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MONETARY MOMENTUM - EGY GLOBÁLIS JELENSÉG
MONETARY MOMENTUM - A WORLDWIDE PHENOMENON
EXPLAINED

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1 Introduction

Monetary policy plays a crucial role not only in promoting economic stability but also in affecting financial markets. Bernanke & Kuttner (2005) documented a 1% increase in the stock market of the United States as a response to an unexpected 25-basis-point cut in the federal funds target rate. Cieslak et al. (2019) argued that equity premiums in the US are earned entirely 0, 2, 4, and 6 weeks after the Federal Open Market Committee's ¹ decision.

The effect of monetary policy is measured by policy shocks capturing asset price movements in a small event window around the FOMC policy decision announcements. For instance, Kuttner (2001) estimates monetary policy surprises by measuring changes in the current-month federal funds futures rate in a 30-minute event window around the FOMC announcement.

With the help of policy shocks that capture unexpected component of monetary policy decisions, researchers have been able to estimate the response of financial markets to policy announcements. Interestingly, some asset prices move conditional on the sign of policy shocks. A contractionary shock, which indicates a higher-than-expected target rate, increases long-term US and German government bond futures (Indriawan et al., 2021). Expansionary policy shocks (lower-than-expected target rate decisions) increase the CRSP value-weighted index (Neuhierl & Weber, 2021) and the US dollar exchange rates (Rosa, 2011). Importantly, the sign of monetary policy shocks does not correspond to the sign of the target rate decision. Furthermore, Mueller et al. (2017) documented that the impact of monetary policy shocks on the foreign exchange market is stronger when the uncertainty of monetary policy is greater.

Neuhierl & Weber (2021) shed light on the abnormal return drift that begins 15 days before scheduled FOMC decisions and interestingly continues 15 days following the decision in the case of the US stock market and the euro-dollar exchange rate. The sign of the return drift is conditional on the sign of policy shocks. The return drift was named monetary momentum, illustrated in my research by figure 1. What kind of instruments show a similar return drift? What is the magnitude of the return drift in different asset classes? How does uncertainty affect monetary momentum? And how is it possible that asset prices start to drift several days before the monetary policy shock is measurable? To answer these questions, I analyse cumulative return movements in the 30-day event window defined by Neuhierl & Weber (2018) between 1994 and 2019 on 55 futures from 4 asset classes applied by Moskowitz et al. (2012) in the research of time series momentum.

¹henceforth FOMC.

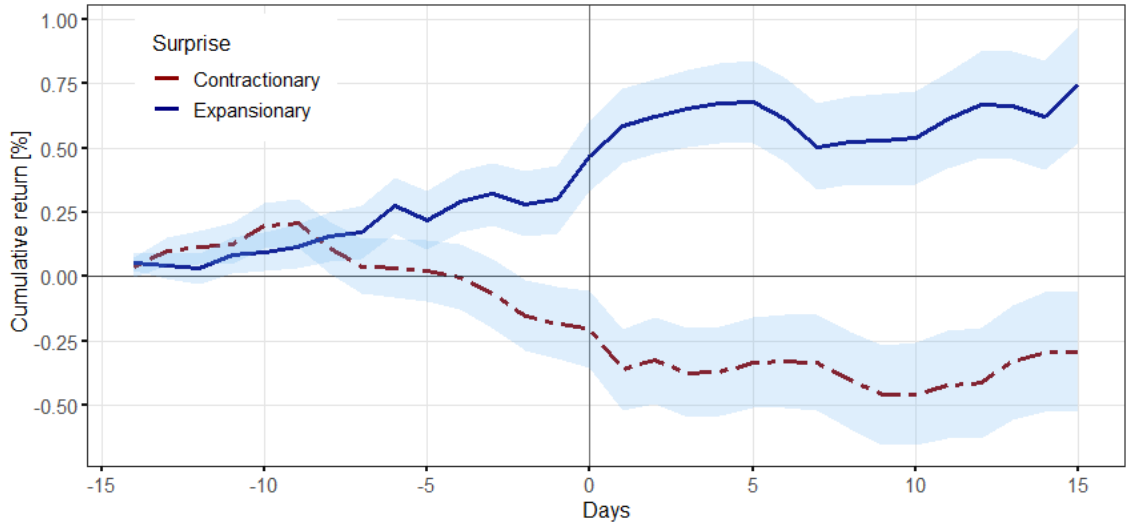


Figure 1: Cumulative return drift of the 55 futures around FOMC decisions.

Note. The figure illustrates the average cumulative returns of the 55 futures from four asset classes in percent around scheduled FOMC decisions between 1994 and 2019. The blue line indicates a negative monetary policy shock (expansionary) and the dashed red line indicates a positive (contractionary) surprise. The shaded areas are the 95% confidence intervals around mean returns constructed with bootstrap standard errors.

My contribution to the FOMC literature is threefold. First, I analyse four asset classes altogether with panel regression instead of focusing on a few assets that were mostly researched in the existing literature ². Instruments are analysed separately, detecting asset-class-specific characteristics in the reaction of financial markets to central bank announcements. In comparison to other research papers, I apply the largest sample period possible, including both periods before and following the global financial crisis of 2007-2009, as well as the zero lower bound period.

Second, I apply different measures of uncertainty to gauge their impacts on the transmission of monetary policy shocks to financial markets. Existing literature often tested the impact of uncertainty strictly related to monetary policy. I contrast the role of monetary policy, market, and policy uncertainty in multiple asset classes concluding that financial market uncertainty increases and monetary policy apprehension presumably decreases the impact of monetary policy on asset prices ³.

Third, I intend to understand the return drift prior to the announcement depicted in figure 1. Based on the literature of monetary policy shocks, I re-examine that policy surprises are predictable with private sector macroeconomic forecasts. Predicting the signs of policy shocks with them has significantly better predictive accuracy than standard forecasting methods. To

² Altavilla et al. (2019); Schmeling & Wagner (2019) for the Euro Area and De Pooter et al. (2021); Rosa (2011) for the United States monetary policy shocks, among others.

³De Pooter et al. (2021) analysed the same measures of uncertainty I apply however, only for the long-term US zero-coupon yields.

my best knowledge, this is the first time that monetary momentum has been analysed on such a large scale of assets with panel regression including different measures of uncertainty.

The remainder of the paper is organised as follows. In section 2 I briefly summarise the literature related to monetary policy and financial markets. Section 3 provides a description of the data implemented in the research. In section 4 the methodology is described. Section 5 details the empirical results and section 6 provides robustness tests. Section 7 concludes.

2 Literature review

A large literature investigates in an event-study framework the return patterns around the Federal Open Market Committee's policy decisions. Researchers tend to focus on the United States, as Brusa et al. (2020) documented that the Federal Reserve is the only central bank that can affect international stock market returns, and non-US central bank announcements have no similar impact, not even on their domestic stock market ⁴.

The literature on FOMC announcements is divided into conditional and unconditional returns. In an influential paper, Lucca & Moench (2015) documented the so-called 'pre-FOMC' *unconditional* return drift that accounted for 80% of US equity returns between 1994 and 2011. The article showed that 24 hours before scheduled FOMC decisions the S&P500 increased by 49 basis points on average regardless of the announced target rate. Interestingly, pre-FOMC returns tend to be high when market uncertainty as measured by the VIX is higher and the slope of the Treasury yield curve is low. These findings led X. Hu et al. (2019) to further analyse the dynamics of the VIX in anticipation of monetary policy decisions and conclude that the pre-FOMC return drift is caused by a build-up in the VIX and can be interpreted as compensation to investors for monetary policy uncertainty. By the same token, Kurov et al. (2021) attributed the disappearance of the pre-FOMC returns after 2015 to decreased uncertainty as measured by the VIX.

Taking into account that VIX reflects the general uncertainty of the financial markets, new measures evolved to specify the measured uncertainty. Researchers either decomposed existing factors, for instance, the VIX into risk aversion and uncertainty components Bekaert &

⁴Albagli et al. (2019) documented furthermore that the spillover effect of US monetary policy shocks on international bond market has increased substantially since the global financial crisis of 2007-2009. Miranda-Agrippino & Rey (2020) found a significant comovement between the global risk factor and US monetary policy shocks supported by the considerable deleveraging of financial intermediaries as a response to contractionary surprises.

Hoerova (2014), or identified new measures as the macroeconomic uncertainty component of Jurado et al. (2015). In the case of central bank announcements, Swanson (2006) proposed to measure monetary policy uncertainty with the market-implied distribution of the federal funds rate. De Pooter et al. (2021) implemented this measure of monetary policy uncertainty and concluded that the transmission of monetary policy shocks to the longer-term Treasury yields is muted when monetary policy uncertainty is in the upper quartile of its historical distribution. M. Bauer et al. (2019) concluded a similar pattern for stock market returns: the pass-through of monetary policy shocks is more pronounced when the market-based measure of uncertainty is lower around FOMC decisions. A different approach to measuring policy uncertainty was proposed by Husted et al. (2020) constructing a monetary policy uncertainty index based on public perception about the Federal Reserve's actions and their implications.

My research is closely related to the returns around FOMC announcements *conditional* on monetary policy shocks. Neuhierl & Weber (2021) documented monetary momentum, which is a significant return drift in the US stock market that begins 25 days prior to monetary policy decisions and continues 15 days after. The difference in returns between the expansionary and contractionary monetary policy surprises is on average 4.5% for the US stock market. Similarly, Indriawan et al. (2021) documented disproportionately large excess returns on long-term US and German government bonds that are conditional on monetary policy surprises. Notably, similar return patterns are not observable when easing and tightening monetary policies are measured by raw changes in the federal funds target rate.⁵

In order to quantify the unexpected component of monetary policy decisions, Kuttner (2001) proposed applying changes in the federal funds futures around FOMC decisions. Although Gürkaynak et al. (2007) argued that monetary policy shocks measured by federal funds futures are the best way to represent the unexpected component of the announced target rate, in the zero lower bound period, this measure is ineffective⁶. The impact of unconventional monetary policy tools stimulating the economy in the effective lower bound were also decomposed from the principal components of policy shocks (Swanson, 2021a). Furthermore, Nakamura & Steinsson (2018) pointed out that conventionally measured monetary policy surprises include the effects that monetary policy announcements have on private sectors' economic outlook and identified

⁵Existing literature classifies monetary policy announcements as expansionary or contractionary based on the surprise component of monetary policy decisions and not by the increase or decrease in the target rate.

