Fed Information Effects: Evidence from the Equity Term Structure

Benjamin Golez Ben Matthies[*,†]

December 2023

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.

JEL Classification: E50, G10

Keywords: information effects, term structure, asset pricing

[*]We thank Nicholas Barberis, Anna Cieslak, Zhi Da, Stefano Giglio, Andrei Goncalves (discussant), Ralph Koijen, Eben Lazarus (discussant), Federico Mainardi (discussant), Shane Miller (discussant), Emi Nakamura, Ali Ozdagli (discussant), Nikolai Roussanov, Michael Weber and seminar participants at Baruch College, Boston College, Johns Hopkins University, Mid-Atlantic Research Conference, Midwest Finance Association Annual Meeting, Rutgers Business School, SFS Cavalcade North America, Tilburg University, University of Connecticut, University of Notre Dame, University of Texas at Austin, University of Virginia Darden, the USC Macro-finance Conference, and the Wabash Conference for helpful comments. This paper was circulated in December 2020 under the title "Monetary Policy and the Equity Term Structure."

[†]Benjamin Golez (corresponding author) is with the University of Notre Dame, email: bgolez@nd.edu. Ben Matthies is with the University of Notre Dame, email: bmatthie@nd.edu, tel: 574-631-1492, address: 259 Mendoza College of Business, University of Notre Dame, Notre Dame, IN 46556.

1 Introduction

Whether central bank announcements reveal information about the state of the economy is a central question in macroeconomics.[1] 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. One of the most widely cited evidence in support of Fed information effects is provided by Nakamura and Steinsson (2018). They 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 the monetary policy would predict a negative relationship. However, Bauer and Swanson (2023a) and Karnaukh and Vokata (2022) challenge this evidence, arguing that economic news released prior to Federal Open Market Committee (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. Given the underestimation of the policy rule and the low, monthly frequency of available growth forecasts, the 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 (2018). Similarly, Karnaukh and Vokata (2022) document that 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 (2023a) and Karnaukh and Vokata (2022). 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., 2012)).[2]

[1] E.g. Romer and Romer, 2000; Campbell et al., 2012; Nakamura and Steinsson, 2018; Cieslak and Schrimpf, 2019; Jarocinski and Karadi, 2020; Bauer and Swanson, 2023a,b.

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

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 (2018) - since short-term equity claim depends directly on investor expectations for near-term aggregate cash flows, the short-term equity announcement return functions as a "nowcast" of changes in investor economic growth expectations, similar to economic forecast revisions from Nakamura and Steinsson (2018). 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 (2023b) critique.[3]

Previous research has explored the reaction of the aggregate stock market to monetary policy surprises (e.g. Bernanke and Kuttner, 2005). 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 how monetary policy announcements affect investor perceptions of near-term economic conditions, which provides a sharper characterization of Fed information effects.[4]

We begin by presenting a stylized model of monetary policy and 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. Investors know the central bank policy rule, prior realized GDP growth, and observe the central bank policy decision (target rate), but do not observe the shocks. Based on the observed target rate, investors infer a 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

[3]See also Bauer and Swanson (2023b) who discuss how high-frequency asset price responses to monetary shocks address the omitted variable issue and are not subject to "Fed response to news" channel.

[4]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.

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. The 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: 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 (2018). 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 (2005), with the existence of Fed information effects. Finally, the model predicts that the short-term asset announcement return should forecast near-term economic output growth with a positive sign.

To conduct our empirical tests, we obtain two high-frequency measures of monetary policy 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., 2004). The second measure is the orthogonalized monetary policy shock constructed by Bauer and Swanson (2023b) 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. (2012) and Golez and Jackwerth (2023) 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 six-month maturities. This choice is governed by existing research on information effects that focuses on forecasts over the near quarters (Nakamura and Steinsson, 2018). It also strikes the balance between more liquid short-dated options and less liquid longer-dated options (Golez, 2014). 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.[5] In our baseline tests, we follow prior literature (e.g. Nakamura and Steinsson, 2018) 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. We find a positive coefficient estimate on the monetary policy surprise that is 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 shock. 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. Furthermore, the findings are robust to winsorizing variables at the 5 percent level, implementing GMM heteroscedasticity-consistent standard errors, controlling for option market liquidity using changes in bid-ask spreads, extending the estimation window to 60 minutes (instead of the standard 30-minute window), and using 270-day maturity dividend strips instead of the conventional 180-day strips.

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, 2005). 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-

[5]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.

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. 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.

Our results do not rule out the possibility that changes in risk premia may drive part of the variation in the short-term asset announcement return.[6] However, for our main test of information effects, it does not matter whether the short-term asset return is driven by cash flow news or changes in risk premia: even if the announcement return is 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.[7] 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.

Nonetheless, understanding the mechanism behind these effects is an important question. We elect to model information effects through the cash flow channel in order to remain 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.[8]

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

[6] Golez (2014) argues that risk-premia in six-month maturity dividend strips is small.

[7] We extend our gratitude to Emi Nakamura for pointing out that even if the short-term asset response is driven purely by changes in risk premia (and not cash flow news), the loading on the monetary policy surprise we document would still be novel evidence of information effects.

[8] This exercise is similar in spirit to a Campbell-Shiller decomposition of the variation in the short-term asset announcement return (which must be driven by cash flow news or discount rate news).

in magnitudes 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.

