Fed Information Effects: Evidence from the Equity Term Structure[1]

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Abstract

Do investors interpret central bank target rate decisions as signals about the current state of the economy? We study this question using a short-term equity asset that entitles the owner to the near-term dividends of the aggregate stock market. We develop a stylized model of monetary policy and the equity term structure and derive tests of Fed information effects using the short-term asset announcement return. Consistent with the existence of information effects, we find that the short-term asset return in a 30-minute window around FOMC announcements loads positively on monetary policy surprises. Furthermore, the announcement return predicts near-term macroeconomic growth.

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1. Introduction

Whether central bank announcements reveal information about the state of the economy is a central question in macroeconomics.[3] In standard models of monetary policy where central banks and investors have the same information about economic conditions, monetary policy transmits to the economy through conventional channels: a reduction in the target rate stimulates economic activity by reducing the cost of capital and encouraging consumption and investment. However, if investors believe that the central bank possesses superior information about the macroeconomy, an unexpected cut in the target rate may be perceived as a signal of deteriorating economic conditions. These beliefs may discourage spending and investment, working against intended policy and reducing the overall effectiveness of central bank actions.

The existence of this signaling channel, known as "Fed information effects," is heavily debated. Romer and Romer [62] provide evidence that central banks possess an informational advantage about macroeconomic conditions compared to the private sector.[4] Federal Open Market Committee (FOMC) meeting transcripts reveal that meeting participants are concerned about the signaling effect of their actions.[5] However, it remains an open debate in the literature whether investors actually interpret central bank target rate decisions as signals about the current state of the economy.

Some of the most widely cited evidence in support of Fed information effects is provided by Nakamura and Steinsson [59] who show that analysts revise their near-term macroeconomic growth forecasts in the direction of unexpected changes in the target rate, whereas the conventional effects of monetary policy would predict a negative relationship. However, many studies, including recent work from Bauer and Swanson [7] and Karnaukh and Vokata [48], argue against the exis-

[3] E.g. Romer and Romer [62], Campbell et al. [13], Nakamura and Steinsson [59], Cieslak and Schrimpf [19], Jarocinski and Karadi [47], Bauer and Swanson [7, 8].

[4] Romer and Romer [62] compare central bank Greenbook forecasts (not made available to the public until five years after each Federal Open Market Committee meeting) against different sets of commercial forecasts and show that Fed forecasts contain information about macroeconomic conditions beyond what is known to private sector forecasters (see also El-Shagi et al. [26], Ekşi et al. [25]). In Section 6.1, we extend the analysis from Romer and Romer to the recent sample and find results consistent with these studies.

[5] In the December 11, 2007 FOMC meeting Thomas Hoenig states, "I think that (*50 basis point cut*) would send a signal to financial markets that we view the outlook as more dire than it is, thus adding to financial turmoil rather than alleviating it." In the January 30, 2008 meeting, Richard Fisher states, "My CEO contacts tell me that we're very close to the 'creating panic' line. They wonder if we know something that they do not know, and the result is, in the words of the CEO of AT&T, Randall Stephenson, 'You guys are talking us into a recession.' ... I'm going to quote Tim Eller, whom I consider the most experienced and erudite of the big homebuilders, which is Centex, who told me, 'We had just begun to feel that we were getting somewhat close to at least a sandy bottom. Then you cut 75 basis points and add 'appreciable downside risks to economic growth remain' in your statement, and it scares the 'beep' out of us.'... The CEOs and CFOs I speak to from Disney to Wal-Mart, to UPS, to Texas Instruments, Cisco, Burlington Northern, Southwest Airlines, Comerica, Frost Bank, even the CEO of the felicitously named Happy State Bank in Texas, repeated this refrain, 'You must see something that we simply do not see through our own business eyes.'"

tence of information effects. These papers challenge the evidence from Nakamura and Steinsson [59], arguing that economic news released prior to FOMC announcements is an important omitted variable in such tests of information effects. Bauer and Swanson propose an alternative explanation, referred to as the "Fed response to news," according to which investors have access to the same information about economic conditions as the central bank but underestimate the extent to which the Fed reacts to economic news. Underestimation of the policy rule and the low, monthly frequency of available growth forecasts, means that economic news released between the initial forecast and the FOMC meeting jointly determines forecast revisions and the monetary policy surprise. The authors present empirical evidence supporting their argument that the "Fed response to news" mechanism generates the positive relationship between forecast revisions and monetary surprises documented by Nakamura and Steinsson [59]. Similarly, Karnaukh and Vokata [48] document that the evidence for Fed information effects dissipates after accounting for the predictable component of policy surprises.

In this paper, we propose a new test of Fed information effects which directly addresses the concerns raised by Bauer and Swanson [7] and Karnaukh and Vokata [48]. Specifically, we derive a test based on short-term equity claims that entitle the owner to the near-term dividends of the aggregate stock market (i.e., short-term dividend strips (Van Binsbergen et al. [68])).[6] We estimate the price of this short-term equity claim in a narrow window before and after each central bank announcement and document how the short-term asset responds to monetary policy surprises. Our test is analogous to that of Nakamura and Steinsson [59] - since the short-term equity claim depends directly on investor expectations for near-term aggregate cash flows, the short-term equity announcement return captures changes in investor economic growth expectations, similar to economic forecast revisions from Nakamura and Steinsson [59]. The advantage of our test is that the short-term equity return can be estimated in a narrow (e.g., 30-minute) window around the central bank announcement while macroeconomic forecasts are typically only available at a low (e.g., monthly) frequency. This use of high-frequency equity price responses addresses the omitted variable issue, ensuring that our results cannot be driven by the "Fed response to news" channel, and thus are not subject to the Bauer and Swanson [8] critique.[7]

Previous research has explored the reaction of the aggregate stock market to monetary policy surprises (e.g. Bernanke and Kuttner [9]). The key advantage of the short-term equity asset is that its price depends solely on near-term cashflows, whereas the aggregate market price depends on the infinite stream of future cashflows. By isolating the short-term component, we can measure

[6] Throughout this manuscript, we will refer to this short-term equity claim as the "short-term asset" or the "dividend strip." We refer to the aggregate stock market as the "long-term asset".

[7] See also Bauer and Swanson [8] who discuss how using high-frequency asset price responses to monetary shocks addresses the omitted variable issue and is not subject to their "Fed response to news" channel.

how monetary policy announcements affect investor perceptions of near-term economic conditions, which provides a sharper characterization of Fed information effects.[8]

We begin by presenting a stylized model of monetary policy and the equity term structure. The model characterizes the differential effects of monetary policy surprises on the prices of short-term dividend strips and the long-term aggregate stock market, both with and without Fed information effects. We model the central bank target rate as a persistent process that depends on both the economic growth forecasts of the central bank and on an exogenous shock to policy preferences. We incorporate the conventional effects of monetary policy in the economic growth process: lowering (raising) the target rate has an expansionary (contractionary) effect. We model Fed information effects as a signal about next period gross domestic product (GDP) growth that is observed by the central bank but not by investors. The investors' information set consists of the central bank policy rule, prior realized GDP growth, and the central bank policy decision (target rate), but does not include the policy preference shocks or the signal about next period growth. Based on the observed target rate, investors infer the posterior distribution of the policy preference shock and information effect shock which they use to update forecasts for the future path of interest rates and economic growth and to set post-announcement asset prices.

Under the null hypothesis of no information effects, the model predicts that both the short-term and the long-term asset return load negatively on unexpected changes in the target rate, consistent with the conventional effects of monetary policy. When information effects exist, the response of the short-term and long-term asset decouples. This decoupling arises since the short-term asset is relatively more exposed to transitory information effects whereas the longer-duration market is relatively more exposed to the more persistent conventional effects of monetary policy. As the effects work in the opposite direction, the asset returns diverge and the loading of the short-term asset price return on the monetary policy surprise becomes positive.

The model specifies a simple test of information effects based on a regression of the short-term asset announcement return on the monetary policy surprise. A *positive* loading on the monetary policy surprise is sufficient to reject the null hypothesis that information effects do not exist, analogous to the positive loading of forecast revisions proposed as evidence of information effects by Nakamura and Steinsson [59]. The model also shows how the aggregate stock market response to monetary policy news is not informative about the presence of information effects. Specifically, the model can reconcile the negative coefficient of the aggregate market on monetary policy shocks, documented by Bernanke and Kuttner [9], with the existence of Fed information effects.

To conduct our empirical tests, we obtain two high-frequency measures of monetary policy

[8]The short-term equity asset also offers distinct advantages over fixed income securities such as Treasury notes and bonds as the prices of these assets are not sensitive to changes in expected cash flows, which constitute the traditional channel for information effects.

shocks. The first measure uses current-month federal funds futures from the CME Group to measure changes in expectations for the current month's federal funds rate from 10 minutes before the FOMC decision release until 20 minutes after (e.g. Gürkaynak et al. [42]). The second measure is the orthogonalized monetary policy shock constructed by Bauer and Swanson [8] which removes the endogenous component of the target rate decision affected by prior economic and financial news.

We estimate the price of a short-term asset which pays the dividends of the aggregate market from the put-call parity relationship spanning prices of European put and call options on the S&P 500 index. Intuitively, options allow us to construct a synthetic share of the market that has the same payoff as an actual share at the maturity date of the options. However, while an actual share pays aggregate dividends from the present date to the maturity date, the synthetic share does not. The difference in the price of the actual and synthetic share is the implied price of the near-term dividends. Specifically, we innovate on the methodology used in Van Binsbergen et al. [68] and Golez and Jackwerth [35] and employ a linear regression approach to simultaneously estimate dividend prices and risk-free rates from the put-call parity restriction. This approach allows us to estimate the intra-daily price of the short-term asset and the implied risk-free rate in a narrow window around each FOMC announcement. In our main tests, we focus on options with maturities of approximately six months. This choice is governed by existing research on information effects that focuses on forecasts over the near quarters (Nakamura and Steinsson [59]). It also strikes a balance between more liquid short-dated options and less liquid longer-dated options Golez [34]. The long-term asset in our study is the S&P 500 index.

We estimate the return on the short-term and the long-term asset over the 30-minute window around each FOMC announcement: from 10 minutes before the FOMC decision is released to 20 minutes after. Our sample includes a total of 128 scheduled FOMC announcements from January 2004 to December 2019.[9] In our baseline tests, we follow prior literature (e.g. Nakamura and Steinsson [59]) in which monetary policy surprises are assumed to convey Fed information and focus on the sample of 84 FOMC meetings with a non-zero monetary policy surprise (MPS). As robustness, we run all tests on the full sample of FOMC meetings and document similar results.

We implement our test of information effects by regressing the short-term asset announcement return on the monetary policy surprise. The coefficient estimate on the monetary policy surprise is positive and significant at the 1 percent level. We thus reject the null hypothesis of no information effects. The coefficient estimate remains statistically significant whether we employ the monetary policy shock based on current month federal funds futures or the orthogonalized monetary policy

[9]The start of the sample period is limited by the availability of high-quality intraday data for S&P 500 options from the Chicago Board of Options Exchange (CBOE). We exclude unscheduled FOMC announcements because many of them occur outside of stock and derivatives trading hours.

shock from Bauer and Swanson [8]. The results are consistent across different samples: FOMC announcements with a non-zero monetary policy surprise, all FOMC announcements, and when excluding the most influential observations from Bauer and Swanson [7]. Furthermore, the findings are robust to winsorizing variables at the 5 percent level, implementing GMM heteroscedasticity-consistent standard errors, controlling for changes in options bid-ask spread, and using 270-day maturity dividend strips instead of the conventional 180-day strips. The findings are also robust to constructing the dividend strip prices using alternative estimation windows including delaying the post-announcement window until the end of the day, and widening the pre- and post-estimation windows to include most of each FOMC announcement day (instead of the standard 30-minute windows around each announcement).

For the aggregate market, we observe a negative relationship between unexpected changes in the target rate and asset returns, consistent with existing findings in the literature (e.g., Bernanke and Kuttner [9]). These results are consistent with our model of the term structure of information effects. An unexpected cut to the target rate is perceived as a signal about poor economic conditions resulting in a decline in the short-term asset price. For the aggregate market, however, the longer-horizon expansionary effects of the lower rate outweigh the transitory information effects and the market price increases. This generates the opposite response between the short-term and long-term asset.

The opposite reactions of long-term and short-term assets cannot be attributed to changes in the risk-free rate. All else equal, asset prices should rise when risk-free rates decrease and fall when they increase. Empirically, short-term equity prices move in the same direction as short-term risk-free rates. Accounting for the risk-free rate movements therefore makes the documented positive loading of the short-term asset on the monetary policy surprise even more pronounced. For consistency, we verify that short-term Treasury bonds load negatively on monetary policy surprises. Additionally, the short-term asset loading is not driven by differential changes in uncertainty across announcement types, as the volatility implied in S&P 500 options decreases similarly after both positive and negative monetary policy shocks.

In our stylized framework discussed above, we elect to model information effects through the cash flow channel, consistent with the established view of these effects. To study whether this is a reasonable modeling assumption, we conduct a series of predictability tests based on an additional model prediction: if information effects work through the cash flow channel, then the short-term asset announcement return should predict near-term dividend growth and economic growth with a positive sign. Absent any cash flow news, if the short-term asset return is solely driven by risk premia shocks, such predictability would be nonexistent.[10]

[10]This exercise is similar in spirit to a Campbell-Shiller decomposition of the variation in the short-term asset

We run predictive regressions of k-quarter ahead real dividend growth and real gross domestic product (GDP) growth on the short-term asset announcement return. We find that the short-term asset announcement return predicts near-term dividend growth and that this effect is most pronounced for FOMC announcements with a non-zero monetary policy surprise. The estimated coefficient on the short-term asset return is increasing from one to four quarters and then decreasing thereafter. The coefficients remain positive and statistically significant, even after controlling for the long-term asset announcement return, the monetary policy surprise, and changes in implied volatility. The results are robust to restricting the sample to include only the latest FOMC meeting each quarter. The k-quarter ahead quarterly real GDP growth predictive regression results exhibit a similar pattern with positive coefficients on the short-term asset return in the near-horizon which decrease in magnitude over longer horizons. Furthermore, we find that the predictive power of the short-term asset return only exists on FOMC announcement days: we run the same predictive regressions on non-FOMC days and find no evidence of dividend growth or GDP growth predictability. These results provide evidence that these information effects do operate through the cash flow channel, confirming the established view of information effects and our modeling choice.

Finally, we provide a discussion of our results, including some of the key assumptions of our stylized framework, and provide a calibration of the model. We first extend the analysis from Romer and Romer [62] through the recent sample to test whether central bank forecasts contain information beyond what is known to commercial forecasters. We run bivariate specifications using central bank forecasts alongside private sector forecasts (Survey of Professional Forecasters) to predict future k-quarter ahead economic growth. We document a positive coefficient on the central bank forecasts across all horizons that are significant at the 1 percent level for the current quarter and significant at the 5 percent level for the one-quarter and two-quarter ahead specifications. The coefficient estimates for the private sector forecasts are not significantly different from zero at any horizon. While central bank Greenbook forecasts are only available to the public after a lag period of five years and therefore cannot inform investors about current economic conditions (or directly drive information effects), these results indicate that central banks have an information edge over the private sector regarding economic conditions up to two quarters ahead (the same as the maturity of the short-term asset cash flows) and thus possess information that is potentially valuable to the private sector.

Next, we discuss the modeling assumption that information effects operate through the cash flow channel. While we have empirical support for the cash flow channel, we cannot rule out that changes in risk premia may drive part of the variation in the short-term asset announcement

announcement return (which must be driven by cash flow news or discount rate news).

return.[11] However, even if the announcement return were driven entirely by risk premia shocks, a positive loading of the short-term asset response on monetary policy surprises would constitute evidence of information effects.[12] Conceptually, an unexpected cut in interest rates would still be interpreted as a negative signal from the central bank, which would increase short-horizon risk premia and depress the price of the short-term asset.

Then, we discuss an extension of the model which includes soft information released by the central bank about its view on near-term economic conditions. And lastly, we estimate key parameters of the model using external data on central bank forecasts and macroeconomic growth series. We show how these parameter estimates generate the documented response of the short-term and long-term asset to monetary policy surprises. We provide a calibration of the model using these parameters and show how investor economic growth forecasts and beliefs about the future path of the target rate respond to monetary policy surprises with information effects (and without for comparison).

Overall, our findings indicate that investors update their beliefs about near-term economic conditions in response to monetary policy surprises. While our results do not necessarily imply that the Fed has private information about the macroeconomy (for example, the Fed may have an advantage at processing publicly available information), our findings demonstrate that investors view monetary policy surprises as important signals about the state of the economy, suggesting that central banks should consider these effects when making policy decisions.

Our study contributes to the growing literature that investigates short-term dividend strips. Most of the existing literature on dividend strips focuses on analyzing and understanding the equity term structure at monthly or lower frequencies over extended periods (Van Binsbergen et al. [68]; Van Binsbergen et al. [69]; Gormsen and Koijen [38]; Gormsen [37]; Bansal et al. [6]; Gonçalves [36]; Gormsen and Lazarus [40]; Boguth et al. [11]; Golez and Jackwerth [35]). The exception in this context is the work by Gormsen and Koijen [38], who employ daily equity strip data to analyze the evolution of growth expectations around the outbreak of COVID-19. Our contribution lies in our analysis of the high-frequency response of the equity term structure to monetary policy news to distentangle the perceived short-horizon and long-horizon effects of monetary policy.[13]

Our paper also relates to a large body of literature which studies the impact of monetary policy surprises on asset prices and the macroeconomy.[14] Our contribution centers on the ongoing

[11] Golez [34] documents that the risk premium in six-month maturity dividend strips is small.

[12] We thank Emi Nakamura for this insight.

[13] Like Van Binsbergen et al. [68] and Golez and Jackwerth [35], we estimate short-term dividend strips from index options data, rather than relying on dividend futures as done by Van Binsbergen et al. [69] as that enables us to construct high-frequency estimates of dividend strips over a much longer time-period.

[14] Papers include: Kuttner [49]; Gilchrist and Leahy [33]; Gürkaynak et al. [42]; Bernanke and Kuttner [9]; Campbell et al. [13]; Gorodnichenko and Weber [41]; Song [63]; Ozdagli and Weber [61]; Nakamura and Steinsson [59];

debate surrounding the existence of Fed information effects (Romer and Romer [62], Faust et al. [29], Campbell et al. [13], Nakamura and Steinsson [59], Cieslak and Schrimpf [19], Jarocinski and Karadi [47], Lunsford [54], Bundick and Smith [12], Karnaukh and Vokata [48], Bauer and Swanson [7]).[15] As discussed above, Nakamura and Steinsson [59] provide evidence of information effects based on the sign of the coefficient in a regression of forecast revisions on the monetary policy surprise. Bauer and Swanson [7] argue that their findings can be explained by omitted economic news and underestimating the central bank's response to news (see also Karnaukh and Vokata [48]). We provide evidence for information effects based on the short-term asset response to monetary shocks which addresses the omitted variable issue. Cieslak and Schrimpf [19] uses the joint dynamics of bond yields and equity returns to separate between pure monetary shocks, risk premium shocks, and information shocks. They find a small role for information effects in FOMC announcements.[16] Jarocinski and Karadi [47] measure information effects as FOMC announcements when both interest rates and the stock market rise or fall together. Bauer and Swanson [7] argue that this type of methodology produces a very small set of significant information shocks. Our short-term equity asset helps build upon these key papers while addressing the Bauer and Swanson [7] critique, as the short-term asset's announcement return is able to capture changes in beliefs about near-term outcomes even when the comovement between interest rates and the aggregate market is negative, as is often the case in the data (Bernanke and Kuttner [9]).

The remaining sections of this paper are structured as follows: In Section 2, we introduce a stylized framework outlining the Fed Information channel and its connection to dividend strips. In Section 3, we provide a description of how we construct the monetary policy shock and estimate short-term equity prices. In Section 4, we report our main empirical findings. In Section 5, we analyze the relationship between the short-term asset return and the macroeconomy. In Section 6, we discuss the implications and various aspects of our analysis. Section 7 concludes.

2. Stylized Framework

We present a stylized framework to characterize the implications of the existence of information effects on the short-term and long-term asset response to monetary policy news. We build our framework on the existing theory literature on information effects (e.g., Cukierman and Meltzer [21], Ellingsen and Soderstrom [28], Melosi [56], Nakamura and Steinsson [59], Miranda-

Drechsler et al. [24]; Cieslak and Schrimpf [19]; Neuhierl and Weber [60]; Jarocinski and Karadi [47]; Swanson [66]; Elenev et al. [27].

[15] Our paper also contributes to theory work on monetary policy and information effects (e.g. Cukierman and Meltzer [21], Ellingsen and Soderstrom [28], Melosi [56], Nakamura and Steinsson [59], Miranda-Agrippino and Ricco [58]).

[16] They find a larger role for information shocks for FOMC minutes releases and central banks' press conferences.

Agrippino and Ricco [58]). The contribution of our model is to show the impact of monetary policy and information effects across the term structure which allows us to derive closed form expressions for the market return and the short-term asset response to monetary policy surprises with and without information effects. We summarize the model setup and implications below and provide detailed derivations in Section A1 in the Appendix.

2.1. Setup

There are two agents, a central bank which sets the target rate and an investor who trades two securities: a short-term asset which is a claim to the next period aggregate dividend; and a long-term asset which is a claim to all future aggregate dividends. We specify an economic growth process and the target rate policy rule which we describe in detail below. Time is discrete, indexed by t with each period t divided into two subperiods $\underline{t}$ and $\bar{t}$ where subperiod $\underline{t}$ occurs first (corresponding to before the central bank announcement) followed by subperiod $\bar{t}$ (following the announcement). Figure 1 summarizes the timeline of our stylized framework.

2.1.1. Economic growth process and policy rule

Economic growth follows:

$$\Delta\widehat{GDP}_{\underline{t+1}} = \rho_g \Delta\widehat{GDP}_{\underline{t}} + \epsilon_{\bar{t}} + b\widehat{\iota}_{\bar{t}} + w_{\underline{t+1}}, \tag{1}$$

where $\Delta\widehat{GDP}_{\underline{t}}$ denotes the deviation, in percent, of GDP growth from steady state, $0 < \rho_g < 1$ is the persistence of the process, $w_{\underline{t+1}}$ is an exogenous shock with $w_{\underline{t+1}} \sim i.i.d.\ N\left(0, \sigma_w^2\right)$, $b < 0$ captures the conventional effect of monetary policy, and $\widehat{\iota}_{\bar{t}}$ denotes the central bank target rate. We model Fed information effects through $\epsilon_{\bar{t}}$, an exogenous shock with $\epsilon_{\bar{t}} \sim i.i.d.\ N\left(0, \sigma_\epsilon^2\right)$ that is observed by the central bank but not by the investor in period $\bar{t}$.[17] $\Delta\widehat{GDP}_{\underline{t}}$ is realized in subperiod $\underline{t}$ and is observed by both agents. The investor sets the price of the long-term and short-term assets. In subperiod $\bar{t}$, the central bank receives the private signal, $\epsilon_{\bar{t}}$, updates forecasts for next period GDP growth and sets the target Federal funds rate, $\widehat{\iota}_{\bar{t}}$, following the policy rule:

$$\widehat{\iota}_{\bar{t}} = \rho_\iota \widehat{\iota}_{\overline{t-1}} + \alpha \mathbb{E}^{cb}_{\bar{t}}\left(\Delta\widehat{GDP}_{\underline{t+1}}\right) + \mu_{\bar{t}}, \tag{2}$$

where $\widehat{\iota}_{\bar{t}}$ denotes the deviation in percent of the target Federal funds rate from steady state, $0 < \rho_\iota < 1$ is the process persistence, and $\alpha > 0$ is the response of central bank policy to forecasted deviations of GDP growth from steady state. $\mathbb{E}^{cb}_{\bar{t}}\left(\Delta\widehat{GDP}_{\underline{t+1}}\right)$ denotes the forecast of the central

[17] We are agnostic in the model about whether this arises from information the central bank possesses that investors do not, or from superior information processing capacity from the central bank.

bank, cb, based on its time $\bar{t}$ information set.[18] $\mu_{\bar{t}} \sim i.i.d. N\left(0, \sigma_{\mu}^2\right)$ is an exogenous shock to policy preferences that is independent from the central bank's private signal about economic conditions, ϵ.