⁶ Monetary policy shocks of Kuttner (2001) is estimated from the current-month federal funds futures. Prices are quoted as the average daily federal funds rate subtracted from 100. Therefore, in the effective lower period these policy shocks do not vary. The expected component of the Kuttner (2001) shocks is calculated as the target rate minus the unexpected component.

a single factor measuring this ‘information effect’. To exemplify, central bank announcements might convey private information on the state of the economy or future monetary policy actions and financial markets react to this information reducing the impact of target rate changes. Therefore, in my research, different measures of monetary policy are implemented to test the responsiveness of instruments to the expected, unexpected, unconventional monetary policy and information effect components.

This research also relates to the literature on the sensitivity of the stock market to other macroeconomic shocks. Savor & Wilson (2013) documented that between 1958 and 2009 approximately 60% of the annual risk premium was earned on the announcement days of inflation, unemployment, and interest rate. Likewise, Kurov & Stan (2018) found significant price movements in the futures markets of stocks, bonds, crude oil, and exchange rates on the GDP, nonfarm payrolls, and unemployment rate announcement days.

Lastly, I also intend to find an explanation for monetary momentum as it induces a return drift prior to the announcement of the FOMC decisions. M. D. Bauer & Swanson (2020) proposed that the Federal Reserve does not have superior information compared to the private sector and that monetary policy shocks arise because the private sector cannot estimate the response function of the FOMC to the same publicly available macroeconomic data and forecasts. Bu et al. (2021) had similar results showing that certain monetary policy shocks are predictable by private sector forecasts and other leading indicators.

Although trading anomalies are documented on a single instrument or asset class, they are detectable in a wider range of assets. For instance, the pre-announcement drift of Lucca & Moench (2015) found in the case of the S&P500 was also discovered for energy futures (Jang & Seo, 2020). This is not only the case of monetary policy decisions. Carry trading strategy for the currency market was extended to equity and commodity futures as well (Kojien et al., 2018). By the same token, the time series momentum documented by Moskowitz et al. (2012) persists for 55 futures from four asset classes. In other words, the past 12-month excess returns of each asset predict significantly future returns of the same asset. Similarly, the value and momentum trading strategies yield substantial return premia for currency, commodity futures and equity indices (Asness et al., 2013).

My research is closely related to the study of Neuhierl & Weber (2021) that described monetary momentum for 3 assets. The analysis of monetary momentum is extended to 52 additional assets from 4 asset classes, thus generalising certain attributes of this trading anomaly

⁷. Additionally, the impact of monetary policy uncertainty is analysed based on the sign of policy shocks and a larger set of control and explanatory variables is applied: I distinguish between different measures of uncertainty, business cycle fluctuation, and other macroeconomic announcements. In addition, I intend to provide an explanation for this trading anomaly.

3 Data

3.1 Futures contracts

I sample daily returns for the 55 futures prices implemented in the research of Moskowitz et al. (2012) and Huang et al. (2020). The data consists of 24 commodities, 13 developed countries' government bonds, 9 developed countries' equity indexes and 9 currency forwards. The cumulative returns of the futures contracts were calculated in a 30-day event window centred around FOMC press releases, similarly to Neuhierl & Weber (2021) ⁸. For robustness check, the event window will be narrowed to 2 and 10 days. *Table 1* presents a summary statistics of the analysed instruments.

3.2 Monetary policy announcements

The sample period starts from 1994 when the Federal Open Market Committee began to announce its target rate decisions. Prior to 1994, the Federal Reserve did not communicate monetary policy decisions, and market participants had to infer the new target rate from open market operations following the day of the announcement. Nevertheless, this interference was difficult at times when commercial banks' demand for reserves changed inordinately after the FOMC meeting (Kuttner, 2003).⁹ The sample period ends in July 2019.

I focus on the scheduled meetings in the sample period as investors can prepare for monetary policy decisions. Existing literature suggests that macroeconomic pre-announcement returns exist if and only if investors receive a signal prior to the data release (Ai & Bansal, 2018).

⁷Neuhierl & Weber (2018) analysed monetary momentum in the case of the CRSP value-weighted index, the 10-year Treasury yield and dollar-euro exchange rate.

⁸Neuhierl & Weber (2021) chose a 45 days event window that with 8 scheduled FOMC announcements in a year overlap and thus captures the impact of previous monetary policy decisions on assets. A 30-day event window is chosen to contain no overlap between monetary policy decisions.

⁹Lucca & Moench (2015) document significant but smaller pre-FOMC returns in the sample period between 1980 and 1993 and did not detect any difference in returns before 1980. Furthermore, Jang & Seo (2020) found no impact of monetary policy announcements before 1994. These results also prove that market participants pay more attention to the FOMC decision when the target rate change is announced .

Assets	Start date	Mean	Volatility
<i>Commodity futures</i>			
Aluminium	May 2001	-0.41	13.18
Brent oil	January 1994	6.22	33.49
Cattle	January 1994	1.47	16.74
Cocoa	January 1994	2.68	29.27
Coffee	January 1994	1.21	37.17
Copper	January 1994	4.65	26.85
Corn	January 1994	1.01	26.85
Cotton	January 1994	-0.26	28.12
Crude	January 1994	5.40	36.19
Gas oil	January 1994	5.68	30.13
Gold	January 1994	5.07	16.11
Heating oil	January 1994	5.91	34.10
Hogs	January 1994	2.15	34.46
Natural gas	January 1994	0.55	54.60
Nickel	July 1997	3.44	35.02
Platinum	January 1994	3.06	21.33
Silver	January 1994	4.39	28.44
Soybean	January 1994	0.75	23.41
Soymeal	January 1994	1.55	16.00
Soy oil	January 1994	-0.25	22.23
Sugar	January 1994	0.49	25.71
Unleaded gasoline	January 1994	5.30	24.16
Wheat	January 1994	1.02	29.73
Zinc	July 1997	1.94	28.34
<i>Equity index futures</i>			
SP1 200	May 2000	3.95	15.43
DAX	January 1994	6.49	22.32
IBEX 35	January 1994	3.46	22.95
CAC 40	January 1994	3.34	21.81
FTSE/MIB	March 2004	-1.16	23.05
TOPIX	January 1994	0.33	22.25
AEX	January 1994	4.24	21.10
FTSE 100	January 1994	3.02	17.93
S&P 500	January 1994	7.26	18.27
<i>Currency forwards</i>			
AUD/USD	January 1994	-0.29	11.75
EUR/USD	May 1998	-0.04	9.54
CAD/USD	January 1994	-0.01	8.04
JPY/USD	January 1994	0.13	10.78
NOK/USD	May 2002	-0.34	12.05
NZD/USD	May 1998	-0.18	12.80
SEK/USD	May 2002	0.29	11.88
CHF/USD	January 1994	1.57	11.04
GBP/USD	January 1994	-0.71	9.86
<i>Bond futures</i>			
Three-year Australian	January 1994	0.23	1.17
Ten-year Australian	January 1994	1.72	10.82
Two-year European	March 1997	0.56	8.56
Five-year European	January 1994	1.03	3.54
Ten-year European	January 1994	1.72	10.82
Thirty-year European	October 1998	2.66	12.51
Ten-year Canadian	January 1994	-0.41	8.05
10-year Japanese	January 1994	1.10	3.96
Ten-year UK	January 1994	2.04	10.18
Two-year US	January 1994	0.10	1.75
Five-year US	January 1994	0.23	4.27
Ten-year US	January 1994	0.49	6.34
Thirty-year US	January 1994	6.48	9.55

Table 1: Summary statistics on classified into asset classes.

Note. The table reports the annualized mean return and standard deviation (volatility) expressed in percentages. The sample period starts from January 3, 1994 and ends on July 31, 2019.

3.3 Monetary policy surprises

To gauge the impact of FOMC announcements, policy shocks are represented with the series of Bu et al. (2021) that are a unified measure of monetary policy shocks bridging the period before and following the zero lower bound period using changes in the zero-coupon yields with maturities of 1-to 30-years. The authors rely on the two-step regression methodology of Fama & MacBeth (1973) to filter out the central bank information effect proposed by Romer & Romer (2000) and Nakamura & Steinsson (2018).

I also test whether monetary momentum persists if the shocks are measured with changes in the federal funds futures rate although these shocks are indifferent from zero in the effective lower bound period (Kuttner, 2001) ¹⁰. Furthermore, it is also estimated whether assets respond to the expected ¹¹, information effect (Nakamura & Steinsson, 2018), target rate and different measures of unconventional monetary policy shocks (Swanson, 2021a).

3.4 Monetary policy uncertainty

To quantify monetary policy uncertainty, I apply the news-based measure proposed by Husted et al. (2020) that reflects uncertainty in newspaper articles about the Federal Reserve. The authors argued that market-based measures of monetary policy uncertainty reflect only a particular set of investors' opinion participating in the options markets moreover, it might be contaminated by time-varying risk aversion. Considering the aforementioned reasoning, in my research, I opt to measure monetary policy uncertainty by the MPU news-based measure. ¹²

Additional robustness tests include the economic policy uncertainty (Baker et al., 2016) and the 10-year Treasury Note Volatility Index ¹³ calculated from options on the medium- and long-term Treasury futures (Choi et al., 2017) and applied by Indriawan et al. (2021) to proxy monetary policy uncertainty. Nevertheless, M. Bauer et al. (2019) points out that the TIV might be influenced by the supply and demand in the bond market and it captures uncertainty about the risk premium and short-term rates in a single component.

¹⁰Federal funds futures are defined as the average implied rate subtracted from 100. Therefore, in the zero lower bound period, fed funds futures do not change.

¹¹The expected rate is calculated as the announced target rate minus the unexpected shock and is included in the robustness check given that some energy futures prices only respond to the expected component in an asymmetric way (Jang & Seo, 2020).

¹²Potential advantage of measuring monetary policy uncertainty with the MPU comes at its weak correlation with other measures of uncertainty, such as the VIX and EPU (Husted et al., 2020).

¹³Henceforth TIV.

3.5 Control variables

In the analysis of monetary momentum, I add potential explanatory variables accounting for business cycles, macroeconomic announcements and turning points.

Yaron et al. (2019) argued that stock markets reaction to macroeconomic announcements is cyclical. Although Neuhierl & Weber (2021) concluded that the business cycle as measured by the level of the effective federal funds rate does not affect monetary momentum, I intend to investigate cyclical variation again. The Aruoba et al. (2009) business condition index measures cyclical variation by blending high- and low-frequency real-time data with components such as the weekly initial unemployment claims and monthly industrial production. Given that the index has zero mean, positive values indicate a phase of expansion in economic activity.¹⁴ Following Lucca & Moench (2015), I add the NBER dummy to account for the period of severe economic downturn.