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., 2012; Van Binsbergen et al., 2013; Gormsen and Koijen, 2020; Gormsen, 2021; Bansal et al., 2021; Gonçalves, 2021; Gormsen and Lazarus, 2021; Boguth et al. 2022; Golez and Jackwerth, 2023). The exception in this context is the work by Gormsen and Koijen (2020), 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.[9]

Thereby, our paper relates to a large body of literature which studies the impact of monetary policy surprises on asset prices and macroeconomy.[10] Our contribution centers on the ongoing debate surrounding the existence of Fed information effects (Romer and Romer, 2000; Faust et al., 2004; Campbell et al., 2012; Nakamura and Steinsson, 2018; Cieslak and Schrimpf, 2019; Jarocinski and Karadi, 2020; Lunsford, 2020; Bundick and Smith, 2020; Karnaukh and Vokata, 2022; Bauer and Swanson, 2023a).[11] As discussed above, Nakamura and Steinsson (2018) 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 (2023a) argue that their findings can be ex-

[9]Like Van Binsbergen et al. (2012) and Golez and Jackwerth (2023), we estimate short-term dividend strips from index options data, rather than relying on dividend futures as done by Van Binsbergen et al. (2013) as that enables us to construct high-frequency estimates of dividend strips over a much longer time-period.

[10]Papers include: Kuttner, 2001; Gilchrist and Leahy, 2002; Gürkaynak et al., 2004; Bernanke and Kuttner, 2005; Campbell et al., 2012; Gorodnichenko and Weber, 2016; Song, 2017; Ozdagli and Weber, 2021; Nakamura and Steinsson, 2018; Drechsler et al., 2018; Cieslak and Schrimpf, 2019; Neuhierl and Weber, 2019; Jarocinski and Karadi, 2020; Swanson, 2021; Elenev et al., 2022.

[11]Our paper also contributes to theory work on monetary policy and information effects (Cukierman and Meltzer, 1986; Ellingsen and Soderstrom, 2001; Melosi, 2017; Nakamura and Steinsson, 2018; Miranda-Agrippino and Ricco, 2021).

plained by omitted economic news and underestimating the central bank's response to news (see also Karnaukh and Vokata (2022)). We provide evidence for information effects based on the short-term asset response to monetary shocks which addresses the omitted variable issue. Important work by Cieslak and Schrimpf (2019) 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.[12] Jarocinski and Karadi (2020) measure information effects as FOMC announcements when both interest rates and the stock market rise or fall together. Recently, Bauer and Swanson (2023a) 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 (2023a) 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, 2005).

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, 1986; Ellingsen and Soderstrom, 2001; Melosi, 2017; Nakamura and Steinsson, 2018; Miranda-Agrippino and Ricco, 2021). 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 8.1 in the Appendix.

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

2.1 Setup

There are two agents, a central bank which sets the target rate and an investor which 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 $\bar{t}$.[13]

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 $\bar{t}$.[14] $\Delta\widehat{GDP}_{\underline{t}}$ 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:

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

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. $\mathbb{E}_{\bar{t}}^{cb}\left(\Delta\widehat{GDP}_{\underline{t+1}}\right)$ denotes the forecast of the central bank, cb, based on its time $\bar{t}$ information set.[15] $\mu_{\bar{t}} \sim i.i.d.N\left(0, \sigma_\mu^2\right)$ is an exogenous shock to policy preferences that is independent from the central bank's private signal about economic conditions, ϵ.

---

[13] Figure A.I in Section 10 of the Appendix summarizes the timeline of our stylized framework.

[14] 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.

[15] The target rate $\widehat{\iota_{\bar{t}}}$ is chosen at time $\bar{t}$ and affects economic growth realized at time $\underline{t+1}$.

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 (1988) 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 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 $t+j+1$.[16]

For parsimony, we model Fed information effects through the traditional cash flow channel and assume constant discount rates from pre- to post-announcement.[17] 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:

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

where $r_{\bar{t}}^{\infty}$ is the return of the long-term asset from pre-announcement to post-announcement ($\underline{t}$ to

[16] We omit time superscripts and subscripts for ease of notation.

[17] We discuss this assumption in more detail in Section 6 after presenting the model and our empirical results.

$\bar{t}$) 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 the horizon.

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 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 Propogation Across the Horizon

We express investor expectations for k-period ahead economic growth and target rate in recurrence relation 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 in 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 $\bar{t}$.[18]

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.[19] 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 on economic growth from Equation 1, $\beta_d > 0$ captures the positive relationship between

[18]Full derivations for the results in this subsection are provided in Section 8.1.1 in the Appendix.
[19]Section 8.1.2 in the Appendix provides details of the results in this subsection.

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 a positive monetary policy surprise, $\Delta\iota^s_{\bar{t}} > 0$. 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:

$$r^1_{\bar{t}} = \rho\beta_d\left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\Delta\widehat{GDP}_{t+1}\right) = \frac{\rho\beta_d}{\alpha\left(\sigma^2_{\alpha\epsilon} + \sigma^2_\mu\right)}\left(\alpha b\sigma^2_\mu + \sigma^2_{\alpha\epsilon}\right)\Delta\iota^s_{\bar{t}} \tag{13}$$

The long-term asset return is:

$$r^\infty_{\bar{t}} = \frac{\beta_d\left(1-\alpha b\right)}{\left(\left(\rho\rho_g - 1\right)\left(\rho\rho_\iota - 1\right) - \alpha b\right)\alpha\left(\sigma^2_{\alpha\epsilon} + \sigma^2_\mu\right)}\left(\alpha b\sigma^2_\mu + \sigma^2_{\alpha\epsilon} - \rho_\iota\rho\sigma^2_{\alpha\epsilon}\right)\Delta\iota^s_{\bar{t}} \tag{14}$$

