Monetary policy and stock returns beyond FOMC days

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Abstract

We investigate the effect of monetary policy on stock market returns while allowing monetary policy to respond to stock prices by incorporating information beyond FOMC announcement days. Our inferential method exploits shifts in the volatilities of equity returns and interest rate shocks to disentangle both effects without imposing restrictive assumptions previously used in the literature. We find dramatic changes in the relationship between monetary policy and equity returns before, during, and after the effective lower bound (ELB) periods. An increase in stock returns triggers a rise in the policy rate only before the ELB period. Regarding the stock market response to monetary policy, the rise in the policy rate decreases stock returns only before the ELB period. However, since then, a rate hike increases stock market returns, which is explained by the effect of monetary policy on the expected equity premium.

Keywords: Fed put, monetary policy, asset prices, parameter instability, identification by heteroskedasticity

JEL classification: C12, E44, E52, G10

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1 INTRODUCTION

Much of our understanding of the influence of monetary policy on asset prices is based on observations on days of policy announcements. The effect of monetary policy on asset prices is captured primarily by the unexpected movement in interest rates around the time of the policy announcement, the "event day"; see, for example, Bernanke and Kuttner (2005), Gürkaynak et al. (2005), and Nakamura and Steinsson (2018), among others.

However, since the Federal Open Market Committee (FOMC) increased the transparency in the communication of their decisions, making monetary policy more predictable, monetary shocks on event days became increasingly less informative about the effect of interest rate changes on asset prices; see Gürkaynak et al. (2020) and Boehm and Kroner (2024). Figure 1 shows the unexpected change in the average policy rate in a given month,[1] highlighting the three changes in the communication of FOMC decisions: the release of an immediate announcement after the decision in 1994, the introduction of a statement providing the rationale for the decision, and the introduction of press conferences in 2011.

With a more predictable monetary policy, it becomes harder to identify the effect of monetary policy shocks on stock market returns using data limited to policy announcement days.[2] Consequently, a growing literature seeks to incorporate information outside the announcement days. For example, Bianchi et al. (2024) argue that " investor beliefs about the probability of a regime change in the Fed's policy rule continuously evolve *outside* of tight windows surrounding policy announcements. Indeed, most of the variation in investor beliefs about the future conduct of monetary policy occurs at times over the sample that are not temporally close to an FOMC announcement, indicating that the causal effect of central bank policy (...) is substantially more far

[1] Following Piazzesi and Swanson (2008), the unexpected change is the risk-adjusted excess return from buying the fed funds future at the beginning of the month and selling it at the end of the month.

[2] Relying exclusively on information during policy announcement days poses other challenges. For example, Savor and Wilson (2013), Lucca and Moench (2015), and Illeditsch et al. (2020) point to an increased risk premium that creates excess returns on policy announcement days, *regardless* of the monetary decision. Piazzesi and Swanson (2008) and Neuhierl and Weber (2021) find that surprises on event days are predictable, which violates the efficient market hypothesis that underpins event-study identification.

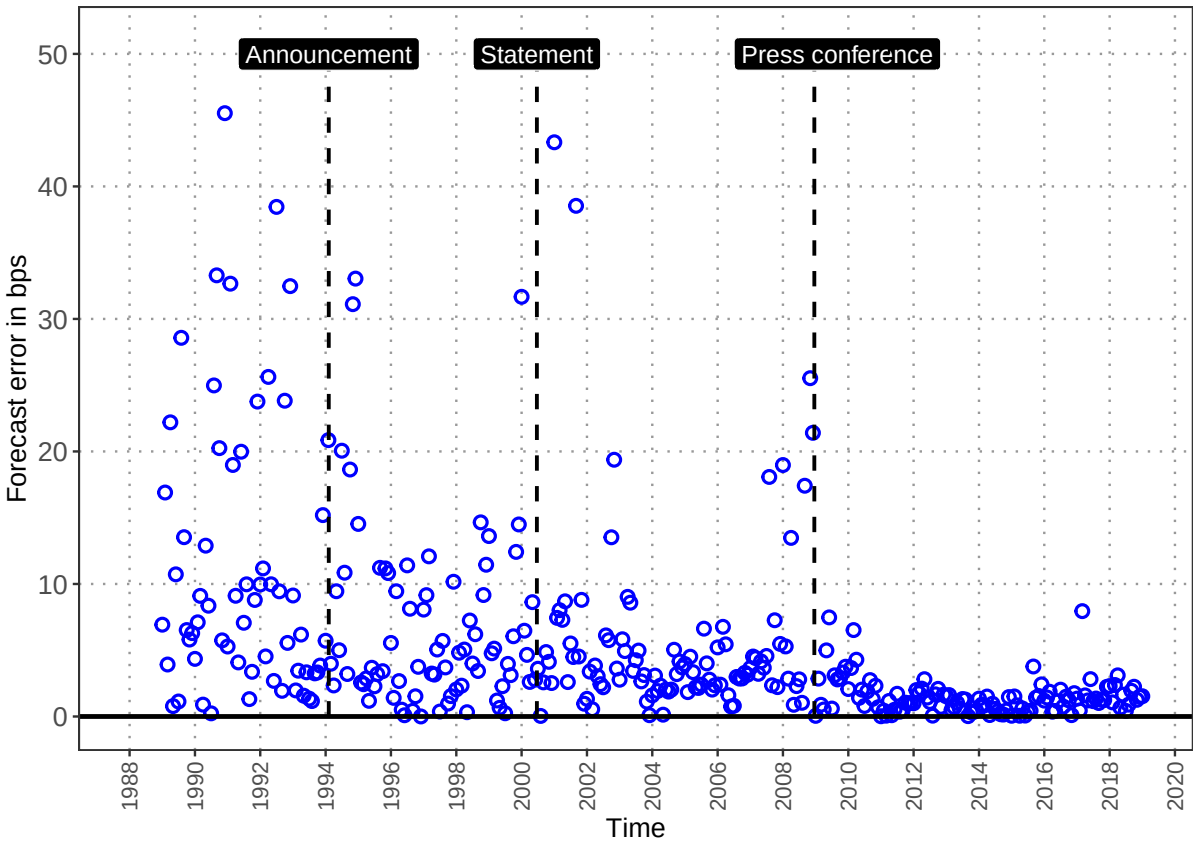


Figure 1: ERRORS IN FORECASTING MONETARY POLICY. The absolute value of the forecast error of the monthly average effective fed funds rate by the fed funds futures market. Forecast errors are risk-adjusted excess returns following Piazzesi and Swanson (2008).

reaching than what can be observed from market reactions in tight windows surrounding Fed communications" (emphasis is theirs). Similarly, Neuhierl and Weber (2019) and Cieslak et al. (2019) highlight that non-announcement days contain relevant information to estimate the impact of monetary policy on long-term yields or stock prices; also see Lucca and Moench (2015), Thornton (2017), and Lewis (2023). Even when FOMC decisions may not react to stock prices on the same day, market expectations of these decisions are formed continuously.[3]

We contribute to the literature on understanding the effect of monetary policy on stock market returns while allowing monetary policy to react to stock prices, incorporating information beyond the announcement days, and thereby capturing the continuous

[3]See, for example, Chair Jerome Powell's Press Conference on September 21, 2022: "Financial conditions have usually been affected well before we actually announce our decisions. Then, changes in financial conditions begin to affect economic activity... within a few months".

influence of monetary policy on stock prices and vice versa. Our empirical findings are based on an inferential method that explores changes over time in the volatilities of the structural shocks to monetary policy and stock market returns, using daily trading data from January 1989 to March 2020, thus covering the effective lower bound period (ELB) of the nominal interest rate and ending before COVID-19. We document that the policy–equity relationship evolves over time, so we estimate results separately for the pre-ELB, ELB, and post-ELB periods. Our main findings are:

(i) Before the ELB period, between 1989 and 2008, we find that the FOMC increases the policy rate by 0.6bps when stock returns increase by 1% and that an unexpected increase of 100bps in the policy rate reduces stock prices by 5%.