Addressing the concern of the large event window that with 8 scheduled FOMC decisions accounts for the majority of trading days, I add control variables for announcements that cause abnormal returns based on existing literature. Importantly, other macroeconomic announcements could contaminate the results because they lead to significant pre-announcement returns similarly to the pre-FOMC returns (G. X. Hu et al., 2021). Baumohl (2012) pointed out that the Purchasing Managers' Index is one of the most important economic indicators released by the private sector. Furthermore, Kurov & Stan (2018) found statistically significant return drifts around nonfarm payrolls and GDP announcements for the stock, bond and foreign exchange markets as well. In my research, I include a control variable accounting for the announcement day of the aforementioned three macroeconomic news.

Turning points were included in the analysis of Neuhierl & Weber (2021) and it is a dummy variable that equals one if the target rate changed in the opposite direction compared to the previous change.

To analyse predictability of monetary policy shocks, I include the forecasts for the annual level of chain-weighted real GDP¹⁵, monthly changes in the nonfarm payrolls and the Brave et al. (2019) business condition index based on the study of M. D. Bauer & Swanson (2020) who analysed the information set of private sector and the Federal Reserve. Furthermore, I apply

¹⁴In a study about macroeconomic news shocks Kurov & Stan (2018) also implemented the ADS index to control for changes in real-business conditions.

¹⁵For further description, please visit the webpage of the Federal Reserve Bank of Philadelphia: <https://www.philadelphiafed.org/-/media/frbp/assets/surveys-and-data/survey-of-professional-forecasters/spf-data-sources.pdf?la=en&hash=B6419274B86DCC5AE22AB5F0D7BF21A2>.

the Michigan Survey unemployment sentiment index and subtract the percentage of consumers who think unemployment would increase from those who believe it would decrease. The survey of the American Association of Individual Investors sentiment and the monthly changes in the S&P500 is incorporated in the analysis based on the study of Sastry (2021).

4 Methodology

4.1 Panel regression

I implement panel regression to analyse the joint reaction of the 55 futures returns to monetary policy announcements, similarly to Hausman & Wongsan (2011). The model selection is described in appendix B and corrects the mistakes that Huang et al. (2020) highlighted in the study of Moskowitz et al. (2012) ¹⁶. The following fixed effect panel model is estimated for all assets, asset classes and with control variables:

$$r_{t,t+h}^i = \beta \mathbf{X}_{t,t+h}^i + \mu_i + \epsilon_{t,t+h}^i, \quad (1)$$

where μ_i denotes the individual-specific effect reporting the average returns around expansionary policy shocks. Returns are cumulated from $t = -15$ days before the scheduled announcements and $h = 1, 2, 3, \dots, 30$ to estimate the impact up until 15 days following monetary policy decisions. In the baseline regression the X_{it} vector represents the monetary policy shock dummy, monetary policy uncertainty and their interaction. The X_{it} explanatory variable is augmented with control variables for business cycle fluctuation, macroeconomic news announcements and monetary policy attributes. $\epsilon_{t,t+h}^i$ are robust standard error estimated with the methodology of Arellano et al. (1987) that controls for heteroscedasticity and serial autocorrelation in the idiosyncratic error terms.

4.2 Predictability test

The substantial returns prior to policy decisions suggest that market participants are able to predict the decision of central banks. Examining the predictability of monetary policy shocks, I

¹⁶Equal mean returns were tested to assess the choice of a pooled panel model. I also conducted the Hausman test with auxiliary regression to choose between random-and fixed-effect models. Homoscedasticity of the error terms was tested with the Koenker & Bassett (1982) version of Breusch-Pagan test that does not assume normality of the error terms. To examine serial autocorrelation the Bresuch-Godfrey test was conducted.

estimate the following OLS regression with heteroscedasticity robust standard errors to obtain variables that significantly predict policy surprises:

$$mps_t = \alpha + \beta news_t + \epsilon_t \quad (2)$$

where $news_t$ incorporates significant predictors of monetary policy shocks described in section 3. The regressors are taken from the studies of M. D. Bauer & Swanson (2020), Bu et al. (2021) and Karnaukh (2020). These researches already proved the predictability of the analysed monetary policy shocks, but in shorter sample periods. The regression is repeated to confirm the results in the sample period of January 1994 to July 2019. I carefully align the regressors so as none of the explanatory variables is published before the announcement.

In order to estimate the performance of the OLS regression model, I test for equal predictive accuracy with the Diebold-Mariano test (Diebold & Mariano, 2002). Chosing the window based on the study of Kroencke et al. (2021), the previous 40 observations are applied to estimate the coefficients of the OLS regression with equation 2 and then predict the shock for next FOMC announcements. The time-series are compared with naïve, and exponentially weighted moving average forecasts estimated on the last four observations.

4.3 Futures cumulative return drift

To examine exactly on which day becomes the return drift between expansionary and contractionary policy significant, I test for equal means in cumulative returns ($\sum_{h=0}^{30} r_{t,t+h}^i$) for each day (h) starting 15 days before the announcement ($t = -15$).

The Mann-Whitney U-test (or Wilcoxon rank-sum test) is a nonparametric test to compare whether the distribution of both populations are equal (Mann & Whitney, 1947). The null hypothesis is that a randomly selected values of the sample X and Y the probability of one being greater than the other is the same:

$$P(X > Y) = P(Y > X) \quad (3)$$

5 Empirical results

5.1 Return drift around FOMC announcements

In the empirical framework, I follow the event study approach of Neuhierl & Weber (2021) and focus on the return drift of assets conditional on expansionary and contractionary monetary policy shocks. Instead of implementing a small 60 minutes event window similarly to De Pooter et al. (2021), I analyse the return drift in 30 days centred around scheduled FOMC announcements.

Figure 1 illustrates that the cumulative returns start to drift well before the announcement and continue to drift in the same direction for the following 15 days. Figure A1 in appendix A shows that the difference in returns between expansionary and contractionary shocks becomes significant at 5% exactly 7 days before the announcement. To gauge the magnitude of the difference, I estimate the fixed effect panel model of equation 1 including monetary policy shocks and uncertainty with their interaction term.

Table 1 reports the response of the 30-day cumulative returns to the policy shocks and the impact of monetary policy uncertainty separately for expansionary and contractionary policy shocks ¹⁷. In the full sample period, the average return drift of the 55 futures was 0.978% for expansionary and -0.286% for contractionary shocks (column 3). The difference between expansionary and contractionary shocks was 1.264% and statistically significant at 1%. Table C1 in appendix C shows similarly significant results for the 2- and 10-day event windows. The magnitude is two times smaller, confirming that the impact of monetary policy on the financial market is not limited to a small event window.

Neuhierl & Weber (2021) found 3% difference in returns in the 30-day event window for the CRSP value-weighted index. The smaller magnitude in this study could be due to the heterogeneity between asset classes. Contrasting the two sample period, before the global financial crisis asset prices' response was larger.

Monetary policy uncertainty seems to have an opposite sign, weakening the impact of policy shocks however, the coefficients are statistically insignificant. Table D1 in appendix D provides a robustness check excluding the global financial crisis from the sample period and in that case the uncertainty components become significant. A one-standard-deviation change

¹⁷The sample period is split at the global financial crisis of 2008 as new, unconventional monetary policy tools were implemented. Note that unscheduled meetings are excluded from the sample period, therefore immediate reaction of the Federal Reserve to the crisis is excluded from the analysis. The first sample period is between 1994.01.01-2008.09.14 ending before the bankruptcy of the Lehman Brothers (column 1). The second sample period starts in 2008.09.15 and ends in 2019.07.31 (column 2). The full sample period is reported in column 3.

in monetary policy uncertainty ¹⁸ lowers the impact of expansionary policy surprises by 0.02% and contractionary surprises by 0.03%.

	Dependent variable: 30-day cumulative returns		
	1994-2008	2008-2019	1994-2019
	(1)	(2)	(3)
<i>Constant</i>	1.690*** (0.001)	0.438 (0.527)	0.978*** (0.000)
<i>S_{BRW}</i>	-1.573** (0.000)	-1.411** (0.000)	-1.264*** (0.000)
<i>MPU</i>	-0.007 (0.115)	0.001 (0.791)	-0.002 (0.367)
<i>S_{BRW} × MPU</i>	0.006 (0.242)	0.002 (0.574)	0.002 (0.531)
Observations	4,595	4,300	8,895
R ²	0.004	0.005	0.004

Table 2: Cumulative returns around scheduled FOMC decisions.

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 55 futures to monetary policy surprises and monetary policy uncertainty. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (S_{BRW}) that equals one for positive values indicating contractionary policy surprise. MPU refers to the news-based monetary policy uncertainty measure of Husted et al. (2020). The sample period starts in January 1994 and ends in July 2019. The first two columns report the sample period between 1994.01.01-2008.09.15 and the following two columns the sample period between 2008.09.15-1994.07.31. *, **, and *** indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.

The following subsections provide a detailed analysis regarding the difference in response to policy surprises between asset classes. Equation 1 is re-estimated with restricting the 30-day cumulative returns $r_{t,t+h}^i$ to each asset class.

5.1.1 Commodity futures

The majority of research papers focused on energy prices that resemble substantial price movements around FOMC decisions (Basistha & Kurov, 2008). Gospodinov & Jamali (2013) extended the analysis to a wide range of commodities, including agricultural products, industrial and precious metals that showed a significant response to central bank announcements. My

¹⁸The average of monetary policy uncertainty is 108.68 and its standard deviation is 49.44.

contribution to the literature is extending the sample period, the analysed commodity futures and including monetary policy uncertainty in panel models.

In the case of the 24 commodities, table 3 illustrates that the return drift is 1.5-2 times higher and its sign is similar to the previous results. Similarly to the results for all futures, in the first sample period between 1994-2008, the difference between expansionary and contractionary shocks is greater than between 2009-2019. In the full sample period, an expansionary shock increased the 30-day returns of commodity futures by 2.1% and contractionary shocks decreased this effect by 1.89% if the level of monetary policy uncertainty was average.

The results align with the study of Gospodinov & Jamali (2013) documenting that the Goldman Sachs Commodity Index increased to expansionary policy shocks up until 2008. The results complement this finding by concluding that the magnitude of commodity futures return drift has decreased, as shown by the constant term in columns 1 and 2.

