0.00	0.00	0.47**	0.01	-0.15***	0.25
	(3.02)	(0.35)		(2.59)	(0.60)	(3.98)	

**Table 11:** Impact of target rate changes (actual, expected, and unexpected) on returns of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). Significance levels are estimated with Newey-West HAC standard errors. T- statistics are provided in the parenthesis.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA IV	-0.66***	-0.01	0.01	-0.63***	-0.01	0.04	0.05
	(3.75)	(0.59)		(3.84)	(0.97)	(1.46)	
NDX IV	-0.74***	0.00	0.00	-0.70***	0.00	0.05*	0.05
	(4.20)	(0.00)		(4.35)	(0.46)	(1.89)	

**Table 12:** Impact of monetary policy announcements on the implied volatility (IV) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). Significance levels are estimated with Newey-West HAC standard errors. T- statistics are provided in the parenthesis.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA RV	0.04 (0.31)	0.00 (0.69)	0.01	0.08 (0.64)	0.00 (0.03)	0.06** (2.42)	0.11
NDX RV	-0.05 (0.30)	0.00 (0.13)	0.00	0.02 (0.16)	0.01 (1.10)	0.10* (1.77)	0.17

**Table 13:** Impact of monetary policy announcements on the realized (RV) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). Significance levels are estimated with Newey-West HAC standard errors. T- statistics are provided in the parenthesis.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA VRP	2.64*** (2.82)	-0.03 (0.89)	0.01	2.55*** (2.71)	-0.02 (0.65)	-0.16 (1.34)	0.02
NDX VRP	2.40** (2.58)	-0.04 (1.40)	0.02	2.27** (2.33)	-0.03 (0.88)	-0.21* (1.76)	0.03

**Table 14:** Impact of monetary policy announcements on the volatility risk premium (VRP) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). Significance levels are estimated with Newey-West heteroskedasticity- and autocorrelation consistent standard errors. T- statistics are provided in the parenthesis.

The findings in these tables are consistent with the ones presented in the baseline findings. The first robustness check confirms the insignificant coefficients for the actual change in the target rate, and its expected component, displaying a stability in the findings. The unexpected changes continue to be significant, however still lacking a relation between the unexpected change in target rate and the implied volatility and the volatility risk premium of the Dow.

Subsequently, a second robustness check is also implemented addressing the lag length incorporated in the Newey-West heteroskedasticity- and autocorrelation consistent standard errors. The common practice in the literature is to include 4 lags<sup>17</sup>, in which the Dissertation deviates due to the implementation of the SBIC information criterium for lag selection<sup>18</sup>. Implementation of a different lag length may cause non-comparable inferences with other results observed in the literature on this subject. The second robustness check performs the initial regressions with an extended

<sup>17</sup> Even though this is the common practice in the academic literature, no proper justification for this specific lag length choice is provided in the references used in the present Dissertation. An assumption is then made that these choices are pursued by optimizing a given set of Information Criteria.

<sup>18</sup> The SBIC is minimized with the lag length of 1 on the sample considered herein.

lag length in the Newey-West heteroskedasticity- and autocorrelation consistent standard errors, as the deviation in lag length may have a non-trivial impact on the inferences drawn. The outcomes are presented in Table 15 to 18.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA return	0.24*** (3.34)	-0.01 (1.08)	0.01	0.20*** (2.70)	0.00 (0.13)	-0.08*** (4.80)	0.10
NDX return	0.47*** (4.27)	-0.01 (0.8)	0.01	0.40*** (3.15)	0.00 (0.30)	-0.15*** (3.93)	0.18

**Table 15:** Impact of target rate changes (actual, expected, and unexpected) on returns of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). T- statistics are provided in the parenthesis. Note that the Newey-West HAC standard errors are implemented with a lag length of 4.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA IV	-0.50*** (4.92)	0.00 (0.49)	0.00	-0.48*** (4.97)	-0.01 (0.95)	0.04* (1.67)	0.02
NDX IV	-0.54*** (4.35)	0.00 (0.21)	0.00	-0.51*** (4.31)	0.00 (0.31)	0.05** (2.59)	0.02

**Table 16:** Impact of monetary policy announcements on the implied volatility (IV) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). T- statistics are provided in the parenthesis. Note that the Newey-West HAC standard errors are implemented with a lag length of 4.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA RV	0.01 (0.11)	0.00 (0.74)	0.01	0.04 (0.43)	0.00 (0.08)	0.06** (2.55)	0.08
NDX RV	-0.06 (0.50)	0.00 (0.07)	0.00	-0.01 (0.10)	-0.01 (0.79)	0.10* (1.87)	0.11

**Table 17:** Impact of monetary policy announcements on the realized (RV) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). T- statistics are provided in the parenthesis. Note that the Newey-West HAC standard errors are implemented with a lag length of 4.