2.1.2. Asset prices

The investor knows the policy rule, the economic growth process, and the unconditional distributions of the shocks ϵ and μ, but does not observe the realized values of the shocks. In subperiod $\bar{t}$, after observing the target rate announcement by the central bank, $\widehat{\iota_{\bar{t}}}$, the investor infers the posterior distributions of $\epsilon_{\bar{t}}$ and $\mu_{\bar{t}}$ which are used to update beliefs about the future path of interest rates and GDP growth. We assume a simple relationship between dividend growth and GDP growth:

$$\Delta d_t = \alpha_d + \beta_d \Delta \widehat{GDP}_t + \omega_t, \tag{3}$$

where $\beta_d > 0$ and $\omega_t \sim N\left(0, \sigma_{\omega}^2\right)$. We then determine how the long-term and short-term assets respond to a monetary policy surprise by mapping the revisions in investor beliefs about economic growth into asset prices. We express the price of the long-term asset following the Campbell and Shiller [15] decomposition as:

$$p_t - d_t = \sum_{j=0}^{\infty} \rho^j \mathbb{E}_t \left(\Delta d_{t+j+1}\right) - \sum_{j=0}^{\infty} \rho^j \mathbb{E}_t \left(r_{t+j+1}\right) + \frac{\kappa}{1-\rho}, \tag{4}$$

where t indexes quarters, p_t is the log price, d_t is the log dividend, $\rho = \frac{1}{1+\frac{D}{P}} \approx 0.99$, $\kappa = -log\left(\rho\right) - \left(1-\rho\right) log\left(\frac{1}{\rho} - 1\right)$, Δd_{t+j+1} is the dividend growth rate from $t+j$ to $t+j+1$, r_{t+j+1} is the return from $t+j$ to $t+j+1$.[19]

For parsimony, we model Fed information effects through the traditional cash flow channel and assume constant discount rates from pre- to post-announcement.[20] We obtain an expression for the announcement returns, assuming d_t is fixed in the 30-minute window around the FOMC announcement, as:

$$r_{\bar{t}}^{\infty} = \sum_{j=0}^{\infty} \rho^j \beta_d \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right) \left(\Delta \widehat{GDP}_{\underline{t+j+1}}\right), \tag{5}$$

where $\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}$ denotes the change in expectations from pre- to post-announcement. Similarly, the return of the short-term asset is given by:

[18] The target rate $\widehat{\iota_{\bar{t}}}$ is chosen at time $\bar{t}$ and affects economic growth realized at time $\underline{t+1}$.
[19] We omit time superscripts and subscripts for ease of notation.
[20] We discuss this assumption in more detail in Section 6 after presenting the model and our empirical results.

$$r^1_{\bar{t}} = \rho\beta_d \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\Delta\widehat{GDP}_{\underline{t+1}}\right), \tag{6}$$

where $r^{\infty}_{\bar{t}}$ is the return of the long-term asset from pre-announcement to post-announcement ($\underline{t}$ to $\bar{t}$) and $r^1_{\bar{t}}$ is the return of the short-term asset from $\underline{t}$ to $\bar{t}$.

2.2. Asset Responses to Monetary Policy Surprises

We derive expressions for the short-term and long-term asset announcement return when information effects exist and when we shut down the information effects channel. To obtain these expressions, we determine how investor beliefs about next period economic growth respond to an unexpected change in the target rate (i.e. a monetary policy surprise) and then determine how these beliefs propagate across horizons.

2.2.1. Monetary Policy Surprise and Economic Growth Expectations

As outlined above, in subperiod $\bar{t}$, the central bank sets the target rate $\widehat{\iota_{\bar{t}}}$ based on the realizations of the Fed information shock, $\epsilon_{\bar{t}}$, and the policy preference shock, $\mu_{\bar{t}}$. Investors do not observe the shocks $\mu_{\bar{t}}$ or $\epsilon_{\bar{t}}$ and must make inference from the observed target rate decision. We define a monetary policy surprise in the model as:

$$\Delta\iota^s_{\bar{t}} = \widehat{\iota_{\bar{t}}} - \mathbb{E}^i_{\underline{t}}\left(\widehat{\iota_t}\right) = \frac{1}{1-\alpha b}\left(\alpha\epsilon_{\bar{t}} + \mu_{\bar{t}}\right), \tag{7}$$

where $\Delta\iota^s_{\bar{t}}$ is the monetary policy surprise, the difference between the target rate announced by the central bank at time $\bar{t}$, $\widehat{\iota_{\bar{t}}}$, and investor forecasts of the target rate made at time $\underline{t}$, $\mathbb{E}^i_{\underline{t}}\left(\widehat{\iota_{\bar{t}}}\right)$. Equation (7) maps the unobserved shocks, μ and ϵ, to the observed target rate surprise, $\Delta\iota^s_{\bar{t}}$. We express Equation (7) as:

$$\mu_{\bar{t}} + \alpha\epsilon_{\bar{t}} = \Delta\iota^s_{\bar{t}}\left(1-\alpha b\right) \tag{8}$$

We denote investor beliefs about the realized values of $\epsilon_{\bar{t}}$ and $\mu_{\bar{t}}$ by $\epsilon^{i,*}_{\bar{t}}$ and $\mu^{i,*}_{\bar{t}}$ respectively. Equation (8) pins down the pairs of realized $\mu_{\bar{t}}$ and $\epsilon_{\bar{t}}$ shocks that would generate an observed target rate surprise. These pairs form a curve on the surface of the bivariate normal distribution of μ and ϵ and the normalized probability density of this curve characterizes the posterior distribution of investor beliefs about the realizations of $\epsilon_{\bar{t}}$ and $\mu_{\bar{t}}$ conditional on $\Delta\iota^s_{\bar{t}}$:

$$\epsilon^{i,*}_{\bar{t}}|\Delta\iota^s_{\bar{t}} \sim N\left(\frac{(1-\alpha b)}{\alpha}\frac{\sigma^2_{\alpha\epsilon}}{\sigma^2_{\alpha\epsilon}+\sigma^2_{\mu}}\Delta\iota^s_{\bar{t}}, \frac{1}{\alpha^2}\frac{\sigma^2_{\alpha\epsilon}\sigma^2_{\mu}}{\sigma^2_{\alpha\epsilon}+\sigma^2_{\mu}}\right), \tag{9}$$

where $\sigma^2_{\alpha\epsilon} = \alpha^2\sigma^2_\epsilon$ and σ^2_μ are the variances of $\alpha\epsilon$ and μ respectively, $\alpha > 0$ is the response of central bank policy to forecasted deviations of GDP growth from steady state, $b < 0$ is the effect of the target rate on economic growth. $\mu^{i,*}_{\bar{t}}$, beliefs about the realized policy preference shock, are obtained similarly. The change in investor expectations of next period's economic growth from $\underline{t}$ to $\bar{t}$ can be expressed as: $\mathbb{E}^i_{\bar{t}}\left(\Delta\widehat{GDP}_{t+1}\right) - \mathbb{E}^i_{\underline{t}}\left(\Delta\widehat{GDP}_{t+1}\right) = b\Delta\iota^s_{\bar{t}} + \mathbb{E}^i_{\bar{t}}\left(\epsilon^{i,*}_{\bar{t}}\right)$.

2.2.2. Propagation Across the Horizon

We express investor expectations for the k-period ahead economic growth and target rate in matrix form as:

$$\begin{pmatrix} \mathbb{E}_t\left(\Delta GDP_{\underline{t+k+1}}\right) \\ \mathbb{E}_t\left(\widehat{\iota}_{\bar{t+k}}\right) \end{pmatrix} = \frac{1}{(1-\alpha b)^k} \begin{pmatrix} \rho_g & b\rho_\iota \\ \alpha\rho_g & \rho_\iota \end{pmatrix}^k \begin{pmatrix} \mathbb{E}_t\left(\Delta GDP_{\underline{t+1}}\right) \\ \mathbb{E}_t\left(\widehat{\iota}_{\bar{t}}\right) \end{pmatrix} \tag{10}$$

We further simplify Equation (10) by expressing the transition matrix, $A \equiv \begin{pmatrix} \rho_g & b\rho_\iota \\ \alpha\rho_g & \rho_\iota \end{pmatrix}$ in the form $A = PDP^{-1}$, the product of diagonal matrix D and rotation matrices P and P^{-1}. Expressions for P, D, and P^{-1} are obtained by the standard procedure. Since the expression PDP^{-1} is a linear transformation of input vector $\begin{pmatrix} \mathbb{E}_t\left(\Delta GDP_{\underline{t+1}}\right) \\ \mathbb{E}_t\left(\widehat{\iota}_t\right) \end{pmatrix}$, we can express Equation (10) in terms of changes in forecasts from $\underline{t}$ to $\bar{t}$.[21]

2.2.3. Asset Return Expressions

To obtain an expression for the long-term asset return, we substitute Equation (10) into the long-term asset return given in Equation (5) and reorder the terms to substitute in the closed form of the resulting geometric series.[22] We provide both the long-term and short-term asset return expressions under two cases: (i) without information effects, and (ii) with information effects.

Without Information Effects. Without information effects, the short-term asset return is given by:

$$r^1_{\bar{t}} = b\beta_d\rho\Delta\iota^s_{\bar{t}}. \tag{11}$$

Similarly, the long-term asset return can be expressed as:

$$r^\infty_t = \frac{b\beta_d(1-\alpha b)}{(\rho\rho_g - 1)(\rho\rho_\iota - 1) - \alpha b}\Delta\iota^s_{\bar{t}}, \tag{12}$$

where $\Delta\iota^s_{\bar{t}}$ is the monetary policy surprise, $b < 0$ captures conventional effects of monetary policy

[21]Full derivations for the results in this subsection are provided in Section A1.1 in the Appendix.
[22]Section A1.2 in the Appendix provides details of the results in this subsection.

on economic growth from Equation (1), $\beta_d > 0$ captures the positive relationship between economic growth and dividend growth from Equation (3), $0 < \rho < 1$ from Equation (4), $\alpha > 0$ the central bank policy rule from Equation (2), and $0 < \rho_g < 1$, $0 < \rho_\iota < 1$ the persistence of the economic growth process and the policy rule respectively.

Without information effects, both the long-term and the short-term asset will load negatively on the monetary policy surprise under the full range of our model parametrizations. For example, suppose that there is a positive monetary policy surprise, $\Delta\iota_{\bar{t}}^{s} > 0$. This positive shock will have a contractionary effect on near-term economic growth and lower the expected cash flows of the short-term asset (this effect arises through the $b\beta_d < 0$ term in Equation (11)) resulting in a decline in the short-term asset price and a negative relationship with the surprise. The persistence of the shock lowers economic growth over the medium-term horizon, causing the price of the long-term asset to fall: the long-term asset loading on the monetary policy surprise also depends on $b\beta_d < 0$ with the longer-horizon effect of the surprise on cash flows captured by the $\frac{(1-\alpha b)}{(\rho\rho_g-1)(\rho\rho_\iota-1)-\alpha b} > 0$ term in Equation (12).

With Information Effects. With information effects, the return on the short-term asset is given by:

$$r_{\bar{t}}^{1} = \rho\beta_d \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\Delta\widehat{GDP}_{t+1}\right) = \frac{\rho\beta_d}{\alpha\left(\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2\right)}\left(\alpha b\sigma_\mu^2 + \sigma_{\alpha\epsilon}^2\right)\Delta\iota_{\bar{t}}^{s}. \tag{13}$$

The long-term asset return is:

$$r_{\bar{t}}^{\infty} = \frac{\beta_d\left(1-\alpha b\right)}{\left(\left(\rho\rho_g - 1\right)\left(\rho\rho_\iota - 1\right) - \alpha b\right)\alpha\left(\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2\right)}\left(\alpha b\sigma_\mu^2 + \sigma_{\alpha\epsilon}^2 - \rho_\iota\rho\sigma_{\alpha\epsilon}^2\right)\Delta\iota_{\bar{t}}^{s}. \tag{14}$$

Unlike in the no information effects case, with information effects it is possible for the short-term and long-term asset to load positively on the monetary policy surprise. For the short-term asset, the sign of the loading on the monetary policy surprise is determined by the sign of the expression $\alpha b\sigma_\mu^2 + \sigma_{\alpha\epsilon}^2$ from Equation (13) and for the long-term asset the sign of the loading is determined by the sign of $\alpha b\sigma_\mu^2 + \sigma_{\alpha\epsilon}^2 - \rho_\iota\rho\sigma_{\alpha\epsilon}^2$ from Equation (14).[23] The short-term asset will load positively on the monetary policy surprise when $\frac{-b}{\alpha} < \frac{\sigma_\epsilon^2}{\sigma_\mu^2}$. If the central bank announces an unexpected cut to the target rate, investors will attribute a portion of this cut to information about poor near-term economic conditions. The higher the relative variance of the information shock compared with the policy preference shock, $\frac{\sigma_\epsilon^2}{\sigma_\mu^2}$, the more investors will attribute the observed cut

[23] The terms $\frac{\beta_d(1-\alpha b)}{\left((\rho\rho_g-1)(\rho\rho_\iota-1)-\alpha b\right)\alpha\left(\sigma_{\alpha\epsilon}^2+\sigma_\mu^2\right)}$ for the long-term asset and $\frac{\rho\beta_d}{\alpha\left(\sigma_{\alpha\epsilon}^2+\sigma_\mu^2\right)}$ for the short-term asset are non-negative over the full range of model parametrizations.

to information effects as shown in Equation (9) above. A belief that the easing is driven by central bank information about poor next period growth forecasts lowers expected next period dividends, which in turn, generates a positive loading of the short-term asset return on the monetary policy surprise.

The intuition for the long-term asset is similar but the long-term asset price also depends on medium and longer-term expected cash flows and therefore depends on the persistence of central bank policy captured in the $-\rho_\iota \rho \sigma^2_{\alpha\epsilon}$ term. This persistence allows the model to capture the negative loading of the long-term asset return on monetary policy surprises documented by Bernanke and Kuttner [9]. In the above example, following an unexpected cut in the target rate, the long-term asset price will also be negatively impacted by the shock to near-term economic growth expectations. However, the long-term asset price will be positively affected by the higher expected medium-term economic growth generated by the conventional effects of monetary policy and the lower target rate. When monetary policy is sufficiently persistent, the longer-duration conventional effects outweigh the more transitory information effects and the stock market price increases. Concretely, with information effects, the market will load negatively on the monetary policy surprise when $\frac{-b}{\alpha}\frac{1}{(1-\rho_\iota\rho)} > \frac{\sigma^2_\epsilon}{\sigma^2_\mu}$. Taken together, the model implies the following conditions under which the short-term asset will load positively on the monetary policy surprise while the long-term asset will load negatively:

$$\frac{-b}{\alpha} < \frac{\sigma^2_\epsilon}{\sigma^2_\mu} < \frac{-b}{\alpha}\frac{1}{(1-\rho_\iota\rho)} \tag{15}$$

Since $\frac{1}{1-\rho_\iota\rho} > 1$ for the full range of our model parameterizations ($0 < \rho_\iota < 1$ and $0 < \rho < 1$), there exists an interval between $\frac{-b}{\alpha}$ and $\frac{-b}{\alpha}\frac{1}{(1-\rho_\iota\rho)}$ within which the shock variance ratio, $\frac{\sigma^2_\epsilon}{\sigma^2_\mu}$, will generate an opposite response of the short-term asset (positive loading on the monetary policy surprise) and the long-term asset (negative loading). This also highlights why we may fail to detect information effects using longer duration asset announcement responses, such as the market return, as the impact of information effects may be offset by the conventional effects of monetary policy over longer horizons.

2.3. Test of Information Effects

The model delivers a simple method to test the existence of information effects based on a regression of the short-term asset announcement return on the monetary policy surprise. As discussed above, in the case of no information effects, the announcement return expressions (Equations (11) and (12)) show that the short-term and long-term asset will both load negatively on the monetary policy surprise, consistent with conventional effects of monetary policy. With information effects, these loadings on the monetary policy surprise may become positive (Equations (13) and (14)).

Moreover, the response of the short-term and long-term asset will decouple since the short-term asset is relatively more exposed to near-term economic conditions. The implications are twofold. First, the long-term asset return can load negatively on monetary policy surprise even in the case of information effects, thus capturing the empirical fact that the equity market loads negatively on the monetary policy surprise (e.g., Bernanke and Kuttner [9]). Second, a positive loading of the short-term asset announcement return on the monetary policy surprise is sufficient to reject the null hypothesis of no information effects. This underlies our main test of information effects:

Under the null hypothesis of no information effects, the short-term asset announcement return loads negatively on monetary policy shocks.

2.3.1. Macroeconomic Predictability

The model also implies that the short-term asset announcement return should predict near-term macroeconomic growth with a positive sign. This predictability test is important for two reasons: first, it provides a direct link between the short-term asset announcement return and information about near-term economic conditions contained in central bank announcements; second, evidence of predictability validates the decision to model information effects through the cash flow channel.[24]

3. Measure Construction

In this section, we discuss the construction of the monetary policy shock and the estimation of the high-frequency changes in short- and long-horizon equity prices around each FOMC announcement.

3.1. Monetary Policy Shock

We obtain FOMC meeting dates and the timestamp when the meeting decision was made public from January 2004 through December 2019.[25] We use two high-frequency measures of monetary policy shocks. First, we use tick-by-tick data on the 30 Day Federal Funds Futures contract from the CME group to measure changes in expectations of the current month Federal Funds rate around

[24] We discuss these implications more thoroughly in Section A1.3 in the Appendix.

[25] This is the period over which we have high-frequency option pricing data used to construct the implied dividend strip prices. The dates and times of FOMC meetings until June 2013 are provided in the Appendix of Lucca and Moench [53] and in Bernile et al. [10]. We extend the data to December 2019 by obtaining FOMC meeting dates from the Federal Reserve website. We obtain the time of each announcement following a similar procedure from Fleming and Piazzesi [31]. Specifically, we record the timestamp of the earliest Dow Jones newswires on the day of each announcement with "Federal Reserve", or "Fed", or "Federal Open Market Committee", or "FOMC" in the headline. We verify that this procedure generates the same times as in Bernile et al. [10] in the latter portion of their sample and then populate the meetings from June 2013 to December 2019.

each FOMC announcement. Like Gürkaynak et al. [42] and Nakamura and Steinsson [59], we measure unexpected changes in interest rates around the 30-minute window surrounding scheduled Federal Reserve announcements. For an FOMC announcement occurring on date t, we define f_{t-} as the implied rate from the current month federal funds futures contract which occured at least 10 minutes before the FOMC announcement time and f_{t+} as the implied rate from this contract that occured at least 20 minutes after the announcement.[26] We construct the FOMC shock variable, $\Delta\iota_t^s$ as:

$$\Delta\iota_t^s = E_{t+}r - E_{t-}r = \frac{m}{m-d}\left(f_{t+} - f_{t-}\right), \tag{16}$$

where d is the day in the month of the FOMC announcement, m is the number of days in the month, and r is the average federal funds rate for the remainder of the month.[27] We denote the first FOMC shock as *Monetary Policy Shock (MPS*).

Second, we use the orthogonalized monetary policy shock from Bauer and Swanson [8]. Recent evidence suggests that monetary policy shocks are partially predictable, even if calculated in a narrow window around the FOMC announcements (Cieslak [18], Karnaukh and Vokata [48], Bauer and Swanson [7]). Bauer and Swanson collect six macroeconomic and financial variables that have been shown to predict monetary policy surprises and extract the residual from a regression of surprises on these variables which they refer to as the orthogonalized monetary policy shock. We download their orthogonalized monetary policy shock from Michael Bauer's website.[28] We denote the second FOMC shock variable as *Orthogonalized Monetary Policy Shock (OMPS).* We use *MPS* and *OMPS* as empirical analogues to the unexpected target rate change from the model, $\Delta\iota_t^s$.

3.2. Short- and Long-term Equity Prices

We use the S&P 500 index as an empirical proxy for the long-term equity asset in the model. For the short-horizon equity asset, we estimate prices of dividend strips that entitle the owner to the stream of dividends paid by the S&P 500 index over the next six months. We estimate the price of the short-term dividend strips from the put-call parity relationship spanning prices of European put and call options on the S&P 500 index. The put-call parity restriction dictates that at any given moment s:

[26] A federal funds futures contract pays off $100 - \bar{r}$ where $\bar{r}$ is the average effective federal funds rate over the month.

[27] We scale the price change by $\frac{m}{m-d}$ to account for the fact that the contract's settlement is based on the average federal funds rate over the entire month. We use the current month futures except when the FOMC meeting occurs in the last 7 days in the month, in which case we use the change in price of the next month's contract. Increases (decreases) in Δi_t^s correspond to increases (decreases) in expected Federal Funds rates.

[28] https://www.michaeldbauer.com/research.

$$c_s^h(X) - p_s^h(X) = \left(S_s - P_s^h\right) - Xe^{-rf_s^h \times h},$$

where h is the time-to-expiration (horizon) of the options, c is the price of a European call option, p is the price of a European put option, S is the value of the underlying index, P is the price of dividends on the underlying index during the life of the options, X is the strike price and rf^h is the annualized required risk-free rate of return over the corresponding period of the option maturity. Assuming an exogenous risk-free rate, we can invert the put-call parity relationship and estimate prices of short-term dividend P directly from the observed options prices (Van Binsbergen et al. [68]). Recent work has argued that funding costs of marginal investors in index options may differ from the standard proxies for risk-free rates (Song [64]) and that even small measurement error in interest rates can have an important impact on estimated dividend prices (Boguth et al. [11]). This is particularly important in our setting as FOMC announcements have a direct effect on interest rates. Golez and Jackwerth [35] advocate an interest rate invariant approach by first using a regression-based approach to estimate risk-free rates implied in the option prices (similar to Van Binsbergen et al. [72]), and then using these option-implied interest rates in the put-call parity relation to estimate dividend prices. This procedure ensures that dividend prices are internally consistent with the estimated risk-free rates. In this paper, we build on the approach used in Golez and Jackwerth [35] to simultaneously estimate dividend prices and risk-free rates from the put-call parity restriction using ordinary least squares.

We obtain minute-by-minute data for S&P 500 options (henceforth SPX options) from 2004 through 2019 from the Chicago Board of Options Exchange (CBOE). The data includes quotes on all the SPX options along with implied volatilities. We only keep standard monthly options that expire on the third Friday each month and have more than 0.3 years until the expiration. We eliminate observations before 10:00 am and after 16:00 pm. We use the bid-ask midpoint and we eliminate all options with bid or ask prices lower than 3 dollars. We also eliminate options with moneyness levels below 0.5 or above 1.5. We estimate prices of dividend strips and risk-free rates from these option prices immediately before each FOMC announcement and immediately after. For each FOMC announcement day, we define two 30 minute periods: the pre-announcement window and the post-announcement window. The pre-announcement window runs from 40 minutes before to 10 minutes before the FOMC announcement time. The post-announcement window runs from 20 minutes after to 50 minutes after the announcement time. For each estimation window, we run the following regression based on all put-call pairs within that interval:

$$S_s - c_s^h(X) + p_s^h(X) = \alpha + \beta X + \epsilon, \tag{17}$$

where c is the price of a European call option, p is the price of a European put option with the same strike price X and maturity h, and S is the value of the underlying index. All prices are measured at the same minute s. Identification comes from variation in the strike price X across put-call pairs with the same time-to-expiration h. The implied price of dividends over horizon h is $P_s^h = \hat{\alpha}$. The implied risk-free rate is $rf^h = -\frac{1}{h} log\left(\hat{\beta}\right)$.