	Dependent variable: 30-day cumulative returns of commodity futures		
	1994-2008	2009-2019	1994-2019
	(1)	(2)	(3)
<i>Constant</i>	3.236*** (0.000)	1.204 (0.124)	2.101*** (0.000)
<i>S_{BRW}</i>	-2.959** (0.012)	-1.825* (0.044)	-1.889** (0.008)
<i>MPU</i>	-0.016** (0.033)	-0.005 (0.452)	-0.010** (0.018)
<i>S_{BRW} × MPU</i>	0.014 (0.128)	-0.0001 (0.990)	0.003 (0.572)
Observations	2,147	1,968	4,115
R ²	0.007	0.008	0.007

Table 3: Commodity futures cumulative returns around FOMC decisions.

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 24 commodity futures to monetary policy surprises and monetary policy uncertainty. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (*S_{BRW}*) that equals one for positive values indicating contractionary policy surprise. *MPU* refers to the news-based monetary policy uncertainty measure of Husted et al. (2020). The sample period starts in January 1994 and ends in July 2019. The first two columns report the sample period between 1994.01.01-2008.09.15 and the following two columns the sample period between 2008.09.15-1994.07.31. *, **, and *** indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.

Interestingly, uncertainty has the same effect for both expansionary and contractionary shocks: a one-standard deviation in uncertainty decreases returns by 0.49% in the full sample

period.¹⁹ The difference between expansionary and contractionary shocks is 1.89% for the average level of monetary policy uncertainty (column 3). Comparing the two subsamples this difference was approximately 1% larger and 1% smaller in the first and second sample periods, respectively.

5.1.2 Equity index futures

Equity indices respond remarkably to central bank decisions. Brusa et al. (2020) found a significant response of 37 stock markets to FOMC decisions and Neuhierl & Weber (2021) concluded similar return patterns in a 30-day event window for international equity indices.

Based on the the panel regression, the empirical results over the entire sample period are difficult to reconcile with the subsamples.

Column 3 of table 4 shows that policy surprises have a statistically significant impact at 1% and the magnitude is slightly larger compared to the results of the 55 futures. The difference between expansionary and contractionary shocks is 1.971% if the impact of monetary policy uncertainty is not considered in the full sample period.

Unlike commodity futures, uncertainty has an asymmetric impact on asset prices. In the case of a ‘tightening’ shock, a one-standard-deviation in uncertainty lowers the impact of the surprise by increasing returns with 0.6%.

In the sample period until 2008, expansionary shock led to a three times larger increase in returns, so that asset prices even slightly increased in the case of contractionary shocks. Differently from commodity futures, monetary policy uncertainty decreased the returns for both expansionary and contractionary shocks. Meanwhile, in the second subsample contractionary shocks had no significant impact (column 2).

M. Bauer et al. (2019) found similar effect of monetary policy on the S&P500 with expansionary shocks leading to an increase and contractionary shocks decreasing the cumulative returns around FOMC announcements. The findings complement their research by noting that the return drift lasts in a longer event window and for a larger set of equity indices.

Neuhierl & Weber (2021) analysed the same equity indices; however, excluding the zero lower bound period and obtained a similar but larger return drift for policy shocks in the 30-day event window. W. Wu (2016) concluded that in the beginning of the zero lower bound period,

¹⁹The findings are similar to the research of Gospodinov & Jamali (2013): uncertainty associated with expansionary policy shocks decreases the impact of policy surprise. The completion of their findings is that in the extended sample period, between 2009-2019, this effect of monetary policy uncertainty disappeared.

between 2008-2010, the stock market was less responsive to monetary policy shocks.

	Dependent variable: 30-day cumulative returns of equity index futures		
	1994-2008	2009-2019	1994-2019
	(1)	(2)	(3)
<i>Constant</i>	2.774*** (0.000)	−0.724** (0.015)	0.721*** (0.007)
<i>S_{BRW}</i>	−1.779*** (0.000)	−1.464 (0.002)	−1.971*** (0.000)
<i>MPU</i>	−0.014*** (0.000)	0.013** (0.000)	0.002 (0.376)
<i>S_{BRW} × MPU</i>	0.004 (0.374)	0.009** (0.040)	0.012*** (0.000)
Observations	745	738	1,483
R ²	0.019	0.025	0.009

Table 4: Equity index futures cumulative returns around FOMC decisions.

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 9 equity index futures to monetary policy surprises and monetary policy uncertainty. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (S_{BRW}) that equals one for positive values indicating contractionary policy surprise. MPU refers to the news-based monetary policy uncertainty measure of Husted et al. (2020). The sample period starts in January 1994 and ends in July 2019. The first two columns report the sample period between 1994.01.01-2008.09.15 and the following two columns the sample period between 2008.09.15-1994.07.31. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.

Therefore, it is possible that in the zero lower bound period either returns became less responsive to monetary policy shocks or policy decisions were communicated well-ahead. In the latter scenario, the monetary policy shocks might be different from zero, but smaller and market participants may also infer the FOMC decision.

5.1.3 Currency forwards

The exchange rates have been analysed by Ferrari et al. (2021) documenting return drift conditional on the sign of the announcements for the exchange rates of six advanced economies.

Analysing the G10 currencies, columns 1, 2, and 3, shows that monetary policy surprises have a similar but smaller impact on currencies compared to all assets. Akin to previous results, the difference in the return drift is 1.04%. Contrary to previous results, currency forwards seem to become more responsive over time. Ferrari et al. (2021) attributed the increased sensitivity of the exchange rates to unconventional policy tools and the zero lower bound period. Hausman

& Wongswan (2011) found that exchange rates mainly respond to the ‘path’ factor of monetary policy that can be interpreted as forward guidance of the Federal Reserve. This provides an explanation for the insignificant and smaller returns in currency forwards. The shock series of Bu et al. (2021) is a single measure for both target rate and forward guidance shocks, and the latter became more prevalent since the beginning of the zero lower bound period, thus inducing a significant response of currency forwards in the second sample period (Andrade & Ferroni, 2021).

	Dependent variable: 30-day cumulative returns of currency forwards		
	1994-2008	2009-2019	1994-2019
	(1)	(2)	(3)
<i>Constant</i>	−0.759 (0.262)	0.209 (0.217)	−0.031 (0.859)
<i>S_{BRW}</i>	−0.759 (0.146)	−1.690*** (0.000)	−1.041** (0.000)
<i>MPU</i>	0.010** (0.014)	−0.001 (0.618)	0.004** (0.041)
<i>S_{BRW} × MPU</i>	0.001 (0.890)	0.007*** (0.000)	0.002 (0.226)
Observations	696	679	1,375
R ²	0.028	0.019	0.017

Table 5: Currency forwards cumulative returns around FOMC decisions.

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 9 currency forwards to monetary policy surprises and monetary policy uncertainty. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (*S_{BRW}*) that equals one for positive values indicating contractionary policy surprise. *MPU* refers to the news-based monetary policy uncertainty measure of Husted et al. (2020). The sample period starts in January 1994 and ends in July 2019. The first two columns report the sample period between 1994.01.01-2008.09.15 and the following two columns the sample period between 2008.09.15-1994.07.31. *, **, and *** indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.

Turning to the impact of monetary policy uncertainty, in the first sample period it is the only significant variable that increases returns by 0.49% in the event window regardless of the sign of the policy shock. Results are very similar in the second and full sample period, with significant positive coefficients for the uncertainty term. These findings are in line with the study of Mueller et al. (2017) who documented a similar effect in a 2-hour event window following FOMC announcements. Nevertheless, in the second period it seems that only contractionary policy shocks impact currency forwards if monetary policy uncertainty is included by decreasing

returns and policy uncertainty diminishes this impact of contractionary shocks by increasing returns.

5.1.4 Bond futures

The expectations based on existing literature is strong and immediate response both in short- and long-term rates to monetary policy decisions (Hanson & Stein, 2015). In table 6 the estimated effects suggest that a positive monetary policy surprise, or tightening shock, increases 30-day returns of developed countries bond futures, contrary to the previous findings where contractionary policy shocks increased returns. Henceforth, the magnitude of monetary momentum for the 55 futures was much smaller, compared to the previous asset classes return drift, because of the inclusion of the bond market. Even so, results are not surprising, as Indriawan et al. (2021) came to a similar conclusion for 10-year US and German government bonds.

	Dependent variable: 30-day cumulative returns		
	1994-2008 (1)	2009-2019 (2)	1994-2019 (3)
<i>Constant</i>	−1.102*** (0.000)	−0.122 (0.217)	−0.551 (0.859)
<i>S_{BRW}</i>	1.261*** (0.002)	−0.255 (0.310)	0.540* (0.053)
<i>MPU</i>	0.010*** (0.000)	0.005*** (0.000)	0.007*** (0.000)
<i>S_{BRW} × MPU</i>	−0.011*** (0.000)	−0.005*** (0.008)	−0.008*** (0.000)
Observations	1,007	915	1,922
R ²	0.014	0.030	0.014

Table 6: Bond futures cumulative returns around FOMC decisions.

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 13 bond futures to monetary policy surprises and monetary policy uncertainty. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (S_{BRW}) that equals one for positive values indicating contractionary policy surprise. MPU refers to the news-based monetary policy uncertainty measure of Husted et al. (2020). The sample period starts in January 1994 and ends in July 2019. The first two columns report the sample period between 1994.01.01-2008.09.15 and the following two columns the sample period between 2008.09.15-1994.07.31. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.

In the first sample period, the difference in return drift has a magnitude of 1.261%. Similarly

to the research of De Pooter et al. (2021) monetary policy uncertainty decreases the impact of policy shocks by leading to a 0.49% increase in returns with a one-standard-deviation change and slightly decreasing returns for tightening shocks. In the second period, again the impact of monetary policy shocks weakened and became insignificant. Interestingly, the impact of monetary policy uncertainty differs based on the sign of policy shocks. In the full sample period, a smaller but significant return difference is reported in column 3, and monetary policy uncertainty has the same impact.

Considering that for equity indices, currency forward and commodities expansionary shocks increased returns, meanwhile for bond futures they lead to a decrease, I opt to exclude the bond market from the following analysis. The inclusion would always raise the question whether insignificant results are due to the bond market or other factors changing throughout the analysis, such as control variables or the sample period.

5.2 Control variables

The previous subsection showed that the 30-day returns of the 55 futures from 4 asset classes respond significantly to monetary policy conditional on the sign of the shocks. Moreover, the transmission of surprises to financial markets is influenced by uncertainty inasmuch as it weakens the impact of policy shocks.

This section supplements the baseline analysis by including control variables that also lead to significant return drift within the 30-day event window, most importantly macroeconomic announcements (Kurov & Stan, 2018). Furthermore, I also test hypotheses from the FOMC literature concerning additional explanatory variables, such as cyclical variation in the response of financial markets to monetary policy (Yaron et al., 2019) ²⁰.