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 $\alpha b\sigma^2_\mu + \sigma^2_{\alpha\epsilon}$ from Equation 14 and for the long-term asset the sign of the loading is determined by the sign of $\alpha b\sigma^2_\mu + \sigma^2_{\alpha\epsilon} - \rho_\iota\rho\sigma^2_{\alpha\epsilon}$ from Equation 14.[20] The short-term asset will load positively on the monetary policy surprise when $\frac{-b}{\alpha} < \frac{\sigma^2_\epsilon}{\sigma^2_\mu}$. 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, $\frac{\sigma^2_\epsilon}{\sigma^2_\mu}$, the more investors will attribute the observed cut to information effects as shown in Equation 9 above. Beliefs that the easing is driven by central

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

bank information about poor next period growth forecasts lower 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 $-\rho_\iota \rho \sigma_{\alpha\epsilon}^2$ term. This persistence allows the model to to reconcile the negative loading of the long-term asset return on monetary policy surprises documented by Bernanke and Kuttner (2005). 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 $\frac{-b}{\alpha}\frac{1}{(1-\rho_\iota\rho)} > \frac{\sigma_\epsilon^2}{\sigma_\mu^2}$. 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:

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

Since $\frac{1}{1-\rho_\iota\rho} > 1$ for the full range of our model parametrizations ($0 < \rho_\iota < 1$ 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, $\frac{\sigma_\epsilon^2}{\sigma_\mu^2}$, will generate an opposite response of the short-term asset (positive loading on the monetary policy surprise) and the long-term asset (negative loading).

2.3 Test of Information Effects

The model delivers a simple test of information effects: the 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 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 implication is twofold. First, the long-term asset return can load negatively on monetary policy surprise even in the case of information effects, thus reconciling the empirical fact that the equity market loads negatively on the monetary policy surprise (e.g., Bernanke and Kuttner, 2005). 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.[21]

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.[22] 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 each FOMC announcement. Like Gürkaynak et al. (2004) and Nakamura and Steinsson (2018), we measure unexpected changes in interest rates around the 30-minute window surrounding scheduled

[21]We discuss these implications more thoroughly in Section 8.1.3 in the Appendix.

[22]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 (2015) and from Bernile et al. (2016). 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 (2005). 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. (2016) in the latter portion of their sample and then populate the meetings from June 2013 to December 2019.

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.[23] 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 be 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.[24] We denote the first FOMC shock as *Monetary Policy Shock (MPS*). Second, we use the orthogonalized monetary policy shock from Bauer and Swanson (2023b). Recent evidence suggests that monetary policy shocks are partially predictable, even if calculated in a narrow window around the FOMC announcements ((Cieslak, 2018; Karnaukh and Vokata, 2022; Bauer and Swanson, 2023a)). Bauer and Swanson collect six macroeconomic and financial variables that have been shown to predict monetary policy shock and use the residual from regressing monetary policy shock on these variables as the orthogonalized monetary policy shock. We download their orthogonalized monetary policy shock from Michael Bauer's website.[25] 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 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:

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

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

[24] 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.

[25] Https://www.michaeldbauer.com/research.

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., 2012). Recent work has argued that funding costs of marginal investors in index options may differ from the standard proxies for risk-free rates (Song, 2016) and that even small measurement error in interest rates can have an important impact on estimated dividend prices (Boguth et al., 2022). This is particularly important in our setting as FOMC announcements have a direct effect on interest rates. Golez and Jackwerth (2023) 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. 2022), 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 (2023) 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 90 days until the expiration. 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, 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.[26][27]

3.3 Option-Implied Variable Construction

We denote by P_{t-}^{180} and P_{t+}^{180} as 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 rf_{t-}^{180} and the 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.[28] 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 $r_{\bar{t}}^{1}$ and $r_{\bar{t}}^{\infty}$ 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.[29]

[26]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.

[27]At the beginning of our sample period (first FOMC meeting is on January 28, 2004), we have at least 500 observations for each maturity for which we estimate dividend strip prices and interest rates. This number increases to close to 2,000 by the end of our sample period (last FOMC announcement is on December 11, 2019).

[28]We additionally collect the information on options implied volatility and the options bid-ask spreads provided by the CBOE. The 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 $\left(\left(p^{Ask} - p^{Bid}\right) + \left(c^{Ask} - c^{Bid}\right)\right) / \left(p^{Mid-point} + c^{Mid-point}\right)$.

[29]$\Delta rf_t^{180} = rf_{t+}^{180} - rf_{t-}^{180}$, $\Delta IV_t^{180} = IV_{t+}^{180} - IV_{t-}^{180}$, 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. (2012) and Golez and Jackwerth (2023). 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., 2013; Bansal et al., 2021). Van Binsbergen et al. (2012) and Golez and Jackwerth (2023) 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., 2022). 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.[30]

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., 2022). Noise can contribute to the volatility of dividend strip returns (Golez and Jackwerth, 2023). 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.

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

[30] We provide more details in Section 8.5 of the Appendix.

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 0.54. 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 $OMPS$ (0.21 and 0.26 respectively). In contrast, the long-term asset announcement return is negatively correlated with both policy surprise measures (−0.32 with the MPS and −0.54 with the $OMPS$). Figure 1 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. This 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 (2023b).

We present the time-series of monetary policy shocks and of orthogonalized monetary policy shocks in Figure A.V in Section 10 of the Appendix. Figure A.VI in the Appendix presents the time-series of the aggregate stock market return and of the 180-day dividend strip return at each FOMC meeting date.[31]

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:

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

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

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

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.[32] 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, 2005). The estimated coefficient is 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.[33]

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 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 corresponding results for the sample of all FOMC announcements are similar and are reported in Table A.II in Section 10 of the Appendix. Panel A presents results from specifications using asset returns winsorized 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 (2023b) identify eight FOMC Announcements that are particularly important for the macroeconomy and asset prices. Panel B resports the results when we filter out most influential observations identified by Bauer and Swanson (2023a) that correspond to our sample period (1/28 2004, 9/18/2007, 1/30/2008,

[32]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.