The dividend strip horizons depend on the maturities of the option contracts available on the date of the given FOMC announcement. We estimate the dividend strip prices at a standardized 180-day maturity by linearly interpolating between the option-implied prices for horizons slightly above and below each standardized maturity. We follow the same procedure to obtain 180-day maturity risk-free rates. In the robustness check, we vary the maturity of dividend strip prices and interest rates to 270 days.[29]

3.3. Option-Implied Variable Construction

We denote by P_{t-}^{180} and P_{t+}^{180} the price of the S&P 500 dividend strip with 180-day maturity estimated in the 30-minute pre- and post-announcement window around the FOMC announcement on date t respectively. The variables rf_{t-}^{180} and rf_{t+}^{180} mark the pre-announcement and the post-announcement risk-free rates. We denote by P_{t-}^{∞} and P_{t+}^{∞} the average value of the S&P 500 index over the same 30-minute intervals used for calculating dividend price before and after the FOMC announcement time on date t. Additionally, we collect information on options' implied volatility and bid-ask spreads provided by the CBOE. The variables IV_{t-}^{180} and IV_{t+}^{180} denote the average volatility implied by SPX options for the 180-day maturity over the same 30-minute intervals before and after each FOMC announcement. $Bid-ask_{t-}^{180}$ and $Bid-ask_{t+}^{180}$ denote the average bid-ask spread for SPX put-call pairs that we use in the estimation of dividend strip prices for 180-day maturity over the same 30-minute intervals before and after each FOMC announcement. We define bid-ask spread for a given options pair as $\left(\left(p^{Ask} - p^{Bid}\right) + \left(c^{Ask} - c^{Bid}\right)\right) / \left(p^{Mid-point} + c^{Mid-point}\right)$. We measure the response of asset prices, risk-free rates, implied volatility, and bid-ask spread at each horizon to monetary policy shocks by computing the change in each variable from immediately before to immediately after each FOMC announcement. For asset prices, we use the change in log prices, $\Delta P_t^{180} = log\left(\frac{P_{t+}^{180}}{P_{t-}^{180}}\right)$ and $\Delta P_t^{\infty} = log\left(\frac{P_{t+}^{\infty}}{P_{t-}^{\infty}}\right)$ (the empirical analogues to $r_{\tilde{t}}^{1}$ and $r_{\tilde{t}}^{\infty}$ from the model respectively), where t is the FOMC announcement date. We use simple differences to measure the FOMC response of the risk-free rate, the implied volatility, and the options bid-ask spread over the same 30-minute intervals before and after the FOMC announcements.[30]

[29] On FOMC dates where the standardized shorter horizon maturities do not fall between the option maturities, we linearly extrapolate dividend prices based on the price of the shortest interior maturity and using the fact that dividend price ultimately converges to zero at the options maturity. For the risk-free rate, the implied volatility, and the bid-ask spread, we extrapolate by setting the values equal to the interest rate, the implied volatility, and the bid-ask spread of the closest interior maturity.

[30] $\Delta rf_t^{180} = rf_{t+}^{180} - rf_{t-}^{180}$, $\Delta IV_t^{180} = IV_{t+}^{180} - IV_{t-}^{180}$, and $\Delta Bid-ask_t^{180} = Bid-ask_{t+}^{180} - Bid-ask_{t-}^{180}$.

3.4. Use of Option Prices

Our approach to estimate short-term dividend strip prices from index options data rather than relying on dividend futures follows Van Binsbergen et al. [68] and Golez and Jackwerth [35]. Using options data enables us to construct a much longer time series of high-frequency estimates going back to 2004. Exchange-traded dividend futures on the S&P 500 dividend index were introduced in 2015 and provide a very short sample for analysis. Studies that use dividend futures prior to 2015 rely on proprietary sources (e.g., Van Binsbergen et al. [69]; Bansal et al. [6]). Van Binsbergen et al. [68] and Golez and Jackwerth [35] estimate the equity term structure using options data going back to 1996. However, high-frequency options data before 2004 are of low quality: options trading in the initial years prior to 2004 is several orders of magnitudes lower than today, which makes it difficult to construct high-frequency estimates of equity term structure. Accordingly, we start our sample in 2004 when the high-quality intra-daily S&P 500 options data begins (see also Van Binsbergen et al. [72]). In this period, we have over 500 put-call option price pairs to estimate short-term asset prices at the start of our sample and over 2,000 put-call pairs at the end of our sample.[31]

Despite the large number of put-call pairs used in our estimations, it is still possible that our estimates contain measurement error. This is because the put-call parity assumes a highly leveraged position so any noise in the data can have a non-negligible effect on the dividend strip estimates (Boguth et al. [11]). Noise can contribute to the volatility of dividend strip returns (Golez and Jackwerth [35]). Note, however, that our empirical tests (which we discuss in the next section) are based on the change in the short-term asset price in the 30 minute window around each FOMC announcement. Any systematic biases in our estimate of the short-term asset price arising from frictions in the options market will therefore be differenced out and will not affect our measurement of the short-term asset return. Similarly, changes in option market frictions around each FOMC announcement cannot generate our results unless these changes correlate with the sign of the monetary policy surprise and are related to near-term economic conditions.

[31] Table B.1 in the Internet Appendix provides information on the number of put-call option price pairs used to estimate the short-term asset price in the pre-announcement and the post-announcement window. Panel A shows this information on the first date in our sample, January 28, 2004 and Panel B shows the information on the last date in our sample, December 11, 2019. The Before row indicates the pre-announcement window and the After row indicates the post-announcement window. On January 28, 2004, we estimate the price of the 143 day dividend strip in the pre- and post-announcement windows using 510 and 540 put-call option price pairs respectively. We estimate the price of the 234 day maturity dividend strip in the pre- and post-announcement windows using 570 put-call pairs. We obtain the price of the 180-day dividend strip via linear interpolation. On December 11, 2019 the 156 day and 191 day maturity dividend strips have approximately 6,900 and 2,000 put-call pairs respectively (in both the pre- and post-announcement windows).

3.5. *Summary Statistics*

Table 1 presents the summary statistics and pair-wise correlations for our main variables. The sample period runs from January 2004 through December 2019 and covers 128 scheduled FOMC meetings. We do not include unscheduled FOMC announcements since many of them fall outside of the stock and derivatives trading hours.

Out of a total of 128 monetary policy shocks, we have 84 non-zero shocks, of which 53 are negative and 31 are positive. The average value of the monetary policy surprise, MPS, is -0.003 with a standard deviation of 0.030. The orthogonalized monetary policy surprise ($OMPS$) has an average value of 0.005 with a higher standard deviation of 0.044 in our sample. The correlation between the MPS and the $OMPS$ is 0.543. The average short-term asset announcement return is 0.003, with a standard deviation of 0.037. The average long-term asset announcement return is 0.001, with a smaller standard deviation of 0.006. The short-term asset return is positively correlated with both the MPS and the $OMPS$ (0.205 and 0.260 respectively). In contrast, the long-term asset announcement return is negatively correlated with both policy surprise measures (-0.320 with the MPS and -0.538 with the $OMPS$). Figure 2 presents scatter plots of short- and long-term asset announcement return against the monetary policy surprises. We observe the positive (negative) association between the short-term (long-term) asset return and both measures of the monetary policy surprise. The positive relationship between the short-term asset return and the policy surprise is especially pronounced using the orthogonalized monetary policy shocks (*OMPS*) from Bauer and Swanson [8].

We present the time-series of monetary policy shocks and of orthogonalized monetary policy shocks in Figure B.3 in the Internet Appendix. Figure B.4 in the Internet Appendix presents the time-series of the aggregate stock market return and of the 180-day dividend strip return at each FOMC meeting date.[32]

4. Asset Response to Monetary Policy Surprises

In this section, we implement the main test of information effects from the model. Specifically, we test whether we can reject the null hypothesis of no information effects based on the loading of the short-term asset return on the monetary policy surprise.

4.1. *Analysis*

We estimate the response of the short-term asset and the long-term asset to monetary policy shocks:

[32]The most negative short-term asset return occurs during the global financial crisis.

$$\Delta P_t = \alpha + \beta \Delta \iota_t^s + \epsilon, \tag{18}$$

where $\Delta \iota_t^s$ is the monetary policy surprise at date t (either the MPS or the $OMPS$ as defined in Section 3.1), ΔP_t^h is the change in the log asset price over the same window (ΔP^{180} denotes the short-term asset announcement return and ΔP^{∞} denotes the long-term asset announcement return). Results are reported in Table 2 separately for our baseline sample of FOMC days with non-zero monetary policy shocks in Panel A and for the sample of all FOMC meetings in Panel B. We also report results with the difference between the short-and the long-term asset announcement returns as the dependent variable. OLS standard errors are in parentheses below each coefficient estimate.

For the short-term asset return, we document a positive coefficient on the monetary policy surprise. In the MPS specifications, the estimated coefficient on the monetary policy surprise is 0.241 and significant at the 1 percent level in our baseline sample. The coefficient on the MPS is 0.249 and significant at the 5 percent level in the sample of all FOMC meetings.[33] In the orthogonalized shock (*OMPS*) specifications, the estimated coefficient is 0.236 in the baseline sample and 0.217 in the all-meetings sample, and always statistically significant at the 1 percent level. A one standard deviation monetary policy surprise corresponds to between 0.72 and 1.04 percent return on the short-term asset depending on the specification.

For the long-term asset, we find a negative coefficient on the monetary policy shock, consistent with prior literature (e.g., Bernanke and Kuttner [9]). The estimated coefficient on the MPS is -0.060 or -0.059, depending on the sample choice, and always statistically significant at the 1 percent level. In the $OMPS$ specifications, the estimated coefficient is -0.072 in the baseline sample and -0.068 in the all-meetings sample, and statistically significant at the 1 percent level. The difference in response of the short-term and long-term equity to monetary policy news is positive and significant at the 1 percent level in all specifications.

4.2. Robustness and Discussion

In this section, we conduct robustness checks of our baseline result. We also discuss the high-frequency response of implied interest rates, short-term Treasury bonds, and implied volatility to monetary policy surprises.

4.2.1. Robustness

Table 3 reports the robustness results using the sample of FOMC days with non-zero monetary policy shocks. The left three columns show specifications using the baseline monetary policy

[33] We report statistical significance based on the two-tailed test. The model implies a one-tailed t-test of the null hypothesis that $\beta < 0$. If we implement this test, we reject the null hypothesis at the 1 percent level across all specifications considered in Table 2.

surprise and the right three columns show specifications using the orthogonalized monetary policy surprise from Bauer and Swanson [8]. Standard errors are presented in parentheses below each coefficient estimate. The corresponding results for the sample of all FOMC announcements are similar and are reported in Table B.2 in the Internet Appendix.

Main Robustness Checks. Panel A of Table 3 presents results from the main set of robustness tests. The first specification (first subpanel) winsorizes asset returns at the 5 percent level. The estimated coefficients on the short-term and the long-term asset announcement return (and the difference between them) are significant at the 1 percent level in all specifications. Bauer and Swanson [8] identify eight FOMC announcements that are particularly important for the macroeconomy and asset prices. In the second specification (second subpanel), we remove the most influential observations from our sample as identified by Bauer and Swanson [7] (in our sample this set consists of the meetings on 1/28/2004, 9/18/2007, 1/30/2008, and 4/30/2008). We find similar results compared with our baseline specification. We find similar results if we exclude the 2008 financial crisis from our sample. Based on this evidence, we conclude that our results are not driven by a handful of influential observations. Next, we report results from specifications run using heteroscedasticity consistent GMM standard errors. If our option-implied short-term asset prices contain noise, the coefficient estimate on monetary policy shock will remain unbiased,[34] but the standard error of the coefficient estimate may be higher. Estimated coefficients on the short-term and the long-term asset announcement return (and the difference between them) are significant at the 1 percent level in all specifications. Next, we control for the average bid-ask spread in the option prices used to construct the short-term asset price. The concern is that our results could be driven by the bid-ask bounce. We calculate bid-ask spread for put-call pairs that we use in the estimation of dividend strip prices around the same 30-minute window around each FOMC announcement (see Section 3.3 for details). We note that the change in the average bid-ask spread from pre- to post-announcement is very similar for positive and negative monetary policy shocks. When we include the change in the bid-ask spread as a control variable the estimated coefficients on the monetary policy surprises increase in magnitude and are significant at the 1 percent level across all specifications. Finally, we replace the 180-day dividend strip with a 270-day maturity dividend strip as the short-term asset. The estimated coefficients on the short-term asset announcement return decrease somewhat but remain significant.[35]

[34] Assuming the monetary policy shock does not contain measurement error.

[35] We also consider CAPM risk-adjusted short-term asset returns. We estimate beta for dividend strips on a placebo sample (7 days before and 7 days after the FOMC announcements) to be 0.291. We assume that dividend strip beta is constant throughout our sample and use this beta to compute the market-adjusted short-term asset announcement return. Results are reported in Table B.3 in the Internet Appendix. Adjusting raw returns for market movements strengthens our results since, consistent with prior literature, our estimate for the short-term asset CAPM beta is

Overreaction. In our baseline test, to align with existing studies of high-frequency asset price responses around FOMC announcements, we measure dividend strip prices in 30 minute windows around each announcement (where the pre-announcement window ends 10 minutes before the announcement and the post-announcement window begins 20 minutes after the announcement). These narrow windows provide clean identification of the impact of central bank policy. However, it is interesting whether the initial asset price response that we document reverts over slightly longer windows. We study this question in two ways.

First, we plot the intra-daily cumulative average return of the short-term and long-term asset around each announcement grouped by positive and negative monetary shocks in Figure 3. We estimate asset prices in the following 30 minute windows: 70 minutes to 40 minutes before the announcement; 40 minutes to 10 minutes before the announcement; 20 minutes to 50 minutes after the announcement; and the last 30 minutes of the trading day from 3:30 pm to 4:00 pm. In Panel A, we plot cumulative average returns for the short-term asset conditional on the sign of either our monetary policy shock (left panel) or the orthogonalized monetary policy shock (right panel). For consistency, we plot the same figure for the long-term asset in Panel B.

The returns before the announcement are largely flat and similar across negative and positive monetary policy surprises (for both the short-term and long-term asset). At the announcement, we see positive short-term asset returns when Fed unexpectedly increases interest rates and negative returns when Fed unexpectedly decreases interest rates, consistent with our main results. Extending the cumulative return of the short-term asset to the end of the day, we observe that the announcement response does not revert by the end of the day following positive monetary policy surprises. For negative monetary policy surprises, the negative announcement return becomes even more negative by the end of the day. These results confirm that the positive loading of dividend strips on monetary shocks does not mean-revert using longer windows extended to the end of the day.

Second, we report results from specifications which replace our original measure of dividend strip announcement returns with announcement returns calculated in two alternative ways. For the first alternative, we keep the pre-announcement estimation window fixed (40 minutes to 10 minutes before the announcement) and move the post-announcement window to the last 30 minutes of the trading day, from 3:30 pm to 4:00 pm. In this way, we capture the total (cumulative) return on the FOMC announcement days. For the second alternative, we expand the estimation windows. That is, instead of using 30 minute estimation windows, we let the pre-announcement window run from 10:00 am until 10 minutes before the FOMC announcement and we let the post-announcement

positive and the market reacts in the opposite direction to the strip.

window run from 20 minutes after the announcement to the end of the trading day at 4:00 pm.[36] These longer estimation windows reduce the noise in the short-term asset price estimation.

We report the results in Panel B of Table 3. Under the first alternative, the estimated coefficient of short-term asset announcement return on our monetary policy shock is 0.171 and significant at the 10 percent level. In the specification with the orthogonalized monetary policy shock, the estimated coefficient is 0.196 and significant at the 5 percent level. Under the second alternative, the estimated coefficients are positive and significant at the 5 percent level in the monetary policy surprise specification and significant at the 1 percent level in the orthogonalized monetary policy surprise specification.

4.2.2. Implied Risk-free Rate

Intuitively, following an unexpected change in the federal funds rate, the risk-free rate should move in the same direction. We obtain a direct estimate of the risk-free rate through the put-call parity restriction. We find indeed that the implied risk-free rate increases for positive monetary policy shocks and decreases for negative monetary policy shocks.[37] All else equal, the short-term asset price should decrease (increase) following an increase (decrease) in the risk-free rate. Accordingly, the changes in risk-free rates would generate a negative loading of the short-term asset return on the monetary policy surprise which is the exact opposite pattern that we document empirically. This indicates that our results are not driven by changes in risk-free rates.

4.2.3. Short-Term Treasury Bonds

We also test how short-term Treasury bonds react to monetary policy shocks. Specifically, we analyze the price reaction of the iShares Short Treasury Bond ETF (SHV) in narrow windows around the FOMC announcement. We obtain the data for the SHV from the NYSE Trade and Quote database. In total, the data covers 104 FOMC announcements from the introduction of SHV at the begining of 2007 until the end of 2019. We calculate the log return of the SHV based on the last mid-quote 10 minutes before the FOMC announcement to the first mid-quote 20 minutes after the FOMC announcement.[38]

We report the results in Table B.4 in the Internet Appendix. We find a negative association between bond prices and monetary policy surprises. The estimated coefficient is -0.001 and significant at the 1 percent level when we use the baseline monetary policy surprise measure and when we use the orthogonalized monetary policy shock from Bauer and Swanson, both when we restrict

[36] Scheduled FOMC meetings in our sample take place around 12 pm or 2 pm so pre-/post-announcement estimation windows under the second alternative are always longer than an hour and can be as long as four hours.

[37] Specifically, for $MPS > 0$, the 180-day implied risk-free rate increases on average by $\Delta rf_t^{180} = 0.04$ percentage points; for $MPS < 0$, the 180-day implied risk-free rate decreases on average by $\Delta rf_t^{180} = -0.02$ percentage points.

[38] We eliminate any quotes below 105 or above 115 and observations where the bid-ask spread is higher than 0.1.

the sample to non-zero surprises and in the full sample. Overall, the reaction of Treasury bonds around FOMC announcements is consistent with the change in the federal funds target rate and the change in the implied risk-free rate.

4.2.4. S&P 500 Implied Volatility

Our baseline result is not driven by changes in volatility. Specifically, for $MPS > 0$, 180-day option-implied volatility decreases on average by $\Delta IV^{180} = -0.08$ percentage points; for $MPS < 0$, 180-day option-implied volatility decreases on average by $\Delta IV^{180} = -0.16$ percentage points.[39] We take some caution in interpreting these results given that we observe the change in implied volatility for the S&P 500 index and not for the short-term dividend strip which means we are measuring the level of uncertainty regarding the market return.[40] However, the decrease in uncertainty for both positive and negative monetary policy surprises cannot explain our empirical results: following an unexpected cut in the target rate, uncertainty decreases implying that the short-term asset price should rise which is opposite to what we observe empirically.

5. Short-term Asset Return and Economic Conditions

The positive loading of the short-term asset on the monetary policy surprise comprises our main evidence of information effects. The model makes the assumption that information effects operate through the cash flow channel. This generates a testable implication that the short-term announcement return should positively predict near-term economic growth.

5.1. Macroeconomic Predictability

We test the predictive power of the short-term asset announcement returns for future real dividend growth and real GDP growth over different horizons:

$$\Delta x_{t+k} = \alpha_k + \beta_k \Delta P_t^{180} + \delta_k Controls_t + \epsilon_{t+k}, k \in \{1, 2, ..., 6\}, \tag{19}$$

where Δx_{t+k} is the $k-$quarter ahead real economic growth (real dividend or real GDP growth), ΔP_t^{180} is the announcement return on the short-term asset (180-day dividend strip) in the 30-minute window around the FOMC announcements in quarter t. Controls include the monetary policy shock Δi_t^s, the long-term asset announcement return ΔP_t^{∞} (S&P 500 index), and the change in the option implied volatility ΔIV_t. Dividend growth corresponds to dividends accrued by the

[39] A decrease in the implied volatility following both positive and negative monetary policy shocks is consistent with the resolution of uncertainty associated with the FOMC announcement.

[40] To directly measure uncertainty related to short-term asset, we would require options on index dividends. Such options were recently introduced in Europe but not in the US (Gormsen et al. [39]).

S&P 500 index.[41] To account for seasonality, we calculate quarterly dividend growth as the difference in log dividends in quarter k and log dividends in the same quarter in the previous year, $\Delta d_{t+k} = log\left(\frac{D_{t+k}}{D_{t+k-4}}\right)$. Similarly, we calculate quarterly GDP growth as $\Delta gdp_{t+k} = log\left(\frac{GDP_{t+k}}{GDP_{t+k-4}}\right)$ using seasonally unadjusted quarterly real GDP from the St. Louis Federal Reserve. We run our predictability tests on the baseline sample of FOMC announcements with non-zero monetary policy surprises.

The first six columns in Panel A of Table 4 present univariate predictive regressions for real dividend growth. We report Newey-West standard errors with $k + 1$ lags in parentheses. The estimated coefficient on the short-term asset announcement return is positive and significant at the 1 percent level across all specifications. The estimated coefficient varies from 0.671 for one-quarter ahead dividend growth to 1.203 for four-quarter ahead dividend growth and then declines to 1.038 for the six-quarter ahead specification. A one standard deviation decrease in the short-term asset price corresponds to a 0.27 standard deviation decline in real dividend growth over the next quarter. Panel B of Table 4 presents similar predictive regressions which include the monetary policy surprise, the market return, and the change in implied volatility as controls. The coefficient estimates on the short-term asset announcement return are significant at the 5 percent level or higher across all specifications and follow a similar pattern to the univariate tests.[42]

The last six columns in Panel A of Table 4 present the corresponding predictive regressions for real GDP growth. The overall pattern of results is similar to the real dividend growth forecasting regressions (although the coefficients are significant at the 1 percent or 5 percent level only up to three quarters ahead). The coefficient on the short-term asset return reaches 0.242 for three-quarter ahead GDP growth before decreasing to 0.045 in the six-quarter ahead specification. Panel B of Table 4 presents the results including the control variables. The estimated coefficients on the short-term asset return remain positive, but are only significant at the 5 percent level in the three-quarter ahead specification and at the 10 percent level in the other specifications except for the six-quarter ahead regression which is not significant.

[41] We construct dividends following the approach in Golez [34]. We first estimate daily dividends from the S&P 500 price index and total return index from Datastream. We then aggregate daily dividends to the monthly level, at which point we adjust dividends for inflation using the monthly CPI time series from Robert Shiller's webpage. We aggregate real monthly dividends across each quarter.

[42] We run a number of robustness tests in the Internet Appendix. Table B.5 in the Internet Appendix documents similar results using only the latest FOMC meeting each quarter. We report results where we vary the estimation windows for calculating asset returns in Tables B.6 and B.7). The results are strongest when we use wide windows to estimate dividend strip prices. Additionally, Table B.8 in the Internet Appendix, reports the results for all FOMC announcements (not only for non-zero MPS announcements). The overall patterns for the all-meetings sample are similar but the significance is lower, consistent with the notion that announcements with monetary policy surprises contain more information about economic fundamentals.

5.1.1. Macroeconomic Predictability: Non-FOMC Days

We would expect information effects to be concentrated on days when the central bank unexpectedly changes the target federal funds rate (i.e. FOMC announcements with non-zero monetary policy shocks) and absent from days without new information released by the central bank (e.g. non-FOMC meeting days). As a placebo test, we estimate the change in the short-term asset price seven days before and seven days after each FOMC announcement date using a 30-minute window around the same time of day of the actual FOMC announcement.[43] We run the predictive regression specification from Equation (19) using the return of the short-term asset on non-FOMC meeting days. Table 5 presents the results of these regressions. The short-term asset return on non-FOMC days has no predictive power for future dividend growth or GDP growth at any horizon. Most coefficient estimates are negative and all are insignificant.[44]

6. Discussion

We have documented that (i) the short-term asset return around FOMC announcements loads positively on monetary policy shocks, and that (ii) the short-term asset announcement return predicts growth in near-term economic conditions. These findings are consistent with our model of Fed information effects and suggest that investors perceive FOMC announcements as important signals about the current state of the economy. Importantly, our results are not driven by the omitted economic news channel proposed by Bauer and Swanson [7]. In this section, we provide supplementary analysis and discussion for these main results.

We first extend the analysis from Romer and Romer [62] through the recent sample to test whether central bank forecasts contain information beyond what is known to commercial forecast-

[43] For example, if FOMC announcement takes place on Thursday at 2 pm, we estimate the short-term asset return on the previous and next Thursday over the 30 minute window around the 2 pm. We observe a data issue on January 21, 2004 (first observation in our placebo sample) where the short-dated dividend strip return is implausibly low. To address this issue, we calculate the 180-day dividend strip return on this day by extrapolating from the longer-maturity dividend strip (rather than by interpolating between dividend strips with different maturities).