	Target rate changes			Expected and unexpected target rate changes			
	$\alpha$	$\beta_{Act}$	$R^2$	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$R^2$
DJIA VRP	3.06*** (4.87)	-0.03 (1.52)	0.01	3.00*** (4.72)	-0.02 (1.19)	-0.15* (1.92)	0.02
NDX VRP	3.04*** (4.62)	-0.04** (2.01)	0.01	2.96*** (4.29)	-0.03 (1.28)	-0.20** (2.10)	0.03

**Table 18:** Impact of monetary policy announcements on the volatility risk premium (VRP) of Dow Jones Industrial Average and NASDAQ-100. Asterisks denote statistical significance at 1% (\*\*\*), 5% (\*\*) and 10% level (\*). T- statistics are provided in the parenthesis. Note that the Newey-West HAC standard errors are implemented with a lag length of 4.

The robustness check does not only reinforce the initial empirical findings, but also enhances its statistical significance and magnitude. The statistically significant coefficient of the actual change in the NASDAQ-100 regression (Table 18) on the volatility risk premium may be interpreted as an errors-in-variables problem, as these regressions do not control for market expectations. This is underlined in the subsequent regression with the target rate change decomposed, where the coefficient of the expected change is insignificant, whereas the unexpected change is significant at the 5% level. The insignificant reaction in implied volatility and volatility risk premium of the Dow in the baseline findings are significant in this robustness check. This implies that the unexpected changes in target rates are significant for all relations which the Dissertation explores in the robustness test. Thereby, the empirical findings presented in the Dissertation are seemingly conservative, relative to other results found in similar research<sup>19</sup>.

The overall conclusion of the robustness checks suggests stability of the baseline findings previously presented in the Dissertation, and that the estimations conducted are more conservative relative to the results observable in previous academic literature.

---

<sup>19</sup> The impact of changing the lag length in the Newey-West HAC standard errors are sample dependent.

## 6. Conclusion

The main goal of the present Dissertation is to investigate the impact of U.S. monetary policy on U.S. equity markets. The Dissertation explores both the magnitude and persistence of changes in the target rate of the FED in the financial markets to provide comprehensive insight to the important research topic. Examining the relation is of great importance to market participants, policy markets, politicians, and the community in general due to the spillover effects the financial markets may have on the global economy as seen during the Global Financial Crisis.

To address the relation between monetary policy and equity markets, this Dissertation uses the framework proposed by Kuttner (2001) to gauge for market expectations to changes in the target rate. It is evident that accounting for the expectations of the markets is crucial to obtain reliable outcomes when observing the reaction of financial markets upon monetary policy announcements. The Dissertation finds a significant and positive relation between the target rate of the FED and the prevailing interest rates in the economy, when employing regressions similar to Cook and Hahn (1989). Further, it provides a theoretical framework of how changes in the target rate may change the equity valuations. By addressing market expectations in the context of monetary policy announcements between 2001 and 2023, this Dissertation assesses its impact on the equity markets. The Dissertation observes that the actual changes in the target rate are becoming increasingly aligned with the expectations of the market. The most likely explanation for this observation may be related to enhanced abilities of market participants to anticipate future changes in the target rate, that the FED to a greater extent take the expectations of the market into account when determining their target rates or greater transparency in central bank communications.

The Dissertation finds a strong link/relation between target rate changes and the equity markets. Both the Dow and the NASDAQ-100 react negatively to positive surprises in the target rate, where the sensitivity of the NASDAQ-100 is considerably greater. The Wald test infers that the reactions are significantly different from each other. The Dissertation justifies this by considering the characteristics of the inherent firms of each index. Furthermore, the findings are aligned with the Efficient Market Hypothesis, as the markets both incorporate the expected changes of the target rate to equity prices, but provides significant reactions only to unexpected changes. Hence, the actual and expected change does not exhibit any significance. The

Dissertation implements a Wald test which rejects the null hypothesis of equal market reactions to expected and unexpected changes in the target rate. Through the inclusion of dummy variables in the regressions, the Dissertation does not find evidence of different market reactions to monetary policy announcements in recessions, nor for reversal decisions. The persistence of the shocks is also evident, with increases in both the implied and realized volatility in the markets upon unexpected changes in the target rate. Furthermore, the Dissertation finds that the volatility risk premium of both indices is on average positive but tends to turn negative in turbulent environments. Subsequently, robustness checks were applied to the findings. These robustness checks underlined the baseline findings presented in the Dissertation, as they maintained the statistical significance, highlighting the more conservative approach herein pursued. Thereby the robustness checks confirm the robustness and stability of the results presented and critically examined.