[33]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.

4/30/2008).[34] The results are comparable to the baseline specification. Based on results from Panel A and B, we thus conclude that results are not driven by a handful of influential observations. We find similar results if we exclude the 2008 financial crisis from our sample. Panel C reports 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,[35] but this measurement error may affect our estimates of the statistical significance of this coefficient. 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. Panel D reports results including the change in the bid-ask spread as a control variable. The estimated coefficients on the monetary policy surprises increase and are significant at the 1 percent level across all three specifications.

We also repeat our analysis using short-term asset prices estimated using 60 minute windows around the announcement. The pre-announcement window runs from 70 minutes before the announcement to 10 minutes before the announcement. The post-announcement window runs from 20 minutes after the announcement to 80 minutes after the announcement. Panel E reports the results. The estimated coefficients on the monetary policy surprise remain significant at the 1 percent level. In the last specification, we replace the 180-day dividend strip with a 270-day maturity dividend strip as the short-term asset. Results are reported in Panel F. The estimated coefficients on the short-term asset announcement return decreases somewhat but remains significant.

4.2.2 Implied Risk-free Rate

Intuitively, following an unexpected change in the federal funds rate, risk-free rate should change in the same direction. We obtain direct estimate of the risk-free rate through our estimation based on the put-call parity restriction. We find indeed that implied risk-free rate increases for positive monetary policy shocks and it decreases for negative monetary policy shocks.[36] All else equal, the short-term asset price should decrease (increase) following an increase (decrease)

[34] For 1/28/2004, our shock variable based on first maturity federal funds futures is zero.

[35] This is because noise affects the dependent variable rather than independent variable. We assume here that monetary policy shock does not contain measurement error.

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

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.

4.2.3 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.[37] 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.[38] 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. However, the model also implies that the short-term announcement return should positively predict near-term economic growth if information effects operate through the cash flow channel.

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 return on the 180-day dividend strip in the 30-minute window around the FOMC announcements in quarter t. Controls include the monetary policy shock Δi^s, the aggregate market announcement return ΔP^{∞}, and the change in the option implied volatility ΔIV. Dividend growth

[37]The implied volatility decreases following both positive and negative monetary policy shocks which is consistent with the resolution of uncertainty associated with the FOMC announcement.

[38]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., 2021).

corresponds to dividends accrued by the S&P 500 index.[39] 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 real quarterly GDP growth 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 β_k on the short-term asset return is positive and significant at the 5 percent level or higher across all specifications. The estimated coefficient varies from 0.67 for one-quarter ahead dividend growth to 1.20 for four-quarter ahead dividend growth and then declines to 1.04 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 return, β_k, remain significant at the 5 percent level across all specifications and follow a similar pattern to the univariate tests.[40]

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 5 percent level only up to three quarters ahead). The coefficient on the short-term asset return reaches 0.24 for three-quarter ahead GDP growth before decreasing to 0.05 in the six-quarter ahead specification.

Panel B of Table 4 presents the results including the same set of 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.

[39] We construct dividends following the approach in Golez (2014). 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.

[40] We run a number of robustness tests in the Appendix. Table A.IV in Section 10 of the Appendix documents similar results using only the latest FOMC meeting each quarter. Additionally, Table A.III in the 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.[41] 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.[42]

6 Discussion

We have documented that (i) short-term asset return around the FOMC announcements loads positively on monetary policy shocks, and that (ii) 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 (2023a). Still, two aspects of our analysis merit further discussion.

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, 2023). Table 4 shows that short-term asset announcement return predicts near-term dividend growth after controlling for monetary policy surprise. Thus, the additional

[41]For example, if FOMC announcement takes place on Thursday at 2pm, we estimate short-term asset return on the previous and next Thursday over the 30 minute window around the 2pm.

[42]In Section 8.6 in the Appendix, 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. We confirm that the predictive power of the short-term asset return comes from information contained in FOMC announcements and not on non-announcement days.

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 the Appendix 8.3, we extend the model by allowing for soft information being released from the Fed to formalize how short-term asset announcement return can decouple from target rate surprise.

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 to 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.[43] 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 results of 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. 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.[44]

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 short-term dividend strip price reaction around FOMC announcements positively predicts near-term macroeconomic growth. Overall,

[43] We again thank Emi Nakamura for this observation.

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

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.

8 Appendix

8.1 Model Derivations

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

8.1.1 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:[45]

$$\mathbb{E}_t\left(\Delta GDP_{t+k+1}\right) = \rho_g \mathbb{E}_t\left(\Delta\widehat{GDP}_{t+k}\right) + b\mathbb{E}_t\left(\widehat{\iota}_{t+k}\right) \tag{20}$$

$$\mathbb{E}_t\left(\widehat{\iota}_{t+k}\right) = \rho_\iota \mathbb{E}_t\left(\widehat{\iota}_{t+k-1}\right) + \alpha\mathbb{E}_t\left(\Delta\widehat{GDP}_{t+k+1}\right) \tag{21}$$

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 21 into Equation 20 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:

[45] For simplicity, below we denote expectations using time t subscripts and omit the subperiod notation, $\underline{t}$ and $\overline{t}$. These relationships hold for expectations as of $\underline{t}$ 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:

$$\begin{pmatrix}\mathbb{E}_t\left(\Delta GD\hat{P}_{t+k+1}\right)\\ \mathbb{E}_t\left(\widehat{\iota}_{t+k}\right)\end{pmatrix} = \frac{1}{(1-\alpha b)^k}\begin{pmatrix}\rho_g & b\rho_\iota\\ \alpha\rho_g & \rho_\iota\end{pmatrix}^k\begin{pmatrix}\mathbb{E}_t\left(\Delta G\hat{D}P_{t+1}\right)\\ \mathbb{E}_t\left(\widehat{\iota}_t\right)\end{pmatrix} \tag{22}$$