[44] We also implement a joint specification which combines FOMC meetings with the non-FOMC days and run the following predictive regression:

$$\Delta x_{t+k} = \alpha_k + \beta_k \Delta P_t^{180} + \delta_k FOMC_t^{NZ} + \theta_k \Delta P_t^{180} \times FOMC_t^{NZ} + \epsilon_{t+k}, k \in \{1, 2, ..., 6\},$$

where Δx_{t+k} is the $k-$quarter ahead real economic growth (real dividend or real GDP growth) and $FOMC^{NZ}$ a dummy variable equal to 1 on non-zero monetary policy shock meeting days and 0 otherwise. Panel A in Table B.9 in the Internet Appendix reports the results for the dividend growth specifications. We focus on the interaction term, θ_k, which estimates the differential relationship between the short-term asset return and future economic conditions on FOMC announcement days versus on non-announcement days. The coefficient estimate on the interaction term is positive and significant at the 1 percent level at all horizons. The results for the real GDP growth regressions are reported in Panel B and show a similar pattern. These results indicate that the short-term asset announcement return is driven by news about macroeconomic conditions contained in the FOMC announcement, consistent with information effects.

ers. While central bank (Greenbook) forecasts are only available after a lag period of five years, and therefore cannot directly inform investors about current economic conditions, this test tells us whether it is reasonable for investors to assume that central banks have an information edge.[45]

Then, we discuss two aspects of the stylized framework from Section 2: the assumption of a contant risk premium; and an extension of the model with soft information. We end by providing a simple calibration of the model. The calibration provides estimates of the key parameters in the model and places bounds on the variances of the information effect and policy preference shocks. This enables us to estimate model-implied variances of shocks and to characterize how growth expectations and beliefs about the path of the target rate respond to monetary policy surprises in our model.

6.1. Fed versus Private Sector Forecasts

We test whether Fed forecasts contain information above and beyond what is known to private sector forecasters. We compare central bank Greenbook forecasts with private sector forecasts from the Survey of Professional Forecasters. Our sample runs from the third quarter of 1990 to the fourth quarter of 2018.[46] We discuss the data and our main specification below.

Fed forecasts come from Greenbook data obtained from the Philadelphia Federal Reserve's Greenbook dataset. The Greenbook is produced by research staff at the Board of Governors for each meeting of the Federal Open Market Committee and contains projections about various economic variables. The Greenbook is produced eight times per year and is available at a lag of five years.[47] Greenbook forecasts, which we will refer to as "Fed forecasts," are constructed as:

$$G_t = 100 \times \left(\frac{X_t}{X_{t-1}} \right)^4 - 1, \tag{20}$$

where X_t denotes the period t observation for level variable X and the t subscript indexes a quarterly observation date. We study Fed forecasts for Real Gross Domestic Product growth (RGDP growth), defined as the quarter-over-quarter growth in real GDP, chain weighted (annualized percentage points).

[45]The central bank may possess additional information including advance knowledge of industrial production data and reports submitted by bank directors. However, even in the case where the central bank does not possess additional information, information effects may exist given differences in processing capacity arising from the many teams of economists employed by the central bank whose primary function is to process data on economic conditions (Nakamura and Steinsson [59]).

[46]The sample start date corresponds to the transition date when the Philadelphia Federal Reserve first took over the survey from ASA/NBER in the second quarter of 1990. The first survey conducted by the Philadelphia Federal Reserve in real time is the third quarter of 1990. The Philadelphia Federal Reserve provides exact dates for the survey deadlines starting in this period and the deadlines ensure that SPF forecasters have access to the advance report of the national income and product accounts. The exact timing of prior surveys before 1990 is not known.

[47]There are years with more than eight Greenbooks but these occur prior to the start of our sample.

We combine the Fed forecast data with private sector forecasts from the Survey of Professional Forecasters (SPF) provided by the Federal Reserve Bank of Philadelphia. The survey's timing is geared to the release of the Bureau of Economic Analysis's advance report of the national income and product accounts (NIPA). This report is released at the end of the first month of each quarter and contains the first estimate of GDP for the previous quarter. The deadline for survey responses is the second to third week of the middle month of each quarter. Each SPF forecast is mapped to the nearest subsequent Greenbook forecast. This produces a one-to-one mapping between SPF and Fed forecasts which are both made within the same quarter. For the SPF forecasts, we also focus on Real Gross Domestic Product, the quarterly level of chain-weighted real GDP (seasonally adjusted). We use forecasts from the median growth file which reports the rate of growth of the median forecast for the level (not the median forecast for the growth rate). These quarterly growth rate forecasts are annualized following the same procedure from Equation (20) above. We obtain the actual quarterly real gross domestic product data from the Philadelphia Federal Reserve's real-time data set on the national income and product (NIPA) accounts. We use data from the latest vintage, the first quarter of 2024, and compute quarterly growth rates which we then annualize following the same procedure from Equation (20) above.

We implement the following regression specification:

$$\Delta RGDP_{t+k} = \alpha_k + \beta_k^{Fed}\mathbb{E}_t^{Fed}\left(\Delta RGDP_{t+k}\right) + \beta_k^{SPF}\mathbb{E}_t^{SPF}\left(\Delta RGDP_{t+k}\right) + \epsilon_{t+k}, k \in \{0,1,2,3,4\}, \tag{21}$$

where $\Delta RGDP_{t+k}$ is the $k-$quarter ahead real GDP growth defined above, $100 \times \left(\frac{GDP_{t+k}}{GDP_{t+k-1}}\right)^4 - 1$, where GDP_{t+k} is the level of real GDP in quarter $t+k$. $\mathbb{E}_t^{Fed}\left(\Delta RGDP_{t+k}\right)$ is the Greenbook forecast made in quarter t and $\mathbb{E}_t^{SPF}\left(\Delta RGDP_{t+k}\right)$ is the SPF forecast made in quarter t, both defined above. k equal to 0 corresponds to forecasts for current quarter economic growth made within the quarter. Including both the Greenbook forecasts and the SPF forecasts alongside each other allows for situations in which the Fed and the private sector both possess orthogonal information about economic conditions. We also implement a univariate specification that regresses future real GDP growth on the Greenbook forecasts.

Table 6 reports the results of these specifications. Panel A presents the univariate specification using only Greenbook forecasts. The coefficient estimates are positive for all horizons and significant at the 1 percent level for the current quarter and one-quarter ahead specifications and significant at the 5 percent level for the two-quarter ahead specification. The adjusted R^2s are 0.52, 0.22, and 0.09, 0.02 for the current quarter through three-quarter ahead specifications respectively and close to zero for the four-quarter ahead specification.

Panel B presents results for the bivariate specifications which include SPF forecasts alongside central bank forecasts. The coefficient estimates on the central bank forecasts remain positive across all horizons and are significant at the 1 percent level for the current quarter and significant at the 5 percent level for the one-quarter and two-quarter ahead specifications. The coefficient estimates for the private sector forecasts are not significantly different from zero at any horizon. These results provide further support for our main results, indicating that central bank forecasts contain information about near-term economic conditions up to two-quarters ahead (the same as the maturity of the short-term asset cash flows) that is not contained within private sector economic growth forecasts.

6.2. Discussion of the Model

In this subsection, we discuss the model's assumption of a constant risk premium and an extension of the model based on soft information.

6.2.1. Modeling Assumption of Constant Risk Premia and Risk-Free Rates.

The assumption of constant risk premia in the model follows the established view of information effects as news about near-term economic conditions. It is possible that discount rate shocks also drive variation in the short-term asset announcement return. However, as discussed in the Introduction, for our main test of information effects, it does not matter whether the observed response of the short-term asset is driven by fluctuations in risk premia or by cash flow news: in either case, a positive loading of the short-term asset response on monetary policy surprises would constitute evidence of information effects. In the risk premia channel, an unexpected cut in interest rates signals weak conditions, which would increase short-horizon risk premia and depress the price of the short-term asset. That said, the analysis of Fed forecasts suggest that Fed has an informational edge over the private sector regarding near-term economic conditions, and the GDP and dividend growth predictability tests indicate that Fed information effects do operate through the cash flow channel: the short-term asset announcement return predicts near-term economic growth and cash flow growth. Still, we do not rule out that variation in the short-term asset return is driven by risk premia shocks - this channel remains an interesting avenue for future research. Lastly, we do not incorporate the direct effect of changes in the risk-free rate on short-term asset prices in our asset return equations. Accounting for this effect would work in our favor, as the direct effect of a decrease (increase) in the risk-free rate would result in an increase (decrease) in short-term asset prices. In other words, accounting for changes in risk-free rates would make the opposite response of short-term assets we document even more pronounced.[48]

[48]The impact of adding changes in risk-free rates to our model is demonstrated in Andrei Goncalves' discussion of our paper available on his website.

6.2.2. Short-term Asset Return and Soft Information

In our model, the target rate surprise uniquely determines revisions in investor expectations and pins down both the short- and long-term asset return. Empirically, the short-term asset return does not move in lockstep with the target rate surprise. In part, this additional variation could be due to measurement error in dividend strip prices (Golez and Jackwerth [35]). Table 4 shows that short-term asset announcement return predicts near-term dividend growth after controlling for monetary policy surprise. Thus, the additional variation could also reflect conditioning information that goes beyond the target rate surprise. Such information could stem from soft information related to Fed conferences and forward guidance. In Appendix A3, we extend the model by allowing for soft information being released from the Fed to formalize how the short-term asset announcement return can decouple from the target rate surprise.

6.3. Calibration

The model from Section 2 provides testable predictions of information effects using features of the equity term structure. In this subsection, we expand the connection between the stylized model and our empirical results by presenting a calibration of the model and illustrating the role of information effects on the announcement response of the short-term and long-term assets.

We use data on real gross domestic product, federal funds rates, and Greenbook forecasts to estimate model parameters from the economic growth process and policy rule specified in Equations (1) and (2). We then compute the bounds on the variance of information effect and policy preference shocks that will generate the observed positive (negative) loading of the short-term (long-term) asset return on monetary policy surprises in the data. Next, we use the observed short-term asset return, long-term asset return, and monetary policy surprises to estimate the variance of both shocks. Finally, we discuss the model-implied changes in expected quarterly growth rates and expected target rates following both negative and positive monetary policy surprises.

6.3.1. Baseline Parameters

We estimate the model parameters below. All parameter estimates and a brief description of each parameter are summarized in Table 7.

Economic Growth Process. To estimate the parameters in Equation (1), we run the following regression:

$$\Delta RGDP_{t+1} = \hat{c} + \hat{\rho_g} \Delta RGDP_t + \hat{b} \iota_{t+1} + \epsilon_{t+1}, \tag{22}$$

where $\Delta RGDP$ is quarterly real gross domestic product growth from the 2024Q1 vintage of the Philadelphia Federal Reserve's real-time data set on the national income and product (NIPA) accounts and ι_{t+1} is the average effective federal funds rate from the first month of quarter $t + 1$

retrieved from FRED, Federal Reserve Bank of St. Louis. The data is quarterly from the third quarter of 1954, the beginning of the effective federal funds rate data from FRED, to the fourth quarter of 2021. Our estimate for $\hat{\rho_g}$ is 0.065 with a standard error of 0.061 and our estimate for $\hat{b}$ is -0.097 with a standard error of 0.074. The negative sign of the $\hat{b}$ coefficient is consistent with the conventional effects of monetary policy and indicates that a 100 basis point increase in the federal funds rate is associated with a 9.7 basis point decline in quarterly real gross domestic product growth.

Policy Rule. We estimate the model parameters from the policy rule by implementing the following specification:

$$\iota_{t+1} = \hat{c} + \hat{\rho}_\iota \iota_t + \hat{\alpha}\mathbb{E}_t^{cb}\left(\Delta RGDP_{t+1}\right) + \epsilon_{t+1}, \tag{23}$$

where, as above, ι_{t+1} is the average effective federal funds rate from the first month of quarter $t+1$ retrieved from FRED, Federal Reserve Bank of St. Louis, and $\mathbb{E}_t^{cb}\left(\Delta RGDP_{t+1}\right)$ is the Fed forecast for next quarter real GDP growth from the Greenbook associated with the latest FOMC meeting in quarter t. The data are quarterly and run from the first quarter of 1967 to the fourth quarter of 2018, the first and last availability of the Greenbook forecast data. Our estimate for $\hat{\rho}_\iota$ is 0.970 with a standard error of 0.022 and our estimate for $\hat{\alpha}$ is 0.105 with a standard error of 0.040. These estimates are consistent with a persistent target rate and conventional policy response to economic conditions. The coefficient estimate for $\hat{\alpha}$ indicates that a 100 basis point lower forecast for next period real GDP growth corresponds to a 10 basis point cut in the target rate: the central bank responds to poor expected economic growth by lowering the target rate.

Other Parameters. We use a quarterly time discount rate, ρ, of 0.99 corresponding to an annual discount rate of 0.96 consistent with prior literature. We set β_d, the parameter governing the relationship between dividend growth and GDP growth from Equation (3), equal to 1. This parameter scales the model-implied returns of the short-term and long-term assets.

6.3.2. Variance of shocks

The variances of the policy preference shock, σ_μ^2, and the information shock, σ_ϵ^2, determine the extent to which investors attribute monetary policy surprises to Fed information about the economy. However, it is not possible to obtain independent estimates of these parameters from external data sources. Accordingly, we input the other parameter estimates into the implications of the model to show the exact boundary of parameterizations for σ_μ and σ_ϵ which will generate an opposite response of the short-term and long-term asset. Then we use the short-term and long-term asset response data and the observed monetary policy surprise series to obtain estimates for these parameters within our setting.

Bounds. We characterize the range of parameterizations for the variance of the information effect shock and the policy preference shock which will generate the observed opposite response of the short-term and long-term asset to monetary policy surprises. We use the parameter estimates from the previous section for ρ_ι, α, b, ρ and the model implication from Equation (15) which determines the bounds on the variance ratio, $\frac{\sigma_\epsilon^2}{\sigma_\mu^2}$, that generate a positive loading of the short-term asset return on the monetary policy surprise and a negative loading of the long-term asset return on the monetary policy surprise. Figure 4 plots the standard deviation of the information effect shock, σ_ϵ, on the y-axis and the standard deviation of the policy preference shock, σ_μ, on the x-axis. The red shaded region indicates σ_ϵ and σ_μ pairs in which the long-term asset loading on the monetary policy surprise will be positive, the opposite of the negative loading documented empirically. The blue shaded region indicates the region in which the short-term asset loading on the monetary policy surprise will be negative, the opposite of the positive loading we document. The white region in between shows the range of parameterizations which will generate the documented positive loading of the short-term asset and negative loading of the long-term asset. As we move northwest on the graph, the variance ratio, $\frac{\sigma_\epsilon^2}{\sigma_\mu^2}$, increases and investors will attribute a larger component of a given monetary policy surprise to information effects. For example, the higher the ratio, the more a negative monetary policy surprise will be attributed to negative news about next period's economic growth. When the ratio is sufficiently high, this negative impact on near-term economic growth will dominate the longer horizon positive effects of the lower rate on economic growth and the long-term asset return will be negative (generating a positive loading on the monetary policy surprise). Conversely, as we move southeast on the graph, the variance ratio decreases and, for example, the more a negative monetary policy surprise is attributed to the policy preference shock. When the ratio is sufficiently low, a negative monetary policy surprise will be primarily attributed to policy preferences and the conventional effects of policy will dominate information effects, even at the near horizon, and the short-term asset return will be positive (generating a negative loading on the monetary policy surprise).

Estimation. We estimate the parameter values for the variance of the information effect shock, σ_ϵ^2, and the variance of the policy preference shock, σ_μ^2. We start with the parameter estimates from the previous section (b, ρ_g, ρ_ι, ρ, α, β_d, summarized in Table 7). Our model implies three moment conditions based on the return of the short-term asset, the return of the long-term asset, and the variance of the monetary policy surprise:

$$r_{\bar{t}}^{1} = \frac{\rho\beta_d\left(\alpha b\sigma_\mu^2 + \sigma_{\alpha\epsilon}^2\right)}{\alpha\left(\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2\right)}\Delta\iota_{\bar{t}}^s$$

$$r_{\bar{t}}^{\infty} = \frac{\beta_d\left(1-\alpha b\right)\left(\alpha b\sigma_\mu^2 + \sigma_{\alpha\epsilon}^2 - \rho_\iota\rho\sigma_{\alpha\epsilon}^2\right)}{\left(\left(\rho\rho_g - 1\right)\left(\rho\rho_\iota - 1\right) - \alpha b\right)\alpha\left(\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2\right)}\Delta\iota_{\bar{t}}^s$$

$$Var(\Delta\iota_{\bar{t}}^s) = \left(\frac{1}{1-\alpha b}\right)^2\left(\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2\right).$$

We estimate the σ_ϵ^2 and σ_μ^2 parameters using the Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm, a quasi-Newton optimization technique optimized for problems where the variables have bounds. We impose the restriction that σ_ϵ^2 and σ_μ^2 are both greater than 0. The third equation restriction is not necessary but provides a sharper characterization based on the observed variance of the monetary policy surprise. We use data for the short-term asset return, long-term asset return, and the monetary policy surprise from the 84 FOMC meetings in our sample from 2004 to 2019 with a non-zero monetary policy surprise. The BFGS algorithm minimizes the sum of squared errors for the three moment conditions (short-term asset return, long-term asset return, and the variance of the monetary policy surprise) over parameterizations of σ_ϵ and σ_μ. We obtain the following estimates: $\sigma_\mu = 0.035$ and $\sigma_\epsilon = 0.125$. We plot these estimates with the blue point in Figure 4. The estimates for σ_ϵ and σ_μ fall within the region of parameterizations for which the short-term asset loads positively on the monetary policy surprise and the long-term asset loads negatively. From these estimates, the standard deviation of the information shock is approximately 3.5 times higher than that of the policy preference shock, consistent with the idea that policy preferences exhibit more stability compared with news about economic conditions in our sample.

6.3.3. Model Implications

We provide a simple calibration of the model using the parameter estimates above. Figure 5 presents the model-implied change in expectations following a monetary policy surprise of -10 basis points (unexpected easing).[49] Panel A shows the change in expected quarterly economic growth across the term structure – the x-axis indicates the quarters ahead from the monetary policy surprise which occurs at quarter 0. Panel B shows the change in expected target rate. The dashed green "Mu" (blue "Epsilon") line shows the change in beliefs if the investor observes the shocks,

[49] Figure B.1 in the Internet Appendix shows the model-implied change in expectations across the term structure following a surprise increase in the target rate of 10 basis points. The results are similar conceptually to those following an unexpected easing but with opposite signs following the positive monetary policy surprise. We also present a calibration of the model which includes soft information released by the central bank about near-term economic conditions in Section A4 in the Appendix.

ϵ and μ, and the entire monetary policy surprise is driven by the exogenous shock μ (ϵ). The black line labeled "Baseline" shows the change in investor beliefs when the investor does not observe the shocks.

We consider the case where investors observe the shocks and the monetary policy surprise is driven solely by the central bank information about economic conditions, ϵ. In this case, the central bank information is incorporated into next period investor economic growth expectations which are revised downwards sharply. Two-period ahead economic growth expectations are also revised downwards but the magnitude of revisions is smaller because of the low persistence of the economic growth process, ρ_g, and the impact of the lower target rate on economic growth. The monetary policy surprise is persistent and generates a downward revision of expected target rates across the horizon. The expected target rate eventually converges to steady state but generates modest upward revisions in economic growth forecasts at medium- and long-term horizons. The downward revision of near-term economic growth expectations dominates the upward revisions to longer-term economic growth forecasts and both the long-term and short-term asset returns are negative (-0.81 percent and -0.94 percent respectively).

Next, we consider the case where the investor observes the shocks and the monetary policy surprise is driven solely by the policy preference shock μ. In this scenario there are no central bank information effects. Next period economic growth forecasts are revised upwards based on the effect of lower target rates on growth. Economic growth expectations are revised upward (target rate expectations are revised downwards) across the term structure and converge towards their steady state values. The long-term and short-term asset returns are positive in this case.

In the baseline case where investors do not observe the shocks and must infer the distribution of ϵ and μ from the observed target rate surprise, investor beliefs lie between the prior two cases. Based on the negative monetary policy surprise, investors infer a negative realization of ϵ and revise their expectations of next period economic growth downwards. Similar to the pure ϵ case discussed above, investor expectations about medium- and long-term economic growth are revised upwards because of the persistent effect of the monetary policy shock on economic growth. The higher expected medium- and long-horizon economic growth expectations outweigh the lower near-term expected economic growth and the market return is positive. The short-term asset return is negative which generates an opposite response of the short-term and long-term asset to the monetary policy surprise.

7. Conclusion

We propose a new test of Fed information effects based on the price response of the short-term dividend strips on the S&P 500 index. We develop a stylized model to characterize the Fed information effects on dividend strips with different maturities. Consistent with the existence of information effects, we document that short-term dividend strip prices move in the same direction as the unanticipated changes in the target rate. We also show that the short-term dividend strip price reaction around FOMC announcements positively predicts near-term macroeconomic growth. Overall, our results suggest that investors perceive FOMC announcements as important signals about the current state of the economy. Our results do not necessarily imply that Fed has private information about the state of the economy: Fed information effects may arise if the central bank is better equipped to process publicly available information (or if investors believe that the central bank is better equipped to process information). Regardless, the existence of these information effects has key implications for central bank communications and policy since these effects reduce the effectiveness of standard monetary policy tools and may discourage investment and consumption following an unexpected cut to the target rate.

Appendix A

A1. Model Derivations

This section supplements the model developed in Section 2 and includes derivations of the key implications discussed in the manuscript.

A1.1. Propagation Across the Term Structure

We determine how changes in expectations about the target federal funds rate and GDP growth propagate across the horizon. Applying the expectations operator to Equations (1) and (2) we have:[50]

$$\mathbb{E}_t\left(\Delta GDP_{t+k+1}\right) = \rho_g \mathbb{E}_t\left(\Delta\widehat{GDP}_{t+k}\right) + b\mathbb{E}_t\left(\widehat{\iota}_{t+k}\right) \tag{A.1}$$

$$\mathbb{E}_t\left(\widehat{\iota}_{t+k}\right) = \rho_\iota \mathbb{E}_t\left(\widehat{\iota}_{t+k-1}\right) + \alpha\mathbb{E}_t\left(\Delta\widehat{GDP}_{t+k+1}\right) \tag{A.2}$$

Expectations about next period GDP growth and next period interest rates are jointly determined. We obtain an expression for $\mathbb{E}_t\left(\Delta GDP_{t+k+1}\right)$ by substituting Equation (A.2) into Equation (A.1) to obtain:

$$\mathbb{E}_t\left(\Delta GDP_{t+k+1}\right) = \frac{1}{1-\alpha b}\left(\rho_g \mathbb{E}_t\left(\Delta\widehat{GDP}_{t+k}\right) + b\rho_\iota \mathbb{E}_t\left(\widehat{\iota}_{t+k-1}\right)\right)$$

Similarly we have:

[50] For simplicity, below we denote expectations using time t subscripts and omit the subperiod notation, $\underline{t}$ and $\overline{t}$.

$$\mathbb{E}_t\left(\widehat{\iota}_{t+k}\right) = \frac{1}{1-\alpha b}\left(\alpha\rho_g\mathbb{E}_t\left(\Delta\widehat{GDP}_{t+k}\right) + \rho_\iota\mathbb{E}_t\left(\widehat{\iota}_{t+k-1}\right)\right)$$

We can express this recurrence relation in matrix form as:

$$\begin{pmatrix}\mathbb{E}_t\left(\Delta GD\hat{P}_{t+k+1}\right)\\ \mathbb{E}_t\left(\widehat{\iota}_{t+k}\right)\end{pmatrix} = \frac{1}{(1-\alpha b)^k}\begin{pmatrix}\rho_g & b\rho_\iota\\ \alpha\rho_g & \rho_\iota\end{pmatrix}^k\begin{pmatrix}\mathbb{E}_t\left(\Delta GD\hat{P}_{t+1}\right)\\ \mathbb{E}_t\left(\widehat{\iota}_t\right)\end{pmatrix} \tag{A.3}$$

We express matrix $A = \begin{pmatrix}\rho_g & b\rho_\iota\\ \alpha\rho_g & \rho_\iota\end{pmatrix}$ in the form $A = PDP^{-1}$, the product of diagonal matrix D and change of basis matrices P and P^{-1}. Expressions for P, D, and P^{-1} are obtained in the standard procedure: we compute the eigenvalues of matrix A, denoted by λ_1 and λ_2 respectively, as the roots of the characteristic polynomial[51]; we obtain eigenvectors associated with each eigenvalue, λ_i, as any vector that spans the kernel $A - \lambda_i I$ where I is the 2×2 identity matrix.