Table 7 reports the results of the re-estimated equation 1 by including control variables for business cycle fluctuations, other macroeconomic announcements and monetary policy cycles. Notably, the impact of monetary policy surprises does not change, only the magnitude varies with 1.74% of a minimum and 2% maximum difference between expansionary and contractionary shocks. Similarly to the previous results, monetary policy uncertainty decreases the impact of policy shocks. Including all control variables, column 4 shows that a one-standard-deviation increase in policy uncertainty decreases the impact of policy shocks by 346 basis points, while

²⁰Noting anew the exclusion of the bond market from the analysis for the reason that this futures market react contrary to monetary policy shocks in comparison to other asset classes. In other words, increasing returns at contractionary and decreasing at expansionary shocks.

it only weakens the impact of contractionary shocks by 49 basis points.

	Dependent variable: 30-day cumulative returns			
	(1)	(2)	(3)	(4)
<i>Constant</i>	1.908*** (0.000)	1.358*** (0.000)	1.384*** (0.000)	2.009*** (0.000)
<i>S_{BRW}</i>	-2.139*** (0.000)	-1.758*** (0.001)	-1.744*** (0.001)	-2.221*** (0.000)
<i>MPU</i>	-0.006** (0.015)	-0.005* (0.068)	-0.004* (0.099)	-0.007*** (0.006)
<i>S_{BRW} × MPU</i>	0.007** (0.034)	0.005 (0.217)	0.005 (0.180)	0.008** (0.019)
<i>ADS</i>	0.313 (0.186)			0.270 (0.256)
<i>NBER</i>	-2.268*** (0.000)			-2.463*** (0.000)
<i>D_{macro}</i>		1.406*** (0.001)		1.688*** (0.000)
<i>D_{Tpoints}</i>			-0.008 (0.961)	-0.270* (0.079)
Observations	6,973	6,973	6,973	6,973
R ²	0.013	0.006	0.005	0.014

Table 7: Cumulative returns around FOMC decisions including control variables

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 42 futures to monetary policy surprises and monetary policy uncertainty including control variables. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (*S_{BRW}*) that equals one for positive values indicating contractionary policy surprise. *MPU* refers to the news-based monetary policy uncertainty measure of Husted et al. (2020). The sample period starts in January 1994 and ends in July 2019. *ADS* is the Aruoba et al. (2009) business condition index and *NBER* represent the US Recession Indicators of the National Bureau of Economic Research. *D_{macro}* is a dummy that equals 1 on the PMI, Nonfarm payrolls and quarterly GDP announcement days and *D_{Tpoints}* indicates a turning point in monetary policy. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.

Column 1 investigates the impact of business cycle fluctuation by applying the Aruoba et al. (2009) business condition index and the impact of recessions by including the National Bureau of Economic Research US Recession dummy. Although the impact of monetary policy surprises is not influenced by economic fluctuations, recessions seem to significantly decrease average returns in the 30-day event window significantly, by 2.46% muting the impact of expansionary

policy shocks. The magnitude could be due to the global financial crisis of 2008, but presumably the significance is unquestionable given that the sample period incorporates 25 years. Yaron et al. (2019) documented significant cyclical variation in the response of asset prices to monetary policy shocks. The results confirm their findings albeit only for severe economic downturns.

Turning to the impact of macroeconomic announcements, columns 2 and 4 show that the PMI, quarterly GDP and nonfarm payrolls announcements increase returns by 1.69% on average if their announcement day coincided with FOMC decision days. The finding is in align with the study of Kurov & Stan (2018) who showed that in the futures market these macroeconomic announcements induce a significant return drift immediately after the data release.

In the case of turning points in column 3, the impact seems to be little and insignificant. These findings are similar to the study of Neuhierl & Weber (2018).

Concluding that monetary momentum is affected by the state of the economy and other macroeconomic announcements, it is important to emphasise that the baseline results remained unchanged. The return drift depends on the sign of the policy shock, and monetary policy uncertainty seems to weaken the transmission of surprises to financial markets.

5.3 Monetary policy uncertainty

In the previous section, I applied an uncertainty measure that only captures apprehension related to monetary policy and filters out other measures of uncertainty that might influence the return drift around FOMC decisions. Therefore, I include broader measures of uncertainty. Market uncertainty as measured by the VIX and economic policy uncertainty along with a market-based monetary policy uncertainty ²¹.

Figure 2 illustrates the 30-day cumulative returns around FOMC decisions when monetary policy uncertainty and market uncertainty as measured by the VIX are in the lower and upper quartile based on the full sample period.

On the one hand, when the VIX is in its lower quartile, no significant return drift happens in the pre-announcement event window and the post-announcement drift is also minor. On the other hand, the return drift remains significant and its magnitude doubles in the upper quartile. These findings complement the research of Neuhierl & Weber (2018) and De Pooter et al. (2021) who found similarly that the transmission of policy shocks is more pronounced in times of elevated

²¹De Pooter et al. (2021) applied the same uncertainty measures in analysing the response of long-term bond prices to monetary policy announcements.

market uncertainty analysing the US stock and bond markets respectively.

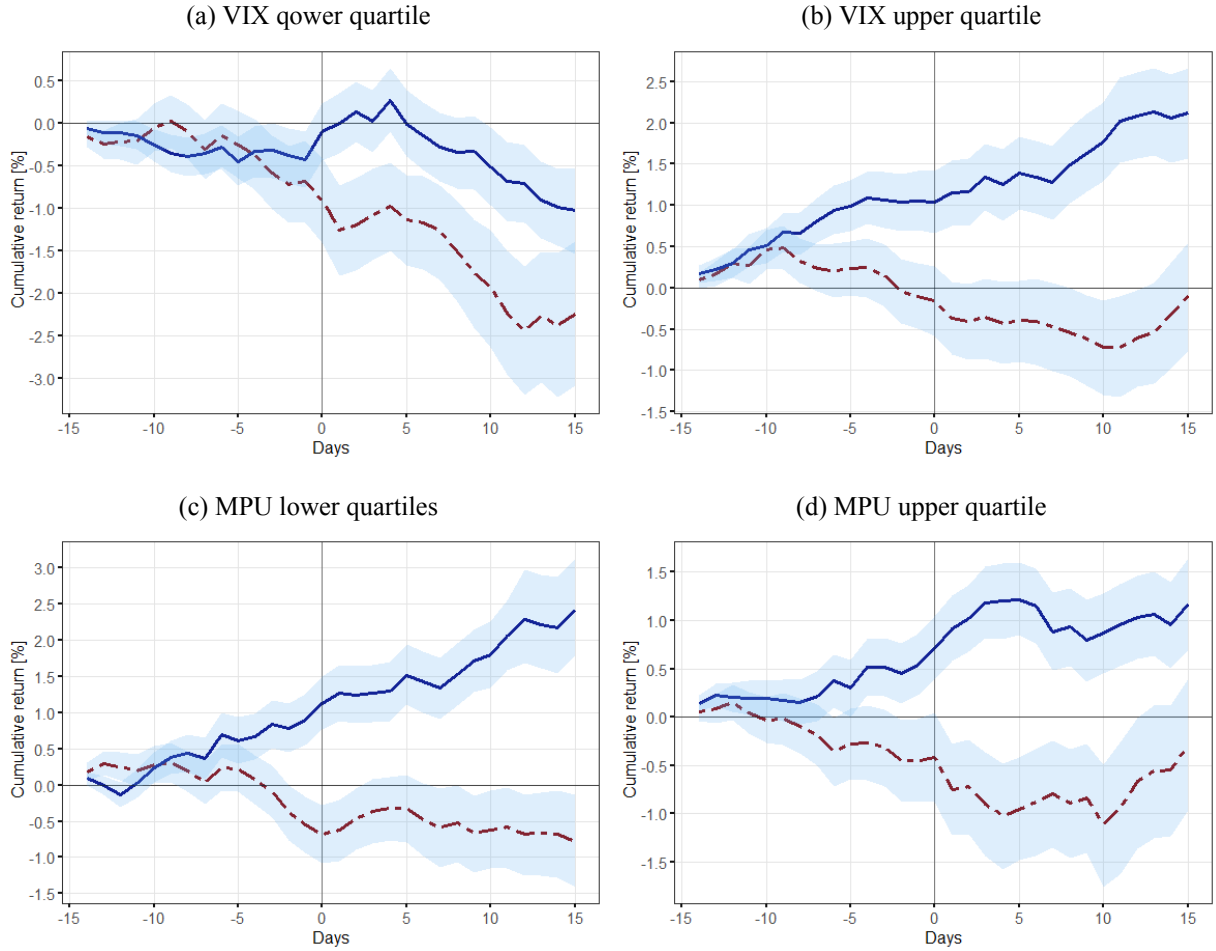


Figure 2: Cumulative return drift of futures around FOMC decisions.

Note. The figure illustrates the average cumulative returns of the 42 futures from 3 asset classes in percent around scheduled FOMC decisions between 1994 and 2019. The blue line indicates a negative monetary policy surprise (expansionary) and the dashed red line indicates a positive (contractionary) surprise. The shaded areas are the 95% confidence intervals around mean returns constructed with bootstrap standard errors. The return drift is conditioned on the uncertainty measure being in the lower or upper quartile of its historical distribution.

Considering monetary policy uncertainty, the difference in the lower and upper quartiles is easily detectable. In the presence of lower monetary policy uncertainty, the difference between expansionary and contractionary policy shocks is 2-3 times larger than the average estimated difference in the sample period. At the same time, the impact of monetary policy shocks persists in the fourth quartile of monetary policy uncertainty, only its magnitude decreases. These findings are confirmed by the existing literature for the bond market by Tillmann (2020).

For the purpose of supporting these results, the baseline fixed effect panel regression of equation 1 is estimated and with uncertainty being at the lower, medium and upper quartile of its historical distribution in the sample period. The two uncertainty measures for monetary

policy uncertainty are the news-based measure of Husted et al. (2020) that I have included in all regressions so far and the market-based monetary policy uncertainty of Choi et al. (2017). The VIX is included to gauge general market uncertainty. Furthermore, I test for the impact of economic policy uncertainty to extend the analysis of De Pooter et al. (2021) ²².

Table 8 shows that the news-based uncertainty measure (*MPU*) decreases the impact of policy shocks, confirming previous results of this research, although its magnitude is conflicting. In the case of expansionary policy, a lower uncertainty reduces the impact of monetary policy by 1.31%, and a higher uncertainty only decreases it by 0.409%. Meanwhile, for contractionary shocks, a one-unit change in monetary policy uncertainty decreases the impact of policy shocks by 0.25% and in the upper quartile by only 0.196%.