(ii) During the ELB period, however, the relationship between monetary policy and stock returns has completely changed: the FOMC is *not* reacting to increments in stock returns, and a rise in the policy rate increases stock returns.

(iii) Even after 2015 with the normalisation of monetary policy, the response of the policy rate to equity returns is close to zero, and a rise in the policy rate increases stock returns.

Our results remain robust after controlling for the release of macroeconomic news, such as unemployment and industrial production, intraday monetary surprises (as in the event study literature), and other extensions to the baseline specification.

To understand the potential channel through which monetary policy influences stock returns, we investigate the contemporaneous response of the expected equity premium to the policy rate. We find that before the ELB, a policy rate hike of 100bps raises the expected equity premium by 2% thus depressing current returns. This result agrees with theoretical models such as Pflueger and Rinaldi (2022), which predict that an interest rate hike reduces consumption relative to the subsistence level, making investors more risk-averse and driving up the equity premium. In contrast, after the ELB period, we find that a rise in the policy rate reduces the expected equity premium, driving up stock returns.

For our empirical investigation, we assume that interest rates and stock returns co-move according to a structural VAR (SVAR) model, which allows us to derive moment conditions linking reduced-form and structural parameters. We then apply the stability restrictions method proposed by Magnusson and Mavroeidis (2014) to obtain confidence sets for the stock return response to monetary policy and for the FOMC's response to stock returns. To identify the responses, we exploit exogenous shifts in the volatility of the structural shocks. These shifts could be driven, for example, by changes in the information flow to the market over time.[4] The approach is similar to the identification via heteroskedasticity literature pioneered by Rigobon (2003). However, unlike this literature, we do not specify the dates of volatility shifts, as in Rigobon and Sack (2004) and Kurov et al. (2022), nor do we limit the observations to policy announcement days, nor do we assume a parametric form for the volatility shifts. Our method is also robust to weak identification, an empirically relevant problem when using heteroskedasticity to estimate structural parameters, as demonstrated by Lewis (2022).

Our results complement Bianchi et al. (2024), who emphasize that the expectation of changes in the monetary policy rule drives asset returns. We find that the FOMC's response to stock returns has declined over time, consistent with the results in Aastveit et al. (2023). A 10% fall in stock returns implies about a 20bps rate cut in the 1990s, but a near-zero response since the ELB period.

Regarding the period before the ELB, our results align with most of the literature, but the FOMC's response to stock returns is smaller, around a third of the value reported by Rigobon and Sack (2003) and a quarter of that reported by Bjørnland and Leitemo (2009), yet still positive, suggesting a "Fed put" during this period (Cieslak & Vissing-Jorgensen, 2020). Since the ELB period, our results differ considerably. While Kurov and Gu (2016), Gu et al. (2018), and Nakamura and Steinsson (2018) find a positive reaction of stock returns to a rate cut, we find that the response of the stock market takes the opposite direction compared to the pre-ELB period. Considering the January 2015 to March 2020 period, a 100bps rate hike *increases* stock returns by about 9%. This reaction of stock

[4]See Ross (1989) and Veronesi (1999) for theoretical models linking the information flow to stock market volatility.

prices to monetary policy undermines the applicability of a "leaning-against-the-wind" policy during this period.

Our finding that stock returns rise following a rate hike since the ELB is in line with the empirical evidence by Galí and Gambetti (2015). Galí (2014) explains this in a theoretical model with a constant equity premium, where stock returns increase in response to a rate hike when stock prices contain a rational bubble component, that is, a non-fundamental component that still satisfies investors' no-arbitrage conditions, and whose value can move in ways that offset the usual discount-rate channel. A second explanation is the Fed information effect (Nakamura & Steinsson, 2018): a rate hike may reveal favourable central-bank private information about output growth, raising expected cash flows and stock prices. In our setting, this channel is less likely to dominate because the positive stock-price response is concentrated in the post-2015 period, when FOMC communication is more transparent and thus less likely to convey incremental private information. Consistent with this interpretation, Hoesch et al. (2023) find that information shocks have become quantitatively smaller since 2008. Our evidence, however, points to an alternative mechanism: policy tightening lowers the expected equity premium, which offsets the negative effects of higher discount rates and lower expected dividends, producing a positive return response on impact.

The next section presents the underlying structural model that captures the relationship between monetary policy and equity returns. Section 3 derives a moment condition from the structural model, specifies our identification strategy relying on Magnusson and Mavroeidis's method, and describes the empirical model and the data. The main empirical results are in Section 4, which are followed by the robustness check in Section 4.2. We show that the effect of monetary policy on the expected equity premium has flipped sign since the ELB period in Section 5. We compare our findings with the literature in Section 6. The algorithm for estimating the confidence sets and detailed information about the data are provided in the Supplementary Material that accompanies this work.

2 THE RELATIONSHIP BETWEEN MONETARY POLICY AND STOCK PRICES

Monetary policy influences economic variables through the interest rate channel. A change in the stance of monetary policy leads to a change in market interest rates, which, in turn, affects real economic activity, altering the cost of capital for investors and firms' future earnings and expected dividends, see Thorbercke (1997) and Bernanke and Kuttner (2005). On the other hand, fluctuations in stock market prices affect aggregate demand through changes in consumption (the wealth effect) and investment (Bjørnland & Leitemo, 2009). Additionally, to fulfill the price stability mandate, the FOMC can target stock prices, in the sense of Christiano et al. (2010), particularly during times of crisis.[5]

Rigobon and Sack (2004), Nakamura and Steinsson (2018), and Kurov et al. (2022) model the joint dynamics of monetary policy changes and stock market returns following a SVAR representation [6]

$$\begin{cases} \Delta i_t = \beta s_t + \varepsilon_{i,t} & \text{(1a)} \\ s_t = \alpha \Delta i_t + \varepsilon_{s,t} & \text{(1b)} \end{cases}$$

where $\varepsilon_{i,t}$ and $\varepsilon_{s,t}$, the shocks of monetary policy and stock market returns are independently distributed and uncorrelated with each other, ensuring that the errors have the required structural interpretation. The parameters α, the stock market's response to changes in monetary policy, and β, the reaction of monetary policy to changes in the value of the stock market, are the coefficients of interest. This model can include lagged values of Δi_t and s_t, as well as other exogenous explanatory variables, suppressed here for ease of exposition.

Equation (1a) is regarded as a high-frequency monetary policy reaction function, resembling a forward-looking Taylor-type rule, as in Arias et al. (2019). The monetary shock

[5] See, for example, Kurov and Gu (2016), who revise FOMC's transcripts during crises with clear references to the stock market.

[6] Rigobon and Sack (2004) also include an unobservable common shock that drives a correlation between shocks of monetary policy and stock returns. We, however, omit this shock for the sake of exposition. Empirically, taking into account the common shock does not change the results, see the Supplementary Material.