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[46]; 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:

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

[46] $\lambda_1 = \frac{1}{2}\left(\rho_g+\rho_\iota+\left(\rho_g^2+\rho_\iota^2+\rho_g\rho_\iota(4\alpha b-2)\right)^{\frac{1}{2}}\right)$ 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:[47]

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

We obtain the eigenvector corresponding to eigenvalue, λ_2, following a similar procedure.[48] The eigenvectors, v^{λ_1} and v^{λ_2}, produce the change of basis matrices, P and P^{-1}:

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

and P^{-1}[49]:

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

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

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

[48]

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

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

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

$$D = \begin{pmatrix} \frac{1}{2}\left(\rho_g + \rho_\iota + \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota\left(4\alpha b - 2\right)\right)^{\frac{1}{2}}\right) & 0 \\ 0 & \frac{1}{2}\left(\rho_g + \rho_\iota - \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota\left(4\alpha b - 2\right)\right)^{\frac{1}{2}}\right) \end{pmatrix} \tag{23}$$

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:

$$\begin{pmatrix} \Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+k+1}\right) \\ \Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota_{t+k}}\right) \end{pmatrix} = \frac{1}{\left(1-\alpha b\right)^k} PD^kP^{-1} \begin{pmatrix} \Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+1}\right) \\ \Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota_t}\right) \end{pmatrix} \tag{24}$$

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.[50] Section 8.2 characterizes exactly how the monetary policy surprise determines the distribution of changes in growth forecasts across the term structure.

8.1.2 Asset Prices

To obtain a closed-form expression for the long-term asset return, we start by substituting Equation 24 into the long-term asset return given in Equation 5:

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

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

Where D^* is a diagonal matrix with entries, $d^*_{11} = \frac{1}{1-\frac{\rho}{(1-\alpha b)}d_{11}}$ and $d^*_{22} = \frac{1}{1-\frac{\rho}{(1-\alpha b)}d_{22}}$.[51] 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:

$$r^{\infty}_{\bar{t}} = \begin{pmatrix} 1 & 0 \end{pmatrix} \beta_d PD^*P^{-1} \overrightarrow{v}_{input}$$
$$= \begin{pmatrix} 1 & 0 \end{pmatrix} \frac{\beta_d}{p_{11}p_{22}-p_{12}p_{21}} \begin{pmatrix} p_{11}p_{22}d^*_{11} - p_{21}p_{12}d^*_{22} & p_{12}p_{11}d^*_{22} - p_{11}p_{12}d^*_{11} \\ p_{21}p_{22}d^*_{11} - p_{22}p_{21}d^*_{22} & p_{22}p_{11}d^*_{22} - p_{21}p_{12}d^*_{11} \end{pmatrix} \overrightarrow{v}_{input}$$
$$+ \frac{\beta_d}{p_{11}p_{22}-p_{12}p_{21}} \left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\widehat{\iota_t}\right)\left(p_{12}p_{11}d^*_{22} - p_{11}p_{12}d^*_{11}\right)$$

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

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: $X \equiv \left(\rho_g^2 + \rho_\iota^2 + \rho_g\rho_\iota(4\alpha b - 2)\right)^{\frac{1}{2}}$, $A \equiv \frac{1}{2}\rho_g - \frac{1}{2}\rho_\iota$ and $B \equiv \rho_g + \rho_\iota$. Then we have:

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

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

[51] 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 23.

$$p_{11}p_{22}d_{11}^{*}-p_{21}p_{12}d_{22}^{*}$$

$$=-\frac{b\rho_{\iota}}{\rho_g-\frac{1}{2}\left(\rho_g+\rho_{\iota}+X\right)}\times\frac{1}{1-\frac{\rho}{(1-\alpha b)}\frac{1}{2}\left(\rho_g+\rho_{\iota}+X\right)}+\frac{b\rho_{\iota}}{\rho_g-\frac{1}{2}\left(\rho_g+\rho_{\iota}-X\right)}\times\frac{1}{1-\frac{\rho}{(1-\alpha b)}\frac{1}{2}\left(\rho_g+\rho_{\iota}-X\right)}$$

$$=\frac{-X\left(\rho_{\iota}\rho-1+\alpha b\right)}{\rho\alpha\rho_g\left(\frac{(1-\alpha b)}{\rho}+\rho\rho_g\rho_{\iota}-\rho_g-\rho_{\iota}\right)}$$

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

$$p_{12}p_{11}d_{22}^{*}-p_{11}p_{12}d_{11}^{*}$$

$$=p_{12}p_{11}\left(d_{22}^{*}-d_{11}^{*}\right)$$

$$=(1-\alpha b)\frac{b\rho_{\iota}}{\frac{1}{2}\rho_g-\frac{1}{2}\rho_{\iota}+\frac{1}{2}X}\times\frac{b\rho_{\iota}}{\frac{1}{2}\rho_g-\frac{1}{2}\rho_{\iota}-\frac{1}{2}X}\times\left(\frac{1}{(1-\alpha b)-\rho\frac{1}{2}(B-X)}-\frac{1}{(1-\alpha b)-\rho\frac{1}{2}(B+X)}\right)$$

$$=\frac{b\rho_{\iota}X}{\alpha\rho_g\left(\frac{(1-\alpha b)}{\rho}+\rho\rho_g\rho_{\iota}-\rho_g-\rho_{\iota}\right)}$$