The market-based monetary policy uncertainty measure (*TIV*) has almost no impact, only decreasing cumulative returns. The different impact in columns 1 and 2 is either a result of non-linearity Tillmann (2020) or the distinct measurement of uncertainty. The news-based measure of Husted et al. (2020) counts the ratio of words associated with monetary policy apprehension in US newspapers therefore, it does not concretely capture trading activity and price fluctuations. Meanwhile, the uncertainty measure of Choi et al. (2017) applies futures and options data to construct bond variance swap payoffs, thus reflecting only a particular set of investors' opinions participating in the options market, and the measure also includes the time-varying risk aversion.

Turning to the market uncertainty measure (*VIX*) the results clearly show that the higher the quartile, the larger the asset return in the 30-day period. Furthermore, the interaction term in the highest quartile also increases the impact of contractionary policy shocks by lowering the returns by 0.641% with a one-unit change.

Column 4 shows the estimated impact of the economic policy uncertainty index. Results seem to be similar to monetary policy uncertainty in decreasing the impact of policy shocks. Differently though, there is no clear pattern for its magnitude. For instance, the impact of the medium and higher quartile of economic uncertainty is very similar. These results are contrary to the study of De Pooter et al. (2021) in the bond market. Nevertheless, it was noted earlier that the bond market responds differently to policy shocks therefore, it is excluded from the analysis.

²²De Pooter et al. (2021) estimated the impact of monetary policy shocks on the 5- and 10-year US Treasury yield. The research concluded that monetary policy uncertainty decreases, while market uncertainty and economic policy uncertainty increases the impact of monetary policy shocks.

	<i>Dependent variable: 30-day cumulative returns</i>			
	<i>MPU</i>	<i>TIV</i>	<i>VIX</i>	<i>EPU</i>
	(1)	(2)	(3)	(4)
<i>Constant</i>	1.079*** (0.000)	0.734*** (0.000)	−0.315*** (0.003)	0.956*** (0.000)
<i>S_{BRW}</i>	−1.334*** (0.000)	−0.946*** (0.001)	−0.645** (0.011)	−0.946*** (0.000)
<i>Evaluation</i>				
<i>Uncertainty_{Q2}</i>	−1.311*** (0.000)	−0.088 (0.631)	0.854*** (0.000)	−0.088*** (0.000)
<i>Uncertainty_{Q3}</i>	−0.737*** (0.000)	−0.396* (0.054)	1.244*** (0.000)	−0.396*** (0.000)
<i>Uncertainty_{Q4}</i>	−0.409* (0.080)	−0.347 (0.135)	1.474*** (0.000)	−0.347*** (0.002)
<i>S_{BRW} × Uncertainty_{Q2}</i>	1.561*** (0.000)	0.039 (0.899)	0.217 (0.518)	0.039*** (0.002)
<i>S_{BRW} × Uncertainty_{Q3}</i>	0.656** (0.014)	0.099 (0.773)	−0.346 (0.357)	0.099*** (0.051)
<i>S_{BRW} × Uncertainty_{Q4}</i>	0.196 (0.534)	0.111 (0.792)	−0.641** (0.083)	0.111 (0.167)
Observations	237,283	202,061	230,023	202,061
R ²	0.007	0.005	0.010	0.005

Table 8: The impact of monetary policy and market uncertainty.

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 42 futures to monetary policy surprises for various levels of monetary policy uncertainty. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (S_{BRW}) that equals one for positive values indicating contractionary policy surprise. Uncertainty measured are the news-based monetary policy uncertainty of Husted et al. (2020), the market based monetary policy uncertainty of Choi et al. (2017), the VIX and the economic policy uncertainty index. Q2/Q3/Q4 corresponds to the second, third and fourth quartile of the monetary policy uncertainty distribution in the sample period. The sample period starts in January 1994 and ends in July 2019. * *, * and * indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.

5.4 Predictability of monetary policy shocks

Recent studies on the transmission of monetary policy emphasise the importance of policy shocks predictability ²³. M. D. Bauer & Swanson (2020) shows that monetary policy shocks

²³Bu et al. (2021) and M. D. Bauer & Swanson (2020) among others.

of Nakamura & Steinsson (2018) are predictable, and therefore the surprise effect on FOMC announcement days is caused by the ‘Fed response to news effect’. In other words, the FOMC and market participants dispose of the same information, but investors cannot estimate the reaction of the Federal Reserve given the economic outlook.

	<i>Dependent variables:</i>			
	<i>BRW</i>	<i>SS_{FR}</i>	<i>NS_{information}</i>	<i>Kuttner</i>
	(1)	(2)	(3)	(4)
<i>ADS</i>	−0.025** (0.018)	−0.233* (0.159)	−0.003 (0.699)	−1.052 (0.315)
<i>Brave</i>	0.006 (0.168)	0.012 (0.787)	−0.001 (0.584)	−0.099 (0.803)
$\Delta Nonfarm$	−0.00001 (0.500)	−0.001** (0.021)	−0.00001 (0.562)	−0.004* (0.098)
<i>GDP₁</i>	0.007** (0.022)	0.175*** (0.005)	0.015*** (0.000)	1.238*** (0.008)
<i>CPI</i>	0.003* (0.051)	−0.046** (0.029)	−0.004** (0.016)	−0.344** (0.020)
<i>Unemp sentiment₂</i>	−0.0001 (0.638)	−0.001 (0.693)	−0.0003 (0.135)	−0.006 (0.791)
<i>Investors sentiment</i>	0.030* (0.061)	0.246 (0.313)	0.024* (0.052)	0.812 (0.685)
$\Delta S\&P500$	0.00000 (0.230)	0.001 (0.283)	−0.00002 (0.646)	0.001 (0.857)
Observations	202	202	196	202

Table 9: Predictability of monetary policy shocks.

Note. Estimated coefficients β from equation 2, where $news_t$ denotes the following variables. The Brave et al. (2019) business cycle index (*Brave*) and the Aruoba et al. (2009) business condition index (*ADS*). The $\Delta Nonfarm$ denotes monthly changes in the Nonfarm payrolls. *GDP₁* and *CPI* are the forecasts of the next quarter real GDP growth and consumer price index from the Survey of Professional Forecasters (Federal Reserve Bank of Philadelphia). *Unemp sentiment* reports consumers estimate about how unemployment will evolve in the upcoming year (Michigan Survey of Consumers). *Investors sentiment* refers to investors sentiment about how the stock will be in the following 6 months (American Association of Individual Investors). $\Delta S\&P500$ reports the monthly changes in the S&P500. mps_t includes the BRW shocks of Bu et al. (2021), the target rate shocks of Swanson (2006), the policy shocks of Kuttner (2001), the information effect shock of Nakamura & Steinsson (2018). The sample period starts in January 1994 and ends in July 2019. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. P-values are reported in parenthesis.

In my research, I documented that on average market participants are able to foresee at least target rate shocks, since the return drift begins 7 days before the announcement and continues in

the same direction 15 days afterwards, illustrated in figure 1. Consequently, market participants must be able to estimate the reaction of the Federal Reserve, and only the magnitude of target rate, large-scale asset purchase change or the communication in press conferences causes the dissent in trading activities.

To test the predictability of monetary policy shocks by estimating the OLS regression of equation 2. The results shown in table 9 clearly illustrate that the applied high-frequency shocks are predictable mostly by investors sentiment, real GDP growth, and CPI forecasts.

To test the out-of-sample performance of the forecasts and macroeconomic indicators, I apply the Diebold & Mariano (2002) test and compare the equal predictive accuracy of the regression model with the naïve and exponentially weighted moving average forecasts in the case of the BRW shock that I used throughout the empirical analysis. Taking the last 40 observations in the test set to estimate the following monetary policy shock with the regression described by equation 2 ²⁴.

Table 10 displays the p-value of the equal predictive accuracy test. The results suggest that the estimated regression model has better predictive accuracy, at 1% significance level.

	Naïve	$EWMA_4$
p-value	0.000	0.010

Table 10: Diebold-Mariano test test for equal predictive accuracy.

Note. The table reports the results of the Diebold-Mariano test for equal predictive accuracy estimated for the monetary policy shock series of Bu et al. (2021) The Naïve forecasts the previous value for each time. The exponentially weighted moving average weights the last $n = 4$ observations with $\frac{0.2^i}{\sum_{j=1}^4 0.2^j}$ $\forall i = 1, 2, 3, 4$ in decreasing order. The sample period starts in January 1994 and ends in July 2019.

Concluding that monetary policy shocks and their sign is predictable by forecasts and macroeconomic indicators available before the announcements provides an intuitive explanation for the significant pre-announcement drift. Market participants are able to approximate monetary policy decisions; however, the communication of the FOMC, forward guidance or the magnitude of target rate decision leads them to update their information about monetary policy decisions and economic outlook. Leombroni et al. (2021) documents a similar phenomenon in the case of the European Central Bank press conferences. The communication of the central bank has a similar impact to policy shocks not only in the case of press conferences following policy decisions but generally when the ECB president gives speeches.

²⁴Kroencke et al. (2021) estimates the rolling window regression with the last 40 observations of the scheduled FOMC announcement that correspond to roughly 5 years. For consistency, I use the same window both in the rolling window regression and in the predictability test.

6 Robustness check

6.1 Monetary policy shocks

In the empirical analysis, it was tested in subsamples, asset classes, and control variables that there is a significant return drift around scheduled FOMC decisions conditional on the sign of monetary policy shocks that is approximately 1.5%. In this section, I explore whether the choice of monetary policy shocks changes the results and estimate equation 1 with conventional, unconventional and even expected policy shocks calculated with different methodologies. In alignment with the previous analysis, the bond market is excluded due to its contrary response to policy shocks.

Table 11 illustrates the results. Columns 1 and 2 explore the expected and unexpected components of monetary policy and show that returns are even more responsive to policy shocks of Kuttner (2001) with an almost 2% difference in return drift. A possible explanation is that these policy surprises have no value in the zero lower bound period when financial markets did not fluctuate substantially ²⁵. Disregarding the zero lower bound period could be perceived as a complement to the robustness check in excluding the financial crisis.

In columns 3 to 5 the different tools of monetary policy are investigated with the surprise series of Swanson (2021a). In accordance with existing literature, target rate shocks lead to a significant return drift both expansionary and contractionary ²⁶, while unconventional policy shocks seem to have no impact in the 30-day event window.