$\varepsilon_{i,t}$ captures not only deviations of the policymaker from its underlying monetary policy rule but also changes in the rule itself. The stock market shock $\varepsilon_{s,t}$ comprises changes in risk aversion, technology affecting firms' productivity, and possible non-fundamental price movements like sunspots or rational bubbles.

3 INFERENCE STRATEGY

The reduced form representation of the SVAR (1a - 1b) is

$$\mathbf{y}_t = \mathbf{u}_t \tag{2}$$

where $\mathbf{y}_t = [\Delta i_t : s_t]$, $\mathbf{u}_t = A^{-1}\boldsymbol{\varepsilon}_t$, $A = [1 \quad -\beta : -\alpha \quad 1]$, and $\boldsymbol{\varepsilon}_t = [\varepsilon_{i,t} : \varepsilon_{s,t}]$, with $\mathbb{E}_t[\mathbf{u}_t\mathbf{u}_t'] = \Omega = [\omega_{ii} \quad \omega_{is} : \omega_{si} \quad \omega_{ss}]$, and $\mathbb{E}_t[\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_t'] = \Sigma = [\sigma_{ii} \quad 0 : 0 \quad \sigma_{ss}]$. Since $\Omega = A^{-1}\Sigma A^{-1'}$, we obtain the following map between the estimable and unknown structural parameters.

$$\omega_{ii} + \beta^2\omega_{ss} - 2\beta\omega_{is} - \sigma_{ii} = 0 \tag{3a}$$

$$-\alpha\omega_{ii} - \beta\omega_{ss} + (1 + \alpha\beta)\omega_{is} = 0 \tag{3b}$$

$$\alpha^2\omega_{ii} + \omega_{ss} - 2\alpha\omega_{is} - \sigma_{ss} = 0. \tag{3c}$$

which illustrates that, without additional restrictions, the four structural parameters are not identified by the three (estimable) Ω terms. For example, Bjørnland and Leitemo (2009) considers the restriction that a monetary policy shock has no long-run effect on the level of real stock prices. D'Amico and Farka (2011) and Nakamura and Steinsson (2018) assume that, in tight intervals around the FOMC announcement, stock market shocks do not affect monetary policy ($\beta = 0$).[7] Rigobon (2003) proposes using exogenous shifts that affects only the variance of $\boldsymbol{\varepsilon}_t$ to identify $\boldsymbol{\theta} = [\alpha : \beta]$, which remains constant over time. Rigobon's approach requires knowing when the regime shifts occur, see, for example,

[7] A possible strategy for identifying the structural parameters is the use of the instrumental variables (IV). However, as raised by Rigobon and Sack (2003), no macroeconomic variable is correlated with stock prices but is not correlated with monetary policy decisions, violating the exogeneity condition.

Rigobon and Sack (2003) and Nakamura and Steinsson (2018). However, Lewis (2022) finds evidence of weak identification when using daily data from Nakamura and Steinsson (2018). Our approach circumvents this problem by relying on a weak-identification robust method without assuming the dates of regime shifts.

Following Rigobon (2003), we consider that σ_{ii} and σ_{ss} are potentially time varying, inducing changes ω_{ii}, ω_{ss}, and ω_{is}, but $\boldsymbol{\theta} = [\alpha : \beta]$ remains unchanged over time. From Equation (3b), we define the following moment condition:

$$f_t(\boldsymbol{\theta}) = (1 + \alpha\beta)\omega_{is,t} - \alpha\omega_{i,t} - \beta\omega_{s,t} \tag{4}$$

We focus on this moment condition because the unobservable structural variances σ_{ii} and σ_{ss} are absent.[8] We are interested in inference of the vector of structural parameters $\boldsymbol{\theta}$, which can be done indirectly by investigating if the moment condition (4) is satisfied. Formally, we can test the following null and alternative hypotheses

$$H_0 : \boldsymbol{\theta} = \boldsymbol{\theta}_0 \text{ and } H_a : \boldsymbol{\theta} \neq \boldsymbol{\theta}_0.$$

by verifying if

$$H_0 : \mathbb{E}_{\boldsymbol{\theta}}\left[f_t(\boldsymbol{\theta}_0)\right] = 0 \text{ for all } t \leq T, \text{ and } H_a : \mathbb{E}_{\boldsymbol{\theta}}\left[f_t(\boldsymbol{\theta}_0)\right] \neq 0 \text{ for any } t \leq T. \tag{5}$$

Since the expectation is taken under $\boldsymbol{\theta}$, if the null assumption in (5) is not satisfied for the hypothesized $\boldsymbol{\theta}_0$, then $\boldsymbol{\theta}_0$ cannot be the true value of $\boldsymbol{\theta}$. By collecting all points in the parameter space that do not reject the above null assumption at a 10% (15%) significance level, we construct the 90% (85%) confidence set for $[\alpha, \beta]$. Hypothesis (5) makes clear that the T moment conditions should be satisfied, that is, the moments should be stable over time.

Magnusson and Mavroeidis (2014) propose a test, the qLL-S test, which examines if the T moment conditions are stable over time at the hypothesized value of θ. The rejection

[8] We omit the inclusion of a constant that captures a time-invariant common shock variance as in Rigobon and Sack (2003) and Rigobon and Sack (2004) for ease of exposition.

of the test may indicate that the structural parameters are time-varying or the T moment conditions are not valid in a sample sub-period. For the computation of the qLL-S, it is not assumed that the break dates are known, as in Rigobon and Sack (2003), nor the underlying distribution of $\boldsymbol{u}_t$, as in Lütkepohl and Netšunajev (2017). The test has power against different types of instabilities, such as those modelled by step functions with a finite number of discontinuities, or a smooth deterministic function of time representing transitions between regimes, or instabilities representing a realization of a continuous stochastic process. For each $\boldsymbol{\theta}_0$, we compute the qLL-S and use the critical values as tabulated by Magnusson and Mavroeidis (2014). Details of the procedure are in Section S2 in the Supplementary Material.

A different approach to estimate the reactions is to impose short-run (Galí & Gambetti, 2015), long-run (Bjørnland & Leitemo, 2009), or sign restrictions (Jarociński and Karadi 2020; Breitenlechner et al. 2021). Those restrictions constrain the direction or the magnitude of the central bank's reaction to equity returns, or the response of stock returns to changes in monetary policy. Our approach does not impose such restrictions and, therefore, it is agnostic about the direction and magnitude of the reactions. Being sign-agnostic is useful when discussing a "leaning-against-the-wind" policy which requires that a rise in the policy rate reduces asset prices.

3.1 Baseline specification and variables

The general reduced-form VAR representation obtained from the system (1a-1b) is

$$\mathbf{y}_t = \sum_{j=1}^{p} \Phi_j \mathbf{y}_{t-j} + \Pi \mathbf{x}_t + \mathbf{u}_t \tag{6}$$

The vector $\mathbf{x}_t$ contains a constant and other control variables, which are detailed below. We use daily data on all trading days, which allows incorporating changes in expectations of market participants about monetary policy on days outside the FOMC meetings. Furthermore, the daily frequency better captures the volatility of the shocks, improving the power of the qLL-S test. Detailed information regarding the data is in Section S3 of

the Supplementary Material.

The variable Δi_t is the scaled daily change of the front-month fed funds future contract (the first future contract) except for the ELB period. This contract captures short-term expectations of the monetary policy instrument, the effective Fed funds rate, see Kuttner (2001) and Bernanke and Kuttner (2005).[9] During the ELB period, we consider the first principal component (PCA) of the daily change in 5 future rates as in Nakamura and Steinsson (2018), Lakdawala (2019), and Bauer and Swanson (2020).[10] The stock market return (s_t) is obtained from the S&P500 price index. Both variables, Δi_t and s_t, are measured in basis points.