Specifically, we compute the eigenvalues of matrix $A = \begin{pmatrix}\rho_g & b\rho_\iota\\ \alpha\rho_g & \rho_\iota\end{pmatrix}$ from the characteristic polynomial: $C_A(\lambda) = det(A-\lambda I) = \lambda^2 - \left(\rho_g+\rho_\iota\right)\lambda + \rho_g\rho_\iota(1-\alpha b)$, where I is the identity matrix. The roots of the characteristic polynomial are: $\frac{\rho_g+\rho_\iota\pm\left(\left(\rho_g+\rho_\iota\right)^2-4\rho_g\rho_\iota(1-\alpha b)\right)^{\frac{1}{2}}}{2} = \frac{\rho_g+\rho_\iota\pm\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}}{2}$. The eigenvalues, λ_1 and λ_2 are:

$$\lambda_1 = \frac{1}{2}\left(\rho_g+\rho_\iota+\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right)$$

and

$$\lambda_2 = \frac{1}{2}\left(\rho_g+\rho_\iota-\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right)$$

We find eigenvectors associated with each eigenvalue. An eigenvector, $v^{\lambda_1} = \begin{pmatrix}v_1^{\lambda_1}\\ v_2^{\lambda_1}\end{pmatrix}$, corresponding to eigenvalue, λ_1, is any vector which spans the kernel $A - \lambda_1 I$. We have:

$$A-\lambda_1 I = \begin{pmatrix}\rho_g - \frac{1}{2}\left(\rho_g+\rho_\iota+\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right) & b\rho_\iota\\ \alpha\rho_g & \rho_\iota - \frac{1}{2}\left(\rho_g+\rho_\iota+\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right)\end{pmatrix}$$

[51] $\lambda_1 = \frac{1}{2}\left(\rho_g+\rho_\iota+\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right)$ and $\lambda_2 = \frac{1}{2}\left(\rho_g+\rho_\iota-\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right)$

So an eigenvector must satisfy: $v_1^{\lambda_1}\left(\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right) + v_2^{\lambda_1} b\rho_\iota = 0$ and $v_1^{\lambda_1}\alpha\rho_g + v_2^{\lambda_1}\left(\rho_\iota - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right) = 0$. From the first equation we have:[52]

$$v_1^{\lambda_1} = -v_2^{\lambda_1}\frac{b\rho_\iota}{\left(\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right)}$$

We obtain the eigenvector corresponding to eigenvalue, λ_2, following a similar procedure.[53] The eigenvectors, v^{λ_1} and v^{λ_2}, produce the change of basis matrices, P and P^{-1}:

$$P = \begin{pmatrix} -\frac{b\rho_\iota}{\left(\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right)} & -\frac{b\rho_\iota}{\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota - \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)} \\ 1 & 1 \end{pmatrix}$$

[52] We verify that the second equation also equals 0:

$$\begin{aligned} & v_1\alpha\rho_g + v_2\left(\rho_\iota - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right) \\ &= -v_2\frac{b\rho_\iota}{\left(\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right)}\alpha\rho_g + v_2\left(\rho_\iota - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right) \\ &= v_2\left(\frac{\left(\rho_\iota - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right) \times \left(\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right) - \alpha b\rho_\iota\rho_g}{\left(\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right)}\right) \\ &= v_2\left(\frac{2\rho_\iota\rho_g + 4\alpha b\rho_g\rho_\iota - 2\rho_g\rho_\iota - 4\alpha b\rho_\iota\rho_g}{4\left(\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)\right)}\right) \\ &= 0 \end{aligned}$$

[53]

$$v_1^{\lambda_2} = -v_2^{\lambda_2}\frac{b\rho_\iota}{\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota - \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)}$$

and P^{-1}[54]:

$$P^{-1} = p_{scalar} \begin{pmatrix} 1 & \frac{b\rho_\iota}{\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota - \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)} \\ -1 & -\frac{b\rho_\iota}{\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}\right)} \end{pmatrix}$$

Finally, the diagonal matrix, D, is given by:

$$D = \begin{pmatrix} \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota\left(4\alpha b - 2\right)\right)^{\frac{1}{2}}\right) & 0 \\ 0 & \frac{1}{2}\left(\rho_g + \rho_\iota - \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota\left(4\alpha b - 2\right)\right)^{\frac{1}{2}}\right) \end{pmatrix} \tag{A.4}$$

So we can express $A = \begin{pmatrix} \rho_g & b\rho_\iota \\ \alpha\rho_g & \rho_\iota \end{pmatrix} = PDP^{-1}$. Since $A^k = \left(PDP^{-1}\right)^k = PDP^{-1}PDP^{-1}...PDP^{-1} = PD^kP^{-1}$ and the expression PD^kP^{-1} is a linear transformation of input vector $\begin{pmatrix} \mathbb{E}_t\left(\Delta GDP_{t+1}\right) \\ \mathbb{E}_t\left(\widehat{\iota_t}\right) \end{pmatrix}$, we can express changes in forecasts from $\underline{t}$ to $\bar{t}$ as:

$$\begin{pmatrix} \Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+k+1}\right) \\ \Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota_{t+k}}\right) \end{pmatrix} = \frac{1}{(1-\alpha b)^k} PD^kP^{-1} \begin{pmatrix} \Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+1}\right) \\ \Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota_t}\right) \end{pmatrix} \tag{A.5}$$

where $\Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+1}\right) = \mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+1}\right) - \mathbb{E}_{\underline{t}}\left(\Delta GDP_{t+1}\right)$ and $\Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota_t}\right) = \mathbb{E}_{\bar{t}}\left(\widehat{\iota_t}\right) - \mathbb{E}_{\underline{t}}\left(\widehat{\iota_t}\right)$. This expression determines how changes to expectations propagate across the horizon in our model.[55] Section A2 characterizes exactly how the monetary policy surprise determines the distribution of changes in growth forecasts across the term structure.

A1.2. Asset Prices

To obtain a closed-form expression for the long-term asset return, we start by substituting Equation (A.5) into the long-term asset return given in Equation (5):

[54] Where in the formula below, $p_{scalar} = \frac{\left(\rho_g - \frac{1}{2}\rho_g - \frac{1}{2}\rho_\iota + \frac{1}{2}\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right)\left(\rho_g - \frac{1}{2}\rho_g - \frac{1}{2}\rho_\iota - \frac{1}{2}\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right)}{-b\rho_\iota\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}}$

[55] We require $\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota\left(4\alpha b - 2\right) > 0$ to ensure real roots.

$$r_{\bar{t}}^{\infty} = \sum_{j=0}^{\infty} \rho^j \beta_d \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right) \left(\Delta \widehat{GDP}_{t+j+1}\right)$$

$$= \sum_{j=0}^{\infty} \rho^j \beta_d \frac{1}{(1-\alpha b)^j} \begin{pmatrix} 1 & 0 \end{pmatrix} P D^j P^{-1} \begin{pmatrix} \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\Delta GDP_{t+1}\right) \\ \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\widehat{\iota_t}\right) \end{pmatrix}$$

$$= \beta_d \begin{pmatrix} 1 & 0 \end{pmatrix} P D^* P^{-1} \begin{pmatrix} \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\Delta GDP_{t+1}\right) \\ \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\widehat{\iota_t}\right) \end{pmatrix}$$

Where D^* is a diagonal matrix with entries, $d_{11}^* = \frac{1}{1-\frac{\rho}{(1-\alpha b)}d_{11}}$ and $d_{22}^* = \frac{1}{1-\frac{\rho}{(1-\alpha b)}d_{22}}$.[56] For convenience denote the entries in the change of basis matrices, P and P^{-1} as: $P = \begin{pmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{pmatrix}$, $P^{-1} = \frac{1}{p_{11}p_{22}-p_{12}p_{21}} \begin{pmatrix} p_{22} & -p_{12} \\ -p_{21} & p_{11} \end{pmatrix}$, and $D^* = \begin{pmatrix} d_{11}^* & 0 \\ 0 & d_{22}^* \end{pmatrix}$. Then we have:

$$PD^*P^{-1}$$

$$= \frac{1}{p_{11}p_{22} - p_{12}p_{21}} \begin{pmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{pmatrix} \begin{pmatrix} d_{11}^* & 0 \\ 0 & d_{22}^* \end{pmatrix} \begin{pmatrix} p_{22} & -p_{12} \\ -p_{21} & p_{11} \end{pmatrix}$$

$$= \frac{1}{p_{11}p_{22} - p_{12}p_{21}} \begin{pmatrix} p_{11}p_{22}d_{11}^* - p_{21}p_{12}d_{22}^* & p_{12}p_{11}d_{22}^* - p_{11}p_{12}d_{11}^* \\ p_{21}p_{22}d_{11}^* - p_{22}p_{21}d_{22}^* & p_{22}p_{11}d_{22}^* - p_{21}p_{12}d_{11}^* \end{pmatrix}$$

So we have:

$$r_{\bar{t}}^{\infty} = \begin{pmatrix} 1 & 0 \end{pmatrix} \beta_d P D^* P^{-1} \overrightarrow{v}_{input}$$

$$= \begin{pmatrix} 1 & 0 \end{pmatrix} \frac{\beta_d}{p_{11}p_{22} - p_{12}p_{21}} \begin{pmatrix} p_{11}p_{22}d_{11}^* - p_{21}p_{12}d_{22}^* & p_{12}p_{11}d_{22}^* - p_{11}p_{12}d_{11}^* \\ p_{21}p_{22}d_{11}^* - p_{22}p_{21}d_{22}^* & p_{22}p_{11}d_{22}^* - p_{21}p_{12}d_{11}^* \end{pmatrix} \overrightarrow{v}_{input}$$

$$+ \frac{\beta_d}{p_{11}p_{22} - p_{12}p_{21}} \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\widehat{\iota_t}\right)\left(p_{12}p_{11}d_{22}^* - p_{11}p_{12}d_{11}^*\right)$$

where $\overrightarrow{v}_{input} = \begin{pmatrix} \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\Delta GDP_{t+1}\right) \\ \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\widehat{\iota_t}\right) \end{pmatrix}$.

[56] Where $d_{11} = \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g \rho_\iota (4\alpha b - 2)\right)^{\frac{1}{2}}\right)$ and $d_{22} = \frac{1}{2}\left(\rho_g + \rho_\iota - \left(\rho_g^2 + \rho_\iota^2 + \rho_g \rho_\iota (4\alpha b - 2)\right)^{\frac{1}{2}}\right)$ are the entries in the diagonal matrix D from Equation (A.4).

We substitute in the expressions for p_{11}, p_{22}, p_{12}, p_{21}, d_{11}^*, and d_{22}^* in terms of model parameters from the equations for P and D to obtain $\frac{\beta_d}{p_{11}p_{22}-p_{12}p_{21}}$, $p_{11}p_{22}d_{11}^* - p_{21}p_{12}d_{22}^*$, and $p_{12}p_{11}d_{22}^* - p_{11}p_{12}d_{11}^*$. We start with the coefficient $\frac{\beta_d}{p_{11}p_{22}-p_{12}p_{21}}$. For tractability we define: $X \equiv \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota\left(4\alpha b - 2\right)\right)^{\frac{1}{2}}$, $A \equiv \frac{1}{2}\rho_g - \frac{1}{2}\rho_\iota$ and $B \equiv \rho_g + \rho_\iota$. Then we have:

$$
\begin{aligned}
& p_{11}p_{22} - p_{21}p_{12} \\
&= -\frac{b\rho_\iota}{\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota\left(4\alpha b - 2\right)\right)^{\frac{1}{2}}\right)} + \frac{b\rho_\iota}{\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota - \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota\left(4\alpha b - 2\right)\right)^{\frac{1}{2}}\right)} \\
&= \frac{X}{\rho_g\alpha}
\end{aligned}
$$

Next, we calculate the coefficient on economic growth, $p_{11}p_{22}d_{11}^* - p_{21}p_{12}d_{22}^*$:

$$
\begin{aligned}
& p_{11}p_{22}d_{11}^* - p_{21}p_{12}d_{22}^* \\
&= -\frac{b\rho_\iota}{\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota + X\right)} \times \frac{1}{1 - \frac{\rho}{(1-\alpha b)}\frac{1}{2}\left(\rho_g + \rho_\iota + X\right)} + \frac{b\rho_\iota}{\rho_g - \frac{1}{2}\left(\rho_g + \rho_\iota - X\right)} \times \frac{1}{1 - \frac{\rho}{(1-\alpha b)}\frac{1}{2}\left(\rho_g + \rho_\iota - X\right)} \\
&= \frac{-X\left(\rho_\iota\rho - 1 + \alpha b\right)}{\rho\alpha\rho_g\left(\frac{(1-\alpha b)}{\rho} + \rho\rho_g\rho_\iota - \rho_g - \rho_\iota\right)}
\end{aligned}
$$

Finally, we calculate the coefficient on the target rate, $p_{12}p_{11}d_{22}^* - p_{11}p_{12}d_{11}^*$:

$$
\begin{aligned}
& p_{12}p_{11}d_{22}^* - p_{11}p_{12}d_{11}^* \\
&= p_{12}p_{11}\left(d_{22}^* - d_{11}^*\right) \\
&= \left(1 - \alpha b\right)\frac{b\rho_\iota}{\frac{1}{2}\rho_g - \frac{1}{2}\rho_\iota + \frac{1}{2}X} \times \frac{b\rho_\iota}{\frac{1}{2}\rho_g - \frac{1}{2}\rho_\iota - \frac{1}{2}X} \times \left(\frac{1}{(1-\alpha b) - \rho\frac{1}{2}\left(B - X\right)} - \frac{1}{(1-\alpha b) - \rho\frac{1}{2}\left(B + X\right)}\right) \\
&= \frac{b\rho_\iota X}{\alpha\rho_g\left(\frac{(1-\alpha b)}{\rho} + \rho\rho_g\rho_\iota - \rho_g - \rho_\iota\right)}
\end{aligned}
$$

We input these expressions into the long-term asset response equation to obtain:

$$
r_t^\infty = \frac{\beta_d\left(1 - \alpha b\right)}{\left(\left(\rho\rho_g - 1\right)\left(\rho\rho_\iota - 1\right) - \alpha b\right)\alpha\left(\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2\right)}\left(\alpha b\sigma_\mu^2 + \sigma_{\alpha\epsilon}^2 - \rho_\iota\rho\sigma_{\alpha\epsilon}^2\right)\Delta\iota_t^s \tag{A.6}
$$

The return on the short-term dividend strip is similarly given by:

$$
r_{\bar{t}}^1 = \frac{\rho\beta_d}{\alpha\left(\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2\right)}\left(\alpha b\sigma_\mu^2 + \sigma_{\alpha\epsilon}^2\right)\Delta\iota_{\bar{t}}^s \tag{A.7}
$$

Expressions for the long-term and short-term assets without information effects are obtained similarly.[57]

A1.3. Short-term Asset Return and Future Economic Growth

We derive our model implications for the following regression of next period economic growth on the short-term asset response to a monetary policy surprise:

$$\Delta\widehat{GDP}_{t+1} = \alpha^1 + \beta^1 r^1_{\bar{t}} + \delta^1_{t+1} \tag{A.8}$$

where $r^1_{\bar{t}}$ denotes the short-term asset return in the 30-minute window around a policy announcement, α^1 is the intercept and δ^1_{t+1} is the error terms of the regression. The coefficient on the short-term asset return is given by: $\beta^1 = \frac{Cov\left(r^1_{\bar{t}}, \Delta\widehat{GDP}_{t+1}\right)}{Var\left(r^1_{\bar{t}}\right)}$. We compute the coefficient, β^1, in terms of model parameters:

$$\beta^1 = \frac{Cov\left(r^1_{\bar{t}}, \Delta\widehat{GDP}_{t+1}\right)}{Var\left(r^1_{\bar{t}}\right)}$$

$$= \frac{Cov\left(\rho\beta_d\left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\Delta\widehat{GDP}_{t+1}\right), \rho_g\Delta\widehat{GDP}_t + \epsilon_{\bar{t}} + b\iota_t + w_{t+1}\right)}{Var\left(r^1_{\bar{t}}\right)}$$

$$= \frac{\rho\beta_d Cov\left(\frac{b\alpha\sigma^2_\mu + \sigma^2_{\alpha\epsilon}}{\alpha\left(\sigma^2_{\alpha\epsilon} + \sigma^2_\mu\right)}\frac{\mu + \alpha\epsilon}{(1-\alpha b)}, \epsilon_{\bar{t}} + b\frac{\mu + \alpha\epsilon}{(1-\alpha b)}\right)}{\rho^2\beta^2_d Var\left(\frac{b\alpha\sigma^2_\mu + \sigma^2_{\alpha\epsilon}}{\alpha\left(\sigma^2_{\alpha\epsilon} + \sigma^2_\mu\right)}\frac{\mu + \alpha\epsilon}{(1-\alpha b)}\right)}$$

$$= \frac{1}{\rho\beta_d}$$

The coefficient β^1 will be positive under the full range of parametrizations we assume. The positive coefficient arises because of the assumption in Equation (A.7) that fluctuations in the short-term asset price around central bank announcements are driven by changing cash flow expectations. The assumption of the model can be tested directly in the data.[58]

[57] Short-term asset return without information effects is given by: $r^1_{\bar{t}} = b\beta_d\rho\Delta\iota^s_{\bar{t}}$

Long-term asset return without information effects is given by: $r^\infty_{\bar{t}} = \frac{b\beta_d(1-\alpha b)}{(\rho\rho_g - 1)(\rho\rho_\iota - 1) - \alpha b}\Delta\iota^s_{\bar{t}}$

[58] If FOMC announcements contain information about economic conditions and information effects operate through the cash flow channel, then the short-term asset announcement return should predict near-term dividend growth and economic growth with a positive sign. Absent information effects or if information effects exist but operate through

A2. Beliefs About Future Economic Growth

We discuss how the monetary policy surprise will determine the distribution of changes in subsequent period economic growth forecasts. First, given the belief distributions $\epsilon_{\bar{t}}^{i,*}$ and $\mu_{\bar{t}}^{i,*}$ from Equation (8), the change in investor expectations of next period economic growth from $\underline{t}$ to $\bar{t}$ can be expressed as:

$$\mathbb{E}_{\bar{t}}^{i}\left(\Delta\widehat{GDP}_{t+1}\right) - \mathbb{E}_{\underline{t}}^{i}\left(\Delta\widehat{GDP}_{t+1}\right) = b\Delta\iota_{\bar{t}}^{s} + \mathbb{E}_{\bar{t}}^{i}\left(\epsilon_{\bar{t}}^{i,*}\right) \tag{A.9}$$

Then, from Equation (A.5) and the change in next period economic growth forecasts, we have:

$$\begin{pmatrix} \Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+k+1}\right) \\ \Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota}_{t+k}\right) \end{pmatrix} = \frac{1}{(1-\alpha b)^{k}} PD^{k}P^{-1} \begin{pmatrix} b\Delta\iota_{\bar{t}}^{s} + \mathbb{E}_{\bar{t}}^{i}\left(\epsilon_{\bar{t}}^{i,*}\right) \\ \Delta\iota_{\bar{t}}^{s} \end{pmatrix} \tag{A.10}$$

Changes in investor beliefs about future GDP growth and target rates across the term structure are linear transformations of the target rate surprise and normally distributed beliefs, $\epsilon_{\bar{t}}^{i,*}$, and so are normally distributed. The monetary policy surprise, $\Delta\iota_{\bar{t}}^{s}$, pins down the distribution of $\epsilon_{\bar{t}}^{i,*}$ so we can use Equation (9) to substitute out $\mathbb{E}_{\bar{t}}^{i}\left(\epsilon_{\bar{t}}^{i,*}\right)$ to obtain:

$$b\Delta\iota_{\bar{t}}^{s} + \mathbb{E}_{\bar{t}}^{i}\left(\epsilon_{\bar{t}}^{i,*}\right) = \left(\frac{b\alpha\sigma_{\mu}^{2} + \sigma_{\alpha\epsilon}^{2}}{\alpha\left(\sigma_{\alpha\epsilon}^{2} + \sigma_{\mu}^{2}\right)}\right)\Delta\iota_{\bar{t}}^{s}$$

So we have:

$$\begin{pmatrix} \Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+k+1}\right) \\ \Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota}_{t+k}\right) \end{pmatrix} = \frac{1}{(1-\alpha b)^{k}} PD^{k}P^{-1} \begin{pmatrix} \left(\frac{b\alpha\sigma_{\mu}^{2}+\sigma_{\alpha\epsilon}^{2}}{\alpha\left(\sigma_{\alpha\epsilon}^{2}+\sigma_{\mu}^{2}\right)}\right) \\ 1 \end{pmatrix} \Delta\iota_{\bar{t}}^{s} \tag{A.11}$$

A3. Model Extension: Soft Information

In the baseline framework, the target rate surprise uniquely determines revisions in investor expectations across the term structure and pins down both the short- and long-term asset return. Empirically, the short-term asset return does not move in lockstep with the target rate surprise. This additional variation is important because it reflects conditioning information that may not be captured in the target rate surprise (which is fixed at the time of the announcement). The short-term asset price adjusts after the announcement so that the measured price response will reflect other information such as soft information and forward guidance from the central bank, and variation

the risk premia channel, this predictability will be nonexistent.

in economic and financial conditions at different announcement dates which leads investors to interpret identical policy surprises (sign and magnitude) differently in different contexts.[59]

We model soft information released by the central bank by supposing that the central bank provides a noisy signal, $\eta_{\bar{t}} \sim N\left(\epsilon_{\bar{t}}, \sigma_\eta^2\right)$, to investors about its private information about GDP growth, ϵ. The distribution of $\eta_{\bar{t}}$ is centered at the realized value of $\epsilon_{\bar{t}}$ with variance σ_η^2. The central bank cannot inform investors the precise private signal.[60] Investor's conjugate prior is given by Equation (9), and the posterior distribution of beliefs, $\epsilon_{\bar{t},soft}^{i,*}$, after observing the signal $\eta_{\bar{t}}$ is:

$$\epsilon_{\bar{t},soft}^{i,*} \sim N\left(\epsilon_p \frac{\sigma_\eta^2}{\sigma_\eta^2 + \sigma_p^2} + \epsilon_{\bar{t}} \frac{\sigma_p^2}{\sigma_\eta^2 + \sigma_p^2}, \left(\frac{1}{\sigma_\eta^2} + \frac{1}{\sigma_p^2}\right)^{-1}\right) \tag{A.12}$$

where $\epsilon_{\bar{t}}$ is the realization of ϵ, $\epsilon_p = \frac{(1-\alpha b)}{\alpha} \frac{\sigma_{\alpha\epsilon}^2}{\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2} \Delta\iota_{\bar{t}}^s$ is the investor's expected value of $\epsilon_{\bar{t}}$ (from Equation (9)) based on the observed target rate surprise, $\sigma_p^2 = \frac{1}{\alpha^2} \frac{\sigma_{\alpha\epsilon}^2 \sigma_\mu^2}{\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2}$, and $\Delta\iota_{\bar{t}}^s$ is the target rate surprise. Changes in investor beliefs about future economic growth are still governed by Equation (A.10) but with $\mathbb{E}_{\bar{t}}^i\left(\epsilon_{\bar{t},soft}^{i,*}\right) = \frac{(1-\alpha b)\sigma_{\alpha\epsilon}^2 \sigma_\eta^2}{\alpha\left(\sigma_\eta^2 + \sigma_p^2\right)\left(\sigma_{\alpha\epsilon}^2 + \sigma_\mu^2\right)} \Delta\iota_{\bar{t}}^s + \epsilon_{\bar{t}} \frac{\sigma_p^2}{\sigma_\eta^2 + \sigma_p^2}$ so that this term does not depend solely on the target rate surprise, $\Delta\iota_{\bar{t}}^s$.