Neuhierl & Weber (2021) argued that forward guidance policy surprises describing future commitments of the Federal Reserve are not predictable and therefore they trigger no return drift prior to announcements. Nevertheless, this does not provide an explanation for the absence of a return drift in the 30-day event window. Even if policy shocks led to no pre-announcement drift, the post-announcement drift could still be significant as it is the case of information effect shocks illustrated in appendix A. Furthermore, Bu et al. (2021) explored the predictability of monetary policy shocks and found that the Brave et al. (2019) business condition index and Blue Chip forecast revisions predict the forward guidance shocks of Swanson (2021a). A possible explanation could be that as both forward guidance and large-scale asset purchase are calculated

²⁵Monetary policy shocks of Kuttner (2001) is estimated from the current-month federal funds futures. Prices are quoted as the average daily federal funds rate subtracted from 100. Therefore, in the effective lower period, these policy shocks do not vary. The unexpected component of the Kuttner (2001) shocks is the target rate minus the unexpected component.

²⁶Neuhierl & Weber (2018), Swanson (2021a), Mueller et al. (2017) among others.

as the second and third principal components of asset prices movements around FOMC decisions, they might capture additional impacts of monetary policy. For instance, identifying assumption of LSAP factor is to be as small as possible in the pre-crisis period however, the shocks are still indifferent from zero when there was no announcement of bond purchase.

	<i>Dependent variable: 30-day cumulative returns</i>					
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Constant</i>	0.786*** (0.000)	−1.126*** (0.000)	0.954*** (0.000)	0.416*** (0.000)	0.252*** (0.000)	0.821*** (0.000)
<i>Kuttner</i>	−1.931*** (0.000)					
<i>Expected</i>		1.881*** (0.000)				
<i>SS_{FFR}</i>			−0.750** (0.012)			
<i>SS_{FG}</i>				−0.124 (0.530)		
<i>SS_{LSAP}</i>					0.203 (0.288)	
<i>NS_{information}</i>						−0.680*** (0.003)
Observations	6,973	6,973	6,973	6,973	6,775	6,775
R ²	0.008	0.008	0.001	0.0001	0.0001	0.001

Table 11: Monetary policy shocks robustness test

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 42 futures to different monetary policy surprises. *Kuttner* and *Expected* shocks are the unexpected and expected monetary policy shocks of Kuttner (2001). *SS_{FFR}* captures fed funds target rate, *SS_{FG}* the forward guidance and *SS_{LSAP}* the large-scale asset purchase shocks of Swanson (2021a). *NS_{info}* denotes the information shock of Nakamura & Steinsson (2018). The sample period starts in January 1994 and ends in July 2019. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis

The information effect refers to the FOMC communicating not only the target rate decision but also its private information about the economic outlook on the announcement day, leading the private sector to update their estimation about economic fundamentals. The effect might lead to a positive co-movement between the stock market and interest rates Jarociński & Karadi (2020). Column 6 illustrates that the analysed futures respond similarly to information effect shock although with the smallest difference in return drift, only 0.68%.

Table E1 in the appendix shows that in the case of monetary policy surprises affecting significantly returns in the 30-day event window, the monetary policy uncertainty measure is also significant and decreases the impact of policy shocks, as noted earlier. This disproves the

critique of Swanson (2021b) who concluded that the impact of monetary policy uncertainty is sensitive to the measurement of monetary policy shocks.

6.2 Rolling window

For the most part of the analysis, the sample period was split before and following the global financial crisis, but the main results did not seem to vary significantly. To confirm these results, a rolling window regression is estimated with equation 1 using the past 40 scheduled announcements that correspond to a rolling window of 5 years ²⁷.

Figure 3 illustrates the impact of policy shocks on futures returns in basis points with the red dashed line indicating the p-value of the estimated coefficient. A liftoff can be noted before the global financial crisis however, following policy shocks continued to have a significant impact on financial markets. Notably, in the zero lower bound period, monetary policy remained as effective as in normal times, as indicated before by J. C. Wu & Xia (2016) and Swanson (2018) among others. In contrast, following the zero lower bound liftoff in December 2015, the effect of policy shocks on financial markets seemed to disappear.

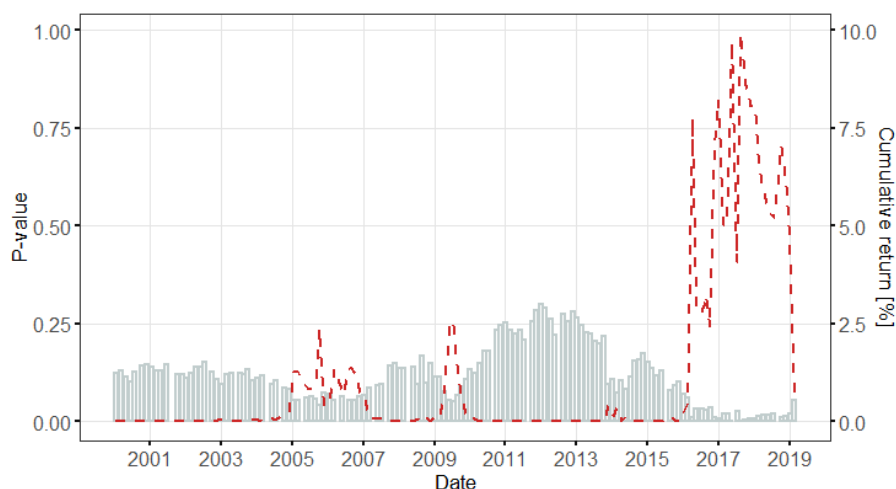


Figure 3: Rolling window estimates of 30-day cumulative returns.

Note. The figure illustrates the average cumulative returns of the 42 futures from 3 asset classes around scheduled FOMC decisions. The rolling window includes the last 40 observations (last five years). The azure bar graph indicates the coefficient of the Bu et al. (2021) policy shocks estimated from equation 1. The dashed red line illustrates the p-value of the coefficient for each estimate. The sample period starts in January 1994 and ends in July 2019.

A possible explanation could be a change in monetary policy. Kurov et al. (2021) noted that pre-announcement return drifts only persisted in monetary policy announcements with press

²⁷Kroencke et al. (2021) applied the same event window in analysing the response of financial markets to monetary policy shocks.

conferences, as financial markets paid close attention to the forward guidance and information effect of the FOMC ²⁸. Nevertheless, since the initiation of press conferences in April 2011 the impact of policy shocks on financial markets did not decrease. Henceforth, the return drift prior to FOMC announcements did not terminate in 2015 but presumably weakened due to a factor that significantly affects the transmission of policy shocks.

Kurov & Stan (2018) argued that the fading pre-announcement return drift following the ZLB liftoff is due to reduced market uncertainty as measured by the VIX. In the same way, figure 3 could depict a temporary decrease in the VIX. As noted earlier, in the lower quartiles of the VIX monetary momentum is insignificant while in the upper quartile the difference between expansionary and contractionary shocks doubles.

In conclusion, the significant response of the financial market to monetary policy surprises remained consistent until December 2015. Following the zero lower bound liftoff its impact weakened but did not terminate. Possible explanation for this change is decreased market uncertainty.

7 Conclusion

I analysed monetary momentum, which is a return drift starting 15 days before scheduled FOMC announcements and continuing 15 days afterwards documented by Neuhierl & Weber (2021). In line with existing literature, commodity, equity futures and currency forwards returns increase around expansionary and decrease in the presence of contractionary monetary policy surprises. The largest difference between the returns for tightening and loosening shocks is experienced in the commodity market with an average 3% cumulative returns before the financial crisis and 1.89% between 1994 and 2019. The bond market is an exception, with decreasing returns following an expansionary shock.

Results remain unchanged for different measures of monetary policy surprises including target rate, expected, and information effect. Similarly, the impact of policy shocks does not disappear after controlling for macroeconomic announcements and business cycle fluctuations, although the latter decreases returns in the period of severe economic downturn.

In the case of the three asset classes that show similar return patterns, news-based monetary

²⁸Pre-announcement return drift was documented by Lucca & Moench (2015) in the case of the S&P500 24-hours prior to scheduled FOMC announcements. It is a return drift that is unconditional on the sign of monetary policy shocks, and its average magnitude was 49 basis points between 1994-2011.

policy uncertainty decreases the transmission of policy shocks, and market uncertainty enhances its impact. Therefore, the insignificant response of returns in the zero lower bound liftoff period is attributed to the decreased market uncertainty as measured by the VIX.

To provide an explanation for the significant pre-announcement return drift, I show that monetary policy shocks are predictable by publicly available information prior to the FOMC announcements, such as macroeconomic forecasts.

An interesting avenue for future research is to analyse the joint impact of the Federal Reserve and the European Central Bank. Lately, the Federal Reserve also began holding press conferences that the ECB held since its establishment. With the help of textual analysis, not only the spillover effect of the two central banks could be estimated, but also their response to each others policy and their common forward guidance could be analysed.

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A Futures cumulative return drift

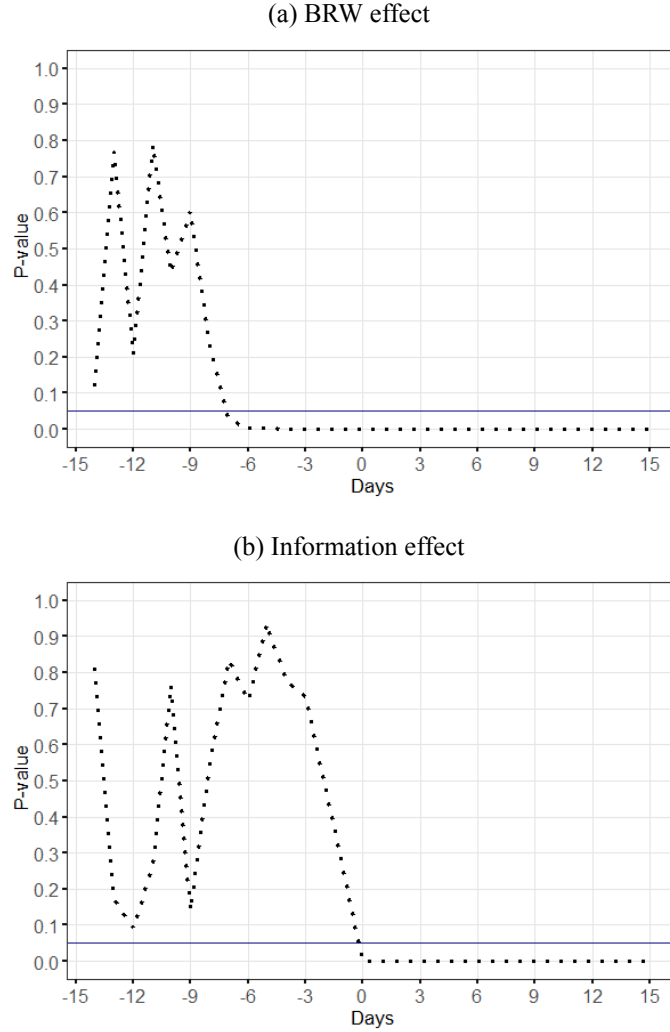


Figure A1: Wilcoxon rank-sum test.