The set of controls includes one-lagged values of the following variables: the expected equity premium (EEP), the risk-free rate, the Aruoba-Diebold-Scotti economic activity index (simply the ADS index), and the slopes of the yield curve in the Fed funds futures market and US Treasury bonds.

The daily EEP and risk-free rate capture movements in stock market returns that are due to changes in investors' risk aversion that are unrelated to monetary policy. For example, on days of monetary policy announcements, the equity premium could be higher to compensate investors for holding risky assets; see Savor and Wilson (2013), Gürkaynak et al. (2020), and Boehm and Kroner (2021). We follow Martin (2017, eq.15) and Lof (2019, eq.1) to obtain the daily EEP. The risk-free rate is available on the Kenneth French website. The ADS index captures the current state of the economy.

The slope of the fed funds futures market captures forward guidance or the future path of monetary policy (Neuhierl & Weber, 2019). The relation between stock market returns and monetary policy could depend on the expected state of the economy (recession or expansion). Including the slope of US Treasury bonds controls this expectation, given its predictive power for recessions (Estrella and Mishkin, 1998; Bauer and Mertens, 2018).

[9] Gürkaynak et al. (2007) find that the fed funds futures are the best predictor of monetary policy. The settlement price of the fed funds futures contract is the monthly average of the effective Fed funds rate rather than the rate at a specific date. We scale the daily changes in the contract price by using Nakamura and Steinsson's variant of Kuttner (2001) scaling factors. See Supplementary Material, Section S3.2.2, for the detailed description of the adjustment.

[10] The five rates are the front-month fed funds future (appropriately scaled by Kuttner's factor), the next-month fed funds future, and the 3-month eurodollar future at horizons of two, three, and four quarters.

Furthermore, this slope can also control investor sentiment (Kurov, 2010). We use the spread between the 10-year US bond and the 3-month US Treasury bill to obtain the slope of US Treasury bonds.

Additional controls include day-of-the-week dummies, the dummy for the week following the 9/11 terrorist attacks, which controls for the market operational problems that occurred in that week (Sultan, 2011), and the flight-to-safety indicator dummy variable of Baele et al. (2019), which can be interpreted as a common shock moving both returns and the interest rate for reasons other than monetary policy.

Table 1 presents the summary statistics of daily data from January 01, 1989, to March 14, 2020, for the main variables. The sample begins with the availability of fed funds futures rates, the main variable for capturing monetary policy expectations, and ends with the start of the COVID-19 pandemic.

We report the statistics for three subperiods: before ELB (January 01, 1989, to December 15, 2008), during ELB (December 16, 2008, to December 15, 2015), and after ELB (December 16, 2015, to March 14, 2020). As argued by Mavroeidis (2021), the underlying structural VAR may have shifted when transitioning from conventional to unconventional monetary policy periods. When the ELB binds, the transmission mechanism of monetary policy to asset prices changes. For example, the transmission operates via banks' balance-sheet channel (Gertler & Karadi, 2011) or the influence on long-term interest rates (Jones & Kulish, 2013).

The summary illustrates changes in the means and standard deviations of the variables across periods. As expected, we observed a decline in the mean and standard deviation of the Interest rate changes from before to during and after ELB periods. Stock market return jumps considerably from before to after the ELB periods. Fluctuations in the means and standard deviations of the control variables are also noticeable. For example, in the period after the ELB, the sample mean of the expected equity premium (proxied by the VIX) is notably lower than in earlier periods, reflecting a period of calm in financial markets. This low expected equity premium coincides with a rise in stock prices, with the S&P 500 index growing 60% between 2015 and 2020 at the same time that the policy

Variable	Before ELB	During ELB	After ELB
Δ Interest rate (bps)	−0.234	−0.001	−0.066
	(3.784)	(1.807)	(1.559)
S&P 500 return (bps)	2.847	5.507	3.158
	(112.160)	(114.042)	(100.553)
Expected equity premium (bps)	447.708	483.402	257.160
	(463.458)	(457.260)	(278.461)
Flight-to-safety	0.034	0.018	0.010
	(0.182)	(0.134)	(0.101)
ADS index	−0.147	−0.251	−0.186
	(0.610)	(0.792)	(0.806)
Risk-free rate (bps)	1.652	0.019	0.490
	(0.774)	(0.039)	(0.318)
Fed funds futures slope	0.069	0.049	0.043
	(4.381)	(0.690)	(2.217)
US Treasury yield curve slope	1.536	2.503	0.941
	(1.226)	(0.611)	(0.649)
Observations	5011	1762	1067

Table 1: DESCRIPTIVE STATISTICS. Mean and standard deviation (in parentheses) of daily variables before, during, and after ELB periods. bps stands for basis points. The definition of the variables is in the text.

rate went from 0.24% to 2.40%. Therefore, we investigate each subperiod separately.

4 EMPIRICAL FINDINGS

4.1 Baseline specification results

The following results are based on a VAR(5), which corresponds to a one-week trade.[11] To facilitate interpretation of the results, we report $100 \times \beta$, the effect of a one percentage point increase in the interest rate on stock returns. Figure 2 shows the 85% and 90% confidence sets based on the qLL-S test for α and β for three distinct periods between 1989 and 2020, reflecting the monetary policy changes. The grid search is $(\alpha, \beta \times 100) \in [-20, 20] \times [-3, 3]$.

The shape and range of the confidence sets differ considerably across subperiods.

[11] This encompasses the 24 hours pre-FOMC announcement drift documented by Savor and Wilson (2013) and Lucca and Moench (2015), and as large as Neuhierl and Weber (2019) who consider weekly changes in fed funds futures as a predictor of weekly stock returns.

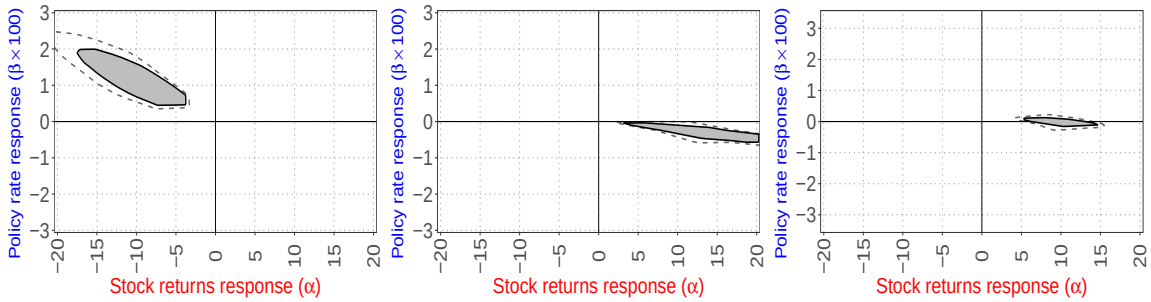
	Before ELB (1989-2008)	During ELB (2008-2015)	After ELB (2015 to 2020-03)
PANEL A. CONFIDENCE SETS			
			
PANEL B. PROJECTED CONFIDENCE INTERVALS			
α	[-17.30, -4.00]	[3.40, 20.00]	[5.60, 14.40]
β	[0.50, 1.95]	[-0.55, -0.05]	[-0.10, 0.10]

Figure 2: Panel A displays the 85% (grey area) and 90% (dashed lined area) qLL-S confidence sets for the reaction of stock returns to monetary policy shock (α) and the reaction of monetary policy to stock returns ($\beta \times 100$). Panel B shows the corresponding projected 85% confidence intervals.