Further research should attempt to take advantage of high-frequency data when exploring this relevant research topic, which could more efficiently capture market reactions. Additionally, the employment of different statistical models may serve as an interesting subject for longer term forecasting of policy rates. The methodology used in the Dissertation may also be utilized to critically examine other relations which are susceptible to changes in the target rate.

Overall, the link/relation between the monetary policy announcements and the equity markets is unquestionable, and both its magnitude and persistence has been critically examined in the present Dissertation. The importance of transparency and communication from policymaking institutions is evident in the strong influence of unexpected changes in the FED's target rate over the financial markets. Minimizing uncertainty related to target rate changes enhances its predictability and contributes to a more stable financial market and economic environment, boosting economic agents' confidence in decision making and the economy.



## References

- Bernanke, B. S., & Kuttner, K. N. (2005). What Explains the Stock Market's Reaction to Federal Reserve Policy? *The Journal of Finance*, 60(3), 1221–1257. <https://doi.org/10.1111/j.1540-6261.2005.00760.x>
- Bollerslev, T., Tauchen, G., & Zhou, H. (2009). Expected Stock Returns and Variance Risk Premia. *Review of Financial Studies*, 22(11), 4463–4492. <https://doi.org/10.1093/rfs/hhp008>
- Bomfim, A. N. (2003). Pre-announcement effects, news effects, and volatility: Monetary policy and the stock market. *Journal of Banking & Finance*, 27(1), 133–151. [https://doi.org/10.1016/S0378-4266\(01\)00211-4](https://doi.org/10.1016/S0378-4266(01)00211-4)
- Brooks, C. (2019). *Introductory Econometrics for Finance* (4th ed.). Cambridge University Press.
- CBOE. (n.d.). *VIX Options Product Specification*. Retrieved April 20, 2023, from [https://www.cboe.com/tradable\\_products/vix/vix\\_options/specifications/](https://www.cboe.com/tradable_products/vix/vix_options/specifications/)
- Chuliá, H., Martens, M., & Dijk, D. van. (2010). Asymmetric effects of federal funds target rate changes on S&P100 stock returns, volatilities and correlations. *Journal of Banking & Finance*, 34(4), 834–839. <https://doi.org/10.1016/j.jbankfin.2009.09.012>
- CME Group. (n.d.). *30 Day Federal Funds. Futures and Options*. Retrieved May 13, 2023, from <https://www.cmegroup.com/markets/interest-rates/stirs/30-day-federal-fund.html>
- Cook, T., & Hahn, T. (1989). The effect of changes in the federal funds rate target on market interest rates in the 1970s. *Journal of Monetary Economics*, 24(3), 331–351. [https://doi.org/10.1016/0304-3932\(89\)90025-1](https://doi.org/10.1016/0304-3932(89)90025-1)
- Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance*, 25(2), 383–417. JSTOR. <https://doi.org/10.2307/2325486>
- Federal Reserve. (n.d.). *Federal Reserve Board—Section 2A. Monetary policy objectives*. Board of Governors of the Federal Reserve System. Retrieved March 29, 2023, from <https://www.federalreserve.gov/aboutthefed/section2a.htm>

- Federal Reserve. (2016). *What is the purpose of the Federal Reserve System?* Board of Governors of the Federal Reserve System. [https://www.federalreserve.gov/faqs/about\\_12594.htm](https://www.federalreserve.gov/faqs/about_12594.htm)
- Goldberg, L. S., Lerman, R., & Reichgott, D. (2022, July 5). The U.S. Dollar's Global Roles: Revisiting Where Things Stand. *Liberty Street Economics*.  
<https://libtystreeteconomics.newyorkfed.org/2022/07/the-u-s-dollars-global-roles-revisiting-where-things-stand/>
- Gospodinov, N., Gavala, A., & Jiang, D. (2006). Forecasting volatility. *Journal of Forecasting*, 25(6), 381–400. <https://doi.org/10.1002/for.993>
- Gospodinov, N., & Jamali, I. (2012). The effects of Federal funds rate surprises on S&P 500 volatility and volatility risk premium. *Journal of Empirical Finance*, 19(4), 497–510.  
<https://doi.org/10.1016/j.jempfin.2012.04.009>
- Gürkaynak, R. S., Sack, B. P., & Swanson, E. T. (2004). *Do Actions Speak Louder than Words? The Response of Asset Prices to Monetary Policy Actions and Statements* (SSRN Scholarly Paper No. 633281). <https://doi.org/10.2139/ssrn.633281>
- Gürkaynak, R. S., Sack, B., & Swanson, E. (2002). *Market-Based Measures of Monetary Policy Expectations*.
- Hausman, J., & Wongswan, J. (2006). *Global asset prices and FOMC announcements* (International Finance Discussion Paper No. 886). Board of Governors of the Federal Reserve System (U.S.). <https://econpapers.repec.org/paper/fipfedgif/886.htm>
- Krueger, J. T., & Kuttner, K. (1996). The Fed funds futures rate as a predictor of federal reserve policy. *Journal of Futures Markets*, 16(8), 865–879.
- Kuttner, K. N. (2001). Monetary policy surprises and interest rates: Evidence from the Fed funds futures market. *Journal of Monetary Economics*, 47(3), 523–544.  
[https://doi.org/10.1016/S0304-3932\(01\)00055-1](https://doi.org/10.1016/S0304-3932(01)00055-1)