Note. The figure illustrates results of the Wilcoxon Rank-Sum Test for target rate effect as measured by the shock series of Bu et al. (2021) and the information effect estimated by Nakamura & Steinsson (2018). The variables for each point t are the logarithmic returns cumulated in a 30-day event window, starting 15 days before the scheduled announcement: $r_{t,t+s}$ with $s = 1, 2, 3, \dots, 30$. The sample period starts in 1994 and ends in 2019.

B Model selection

Addressing the concern of arbitrary model selection, this section provides the results of statistical tests supporting the choice of the fixed effect model and robust standard errors.

Huang et al. (2020) argued that pooled panel regression model cannot be implemented in the data analysed by Moskowitz et al. (2012) since a common intercept would give a biased estimate of the slope. They specified the following equation to highlight the potential fixed

effect in pooled panel regression:

$$y_{it} = \alpha + \beta_{it}X_{it} + \mu_i + \nu_{it} \quad (4)$$

Additional assumptions of the pooled OLS panel regression is that:

$$\begin{aligned} \mu_i &= 0, \forall i = 1, \dots, N \\ \mathbf{E}(X_{it} \nu_{it}) &= 0, \forall t = 1, \dots, T \end{aligned}$$

If the variable μ_i is omitted from the model, the estimation of β will be inconsistent. The bias in the estimation of β is proportional to the covariance between the explanatory variables X_{it} and the omitted variable μ_i :

$$\hat{\beta} = \beta + \frac{\text{Covariance}(X_{it}, \mu_i)}{\text{Variance}(X_{it})} \quad (5)$$

Therefore, Huang et al. (2020) argue that if assets have the same mean, the term μ_i will be zero and the estimate of β will be unbiased. In my research opt for the same specification and test for the equal mean of the 55 assets with the following three test: I apply the analysis of variance (ANOVA) that assumes homoscedasticity and normality of the data. To relax the assumption of equal variance, I apply the Welch (1951) ANOVA test and lastly I also test equal mean returns with the non-parametric Kruskal & Wallis (1952) test. Table B1 suggests different results for the 3 tests.

	ANOVA	Welch's ANOVA	Kruskal-Wallis
p-value	0.2294	0.9855	2.17×10^{-14}

Table B1: Test for poolability.

To verify the assumptions behind the tests and decide about equal mean returns of the 55 futures I test for homoscedasticity and normality of the daily returns. Table B2 shows that based on the Levene's test returns do not have equal variance; therefore, the assumptions of the ANOVA test do not hold. Furthermore, with the Jarque-Bera and Pearson chi-square test the assumption of normality can be rejected. Concluding that based on the Kruskal-Wallis test assets do not have equal mean and applying pooled panel regression would lead to biased estimated. Therefore, I apply an unobserved effect panel model in the analysis.

	Jarque Bera Test	Pearson Chi-Square	Levene's
p-value	2.2×10^{-16}	2.2×10^{-16}	2.2×10^{-16}

Table B2: Test for normality and homoscedasticity.

To select the appropriate model, I estimate whether the individual-specific effect (μ_i) is unrelated to the explanatory variable:

$$\mathbf{E}(\mu_i|X_{it}) = 0, \forall t = 1, \dots, T \quad (6)$$

In this case, the individual-specific effect is a random variable, in other words it is uncorrelated with the explanatory variable. If they are correlated, the fixed effect model has to be implemented. To test for this, I apply the Durbin-Wu-Hausman test however, it assumes homoscedasticity. Therefore, I apply auxiliary regression and use standard errors that allow for heteroscedasticity and serial correlation in the standard errors (Wooldridge, 2010).

$$y_{it} = \alpha + \beta X_{it} + \mu_i + \lambda \hat{x}_{it} + u_{it}, \quad (7)$$

where $\hat{x}_{it}$ denotes the time-averages of the regressors and I test for $H_0 : \lambda = 0$. Table B3 shows that the null hypothesis can be rejected; therefore, I apply fixed effect panel model.

statistic	p-value	parameter	method	alternative
30.355	3.597×10^{-8}	1	Hausman test	one model is inconsistent

Table B3: Test for orthogonality of the individual-specific effect and the explanatory variables.

Afterwards, I test for homoscedasticity and autocorrelation in the error term to specify the model robust standard errors and obtain reliable results. First, I run the Breusch-Pagan test that estimates a second regression model for the residuals of the fixed panel regression model, thus testing for heteroscedasticity. The Koenker & Bassett (1982) studentized version is applied since it does not assume normality of the error terms and has the same limiting distribution as the Breusch-Pagan statistic.

statistic	p-value	paramter	method
137.2826	5.6×10^{-9}	55	studentized Breusch-Pagan test

Table B4: Breusch-Pagan test for homoscedasticity.

Table B4 shows that the null hypothesis of homoscedasticity can be rejected; therefore, I use robust standard errors. Lastly, I test for serial correlation in the error terms with the Breusch-Godfrey test. The null-hypothesis is rejected based on the results of table B5.

statistic	p-value	paramter	method	alternative
449	2.2×10^{-16}	109	Breusch-Godfrey test	serial correlation in idiosyncratic errors

Table B5: Breusch-Godfrey/Wooldridge test for serial autocorrelation in idiosyncratic component of errors.

Throughout the analysis, the robust standard errors are calculated with the methodology of Arellano et al. (1987) that estimates cluster standard errors, allowing for serial autocorrelation and heteroscedasticity in fixed effect panel models. Cluster bootstrap could be an alternative method to estimate standard errors.

C Return drift in the 2-and 10-day event window

	<i>Dependent variables:</i>	
	2-day returns	10-day returns
	(1)	(2)
<i>Constant</i>	0.220*** (0.001)	0.406*** (0.001)
<i>S_{BRW}</i>	−0.415*** (0.000)	−0.642*** (0.000)
<i>MPU</i>	−0.0003 (0.591)	0.001 (0.628)
<i>S_{BRW} × MPU</i>	0.002* (0.089)	−0.001* (0.075)
Observations	10,638	10,550
R ²	0.004	0.009

Table C1: Cumulative returns around FOMC decisions in 2- and 10-day event windows

Note. Reported coefficients denote the 2- and 10-day response around scheduled FOMC announcements of the 55 futures to monetary policy surprises and monetary policy uncertainty. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (S_{BRW}) that equals one for positive values indicating contractionary policy surprise. MPU refers to the news-based monetary policy uncertainty measure of Husted et al. (2020). The sample period starts in January 1994 and ends in July 2019. * * *, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.

D Futures return drift excluding the global financial crisis

This appendix provides further details on the impact of monetary policy shocks, uncertainty on all assets discussed in section 5.

The National Bureau of Economic Research based Recession Indicators for the United States indicates that the global financial crisis led to a recession in the United States between January 2008 until June 2009. The sample period of table D1 excludes this time for robustness check.

	Dependent variable: 30-day cumulative returns	
	(1)	(2)
<i>Constant</i>	0.939*** (0.000)	1.519*** (0.000)
<i>S_{BRW}</i>	-1.019*** (0.000)	-1.744*** (0.000)
<i>MPU</i>		-0.005*** (0.006)
<i>S_{BRW} × MPU</i>		0.007** (0.016)
Observations	8,427	8,427
R ²	0.005	0.006

Table D1: Cumulative returns around FOMC decisions excluding the global financial crisis.

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 55 futures to monetary policy surprises and monetary policy uncertainty. Monetary policy shocks are measured by the series of Bu et al. (2021) and converted to a dummy variable (*S_{BRW}*) that equals one for positive values indicating contractionary policy surprise. *MPU* refers to the news-based monetary policy uncertainty measure of Husted et al. (2020). The sample period starts in January 1994 and ends in July 2019, excluding the global financial crisis between January 2008 to June 2009. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-value are reported in parenthesis.

E Robustness check

In this section, equation 1 is re-estimated by augmenting the panel regression of table 11 in section 6 with the news-based monetary policy uncertainty measure.

	Dependent variable: 30-day cumulative returns					
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Kuttner</i>	−4.483*** (0.000)					
<i>Expected</i>		4.229*** (0.000)				
<i>SS_{FFR}</i>			−0.094 (0.857)			
<i>SS_{fguidance}</i>				−0.867* (0.097)		
<i>SS_{LSAP}</i>					1.374*** (0.008)	
<i>NS_{information}</i>						−1.869*** (0.001)
<i>MPU</i>	−0.004 (0.102)	0.015*** (0.001)	−0.010 (0.116)	0.011*** (0.002)	0.002 (0.056)	−0.009*** (0.008)
<i>MPU × Kuttner</i>	0.021*** (0.000)					
<i>MPU × Expected</i>		−0.020*** (0.0002)				
<i>MPU × SS_{FFR}</i>			0.009 (0.184)			
<i>MPU × SS_{fguidance}</i>				−0.005 (0.308)		
<i>MPU × SS_{LSAP}</i>					−0.011** (0.013)	
<i>MPU × NS_{information}</i>						0.011** p = 0.017
Observations	6,973	6,973	6,973	6,973	6,775	6,775
R ²	0.011	0.010	0.002	0.001	0.001	0.002

Table E1: Monetary policy shocks robustness check with monetary policy uncertainty.

Note. Reported coefficients denote the 30-day response around scheduled FOMC announcements of the 42 futures to different monetary policy surprises. *Kuttner* and *Expected* shocks are the unexpected and expected monetary policy shocks of Kuttner (2001). *SS_{FFR}* captures fed funds target rate, *SS_{FG}* the forward guidance and *SS_{LSAP}* the large-scale asset purchase shocks of Swanson (2021a). *NS_{info}* denotes the information shock of Nakamura & Steinsson (2018). The interaction term with the Husted et al. (2020) monetary policy uncertainty is also reported. The sample period starts in January 1994 and ends in July 2019. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The cluster-robust standard errors are calculated according to the method of Arellano et al. (1987). Standard errors are clustered by instruments. P-values are reported in parenthesis.