Before the ELB, the confidence set comprises negative values for α and positive values for β, meaning that a tightening of monetary policy depresses stock returns, and a surge in stock returns increases the policy rate. Based on the range of the 85% confidence set, the stock returns would drop between -4% and -17.3% with an unexpected increase of 100 bps in the policy rate, while the response of the policy rate to a one-day surge in stock prices of 1% ranges between 0.5 bps and 1.95 bps. Those findings are consistent with those found in the literature; see Section 6, Table 2.

During the ELB, α takes only positive values, indicating that an increase in the policy instrument *raises* stock returns. This response, which is the opposite of the previous period response, contradicts the traditional monetary policy transmission mechanism: a higher policy rate should reduce the stock returns by negatively affecting the present value of expected dividends. A monetary policy reaction coefficient (β) close to 0 suggests that monetary policy barely reacts to stock market returns or does not react at all.

Even after the normalization of monetary policy in December 2015, the confidence set remains similar to that of the ELB period: stock returns increase during monetary

contractions. We measure the effect of an unexpected 100 bps rise in the policy rate on stock returns (α) to be between 6.4% and 15%, as indicated by the 85% confidence set with a point estimate, with 9.6% as the lowest value of the qLL-S. This means that an attempt by the central bank to pursue a "leaning against the wind" policy to deflate asset prices by increasing the policy rate would backfire. At the same time, we find that the central bank's response to movements in stock returns is tightly estimated at around zero.

4.2 Robustness Analysis

We consider several robust exercises by departing from the baseline specification. In the manuscript, we report four departures from the main VAR model: (i) using a different stock return proxy, (ii) increasing the lags of the reduced-form VAR to 30, (iii) controlling for inflation expectations and liquidity, and (iv) the inclusion of intraday monetary surprises in the VAR. In the Supplementary Material, we present four additional results: (i) a VAR that allows for a common unobservable shock, as in Rigobon (2003), (ii) alternative subperiods, (iii) use of other policy rate proxies during the ELB period, and (iv) the inclusion of shocks due to the release of macroeconomic news.

Generally, the results support the baseline findings: a decrease in the FOMC's response to stock returns after the GFC and, since the ELB, monetary policy shocks driving up stock returns with increases in the policy rate.

Alternative proxy for equity returns We replace the S&P 500 index with the Wilshire 5000 total index when computing the stock market return, keeping the same policy instrument and controls used in the baseline specification. The Wilshire index includes reinvested dividends and more firms than the S&P 500 index. Confidence sets using the Wilshire index appear in Panel A of Figure 3. These sets are nearly identical to the baseline ones.

VAR lags We re-estimate the confidence sets using the reduced-form model in (6) with 30 lags, which is equal to a 6-week trade, the average time between FOMC meetings. This allows economic agents to incorporate not only the information available in the week

before a monetary policy decision but also all the information between FOMC meetings. Panel B of Figure 3 shows the confidence sets based on the VAR with 30 lags, while the sets from the baseline specification with 5 lags appear in Panel C. The VAR(30) confidence sets retain their shape and location across subperiods when compared to VAR(5) sets. This similarity is not surprising, given the high-frequency monetary reaction function in (1a): asset prices quickly incorporate all available information, and hence, 5 days seems to be enough time for the market to form expectations about monetary policy changes.

Liquidity and inflation expectations We add measures of market liquidity and inflation expectations as exogenous variables. The inclusion of liquidity measures reflects that stock prices on days when trade is sparse due to high transaction costs may not reflect their fundamental value (Gibson & Mougeot, 2004). We built two liquidity measures: one based on the front-month Fed funds futures market and the other on the front-month CBOE E-mini S&P 500 Index futures market. Inflation expectations affect the real return on assets by influencing the risk premia on inflation; see Cieslak and Pflueger (2023) for a recent review. We use the 2-year instantaneous forward inflation compensation from the Fed NY, based on Gürkaynak et al. (2010)'s model for Treasury inflation-protected securities (TIPS).[12] Only the lagged liquidity measures and inflation compensation are included as control variables since they may be affected by monetary policy contemporaneously. Figure 4 contains the results for the During and After ELB subperiods since data are not available before 2000. Overall, the inclusion of these controls changes the location and shape of the confidence sets only slightly, indicating the robustness of the baseline results.

Intraday monetary surprises We investigate whether intraday monetary policy "surprises" on event days are the main driver of the stock market reaction to monetary policy. We construct the surprise series using intraday data on the baseline policy rates, following Gertler and Karadi (2015) and Nakamura and Steinsson (2018).[13] The data for surprise is only available from 1996 onwards. Since data are not fully available for the Before

[12] See Subsection S3.2.1 and S3.2.2 in the Supplementary Material for details.
[13] See Section S3.2.3 in the Supplementary Material for details.