On average, soft information shifts investor beliefs towards the true realization of ϵ. The weight placed on the soft information provided by the central bank depends on the variance of the noisy signal compared with the variance of the prior beliefs about ϵ. Without soft information, an unexpected cut in the target rate causes investors to infer a negative realization of ϵ. With soft information, if the unexpected cut in target rate is driven by a large negative shock, μ, but the realization of ϵ is positive, investors may infer a positive ϵ after incorporating the soft information released by the central bank. This decouples the one-to-one mapping from the target rate surprise to investor beliefs about $\epsilon_{\bar{t}}$ and expected growth rates that is present in the baseline framework.

A4. Model Calibration with Soft Information

We introduce soft information to our model calibration and discuss how this changes the model implications. We assume the variance of the signal provided by the central bank, σ_η^2, is the same as the variance of the information effect shock, σ_ϵ^2. The qualitative results are similar for a wide range of σ_η^2 parametrizations. Figure B.2 in the Internet Appendix plots the model-implied change in expectations following a monetary policy surprise of -10 basis points (unexpected easing). Panel

[59]One way to capture the idea of variation in announcement contexts is to introduce stochastic volatility in the μ and ϵ distributions. In this case, identical target rate surprises will generate different posterior beliefs about ϵ and μ depending on the volatilities at the time of each announcement.

[60]This could arise for several reasons including central bank credibility but we do not take a stance in our model.

A shows the change in expected quarterly economic growth where the x-axis indicates the quarters ahead (the monetary policy shock occurs at quarter 0). Panel B shows the change in expected target rate.

We consider the cases where investors do not observe the shocks but do observe soft information released by the central bank. The solid green line "Soft (u)" shows the change in investor beliefs with soft information when the entire monetary policy surprise is driven by the exogenous shock μ. The solid blue line "Soft (e)" shows the change in investor beliefs with soft information if the entire surprise is driven by ϵ.[61]

With soft information, investor beliefs shift away from the baseline towards the full information beliefs (the dashed lines). In the baseline case (black line) when the monetary policy surprise is driven by ϵ, investors can only make inference based on the target rate surprise and the unconditional variances of the shocks μ and ϵ. The investor cannot distinguish between a -10 basis monetary policy surprise driven completely by μ and one driven completely by ϵ. Soft information provides valuable conditioning information that allows investors to distinguish between these scenarios and investor beliefs shift towards the complete information beliefs.

[61] For reference, we plot the change in investor expectations with no soft information (black line) and the change in investor expectations in the scenarios where the investor directly observes the shocks and the entire monetary policy surprise is driven by the exogenous shock μ (dashed green line) or by ϵ (dashed blue line).

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Tables and Figures

Table 1: **Summary Statistics**

Panel A: Summary statistics				
	N	Mean	Median	Std. Dev.
Monetary Policy Shock (*MPS*)	128	-0.003	0.000	0.030
Orthogonalized Monetary Policy Shock (*OMPS*)	128	0.005	0.002	0.044
Short-Term Asset Announcement Return (*STA*)	128	0.003	0.001	0.037
Long-Term Asset Announcement Return (*LTA*)	128	0.001	0.001	0.006

Panel B: Pair-wise correlations				
	MPS	*OMPS*	*STA*	*LTA*
Monetary Policy Shock (*MPS*)	1	0.543	0.205	-0.320
Orthogonalized Monetary Policy Shock (*OMPS*)	0.543	1	0.260	-0.538
Short-Term Asset Announcement Return (*STA*)	0.205	0.260	1	-0.172
Long-Term Asset Announcement Return (*LTA*)	-0.320	-0.538	-0.172	1

Panel A presents the summary statistics for the monetary policy shocks and log asset returns around each FOMC announcement. Panel B presents the corresponding pair-wise correlations. *MPS* is monetary policy shock estimated using first to maturity federal funds futures. *OMPS* is the orthogonalized monetary policy shock from Bauer and Swanson [8]. *STA* stands for the short-term asset anouncement return around each FOMC announcement. *LTA* stands for the long-term asset anouncement return around each FOMC announcement. We use 180-day dividend strip estimated from S&P 500 Index options as a proxy for *STA*. For *LTA*, we use the S&P 500 index itself. The period is from January 2004 through December 2019 and covers 128 scheduled FOMC announcements.

Table 2: **Asset Announcement Return on Monetary Policy Shock**

	$\Delta\iota_t^s = MPS_t$			$\Delta\iota_t^s = OMPS_t$		
	ΔP_t^{180}	ΔP_t^{∞}	$\Delta P_t^{180} - \Delta P_t^{\infty}$	ΔP_t^{180}	ΔP_t^{∞}	$\Delta P_t^{180} - \Delta P_t^{\infty}$
Panel A: FOMC Announcements with Non-Zero MPS						
$\Delta\iota_t^s$	0.241***	-0.060***	0.301***	0.236***	-0.072***	0.308***
	(0.090)	(0.017)	(0.095)	(0.069)	(0.012)	(0.071)
Adj. R^2	0.069	0.121	0.098	0.115	0.297	0.175
Obs.	84	84	84	84	84	84
Panel B: All FOMC Announcements						
$\Delta\iota_t^s$	0.249**	-0.059***	0.308***	0.217***	-0.068***	0.285***
	(0.106)	(0.016)	(0.109)	(0.072)	(0.010)	(0.073)
Adj. R^2	0.034	0.095	0.052	0.060	0.284	0.102
Obs.	128	128	128	128	128	128

This table presents the results from the regressions of asset announcement return on the monetary policy surprise:

$$\Delta P_t^h = \alpha + \beta \Delta\iota_t^s + \epsilon$$

where $\Delta\iota_t^s$ is either monetary policy shock estimated using first to maturity federal funds futures MPS_t or the orthogonalized monetary policy shock from Bauer and Swanson [8] $OMPS_t$ at date t. ΔP_t^h is the change in the log asset price over the same window (ΔP_t^{180} denotes the short-term asset announcement return (180-day dividend strip) and ΔP_t^{∞} denotes the long-term asset announcement return (S&P 500 index)). OLS standard errors are reported in parentheses below the coefficient estimate. Panel A presents results for FOMC announcements with non-zero monetary policy shocks (non-zero MPS). Panel B presents results for all FOMC announcements in the period from January 2004 through December 2019. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table 3: **Asset Announcement Return on Monetary Policy Shock: Robustness**

	$\Delta\iota_t^s = MPS_t$			$\Delta\iota_t^s = OMPS_t$		
	ΔP_t^{180}	ΔP_t^{∞}	$\Delta P_t^{180} - \Delta P_t^{\infty}$	ΔP_t^{180}	ΔP_t^{∞}	$\Delta P_t^{180} - \Delta P_t^{\infty}$
Panel A: Main Robustness						
Winsorize (5%)						
$\Delta\iota_t^s$	0.206***	-0.051***	0.269***	0.178***	-0.060***	0.258***
	(0.068)	(0.013)	(0.076)	(0.052)	(0.009)	(0.057)
Adj. R^2	0.090	0.153	0.121	0.113	0.349	0.187
Obs.	84	84	84	84	84	84
Exclude most influential observations from Bauer and Swanson [7]						
$\Delta\iota_t^s$	0.294**	-0.048**	0.342**	0.237***	-0.068***	0.305***
	(0.124)	(0.024)	(0.132)	(0.075)	(0.013)	(0.078)
Adj. R^2	0.054	0.038	0.067	0.100	0.245	0.151
Obs.	81	81	81	81	81	81
GMM standard errors						
$\Delta\iota_t^s$	0.241***	-0.060***	0.301***	0.236***	-0.072***	0.308***
	(0.069)	(0.014)	(0.076)	(0.071)	(0.016)	(0.078)
Adj. R^2	0.069	0.121	0.098	0.115	0.297	0.175
Obs.	84	84	84	84	84	84
Control for bid-ask spread						
$\Delta\iota_t^s$	0.349***	-0.074***	0.423***	0.242***	-0.072***	0.314***
	(0.097)	(0.019)	(0.102)	(0.069)	(0.012)	(0.071)
$\Delta Bid-ask_t$	1.527**	-0.197*	1.725***	0.699	-0.033	0.731
	(0.608)	(0.118)	(0.642)	(0.548)	(0.097)	(0.570)
Adj. R^2	0.126	0.139	0.161	0.122	0.289	0.181
Obs.	84	84	84	84	84	84
270-day short-term asset						
$\Delta\iota_t^s$	0.139**	-0.060***	0.200***	0.148***	-0.072***	0.220***
	(0.057)	(0.017)	(0.064)	(0.044)	(0.012)	(0.047)
Adj. R^2	0.056	0.121	0.096	0.113	0.297	0.202
Obs.	84	84	84	84	84	84
Panel B: Different estimation windows for dividend strips						
Post-announcement window delayed until last 30 minutes in a day						
$\Delta\iota_t^s$	0.171*	-0.067***	0.238**	0.196**	-0.070***	0.266***
	(0.103)	(0.025)	(0.110)	(0.079)	(0.019)	(0.084)
Adj. R^2	0.021	0.070	0.042	0.058	0.137	0.099
Obs.	84	84	84	84	84	84
Extended pre- and post-announcement windows						
$\Delta\iota_t^s$	0.162**	-0.065***	0.227***	0.157***	-0.068***	0.225***
	(0.075)	(0.020)	(0.086)	(0.058)	(0.015)	(0.066)
Adj. R^2	0.042	0.098	0.067	0.071	0.185	0.115
Obs.	84	84	84	84	84	84

This table presents the results from robustness tests of our baseline specification of short-term asset return regressed on the monetary policy surprise:

$$\Delta P_t^h = \alpha + \beta \Delta\iota_t^s + \epsilon$$

where $\Delta\iota_t^s$ is either monetary policy shock estimated using first to maturity federal funds futures MPS_t or the orthogonalized monetary policy shock from Bauer and Swanson [8] $OMPS_t$ at date t. ΔP_t^h is the change in the log asset price over the same window (ΔP_t^{180} denotes the short-term asset announcement return (180-day dividend strip) and ΔP_t^{∞} denotes the long-term asset announcement return (S&P 500 index)). In Panel A, we winsorize variables at 5% level, exclude the most influential observations from Bauer and Swanson [7], replace OLS standard errors with GMM standard errors, add a control for the change in the options bid-ask spread, and replace the 180-day maturity dividend strip with a 270-day maturity dividend strip. In Panel B, we delay the post-announcement window until the last 30 minutes in a day (from 3:30 pm to 4:00 pm) and we extend the estimation windows such that the pre-estimation window starts at 10:00 am and the post-esimtation window runs until 4:00 pm. The period is from January 2004 through December 2019 and includes FOMC announcements with non-zero monetary policy shocks (non-zero MPS). Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table 4: **Real Dividend and GDP Growth Forecasting**

	Real Dividend Growth						Real GDP Growth					
Horizon	1Q	2Q	3Q	4Q	5Q	6Q	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Univariate regressions												
ΔP_t^{180}	0.671***	0.874***	0.994***	1.203***	1.105***	1.038***	0.127**	0.171**	0.242***	0.154*	0.107*	0.045
	(0.243)	(0.253)	(0.354)	(0.425)	(0.414)	(0.364)	(0.061)	(0.080)	(0.091)	(0.089)	(0.059)	(0.029)
Adj. R^2	0.046	0.078	0.081	0.120	0.102	0.087	0.034	0.064	0.145	0.053	0.019	-0.008
Panel B: Additional control variables												
ΔP_t^{180}	0.514**	0.727***	0.852**	1.075**	1.059**	0.997**	0.093*	0.161*	0.243**	0.161*	0.114*	0.033
	(0.227)	(0.234)	(0.412)	(0.506)	(0.496)	(0.438)	(0.057)	(0.090)	(0.101)	(0.097)	(0.064)	(0.037)
$\Delta\iota_t^s$	0.078	0.157	0.137	0.205	0.147	0.344	0.034	-0.010	0.019	0.025	0.094	0.116
	(0.286)	(0.263)	(0.295)	(0.313)	(0.402)	(0.492)	(0.087)	(0.068)	(0.065)	(0.088)	(0.100)	(0.114)
ΔP_t^{∞}	-5.033	-3.376	-2.572	-0.260	2.613	5.151	-0.445	-0.120	0.512	0.838	1.324	0.929
	(3.670)	(3.297)	(3.520)	(3.609)	(4.252)	(4.218)	(0.664)	(0.532)	(0.575)	(0.838)	(0.934)	(0.687)
ΔIV_t^{180}	-6.687	-4.127	-2.222	1.758	5.797	8.565	-0.202	0.227	0.919	1.365	1.528	1.003
	(4.551)	(4.172)	(4.742)	(5.594)	(6.766)	(6.690)	(0.753)	(0.970)	(1.123)	(1.465)	(1.565)	(1.212)
Adj. R^2	0.066	0.072	0.061	0.095	0.080	0.097	0.020	0.032	0.122	0.046	0.066	0.027
Obs.	83	81	79	79	77	75	83	81	79	79	77	75

This table presents the results from the predictive regression of k-quarter ahead real dividend growth and real GDP growth on the 180-day dividend strip return ΔP_t^{180} in the 30 minute window around the FOMC announcement. The specification is given by:

$$X_{t+k} = \alpha_k + \beta_k \Delta P_t^{180} + \delta_k Controls_t + \epsilon_{t+k}, k \in \{1, 2, ..., 6\}$$

The dependent variable is the real dividend growth $X_{t+k} = log\left(\frac{D_{t+k}}{D_{t+k-4}}\right)$ (left side of the table) or the real GDP growth $X_{t+k} = log\left(\frac{GDP_{t+k}}{GDP_{t+k-4}}\right)$ (right side of the table). Panel A presents the results for the univariate regressions. Panel B includes control variables for the monetary policy shock $\Delta\iota_t^s = MPS_t$, the aggregate market announcement return ΔP_t^{∞}, and the change in the option implied volatility ΔIV_t. We report Newey-West adjusted standard errors with $k + 1$ lags in parentheses below the coefficient estimates. The period is from January 2004 through December 2019 and includes FOMC announcements with non-zero monetary policy shocks (non-zero MPS). Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table 5: **Real Dividend and GDP Growth Forecasting: Non-FOMC Days**

Horizon	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Real Dividend Growth						
ΔP_t^{180}	0.024	0.006	-0.031	-0.005	0.079	0.085
	(0.153)	(0.171)	(0.135)	(0.174)	(0.209)	(0.227)
Adj. R^2	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004
Obs.	252	248	244	240	235	232
Panel B: Real GDP Growth						
ΔP_t^{180}	-0.015	-0.022	-0.024	-0.032	-0.002	0.005
	(0.029)	(0.038)	(0.039)	(0.044)	(0.040)	(0.042)
Adj. R^2	-0.004	-0.003	-0.003	-0.002	-0.004	-0.004
Obs.	252	248	244	240	235	232

Panel A presents the results from the predictive regression of k-quarter ahead real dividend growth on the 180-day dividend strip return in the 30-minute window seven days before and seven days after the FOMC announcement:

$$log\left(\frac{D_{t+k}}{D_{t+k-4}}\right) = \alpha_k + \beta_k \Delta P_t^{180} + \epsilon_{t+k}, k \in \{1, 2, ..., 6\}$$

Panel B presents the same results for predicting real GDP growth. Newey-West adjusted standard errors with $k+1$ lags are in parentheses below the coefficient estimates. The period is from January 2004 through December 2019. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table 6: **Comparing Fed and Private Sector Forecasts**

Panel A: Greenbook Forecasts					
Horizon	0Q	1Q	2Q	3Q	4Q
$\mathbb{E}_t^{Fed}(\Delta RGDP_{t+k})$	0.977***	0.780***	0.672**	0.358	0.152
	(0.101)	(0.165)	(0.289)	(0.371)	(0.347)
Adj. R^2	0.520	0.215	0.091	0.015	-0.006
Obs.	114	114	114	114	114

Panel B: Greenbook versus SPF					
Horizon	0Q	1Q	2Q	3Q	4Q
$\mathbb{E}_t^{Fed}(\Delta RGDP_{t+k})$	1.081***	0.654**	0.845**	0.670	0.594
	(0.163)	(0.259)	(0.328)	(0.587)	(0.512)
$\mathbb{E}_t^{SPF}(\Delta RGDP_{t+k})$	-0.143	0.244	-0.423	-0.768	-1.156
	(0.187)	(0.417)	(0.436)	(0.729)	(0.786)
Adj. R^2	0.517	0.212	0.090	0.025	0.021
Obs.	114	114	114	114	114

This table presents the results from predictive regressions of GDP growth on GDP forecasts:

$$\Delta RGDP_{t+k} = \alpha_k + \beta_k^{Fed}\mathbb{E}_t^{Fed}(\Delta RGDP_{t+k}) + \beta_k^{SPF}\mathbb{E}_t^{SPF}(\Delta RGDP_{t+k}) + \epsilon_{t+k}, k \in \{0,1,2,3,4\}.$$

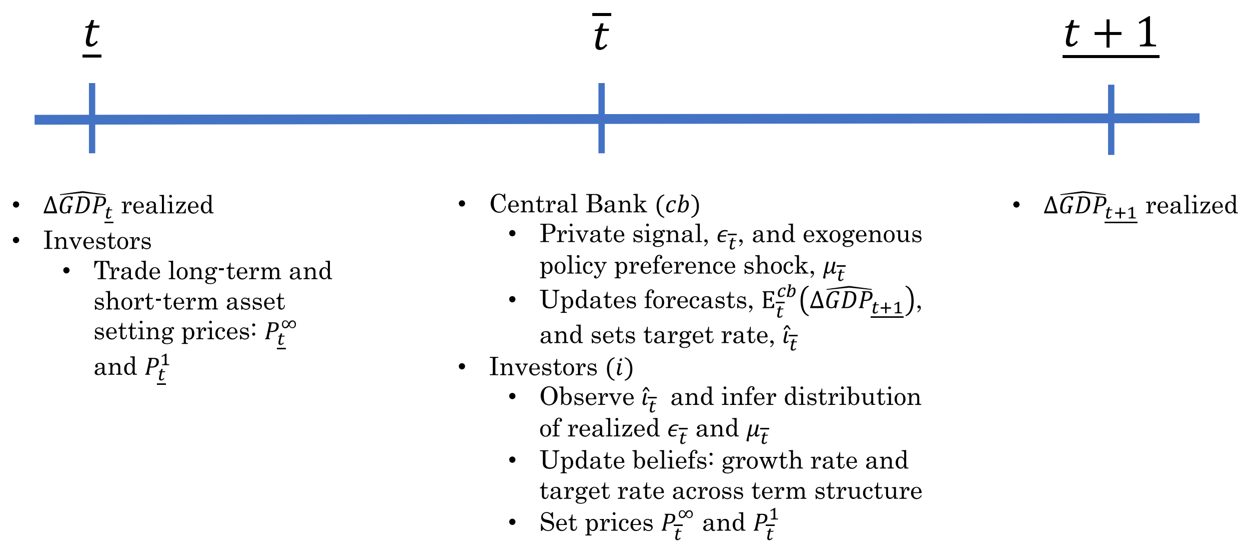
The dependent variable $\Delta RGDP_{t+k}$ is the $k-$quarter ahead real GDP growth defined as $100\times\left(\frac{GDP_{t+k}}{GDP_{t+k-1}}\right)^4 - 1$, where GDP_{t+k} is the level of real GDP in quarter $t+k$. $\mathbb{E}_t^{Fed}(\Delta RGDP_{t+k})$ is the Greenbook forecast made in quarter t and $\mathbb{E}_t^{SPF}(\Delta RGDP_{t+k})$ is the same quarter forecast from the Survey of Professional Forecasters (SPF). We report Newey-West adjusted standard errors with $k+1$ lags in parentheses below the coefficient estimates. The period is from the third quarter of 1990 through the fourth quarter of 2018 and includes FOMC announcements with non-zero monetary policy shocks (non-zero MPS). Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table 7: **Summary of the Parameter Estimates**

Parameter	Description	Estimate	Source
ρ_g	Persistence of the economic growth process	0.065	Estimated from external data (including: quarterly real gross domestic product growth from the 2024Q1 vintage of the Philadelphia Federal Reserve's real-time data set on the National Income and Product Accounts (NIPA))
ρ_ι	Persistence of policy rule	0.970	Estimated from external data (the data is quarterly from the third quarter of 1954, the beginning of the effective federal funds rate data from FRED, to the fourth quarter of 2021.)
ρ	Time discount rate	0.99	From prior literature (corresponds to an annual discount rate of 0.96)
b	Effect of policy on economic growth	-0.097	Estimated from external data (sign consistent with conventional effects of monetary policy)
α	Response of policy rule to forecasted economic conditions	0.105	Estimated from external data (sign consistent with conventional policy rule)
σ_μ	Standard deviation of policy preference shock	0.035	Estimated based on other parameters and asset response data
σ_ϵ	Standard deviation of information shock	0.125	Estimated based on other parameters and asset response data

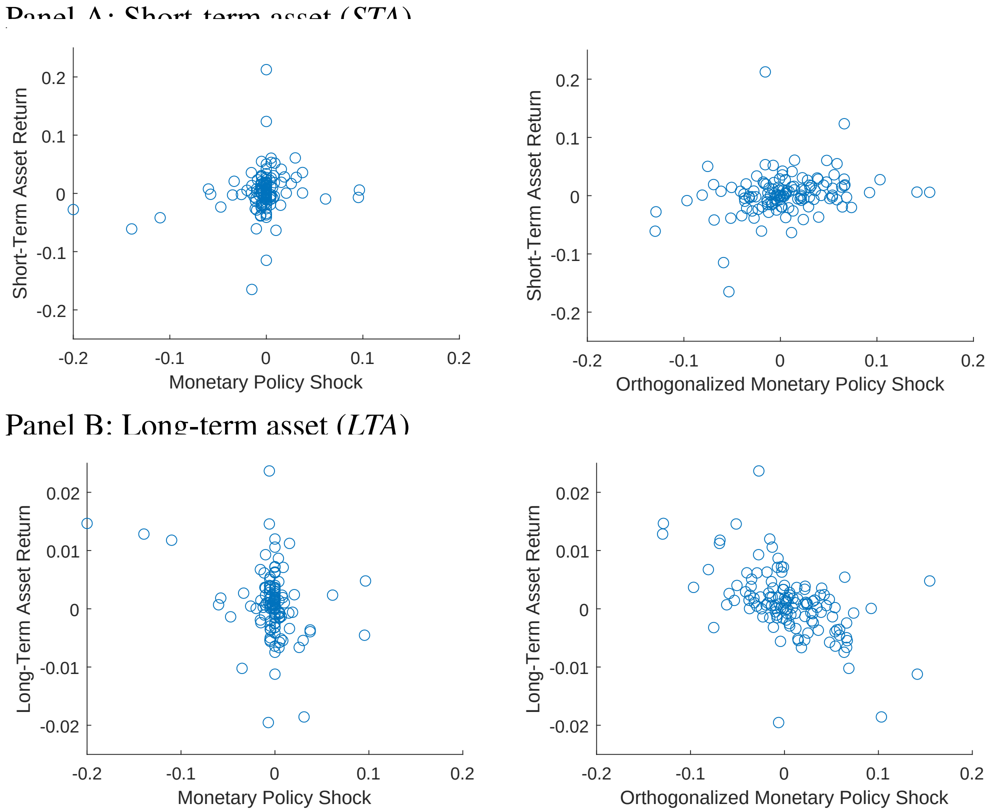
This table presents a summary of the parameter estimates from the model calibration.

Figure 1: **Stylized Framework Timing**



This figure shows the timing of the stylized framework from Section 2.