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

$$r_t^{\infty}=\frac{\beta_d\left(1-\alpha b\right)}{\left(\left(\rho\rho_g-1\right)\left(\rho\rho_{\iota}-1\right)-\alpha b\right)\alpha\left(\sigma_{\alpha\epsilon}^2+\sigma_{\mu}^2\right)}\left(\alpha b\sigma_{\mu}^2+\sigma_{\alpha\epsilon}^2-\rho_{\iota}\rho\sigma_{\alpha\epsilon}^2\right)\Delta\iota_{\bar{t}}^{s} \tag{25}$$

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

$$r_{\bar{t}}^{1}=\frac{\rho\beta_d}{\alpha\left(\sigma_{\alpha\epsilon}^2+\sigma_{\mu}^2\right)}\left(\alpha b\sigma_{\mu}^2+\sigma_{\alpha\epsilon}^2\right)\Delta\iota_{\bar{t}}^{s} \tag{26}$$

Expressions for the long-term and short-term assets without information effects are obtained similarly.[52]

8.1.3 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:

[52] Short-term asset return without information effects is given by: $r_{\bar{t}}^{1}=b\beta_d\rho\Delta\iota_{\bar{t}}^{s}$
Long-term asset return without information effects is given by: $r_t^{\infty}=\frac{b\beta_d(1-\alpha b)}{(\rho\rho_g-1)(\rho\rho_{\iota}-1)-\alpha b}\Delta\iota_{\bar{t}}^{s}$

$$\Delta\widehat{GDP}_{t+1} = \alpha^1 + \beta^1 r^1_{\bar{t}} + \delta^1_{t+1} \tag{27}$$

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:

$$\begin{aligned}
\beta^1 &= \frac{Cov\left(r^1_{\bar{t}}, \Delta\widehat{GDP}_{t+1}\right)}{Var\left(r^1_{\bar{t}}\right)} \\
&= \frac{Cov\left(\rho\beta_d\left(\mathbb{E}_{\bar{t}} - \mathbb{E}_{\underline{t}}\right)\left(\Delta\widehat{GDP}_{t+1}\right), \rho_g\Delta\widehat{GDP}_t + \epsilon_{\bar{t}} + b\iota_t + w_{t+1}\right)}{Var\left(r^1_{\bar{t}}\right)} \\
&= \frac{\rho\beta_d Cov\left(\frac{b\alpha\sigma^2_\mu + \sigma^2_{\alpha\epsilon}}{\alpha\left(\sigma^2_{\alpha\epsilon} + \sigma^2_\mu\right)}\frac{\mu + \alpha\epsilon}{(1-\alpha b)}, \epsilon_{\bar{t}} + b\frac{\mu + \alpha\epsilon}{(1-\alpha b)}\right)}{\rho^2\beta_d^2 Var\left(\frac{b\alpha\sigma^2_\mu + \sigma^2_{\alpha\epsilon}}{\alpha\left(\sigma^2_{\alpha\epsilon} + \sigma^2_\mu\right)}\frac{\mu + \alpha\epsilon}{(1-\alpha b)}\right)} \\
&= \frac{1}{\rho\beta_d}
\end{aligned}$$

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 26 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.[53]

[53] 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 the risk premia channel, this predictability will be nonexistent.

8.2 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:

$$\mathbb{E}_{\bar{t}}^{i}\left(\Delta\widehat{GDP}_{t+1}\right) - \mathbb{E}_{\underline{t}}^{i}\left(\Delta\widehat{GDP}_{t+1}\right) = b\Delta\iota_{\bar{t}}^{s} + \mathbb{E}_{\bar{t}}^{i}\left(\epsilon_{\bar{t}}^{i,*}\right) \tag{28}$$

Then, from Equation 24 and the change in next period economic growth forecasts, we have:

$$\begin{pmatrix} \Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+k+1}\right) \\ \Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota}_{t+k}\right) \end{pmatrix} = \frac{1}{(1-\alpha b)^{k}} PD^{k}P^{-1} \begin{pmatrix} b\Delta\iota_{\bar{t}}^{s} + \mathbb{E}_{\bar{t}}^{i}\left(\epsilon_{\bar{t}}^{i,*}\right) \\ \Delta\iota_{\bar{t}}^{s} \end{pmatrix} \tag{29}$$

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:

$$\begin{pmatrix} \Delta\mathbb{E}_{\bar{t}}\left(\Delta GDP_{t+k+1}\right) \\ \Delta\mathbb{E}_{\bar{t}}\left(\widehat{\iota}_{t+k}\right) \end{pmatrix} = \frac{1}{(1-\alpha b)^{k}} PD^{k}P^{-1} \begin{pmatrix} \left(\frac{b\alpha\sigma_{\mu}^{2}+\sigma_{\alpha\epsilon}^{2}}{\alpha\left(\sigma_{\alpha\epsilon}^{2}+\sigma_{\mu}^{2}\right)}\right) \\ 1 \end{pmatrix}\Delta\iota_{\bar{t}}^{s} \tag{30}$$

8.3 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 in economic and financial conditions at different announcement dates which leads investors to interpret identical policy surprises (sign and magnitude) differently in different contexts.[54]