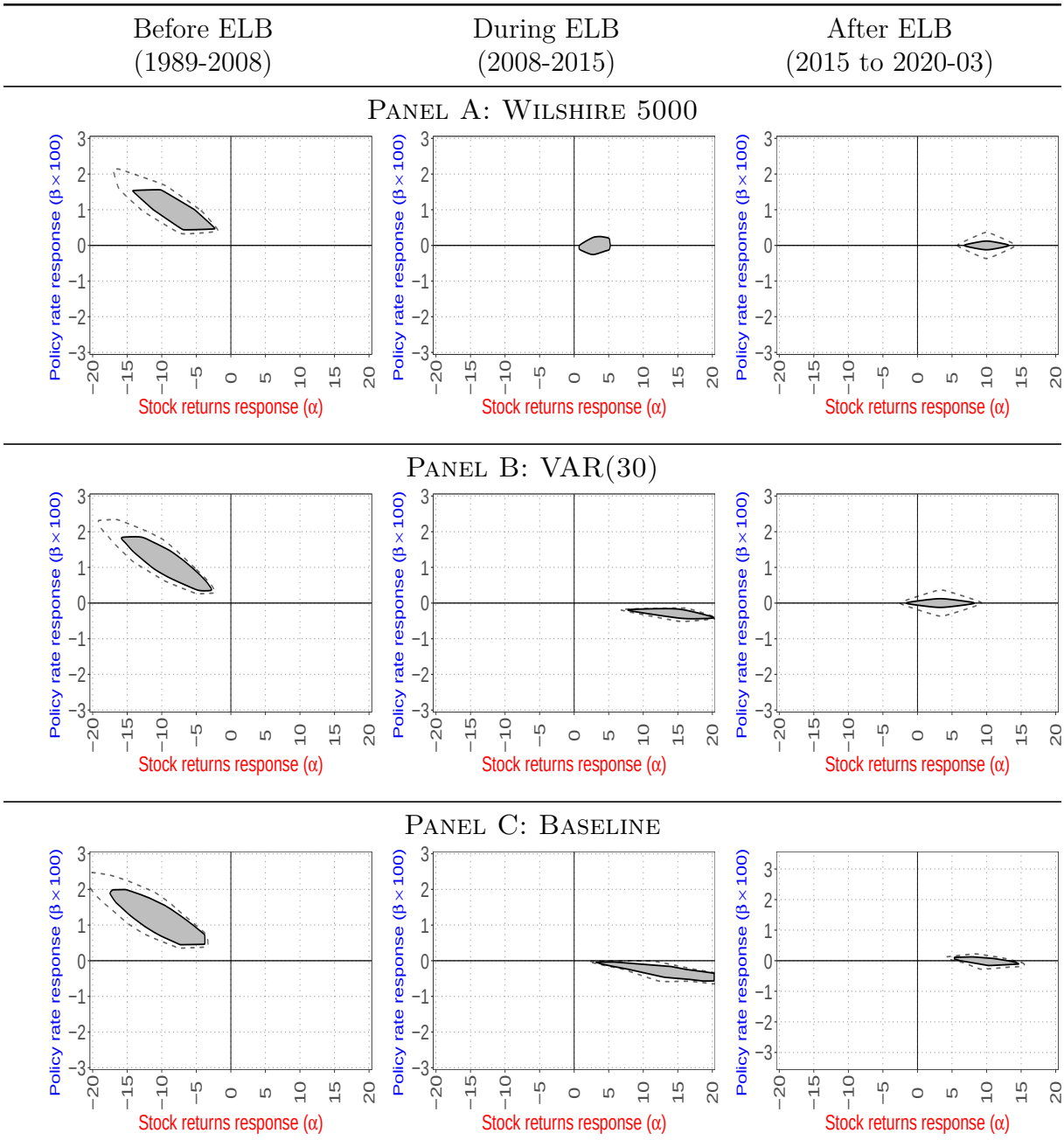


Figure 3: The 85% (grey area) and 90% (dashed lined area) qLL–S confidence sets for the reaction of stock returns to monetary policy shock (α) and the reaction of monetary policy to stock returns ($\beta \times 100$). Panel A uses the Wilshire 5000 stock market return. Panel B estimates the reduced-form VAR with 30 lags.

ELB sample, we only report the results for the During and After ELB periods, which are reported in Panel B of Figure 4. The resulting confidence sets are almost indistinguishable from those under the baseline specification.

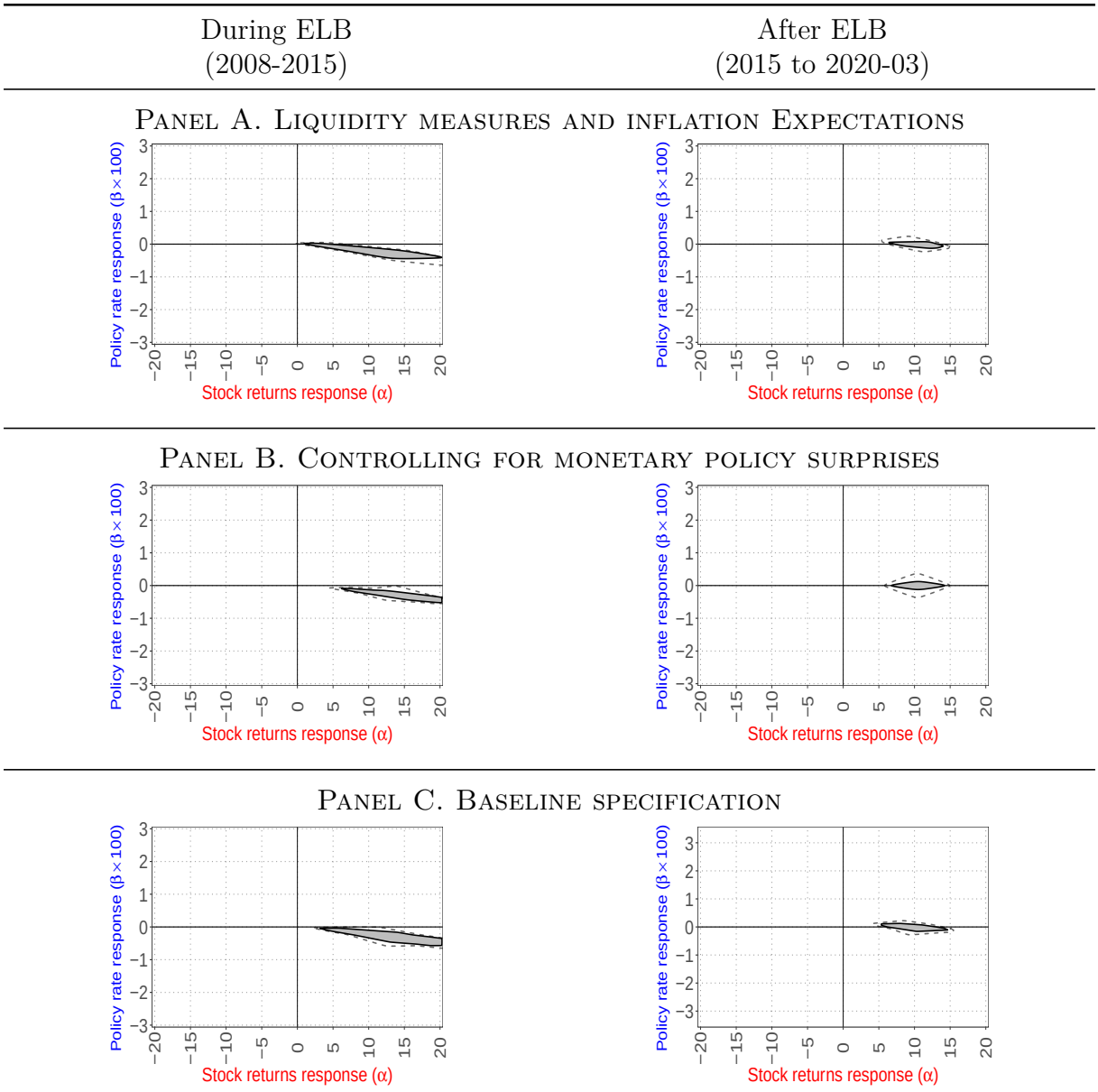


Figure 4: ADDITIONAL CONTROL VARIABLES. Panel A controls for lagged liquidity measures and inflation compensation. Panel B includes monetary policy surprises, while Panel C reproduces the baseline specification.

5 THE EFFECT OF MONETARY POLICY ON THE EQUITY PREMIUM

To understand why stock market returns react positively to monetary tightening after the ELB period, we follow Galí and Gambetti (2015) and decompose the stock return into three terms: news of future dividends, news of future interest rates, and news of future equity premium. A policy rate hike reduces future dividends and increases future interest

rates, both of which depress returns. Now, because a higher expected equity premium also lowers contemporaneous returns on impact, a positive return response to a rate hike is possible only if tightening reduces the expected equity premium.

Although the reduced-form VAR (6) controls for lags in the expected equity premium, it does not separately identify the effect of monetary policy on the equity premium. To investigate this effect, we expand the SVAR model (1a)–(1b) to accommodate a contemporaneous response of the expected equity premium to monetary policy. We can therefore express the dynamics of the policy rate, stock returns, and equity premium as

$$\begin{cases} \Delta i_t = \beta s_t + \varepsilon_{i,t} & \text{(7a)} \\ s_t = \alpha \Delta i_t + \gamma \Delta e_t + \varepsilon_{s,t} & \text{(7b)} \\ \Delta e_t = \eta \Delta i_t + \varepsilon_{e,t} & \text{(7c)} \end{cases}$$

where Δe_t is the daily change in the expected equity premium, and $\varepsilon_{i,t}, \varepsilon_{s,t}, \varepsilon_{e,t}$ are the monetary policy, stock market, and equity premium shocks. Equation (7a) makes explicit that the policymaker reacts only to stock returns, not directly to the equity premium, which captures investors' willingness to bear risk. This is consistent with how policymakers describe their actions as motivated by the effect of stock returns on aggregate demand (Rigobon & Sack, 2003). Equation (7b) links stock market returns to the policy rate and changes in the expected equity premium. Here, the parameter γ captures the effect of the expected equity premium on current stock market returns. Finally, Equation (7c) allows only changes in the policy rate to influence the expected equity premium, thereby restricting the effect of stock market returns on equity premium, as predicted by theoretical models of Pflueger and Rinaldi (2022) and Kekre and Lenel (2022).