- Lunde, A., & Zebedee, A. A. (2009). Intraday Volatility Responses to Monetary Policy Events. *Financial Markets and Portfolio Management*, 23(4), 383–399.
- NBER. (n.d.). *US Business Cycle Expansions and Contractions*. NBER. Retrieved March 31, 2023, from <https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions>
- Nelson, E. (2021). *The Emergence of Forward Guidance As a Monetary Policy Tool*. <https://www.federalreserve.gov/econres/feds/the-emergence-of-forward-guidance-as-a-monetary-policy-tool.htm>
- Reinhart, V., & Radecki, L. (1994). The financial linkages in the transmission of monetary policy in the United States. *Bank for International Settlements, Basel*.
- Roley, V. V., & Sellon, G. H. (1995). Monetary policy actions and long-term interest rates. *Economic Review*, 80(Q IV), 73–89.
- SP Global. (n.d.). *SP Global*. SP Global. Retrieved May 9, 2023, from <https://www.spglobal.com/spdji/en/research-insights/index-literacy/the-sp-500-and-the-dow/>
- Stotz, O. (2019). The response of equity prices to monetary policy announcements: Decomposing the announcement day return into cash-flow news, interest rate news, and risk premium news. *Journal of International Money and Finance*, 99, 102069. <https://doi.org/10.1016/j.jimonfin.2019.102069>
- The Hedge Fund Journal. (2017). *Harvesting the S&P500 Volatility Risk Premium. And doing it in a risk-reduced way*. 121. <https://thehedgefundjournal.com/harvesting-the-s-p500-volatility-risk-premium/>
- Wongswan, J. (2009). The response of global equity indexes to U.S. monetary policy announcements. *Journal of International Money and Finance*, 28(2), 344–365.

## Appendix

	Expected-, unexpected target rate changes, and reversal variable				
	$\alpha$	$\beta_{Exp}$	$\beta_{Unexp}$	$\lambda_{Rev}$	$R^2$
DJIA return	0.19** (2.46)	0.00 (0.13)	-0.07*** (3.86)	0.38 (0.73)	0.10
NDX return	0.34*** (3.26)	0.01 (0.57)	-0.15*** (3.88)	0.48 (0.84)	0.19

**Table 19A:** Impact on target rate changes on equity returns, controlling for market expectations, with a reversal dummy variable ( $\lambda$ ) which takes the value of 1 for the observations when the economy is in a recession. Asterisks \*\*\*, \*\* and \* denote statistical significance at 1%, 5% and 10% level, respectively. Significance levels are estimated with Newey-West heteroskedasticity- and autocorrelation consistent standard errors. T- statistics are provided in the parenthesis.

Hypothesis:

$$DJIA\_RET - NDX\_RET = 0$$

Model 1: restricted model

$$\text{Model 2: } Unexp \sim DJIA\_RET + NDX\_RET$$

	Res.Df	RSS	Df	Sum of Sq	F	F Pr(>F)
1	178	10418				
2	177	10241	1	176.82	3.056	0.08217.

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1

**Table 20A:** Output of Wald test with the null hypothesis of equal responses in the returns of the Dow Jones Industrial Average and NASDAQ-100.

Hypothesis:

$$Unexp - Exp = 0$$

Model 1: restricted model

$$\text{Model 2: } NDX\_RET \sim Unexp + Exp$$

	Res.Df	RSS	Df	Sum of Sq	F	F Pr(>F)
1	174	480.59				
2	173	397.99	1	82.608	35.908	1.17e-08 ***

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1

**Table 21A:** Output of Wald test with the null hypothesis of equal responses to expected and unexpected changes in target rates of the NASDAQ-100.

---

Hypothesis:  
Unexp - Exp = 0

Model 1: restricted model  
Model 2: DJIA\_RET ~ Unexp + Exp

---

	Res.Df	RSS	Df	Sum of Sq	F	F Pr(>F)
1	174	219.67				
2	173	200.50	1	19.173	16.544	7.21e-05 ***

---

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1

---

**Table 22A:** Output of Wald test with the null hypothesis of equal responses to expected and unexpected changes in target rates of the Dow Jones Industrial Average.