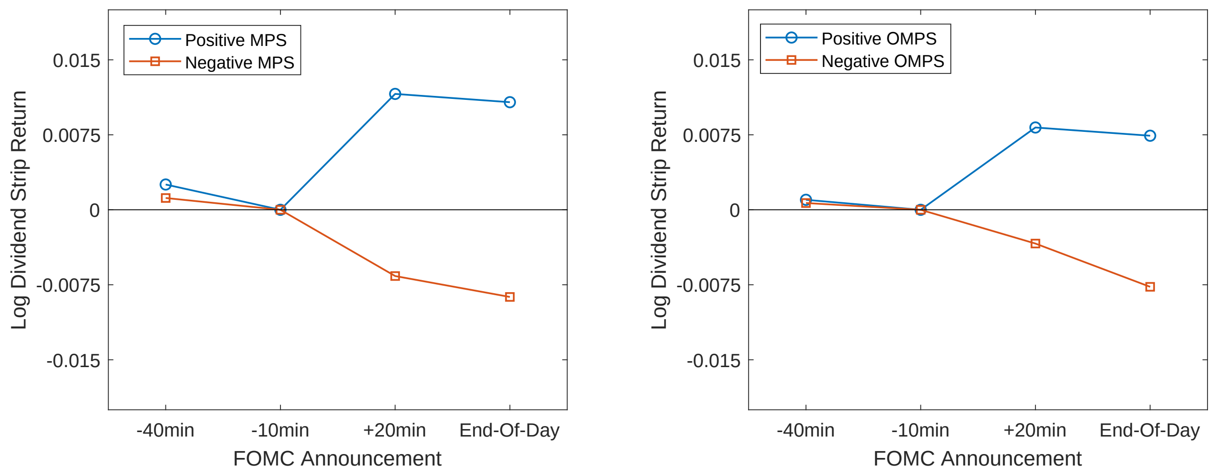
Figure 2: **Asset Announcement Return around Monetary Policy Shocks**



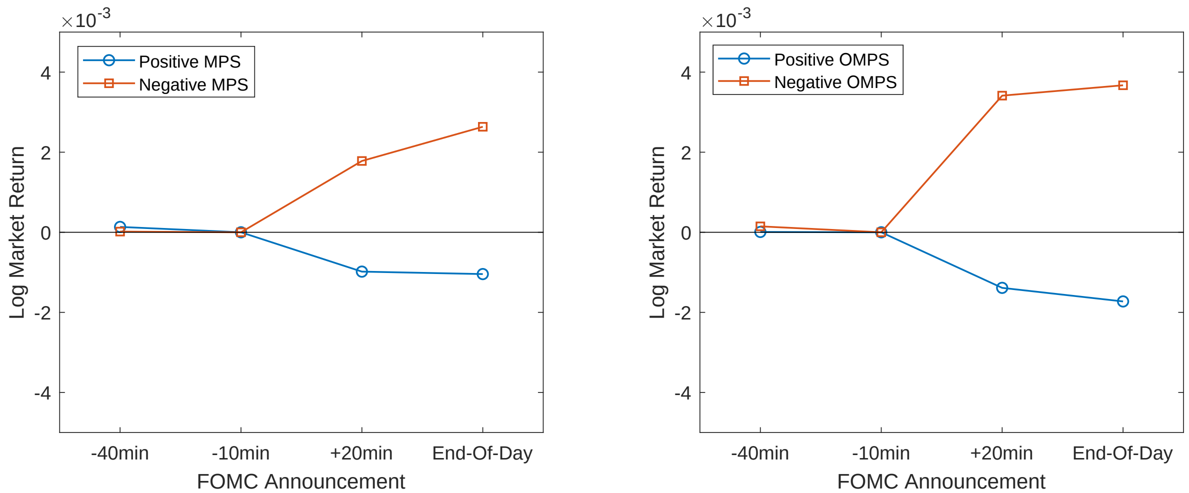
This figure plots the scatter plots of asset return in the 30-minute window around the FOMC announcements versus the monetary policy shocks. In Panel A, we plot the short-term asset announcement returns versus either the monetary policy shock (left) or the orthogonalized monetary policy shock (right) from Bauer and Swanson [8]. In Panel B, we plot the same scatter plots for the long-term asset announcement return. The time period is January 2004 through December 2019 and includes 128 scheduled FOMC announcements.

Figure 3: **Returns Around the FOMC Announcements**

Panel A: Short-term asset (*STA*)

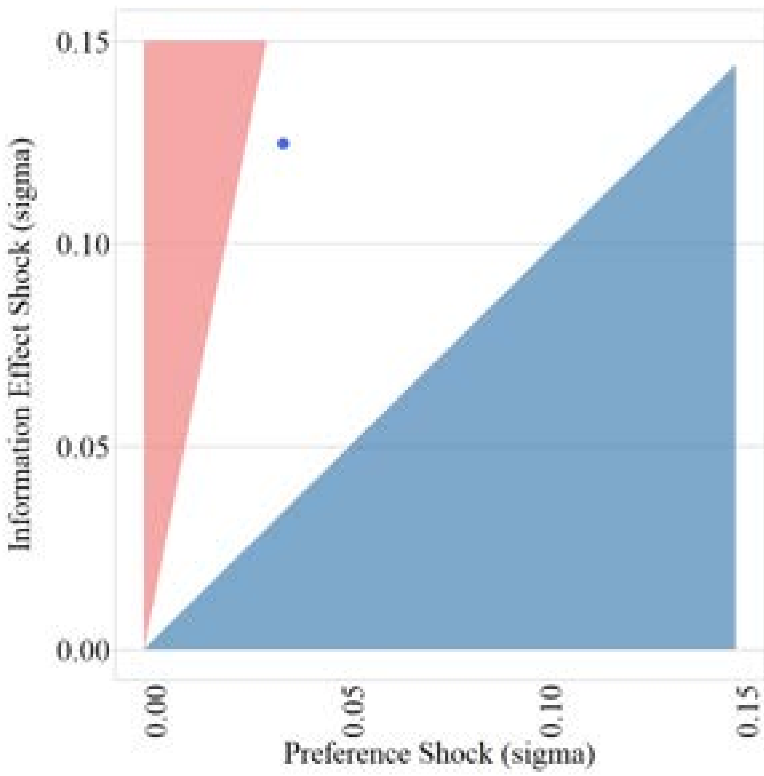


Panel B: Long-term asset (*LTA*)



This figure plots the cumulative average asset returns around the FOMC announcements. The averages are reported separately for positive and negative monetary policy shocks (MPS) and positive and negative orthogonalized monetary policy shocks (OMPS) from Bauer and Swanson [8]. In Panel A, we plot the cumulative average returns for the short-term asset and in Panel B, we plot the cumulative average returns for the long-term asset. The time period is January 2004 through December 2019 and includes 128 scheduled FOMC announcements.

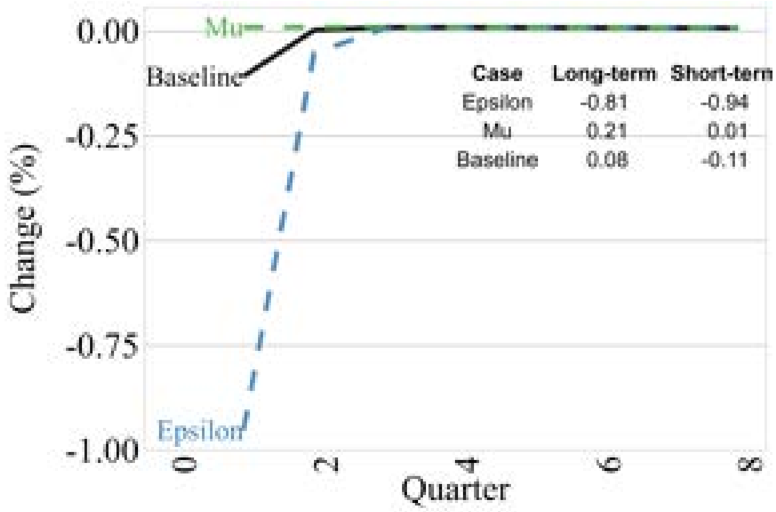
Figure 4: **Shock Bounds with Estimation**



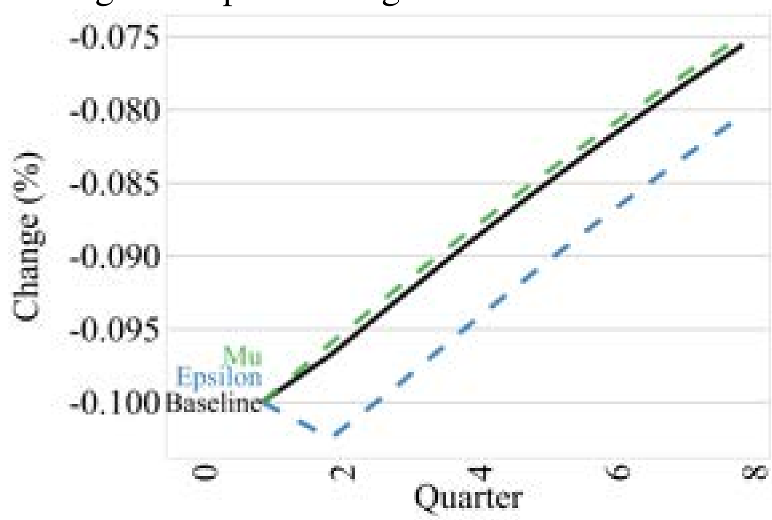
This figure plots the standard deviation of the information shock, σ_ϵ (vertical axis), and the standard deviation of the policy preference shock, σ_μ (horizontal axis). The white region indicates σ_ϵ and σ_μ pairs which generate the empirically documented positive loading of the short-term asset and negative loading of the long-term asset (the red shaded region indicates σ_ϵ and σ_μ pairs where the short- and the long-term asset loadings on the monetary policy surprise are positive; the blue shaded region indicates σ_ϵ and σ_μ pairs where the short- and the long-term asset loadings on the monetary policy shock are negative). The blue dot shows the estimated ratio of $\frac{\sigma_\epsilon}{\sigma_\mu}$ based on the calibrated parameters fitted to the data for the short-term and long-term asset announcement return and the monetary policy surprises.

Figure 5: **Propagation of Monetary Policy Surprise: Easing**

Panel A: Change in Expected GDP Growth



Panel B: Change in Expected Target Rate



This figure plots the model-implied change in expectations across the term structure following a monetary policy surprise of -10 basis points (unexpected easing). Panel A shows the change in expected quarterly economic growth. The x-axis indicates the number of quarters ahead (the monetary policy surprise occurs at quarter 0). The long-term and short-term asset return (in percent) are presented in the table in the top right corner. Panel B shows the change in expected target rate across the term structure. The dashed green "Mu" (blue "Epsilon") line shows the change in expectations if the investor observes the information and policy preference shocks, μ and ϵ, and the entire monetary policy surprise is driven by the shock μ (ϵ). The black line labeled "Baseline" shows the change in investor expectations following the monetary policy surprise when the investor infers the information and policy preference shocks from the change in the target rate.

Internet Appendix B

Table B.1: **Option Market Liquidity**

Panel A: January 28, 2004					
	t = 143	t = 234	t = 325	t = 507	t = 689
Before	510	570	930	600	570
After	540	570	930	600	570

Panel B: December 11, 2019									
	t = 156	t = 191	t = 282	t = 310	t = 345	t = 373	t = 401	t = 555	t = 737
Before	6,960	2,010	2,400	1,950	2,010	2,520	2,550	2,640	2,700
After	6,941	2,000	2,379	1,950	2,010	2,520	2,550	2,640	2,700

This table presents the number of put-call option price pairs used in our estimation of the short-term asset return. Panel A presents data from the first date in our sample, January 28, 2004 and Panel B presents data from the last date in our sample, December 11, 2019. The Before row indicates the pre-announcement window and the After row indicates the post-announcement window. The columns indicate the maturity of the options in days. We include data on maturities ranging from less than half a year to around two years.

Table B.2: **Asset Announcement Return on Monetary Policy Surprise: Full Sample**

	$\Delta\iota_t^s = MPS_t$			$\Delta\iota_t^s = OMPS_t$		
	ΔP_t^{180}	ΔP_t^{∞}	$\Delta P_t^{180} - \Delta P_t^{\infty}$	ΔP_t^{180}	ΔP_t^{∞}	$\Delta P_t^{180} - \Delta P_t^{\infty}$
Panel A: Main Robustness						
			Winsorize (5%)			
$\Delta\iota_t^s$	0.205***	-0.048***	0.264***	0.149***	-0.055***	0.219***
	(0.067)	(0.012)	(0.074)	(0.045)	(0.007)	(0.050)
Adj. R^2	0.063	0.102	0.084	0.071	0.296	0.128
Obs.	128	128	128	128	128	128
			Exclude most influential observations from Bauer and Swanson [7]			
$\Delta\iota_t^s$	0.296**	-0.048**	0.344**	0.229***	-0.063***	0.292***
	(0.148)	(0.021)	(0.152)	(0.080)	(0.011)	(0.081)
Adj. R^2	0.024	0.032	0.032	0.055	0.217	0.088
Obs.	124	124	124	124	124	124
			GMM standard errors			
$\Delta\iota_t^s$	0.249***	-0.059***	0.308***	0.217***	-0.068***	0.285***
	(0.071)	(0.014)	(0.078)	(0.075)	(0.013)	(0.079)
Adj. R^2	0.034	0.095	0.052	0.060	0.284	0.102
Obs.	128	128	128	128	128	128
			Control for bid-ask spread			
$\Delta\iota_t^s$	0.347***	-0.058***	0.405***	0.238***	-0.068***	0.305***
	(0.103)	(0.016)	(0.107)	(0.069)	(0.010)	(0.070)
$Bid - ask_t$	1.461***	0.026	1.435***	1.269***	0.045	1.225***
	(0.368)	(0.058)	(0.380)	(0.358)	(0.050)	(0.364)
Adj. R^2	0.136	0.089	0.142	0.139	0.283	0.170
Obs.	128	128	128	128	128	128
			270-day short-term asset			
$\Delta\iota_t^s$	0.144**	-0.059***	0.204***	0.139***	-0.068***	0.207***
	(0.064)	(0.016)	(0.069)	(0.043)	(0.010)	(0.045)
Adj. R^2	0.031	0.095	0.058	0.068	0.284	0.137
Obs.	128	128	128	128	128	128
Panel B: Different estimation windows for dividend strips						
			Post-announcement window delayed until last 30 minutes in a day			
$\Delta\iota_t^s$	0.177*	-0.068***	0.245**	0.196***	-0.075***	0.271***
	(0.101)	(0.023)	(0.108)	(0.068)	(0.015)	(0.071)
Adj. R^2	0.016	0.059	0.032	0.055	0.167	0.096
Obs.	128	128	128	128	128	128
			Extended pre-and post-announcement windows			
$\Delta\iota_t^s$	0.173**	-0.065***	0.239***	0.138***	-0.067***	0.205***
	(0.069)	(0.019)	(0.077)	(0.047)	(0.012)	(0.052)
Adj. R^2	0.040	0.082	0.063	0.056	0.196	0.103
Obs.	128	128	128	128	128	128

This table presents the robustness specifications run using the sample of all scheduled FOMC announcement from January 2004 through December 2019. In Panel A, we winsorize variables at 5% level, exclude the most influential observations from Bauer and Swanson [7], replace OLS standard errors with GMM standard errors, add a control for options bid-ask spread, and replace the 180-day maturity dividend strip with a 270-day maturity dividend strip. In Panel B, we delay the post-announcement window until the last 30 minutes in a day (from 3:30 pm to 4:00 pm) and we extend the estimation windows such that the pre-estimation window starts at 10:00 am and the post-esimtation window runs until 4:00 pm. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table B.3: **Asset Announcement Return on Monetary Policy Shock: CAPM-implied Dividend Strip Return**

	$\Delta\iota_t^s = MPS_t$			$\Delta\iota_t^s = OMPS_t$		
	ΔP_t^{180}	ΔP_t^{∞}	$CAPM-implied\left(\Delta P_t^{180}\right)$	ΔP_t^{180}	ΔP_t^{∞}	$CAPM-implied\left(\Delta P_t^{180}\right)$
Panel A: FOMC Announcements with Non-Zero MPS						
$\Delta\iota_t^s$	0.241***	-0.060***	0.258***	0.236***	-0.072***	0.256***
	(0.090)	(0.017)	(0.091)	(0.069)	(0.012)	(0.069)
Adj. R^2	0.069	0.121	0.078	0.115	0.297	0.133
Obs.	84	84	84	84	84	84
Panel B: All FOMC Announcements						
$\Delta\iota_t^s$	0.249**	-0.059***	0.266**	0.217***	-0.068***	0.236***
	(0.106)	(0.016)	0.107	(0.072)	(0.010)	0.072
Adj. R^2	0.034	0.095	0.039	0.060	0.284	0.072
Obs.	128	128	128	128	128	128

This table presents the results from the regressions of asset announcement return on the monetary policy surprise:

$$\Delta P_t^h = \alpha + \beta \Delta\iota_t^s + \epsilon$$

where $\Delta\iota_t^s$ is either monetary policy shock estimated using first to maturity federal funds futures MPS_t or the orthogonalized monetary policy shock from Bauer and Swanson [8] $OMPS_t$ at date t. ΔP_t^h is the change in the log asset price over the same window (ΔP_t^{180} denotes the short-term asset announcement return (180-day dividend strip) and ΔP_t^{∞} denotes the long-term asset announcement return (S&P 500 index)). CAPM-implied abnormal dividend strip returns are calculated as:

$$CAPM-implied\left(\Delta P_t^{180}\right) = \Delta P_t^{180} - \left(Rf_t + \beta^{Div} \times \left(\Delta P_t^{\infty} - Rf_t\right)\right),$$

where Rf_t is the risk-free rate proxied by the 180-day implied interest rate and β^{Div} is estimated on the placebo sample (7 days before and 7 days after the announcements) to be 0.291. OLS standard errors are reported in parentheses below the coefficient estimate. Panel A presents results for FOMC announcements with non-zero monetary policy shocks (non-zero MPS). Panel B presents results for all FOMC announcements in the period from January 2004 through December 2019. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table B.4: **Short Term Treasury Bond Announcement Return on Monetary Policy Shock**

	ΔSHV_t	
	$\Delta\iota_t^s = MPS_t$	$\Delta\iota_t^s = OMPS_t$
Panel A: FOMC Announcements with Non-Zero MPS		
$\Delta\iota_t^s$	-0.0009***	-0.0010***
	(0.0002)	(0.0002)
Adj. R^2	0.143	0.306
Obs.	70	70
Panel B: All FOMC Announcements		
$\Delta\iota_t^s$	-0.0008***	-0.0010***
	(0.0002)	(0.0002)
Adj. R^2	0.092	0.238
Obs.	104	104

This table presents the results from the regressions of asset announcement return on the monetary policy surprise:

$$\Delta SHV_t = \alpha + \beta\Delta\iota_t^s + \epsilon$$

where $\Delta\iota_t^s$ is either monetary policy shock estimated using first to maturity federal funds futures MPS_t or the orthogonalized monetary policy shock from Bauer and Swanson [8] $OMPS_t$ at date t. ΔSHV_t is the change in the log asset price of the Short Term Trasury Bond ETF (SHV) over the same window. OLS standard errors are reported in parentheses below the coefficient estimate. Panel A presents results for FOMC announcements with non-zero monetary policy shocks (non-zero MPS). Panel B presents results for all FOMC announcements in the period from January 2007 through December 2019. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table B.5: **Real Dividend and GDP Forecasting: Non-zero Shocks, Latest**

Horizon	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Real Dividend Growth						
ΔP_t^{180}	0.763**	0.949***	1.122***	1.249***	1.054***	1.025***
	(0.338)	(0.331)	(0.370)	(0.385)	(0.303)	(0.234)
Adj. R^2	0.080	0.138	0.171	0.206	0.144	0.131
Panel B: Real GDP Growth						
ΔP_t^{180}	0.169**	0.186**	0.249***	0.160**	0.106***	0.039
	(0.083)	(0.083)	(0.083)	(0.065)	(0.040)	(0.034)
Adj. R^2	0.105	0.123	0.239	0.090	0.022	-0.022
Obs.	40	39	38	38	37	36

Panel A presents the results from the predictive regression of k-quarter ahead real dividend growth on the 180-day dividend strip return ΔP_t^{180} in the 30 minute window around the FOMC announcements with non-zero monetary policy surprises:

$$log\left(\frac{D_{t+k}}{D_{t+k-4}}\right) = \alpha_k + \beta_k \Delta P_t^{180} + \epsilon_{t+k}, k \in \{1, 2, ..., 6\}$$

Panel B presents the same results for predicting real GDP growth. We use non-zero monetary policy shocks from the latest FOMC meeting each quarter. We report Newey-West adjusted standard errors with $k+1$ lags in parentheses below the coefficient estimates. The period is from January 2004 through December 2019. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table B.6: **Real Dividend and GDP Growth Forecasting: Delayed Post-Announcement Window**

	Real Dividend Growth						Real GDP Growth					
Horizon	1Q	2Q	3Q	4Q	5Q	6Q	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Non-zero monetary shocks												
ΔP_t^{180}	0.945***	0.960**	1.011**	0.959**	0.572	0.409	0.169*	0.141	0.139	0.036	-0.019	-0.077
	(0.337)	(0.405)	(0.450)	(0.478)	(0.400)	(0.402)	(0.093)	(0.089)	(0.093)	(0.077)	(0.078)	(0.071)
Adj. R^2	0.133	0.124	0.108	0.092	0.025	0.005	0.091	0.053	0.052	-0.009	-0.012	0.008
Panel B: Full sample												
ΔP_t^{180}	0.882***	0.850***	0.897**	0.825*	0.483	0.326	0.143**	0.125	0.121	0.029	-0.025	-0.099
	(0.307)	(0.324)	(0.376)	(0.426)	(0.404)	(0.447)	(0.070)	(0.079)	(0.090)	(0.081)	(0.081)	(0.079)
$\Delta \iota_t^s$	0.180	0.228	0.208	0.294	0.265	0.458	0.024	-0.002	0.030	0.038	0.095	0.114
	(0.161)	(0.197)	(0.292)	(0.325)	(0.399)	(0.437)	(0.057)	(0.063)	(0.067)	(0.078)	(0.076)	(0.079)
ΔP_t^{∞}	-1.887	-2.653	-2.057	-2.101	-1.294	1.115	-0.347	-0.266	0.077	0.218	0.428	0.048
	(2.179)	(2.419)	(3.088)	(3.001)	(3.328)	(2.843)	(0.515)	(0.563)	(0.532)	(0.595)	(0.657)	(0.543)
ΔIV_t^{180}	-3.435	-3.206	-1.420	-1.371	-0.902	1.821	0.186	0.154	0.743	0.543	0.490	0.002
	(3.941)	(3.656)	(4.056)	(3.796)	(4.401)	(3.748)	(0.734)	(0.750)	(0.739)	(0.906)	(0.986)	(0.851)
Adj. R^2	0.117	0.123	0.098	0.088	0.002	-0.009	0.104	0.038	0.042	-0.038	-0.016	0.019
Obs.	83	81	79	79	77	75	83	81	79	79	77	75

This table presents the results from the predictive regression of k-quarter ahead real dividend growth and real GDP growth on the 180-day dividend strip FOMC announcement return ΔP_t^{180}, where the strip return is calculated as the log difference in prices between the post-announcement window (3:30 pm to 4:00 pm on the announcement day) and the pre-announcement window (40 minutes to 10 minutes before the announcement). The specification is given by:

$$X_{t+k} = \alpha_k + \beta_k \Delta P_t^{180} + \delta_k Controls_t + \epsilon_{t+k}, k \in \{1, 2, ..., 6\}$$

The dependent variable is the real dividend growth $X_{t+k} = log\left(\frac{D_{t+k}}{D_{t+k-4}}\right)$ (left side of the table) or the real GDP growth $X_{t+k} = log\left(\frac{GDP_{t+k}}{GDP_{t+k-4}}\right)$ (right side of the table). Panel A presents the results for the univariate regressions. Panel B includes control variables for the monetary policy shock Δi_t^s, the aggregate market announcement return ΔP_t^{∞}, and the change in the option implied volatility ΔIV_t. We report Newey-West adjusted standard errors with $k+1$ lags in parentheses below the coefficient estimates. The period is from January 2004 through December 2019 and includes FOMC announcements with non-zero monetary policy shocks (non-zero MPS). Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table B.7: **Real Dividend and GDP Growth Forecasting: Extended Estimation Windows**