We extend the same inferential procedure explained in Section 3 to obtain joint confidence sets for $\boldsymbol{\theta}^e = (\alpha, \beta \times 100, \gamma, \eta)$. We obtain the following three moment conditions derived from the mapping between the off-diagonal elements of the reduced-

form and structural variance-covariance matrices,

$$\boldsymbol{f}_t\left(\boldsymbol{\theta}^e\right) = \begin{bmatrix} \omega_{is,t} - \beta\omega_{ss,t} - \alpha(\omega_{ii,t} - \beta\omega_{si,t}) - \gamma(\omega_{ie,t} - \beta\omega_{se,t}) \\ \omega_{ie,t} - \beta\omega_{se,t} - \eta\omega_{ii,t} + \eta\beta\omega_{si,t} \\ \omega_{se,t} - \alpha\omega_{ie,t} - \gamma\omega_{ee,t} + \eta\left(\alpha\omega_{ii,t} - \omega_{is,t} + \gamma\omega_{ie,t}\right) \end{bmatrix} \tag{8}$$

which is similar to the mapping done in Equation (4). We focus on these moments because the structural variances are absent from them.[14] The grid search for $(\alpha, \beta \times 100, \gamma, \eta)$ is $[-20, 20] \times [-3, 3] \times [-20, 20] \times [-20, 20]$. As in the baseline specification, the results are based on a VAR(5).

Figure 5, Panel A, shows the 85% and 90% projected confidence sets for (α, β) and projected confidence intervals for γ and η based on the qLL-S statistic. The 90% projected confidence set corresponds to all values of $(\alpha, \beta \times 100)$ in the parameter space that do not reject the null assumption $H_0 : \mathbb{E}_{\boldsymbol{\theta}^e}\left[\boldsymbol{f}_t\left(\boldsymbol{\theta}_0^e\right)\right] = 0$ for all $t \leq T$ at a 10% significance level. Similarly, Figure 5, Panel B, brings the 85% project confidence intervals for γ and η.

Across all periods, we estimate $\gamma < 0$, indicating that an increase in expected equity premium reduces current returns, reinforcing the evidence in Martin (2017). The monetary policy rate influences the equity premium differently over time. Before the ELB period, the confidence interval for η sits between 1% and 8.5% range in line with the theoretical models of Pflueger and Rinaldi (2022) and Bianchi et al. (2022).[15] However, since the ELB period, the confidence intervals for η are in the positive range, indicating that an increase in the policy rate reduces the expected equity premium. Even after the normalization of monetary policy in December 2015, we observe that while the direct effect of monetary policy on excess returns is negative ($\alpha < 0$), the impact of contractionary monetary policy on the expected equity premium η is positive, resulting in a positive effect of monetary policy on returns, as depicted by the baseline case.

Following equations (7b) and (7c), we measure the total effect of a policy rate on stock returns as $\alpha + \gamma\eta$. The values of α, γ, and η which result in lowest value of the

[14] Detailed derivation is in Section S1 of the Supplementary Material.

[15] Savor and Wilson (2013) and Lucca and Moench (2015) find empirical evidence about η being positive around monetary policy announcements.

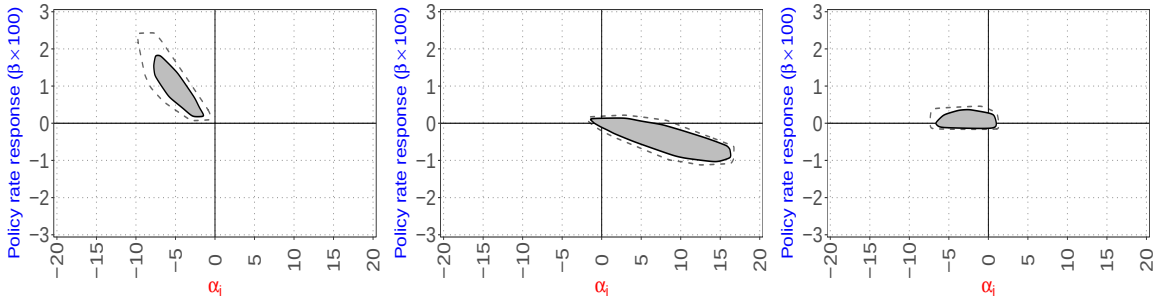
	Before ELB (1989-2008)	During ELB (2008-2015)	After ELB (2015 to 2020-03)
Panel A. Confidence sets			
			
Panel B. Confidence intervals			
γ	[-1.2, -0.8]	[-1.2, -0.7]	[-1.3, -0.6]
η	[1.0, 8.5]	[-20.0, 0.0]	[-17.4, -4.6]

Figure 5: EFFECTS ON COMPONENTS OF STOCK RETURNS. Panel A: The 85% (grey area) and 90% (dashed lined area) projected qLL–S confidence sets for the reaction of stock returns to monetary policy shock (α) and the reaction of monetary policy to stock returns ($\beta \times 100$). Panel B: 85% qLL–S projected confidence intervals for the response of stock returns to expected equity premium (γ) and response of expected equity premium to monetary policy (η).

qLL-S statistic are -4.6, -1.2, and -11.4, respectively. Therefore, a hike of 100bps on the policy rate increases returns by 9.8%. This value is close to 9.6%, the value of α that minimizes the qLL-S statistic in the baseline model. Therefore, the rise in stock returns following an increase in the policy rate since the ELB period is due to the negative effect of interest rates on the expected equity premium. In contrast, before the ELB period, a rate hike increases the expected equity premium, driving down stock market returns.

6 COMPARISON WITH THE LITERATURE

We compare our findings with those previously reported in the literature, reported in Table 2. This table also includes information on the underlying identification assumptions, sample periods, and monetary policy proxies. To facilitate comparison, our 85% projected confidence intervals for parameters α and β are placed at the bottom of the table. We classify the different identifying restrictions into five categories: event study, heteroskedasticity, short-run restriction, long-run restriction, and sign restriction. Event

studies identify the stock market response to monetary policy using observations around policy announcements. Identification through heteroskedasticity, proposed by Rigobon (2003), exploits predetermined shifts in the variances of the structural shocks. Short-run, long-run, and sign restrictions are restrictions imposed in the SVAR that constrain the responses of the endogenous variables to structural shocks.

Before the ELB period, our findings about the stock market response to monetary policy (α) are consistent with previous evidence. For example, the estimated responses in Rigobon and Sack (2004), Bjørnland and Leitemo (2009), and D'Amico and Farka (2011) lie within our projected confidence interval. In the same period, our finding regarding the FOMC response to stock returns (β) is positive, similar to those reported in Furlanetto (2011) and Aastveit et al. (2023), with samples ending around 2008, but lower than in Rigobon and Sack (2003) and Bjørnland and Leitemo (2009), whose samples end around 2000. The lower β for the period 1989-2008 is compatible with a shift in the monetary policy reaction function over the period from 2003 to 2007, as argued by Furlanetto (2011) and supported by Aastveit et al. (2023), who, using a time-varying model, document a reduction in β since the 1990s.