We model soft information released by the central bank by supposing that the central bank provides a noisy signal, $\eta_{\bar{t}} \sim N\left(\epsilon_{\bar{t}}, \sigma^2_\eta\right)$, 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^2_η. The central bank cannot inform investors the precise private signal.[55] Investor's conjugate prior is given by Equation 9, and the posterior distribution of beliefs, $\epsilon^{i,*}_{\bar{t},soft}$, after observing the signal $\eta_{\bar{t}}$ is:

$$\epsilon^{i,*}_{\bar{t},soft} \sim N\left(\epsilon_p \frac{\sigma^2_\eta}{\sigma^2_\eta + \sigma^2_p} + \epsilon_{\bar{t}} \frac{\sigma^2_p}{\sigma^2_\eta + \sigma^2_p}, \left(\frac{1}{\sigma^2_\eta} + \frac{1}{\sigma^2_p}\right)^{-1}\right) \tag{31}$$

where $\epsilon_{\bar{t}}$ is the realization of ϵ, $\epsilon_p = \frac{(1-\alpha b)}{\alpha} \frac{\sigma^2_{\alpha\epsilon}}{\sigma^2_{\alpha\epsilon}+\sigma^2_\mu} \Delta\iota^s_{\bar{t}}$ is the investor's expected value of $\epsilon_{\bar{t}}$ (from Equation 9) based on the observed target rate surprise, $\sigma^2_p = \frac{1}{\alpha^2} \frac{\sigma^2_{\alpha\epsilon}\sigma^2_\mu}{\sigma^2_{\alpha\epsilon}+\sigma^2_\mu}$, and $\Delta\iota^s_{\bar{t}}$ is the target rate surprise. Changes in investor beliefs about future economic growth are still governed by Equation 29 but with $\mathbb{E}^i_{\bar{t}}\left(\epsilon^{i,*}_{\bar{t},soft}\right) = \frac{(1-\alpha b)\sigma^2_{\alpha\epsilon}\sigma^2_\eta}{\alpha\left(\sigma^2_\eta+\sigma^2_p\right)\left(\sigma^2_{\alpha\epsilon}+\sigma^2_\mu\right)} \Delta\iota^s_{\bar{t}} + \epsilon_{\bar{t}} \frac{\sigma^2_p}{\sigma^2_\eta+\sigma^2_p}$ so that this term does not depend solely on the target rate surprise, $\Delta\iota^s_{\bar{t}}$.

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.

8.4 Model Calibration

To make this intuition more concrete, we present a simple calibration of the model to illustrate how information effects determine the response of short-term and long-term assets to monetary policy news. We use parametrizations that approximate real-world properties where possible.[56]

[54] 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.

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

[56] We estimate the persistence of quarterly real GDP growth using data from the third quarter of 1947 to the fourth quarter of 2021. We estimate the persistence of the target federal funds rate using the effective federal funds rate each quarter. Based on these estimates, our baseline quarterly calibration uses $\rho_g = 0.12$ and $\rho_\iota = 0.95$. We use a quarterly time discount rate, ρ, of 0.99 corresponding to an annual rate of 0.96. We set $b = -0.1$, a 1 percentage point decrease in the target federal funds rate corresponds with a 0.1 percentage point increase in economic growth.

We examine the model-implied changes in expected quarterly growth rates and expected target rates following both negative and positive monetary policy surprises. In each scenario, we assume that the target rate and economic growth begin at a steady state before the monetary policy surprise occurs.

Calibration without Soft Information Figure A.II presents the model-implied change in expectations following a monetary policy surprise of -1% (unexpected easing).[57] 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, 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 (-3.15 percent and -3.96 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

We set $\alpha = 0.25$, the central bank lowers (raises) rates given lower (higher) expectations about next period economic growth. The variances of the shocks, σ_μ^2, σ_ϵ^2 determines how investors infer the contribution of the shocks μ and ϵ to an observed target rate surprise. The ratio of the variance parameters is important for model-implied expected values. Similarly, for the variance of soft information, σ_η^2, determines the relative weight on the soft information released by the central bank compared with the investor's prior from the observed target federal funds rate. We choose $\sigma_\epsilon^2 = 4$ (quantities in the model are in percent), $\sigma_\mu^2 = 2$ and $\sigma_\eta^2 = 3$. The higher variance of ϵ versus μ will cause investors to attribute more of the target rate surprise to private information of the central bank. Finally, 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.

[57]Figure A.III shows the model-implied change in expectations across the term structure following a monetary policy surprise of 1% (unexpected tightening). The results are similar conceptually to those following an unexpected easing but with opposite signs following the positive monetary policy surprise.

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.

Calibration with Soft Information We introduce soft information and discuss how this changes the model implications. Figure A.IV plots the model-implied change in expectations following a monetary policy surprise of -1% (unexpected easing). Panel 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.[58]

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 higher the relative variance of ϵ compared to the variance of μ, the more negative investor beliefs about the realization of ϵ following a negative monetary policy surprise. The investor cannot distinguish between a -1% 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.

[58] 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).

8.5 Short-term Asset Estimation

Table A.I 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).

8.6 Economic Predictability on Non-Announcement Days

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

$$\Delta x_{t+k} = \alpha_k + \beta_k \Delta P_t^{180} + \delta_k FOMC_t^{NZ} + \theta_k \Delta P_t^{180} \times FOMC_t^{NZ} + \epsilon_{t+k}, k \in \{1, 2, ..., 8\},$$

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 A.V 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 in Table A.V 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.

References

Ai, H. and R. Bansal (2018). Risk preferences and the macroeconomic announcement premium. *Econometrica 86*(4), 1383–1430.

Ait-Sahalia, Y., M. Karaman, and L. Mancini (2018). The term structure of variance swaps and risk premia. *Swiss Finance Institute Research Paper* (18-37).

Andersen, T. G., O. Bondarenko, and M. T. Gonzalez-Perez (2015). Exploring return dynamics via corridor implied volatility. *The Review of Financial Studies 28*(10), 2902–2945.

Andersen, T. G., N. Fusari, and V. Todorov (2015). The risk premia embedded in index options. *Journal of Financial Economics 117*(3), 558–584.

Andersen, T. G., N. Fusari, and V. Todorov (2017). Short-term market risks implied by weekly options. *The Journal of Finance 72*(3), 1335–1386.

Bansal, R., S. Miller, D. Song, and A. Yaron (2021). The term structure of equity risk premia. *Journal of Financial Economics 142*(3), 1209–1228.