	Real Dividend Growth						Real GDP Growth					
Horizon	1Q	2Q	3Q	4Q	5Q	6Q	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Univariate regressions												
ΔP_t^{180}	1.451***	1.663***	1.791**	1.968***	1.360**	0.917***	0.311**	0.291*	0.276**	0.140	0.038	-0.044
	(0.404)	(0.596)	(0.726)	(0.668)	(0.553)	(0.339)	(0.144)	(0.155)	(0.125)	(0.088)	(0.065)	(0.051)
Adj. R^2	0.174	0.208	0.193	0.226	0.103	0.040	0.177	0.138	0.125	0.024	-0.011	-0.010
Panel B: Additional control variables												
ΔP_t^{180}	1.153***	1.261***	1.372**	1.612**	1.113*	0.791	0.217*	0.223	0.233*	0.126	0.045	-0.076
	(0.338)	(0.457)	(0.613)	(0.639)	(0.639)	(0.560)	(0.112)	(0.144)	(0.133)	(0.106)	(0.099)	(0.099)
$\Delta \iota_t^s$	0.109	0.137	0.087	0.144	0.124	0.335	0.003	-0.023	0.008	0.014	0.074	0.094
	(0.174)	(0.164)	(0.221)	(0.223)	(0.315)	(0.380)	(0.052)	(0.057)	(0.055)	(0.069)	(0.074)	(0.088)
ΔP_t^{∞}	-4.994**	-5.310*	-4.958	-3.490	-1.931	1.291	-0.949*	-0.836	-0.146	0.196	0.745	0.483
	(2.534)	(2.835)	(3.257)	(2.941)	(3.315)	(2.968)	(0.515)	(0.529)	(0.462)	(0.527)	(0.626)	(0.446)
ΔIV_t^{180}	-7.870*	-6.729*	-5.133	-2.898	-0.612	3.435	-0.596	-0.666	0.447	0.712	1.287	1.208
	(4.023)	(3.972)	(4.655)	(4.987)	(5.587)	(5.392)	(0.785)	(1.002)	(1.012)	(1.027)	(1.210)	(1.003)
Adj. R^2	0.214	0.253	0.216	0.227	0.081	0.023	0.218	0.150	0.105	-0.005	0.002	0.020
Obs.	83	81	79	79	77	75	83	81	79	79	77	75

This table presents the results from the predictive regression of k-quarter ahead real dividend growth and real GDP growth on the 180-day dividend strip FOMC announcement return ΔP_t^{180}, where the strip return is calculated as the log difference in prices between the post-announcement window (20 minuts after the announcement until 4:00 pm) and the pre-announcement window (10:00 am to 10 minutes before the announcement). The specification is given by:

$$X_{t+k} = \alpha_k + \beta_k \Delta P_t^{180} + \delta_k Controls_t + \epsilon_{t+k}, k \in \{1, 2, ..., 6\}$$

The dependent variable is the real dividend growth $X_{t+k} = log\left(\frac{D_{t+k}}{D_{t+k-4}}\right)$ (left side of the table) or the real GDP growth $X_{t+k} = log\left(\frac{GDP_{t+k}}{GDP_{t+k-4}}\right)$ (right side of the table). Panel A presents the results for the univariate regressions. Panel B includes control variables for the monetary policy shock Δi_t^s, the aggregate market announcement return ΔP_t^{∞}, and the change in the option implied volatility ΔIV_t. We report Newey-West adjusted standard errors with $k+1$ lags in parentheses below the coefficient estimates. The period is from January 2004 through December 2019 and includes FOMC announcements with non-zero monetary policy shocks (non-zero MPS). Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table B.8: **Real Dividend and GDP Growth Forecasting: All FOMC Days**

	Real Dividend Growth						Real GDP Growth					
Horizon	1Q	2Q	3Q	4Q	5Q	6Q	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Univariate regressions												
ΔP_t^{180}	0.363**	0.398*	0.465	0.627*	0.649*	0.494	0.053	0.090	0.121	0.088	0.073*	0.034
	(0.158)	(0.203)	(0.297)	(0.375)	(0.341)	(0.335)	(0.046)	(0.063)	(0.080)	(0.066)	(0.043)	(0.029)
Adj. R^2	0.014	0.018	0.028	0.058	0.063	0.032	0.005	0.031	0.062	0.030	0.018	-0.003
Panel B: Additional control variables												
ΔP_t^{180}	0.233	0.302	0.380	0.573	0.657*	0.523	0.038	0.087	0.124	0.097	0.077	0.029
	(0.164)	(0.203)	(0.305)	(0.375)	(0.370)	(0.358)	(0.037)	(0.059)	(0.079)	(0.072)	(0.051)	(0.033)
Δi_t^s	0.205	0.356	0.353	0.387	0.302	0.503	0.055	0.014	0.056	0.046	0.097	0.115
	(0.290)	(0.286)	(0.308)	(0.316)	(0.375)	(0.471)	(0.088)	(0.068)	(0.062)	(0.081)	(0.094)	(0.114)
ΔP_t^{∞}	-4.001	-1.598	-1.052	0.563	2.590	5.001	-0.196	0.003	0.523	0.708	0.856	0.597
	(2.937)	(2.851)	(3.137)	(3.351)	(3.906)	(4.080)	(0.590)	(0.473)	(0.536)	(0.776)	(0.898)	(0.657)
ΔIV_t^{180}	-5.980	-2.364	-0.377	4.169	6.401	9.140	0.315	0.729	1.245	1.440	1.109	0.511
	(3.906)	(3.786)	(4.090)	(5.098)	(6.181)	(6.499)	(0.643)	(0.738)	(0.995)	(1.403)	(1.432)	(1.042)
Adj. R^2	0.023	0.014	0.023	0.068	0.067	0.071	0.009	0.024	0.068	0.038	0.042	0.016
Obs.	126	124	122	120	118	116	126	124	122	120	118	116

This table presents the results from the predictive regression of k-quarter ahead real dividend growth and real GDP growth on the 180-day dividend strip return ΔP_t^{180} in the 30 minute window around the FOMC announcement. The sample includes all FOMC meetings, including those with a zero monetary policy surprise. The specification is given by:

$$X_{t+k} = \alpha_k + \beta_k \Delta P_t^{180} + \delta_k Controls_t + \epsilon_{t+k}, k \in \{1, 2, ..., 6\}$$

The dependent variable is the real dividend growth $X_{t+k} = log\left(\frac{D_{t+k}}{D_{t+k-4}}\right)$ (left side of the table) or the real GDP growth $X_{t+k} = log\left(\frac{GDP_{t+k}}{GDP_{t+k-4}}\right)$ (right side of the table). Panel A presents the results for the univariate regressions. Panel B includes control variables for the monetary policy shock Δi_t^s, the aggregate market announcement return ΔP_t^{∞}, and the change in the option implied volatility ΔIV_t. We report Newey-West adjusted standard errors with $k+1$ lags in parentheses below the coefficient estimates. The sample includes all scheduled FOMC announcement from January 2004 through December 2019. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table B.9: **Real Dividend and GDP Forecasting: FOMC and Non-FOMC Days**

Horizon	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Real Dividend Growth						
ΔP_t^{180}	0.040	-0.021	-0.039	0.018	0.120	0.051
	(0.126)	(0.125)	(0.108)	(0.117)	(0.137)	(0.132)
$FOMC_t^{NZ}$	-0.005	-0.012	-0.014*	-0.020***	-0.021**	-0.019*
	(0.008)	(0.009)	(0.009)	(0.008)	(0.009)	(0.010)
$\Delta P_t^{180} \times FOMC_t^{NZ}$	0.631**	0.895***	1.033***	1.185***	0.985***	0.988***
	(0.307)	(0.286)	(0.296)	(0.349)	(0.364)	(0.350)
Adj. R^2	0.005	0.016	0.023	0.039	0.035	0.026
Obs.	378	372	366	360	353	348
Panel B: Real GDP Growth						
ΔP_t^{180}	-0.016	-0.010	-0.015	-0.013	0.012	0.012
	(0.022)	(0.029)	(0.032)	(0.030)	(0.029)	(0.032)
$FOMC_t^{NZ}$	-0.002	-0.004**	-0.005***	-0.005***	-0.003*	-0.002
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
$\Delta P_t^{180} \times FOMC_t^{NZ}$	0.143**	0.181**	0.257***	0.167**	0.095	0.033
	(0.067)	(0.072)	(0.083)	(0.084)	(0.065)	(0.048)
Adj. R^2	0.007	0.022	0.050	0.024	0.008	-0.005
Obs.	378	372	366	360	353	348

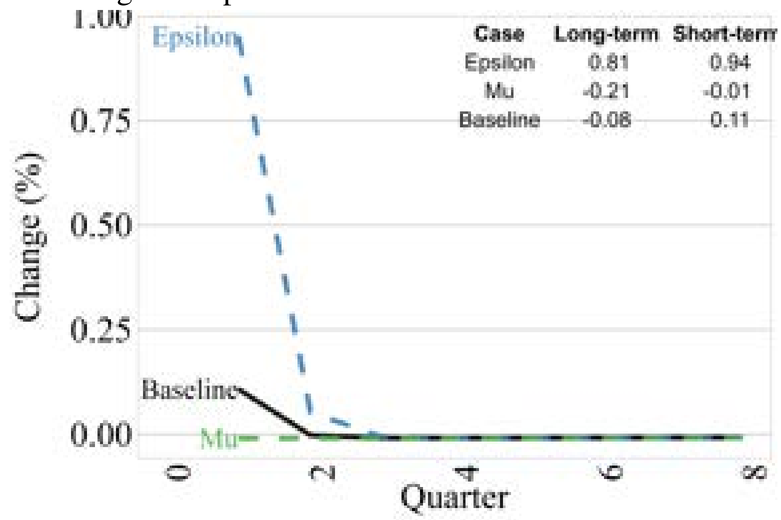
Panel A presents the results from the predictive regression of k quarter ahead real dividend growth on the 180-day dividend strip return ΔP_t^{180} in the 30 minute window on FOMC announcement days and non-FOMC announcement days (seven days before and seven days after the FOMC announcement):

$$log\left(\frac{D_{t+k}}{D_{t+k-4}}\right) = \alpha_k + \beta_k \Delta P_t^{180} + \delta_k FOMC_t^{NZ} + \theta_k \Delta P_t^{180} \times FOMC_t^{NZ} + \epsilon_{t+k}, k \in \{1, 2, ..., 6\}$$

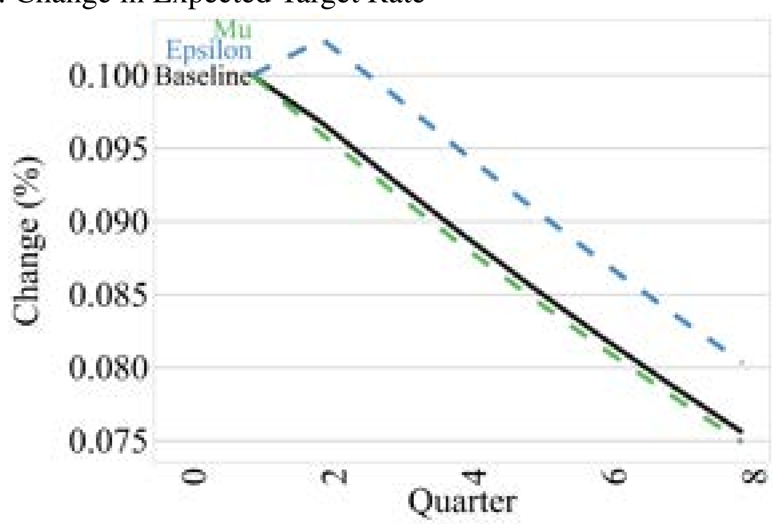
where $FOMC^{NZ}$ is a dummy variable equal to 1 on FOMC announcement dates with a non-zero monetary policy shock and 0 otherwise. Panel B presents results from the GDP growth predictability specifications. Newey-West adjusted standard errors with $k+1$ lags are in parentheses below the coefficient estimates. The period is from January 2004 through December 2019. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Figure B.1: **Propagation of Monetary Policy Surprise: Tightening**

Panel A: Change in Expected GDP Growth



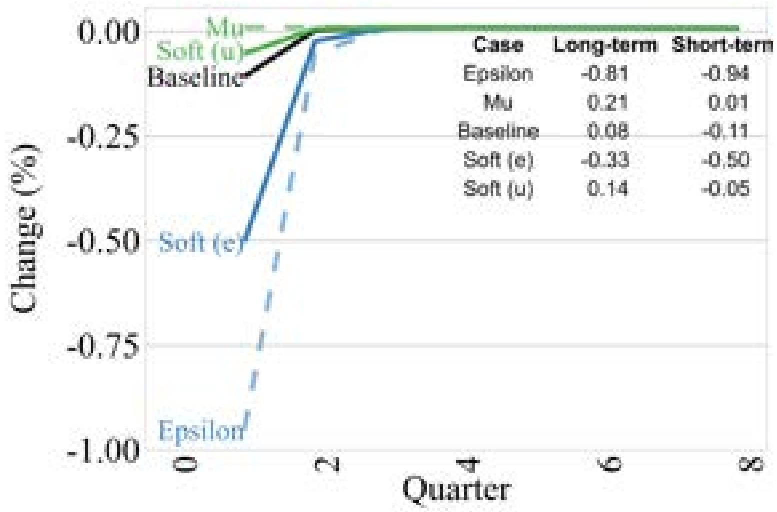
Panel B: Change in Expected Target Rate



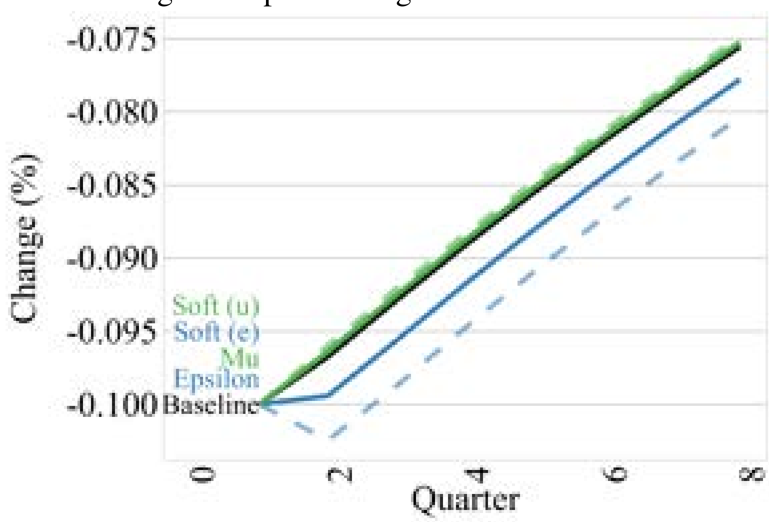
This figure plots the model-implied change in expectations across the term structure following a positive monetary policy surprise of 10 basis points (unexpected tightening). Panel A shows the change in expected quarterly economic growth. The x-axis indicates the number of quarters ahead (the monetary policy surprise occurs at quarter 0). The long-term and short-term asset return (in percent) are presented in the table in the top right corner. Panel B shows the change in expected target rate across the term structure. The dashed green "Mu" (blue "Epsilon") line shows the change in expectations if the investor observes the information and policy preference shocks, μ and ϵ, and the entire monetary policy surprise is driven by the shock μ (ϵ). The black line labeled "Baseline" shows the change in investor expectations following the monetary policy surprise when the investor infers the information and policy preference shocks from the change in the target rate.

Figure B.2: **Propagation of Monetary Policy Surprise: Soft Information**

Panel A: Change in Expected GDP Growth

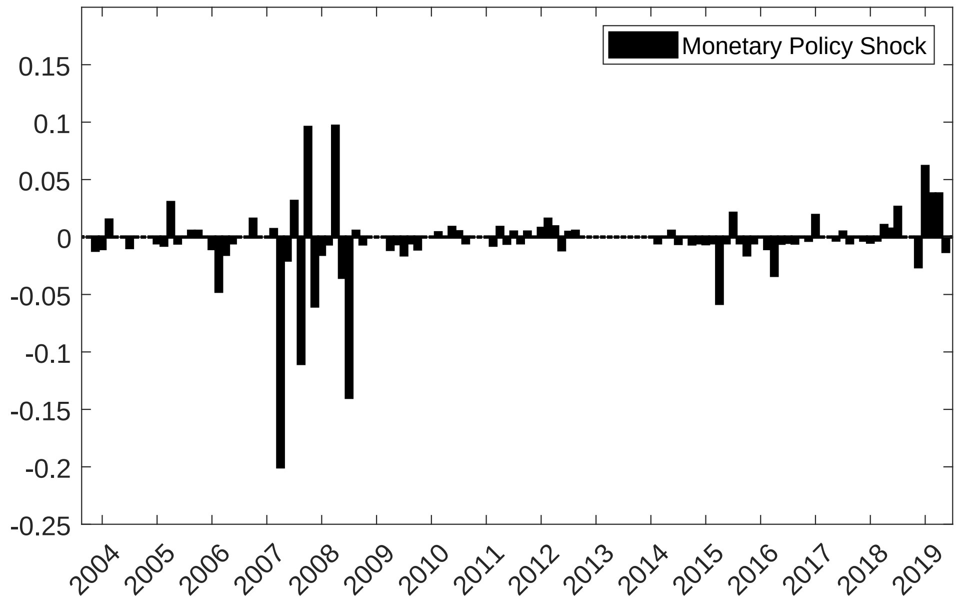


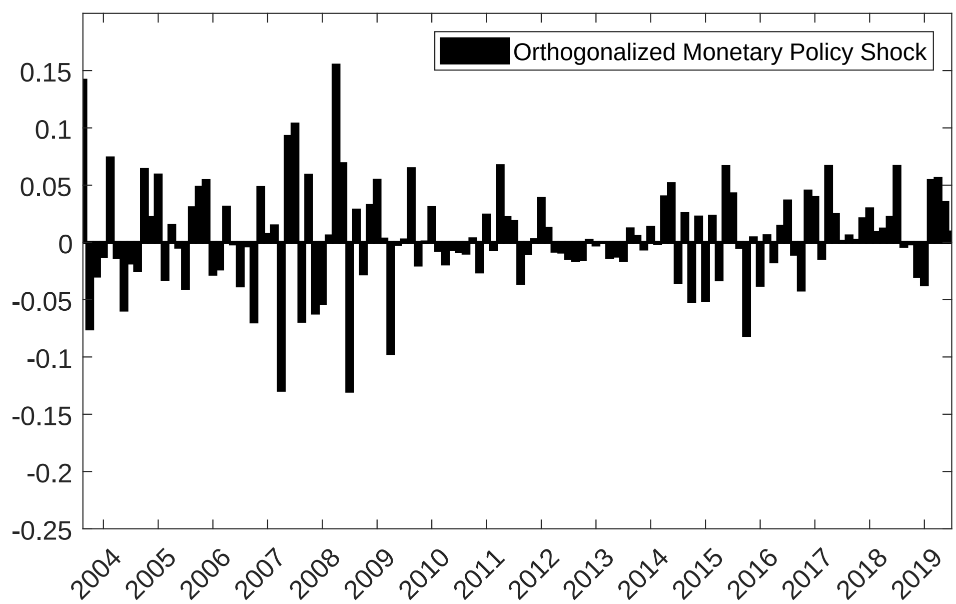
Panel B: Change in Expected Target Rate



This figure plots the model-implied change in expectations across the term structure following a monetary policy surprise of -10 basis points (unexpected easing). Panel A shows the change in expected quarterly economic growth. The x-axis indicates the quarters ahead (the monetary policy shock occurs at quarter 0). Panel B shows the change in expected target rate across the term structure. The solid green line "Soft (u)" shows the change in investor expectations with soft information from the central bank if the entire monetary policy surprise is driven by the exogenous shock μ. The solid blue line "Soft (e)" shows the change in investor expectations with soft information if the entire surprise is driven by ϵ. For reference, we plot the change in investor expectations with no soft information (black line) and the change in investor expectations if the investor directly observes the shocks and the entire monetary policy surprise is driven by the shock μ (dashed green line) or by ϵ (dashed blue line).

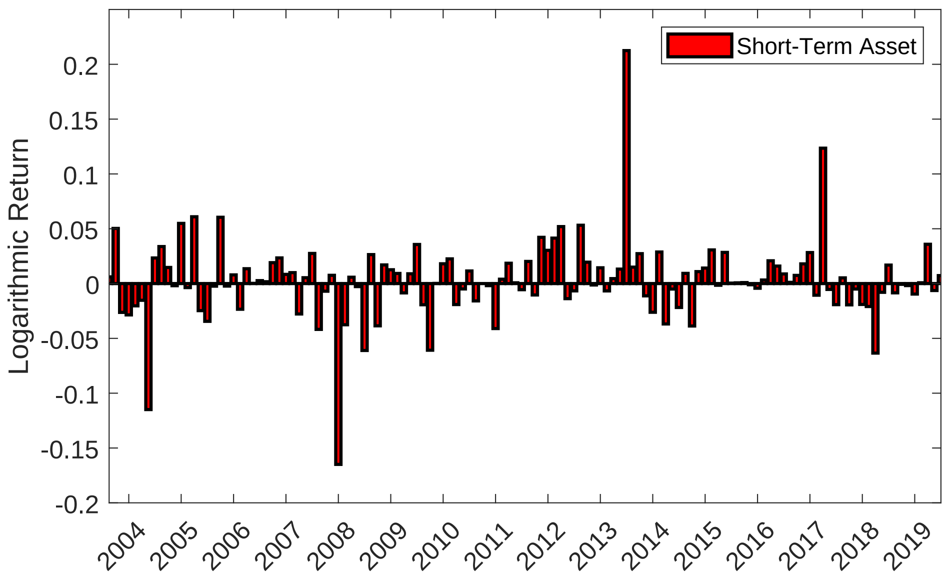
Figure B.3: **Monetary Policy Shock**

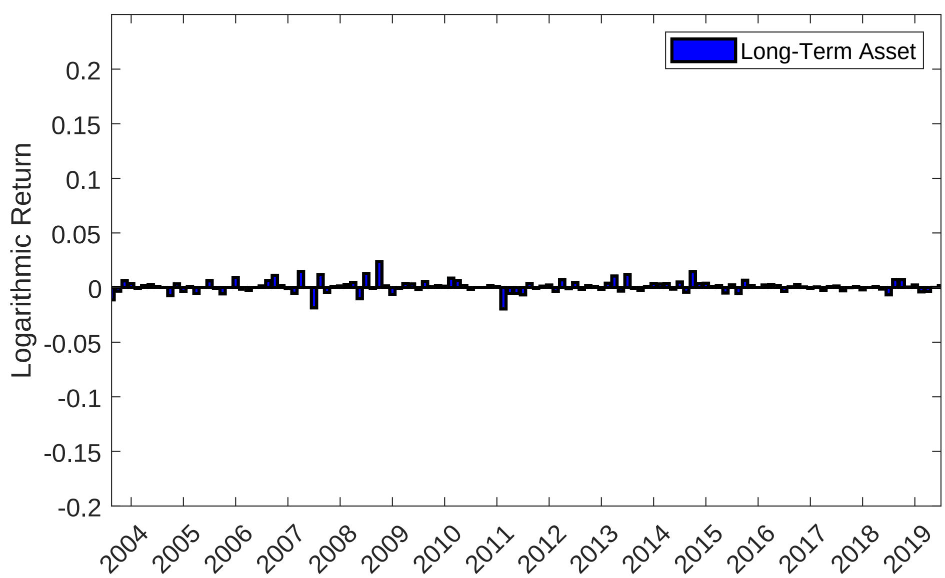




This figure plots the time-series of monetary policy shocks (Panel A) and orthogonalized monetary policy shocks from Bauer and Swanson [8] (Panel B). The time period is January 2004 through December 2019.

Figure B.4: **Asset Return**





This figure plots the time-series of short-term returns over the 30-minute window around each FOMC announcement (Panel A) and the corresponding long-term asset return (Panel B). The time period is January 2004 through December 2019.