During the ELB period, our projected 85% confidence interval for α covers only positive values, which differs from the negative value reported in Gu et al. (2018). Although Nakamura and Steinsson (2018) and Bauer and Swanson (2020) studies do not specifically cover the ELB period, they also find negative values of α. Methodological differences can explain this contradiction. For example, Nakamura and Steinsson (2018) rule out the contemporaneous effect of stock returns on monetary policy. Galí and Gambetti (2015) shows that neglecting this effect can drastically change the results. We, furthermore, do not restrict α to be negative as in Jarociński and Karadi (2020). By assumption, this restriction enables the central bank to pursue a "leaning against the wind" policy, deflating asset prices by increasing the policy instrument. In contrast to event-study identification as in Paul (2020) and Bauer and Swanson (2020), we use information outside the monetary policy announcement, allowing us to capture changes in monetary policy expectations outside meeting days. More importantly, as evidenced in the Section 5, the

Table 2: LITERATURE COMPARISON. Panel A: estimates of the impact of a monetary shock on stock returns (α) and stock returns on the policy instrument (β). Point estimates are presented for constant parameter models and the minimum and maximum for time-varying parameters (TVP) models. Whenever possible, $\hat{\alpha}$ is normalized to the impact of a monetary shock that increases the respective proxy for monetary policy expectations by 1bps. Panel B: projected 90% confidence intervals based on the *gen-S* confidence sets.

PANEL A: Non-TVP models: point estimates / TVP models: min. and max.							
Paper	Ident.[1]	Sample from	Sample to	Proxy[2]	Returns response (α)[3]	Policy response ($\beta \times 100$)[3]	Notes
Rigobon and Sack (2003)	H	1985-03-01	1999-12-31	3-mth T-bill		2.14	p. 656.
Rigobon and Sack (2004)	H	1994-01-03	2001-11-26	1-quarter ED	-7.19		p. 1567.
Bernanke and Kuttner (2005)	ES	1989-06-01	2002-12-31	FFF1	-2.55		p. 1226.
Bjørnland and Leitemo (2009)	LR	1983-01-01	2002-12-31	Effective FF	-9.00	3.40	
Furlanetto (2011)	H	1988-01-01	2003-12-31	3-mth T-bill		0.78	p. 104.
		2003-03-01	2007-07-31			0.18	p. 105.
D'Amico and Farka (2011)	ES	1994-01-01	2006-09-30	FFF1	-5.11	1.85	pp. 132–133.
Galí and Gambetti (2015)	SR	1960-Q1	2011-Q4	Effective FF	-5.00, -1.00		p. 247.
Aastveit et al. (2023)	SR	1975-Q2	2008-Q4	Effective FF		-0.25, 2.00	p. 21.
Gu et al. (2018)	ES	2012-01	2016-12	8-quarter ED	-4.32		p. 5.
Nakamura and Steinsson (2018)	H	1995-01-01	2014-04-01	2-year forward	-6.50		p. 1322.
Paul (2020)	ES	1988-11	2017-09	FFF1	-5.20, -3.80		p. 35.
Alessi and Kerssenfischer (2019)	ES	1976-06	2017-12	2-year T-bond	-0.28[4]		p. 665.
Jarociński and Karadi (2020)	Sign R	1990-02	2016-12	3-mth FFF	-17.30, -3.83		p. 13.
Bauer and Swanson (2020)	ES	1990-02	2007-06	FFF1	-4.24		p. 26.
Bauer and Swanson (2020)	ES	1990-02	2019-06	PCA	-7.82		p. 26.
Kurov et al. (2022)	H	1997-10	2019-12	ED	-7.40	0.68	pp. 9, 14.
PANEL B: qLL–S 85% projected confidence intervals							
Before ELB		1989-01-01	2008-12-15	FFF1	[-17.30, -4.00]	[0.50, 1.95]	
During ELB		2008-12-16	2015-12-15	PCA	[3.40, 20]	[-0.55, 0.05]	
After ELB		2015-12-16	2020-03-14	FFF1	[6.40, 15.00]	[-0.10, 0.10]	

[1]H: heteroskedasticity, ES: event study, LR: long-run restrictions, SR: short-run restrictions, Sign R: sign restrictions

[2]ED: Eurodollar future, FFF1: front-month fed funds futures, FF: Fed funds.

[3]Response to a 1 percentage point change in the variable. For time-varying models, the minimum and maximum are reported.

[4]The coefficients for the S&P 500 divided by the respective fed funds future response from the same table.

positive α is explained by the change of the monetary policy effect on the expected equity premium during and after ELB periods.

Two hypotheses can explain this change: the Fed information effect and a rational bubble. The Fed information hypothesis, proposed by Romer and Romer (2000), argues that the monetary authority has more information about the state of the economy than market agents; see also Lakdawala (2019). Therefore, lowering the policy rate signals weaker economic conditions ahead and hence lower future earnings, as remarked by Nakamura and Steinsson (2018), and, consequently, increasing the expected equity premium.[16]

Galí's (2014) model suggests that the increase in stock market prices with increases in the policy instrument is due to a rational stock market bubble. By decomposing α into a fundamental and a bubble component, and assuming $\beta > 0$, Galí and Gambetti (2015) finds the bubble component to be negative, which drives α toward negative territory, and coincides with our pre-ELB results. When $\beta = 0$, they estimate a positive bubble together with a negative fundamental component, making α close to 0 towards the end of their sample (see Table 2). Our results indicate β near zero and $\alpha > 0$ since the ELB, also suggesting a positive bubble component. However, our empirical finding provides an alternative explanation for Galí and Gambetti's results: a substantial decline in equity premium in response to a tightening of monetary policy is compatible with a positive response of stock returns without any rational bubble component.

7 CONCLUSION

We study the interdependence of US monetary policy and equity prices without restricting the analysis to days of monetary policy announcements. We jointly estimate the effect of monetary policy on stock returns and the equity premium, as well as the impact of stock returns on FOMC decisions. We do so by fully exploring the heterogeneity of the

[16]The authors state that "recent discussions of monetary policy have noted the Fed's reluctance to lower interest rates for fear it might engender pessimistic expectations that would fight against its goal of stimulating the economy." Cieslak and Schrimpf (2019) document that around 30% of FOMC announcements feature a positive and significant stock and policy rate co-movement due to the news about economic growth. See also Boehm and Kroner (2021) who link the unexplained variation of stock returns on event days to the text in the announcement.

monetary policy and stock return shocks. Our method is agnostic about the direction of these effects and robust with respect to time-varying parameters.

A 100bps rise in the policy rate depresses stock returns by about 4% to 17% before the lower bound (ELB). In contrast, since 2008, and even after the normalisation of monetary policy in 2015, we find that increments in the policy rate *increase* stock prices. We show that this occurs because increments in the policy rate reduce the expected equity premium since 2015. Between 1989 and 2008, a policy rate hike raises the equity premium, amplifying the depressing effect of monetary policy on returns; after 2008, we find the opposite: policy rate hikes reduce the expected equity premium, dampening the impact of monetary policy.

Finally, we only find evidence of the "Fed put" before 2008. During this period, we estimate that the FOMC responded to a surge in stock prices by raising the policy rate. Since then, however, this relationship has changed: the monetary policy rate no longer reacts to stock returns. Our results are robust to different measures of the policy instrument and stock returns, the inclusion of intraday monetary surprises and macroeconomic news surprises, movements in the equity premium, alternative subperiods, alternative model specifications, and time-varying parameters.

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