Bauer, M. D. and E. T. Swanson (2023a). An alternative explanation for the fed information effect. *American Economic Review 113*(3), 664–700.

Bauer, M. D. and E. T. Swanson (2023b). A reassessment of monetary policy surprises and high-frequency identification. *NBER Macroeconomics Annual 37*(1), 87–155.

Bernanke, B. S. and K. N. Kuttner (2005). What explains the stock market's reaction to federal reserve policy? *The Journal of Finance 60*(3), 1221–1257.

Bernile, G., J. Hu, and Y. Tang (2016). Can information be locked up? informed trading ahead of macro-news announcements. *Journal of Financial Economics 121*(3), 496–520.

Boguth, O., M. Carlson, A. Fisher, and M. Simutin (2022). The term structure of equity risk premia: Levered noise and new estimates. *Review of Finance*.

Bundick, B. and A. L. Smith (2020). The dynamic effects of forward guidance shocks. *Review of Economics and Statistics 102*(5), 946–965.

Campbell, J. R., C. L. Evans, J. D. Fisher, A. Justiniano, C. W. Calomiris, and M. Woodford (2012). Macroeconomic effects of federal reserve forward guidance. *Brookings papers on economic activity*, 1–80.

Campbell, J. Y. (2008). *Asset prices and monetary policy*. University of Chicago Press.

Campbell, J. Y. and R. J. Shiller (1988). The dividend-price ratio and expectations of future dividends and discount factors. *The Review of Financial Studies 1*(3), 195–228.

Cassella, S., B. Golez, H. Gulen, and P. Kelly (2021). Horizon bias and the term structure of equity returns. *Available at SSRN 3328970*.

Cejnek, G. and O. Randl (2020). Dividend risk premia. *Journal of Financial and Quantitative Analysis 55*(4), 1199–1242.

Cieslak, A. (2018). Short-rate expectations and unexpected returns in treasury bonds. *The Review of Financial Studies 31*(9), 3265–3306.

Cieslak, A. and A. Schrimpf (2019). Non-monetary news in central bank communication. *Journal of International Economics 118*, 293–315.

Coibion, O. and Y. Gorodnichenko (2015). Information rigidity and the expectations formation process: A simple framework and new facts. *American Economic Review 105*(8), 2644–78.

Cukierman, A. and A. H. Meltzer (1986). A theory of ambiguity, credibility, and inflation under discretion and asymmetric information. *Econometrica: journal of the econometric society*, 1099–1128.

Doh, T., D. Song, and S.-K. Yang (2022). Deciphering federal reserve communication via text analysis of alternative fomc statements. *Federal Reserve Bank of Kansas City Working Paper Forthcoming*.

Drechsler, I., A. Savov, and P. Schnabl (2017). The deposits channel of monetary policy. *The Quarterly Journal of Economics 132*(4), 1819–1876.

Drechsler, I., A. Savov, and P. Schnabl (2018). A model of monetary policy and risk premia. *The Journal of Finance 73*(1), 317–373.

Elenev, V., T. H. Law, D. Song, and A. Yaron (2022). Fearing the fed: how wall street reads main street. Technical report, Mimeo, Wharton School.

Ellingsen, T. and U. Soderstrom (2001). Monetary policy and market interest rates. *American Economic Review 91*(5), 1594–1607.

Faust, J., E. T. Swanson, and J. H. Wright (2004). Do federal reserve policy surprises reveal superior information about the economy? *BE Journal of Macroeconomics 4*(1).

Fisher, A. J., C. Martineau, and J. Sheng (2021). Macroeconomic attention and announcement risk premia. In *5th ASU Sonoran Winter Finance Conference*.

Fleming, M. J. and M. Piazzesi (2005). Monetary policy tick-by-tick. *WP*.

Giglio, S., B. T. Kelly, and S. Kozak (2021). Equity term structures without dividend strips data. *Available at SSRN 3533486*.

Gilchrist, S. and J. V. Leahy (2002). Monetary policy and asset prices. *Journal of monetary Economics 49*(1), 75–97.

Golez, B. (2014). Expected returns and dividend growth rates implied by derivative markets. *The Review of Financial Studies 27*(3), 790–822.

Golez, B. and J. C. Jackwerth (2023). Holding period effects in dividend strip returns. *The Review of Financial Studies, Forthcoming*.

Gonçalves, A. S. (2021). Reinvestment risk and the equity term structure. *The Journal of Finance 76*(5), 2153–2197.

Gormsen, N. J. (2021). Time variation of the equity term structure. *The Journal of Finance 76*(4), 1959–1999.

Gormsen, N. J. and R. S. Koijen (2020). Coronavirus: Impact on stock prices and growth expectations. *The Review of Asset Pricing Studies 10*(4), 574–597.

Gormsen, N. J., R. S. Koijen, and I. W. Martin (2021). Implied dividend volatility and expected growth. In *AEA Papers and Proceedings*, Volume 111, pp. 361–365. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.

Gormsen, N. J. and E. Lazarus (2021). Duration-driven returns. *The Journal of Finance, Forthcoming*.

Gorodnichenko, Y. and M. Weber (2016). Are sticky prices costly? evidence from the stock market. *American Economic Review 106*(1), 165–99.

Gürkaynak, R. S., B. P. Sack, and E. T. Swanson (2004). Do actions speak louder than words? the response of asset prices to monetary policy actions and statements. *The Response of Asset Prices to Monetary Policy Actions and Statements*.

Hansen, S. and M. McMahon (2016). Shocking language: Understanding the macroeconomic effects of central bank communication. *Journal of International Economics 99*, S114–S133.

Hansen, S., M. McMahon, and A. Prat (2018). Transparency and deliberation within the fomc: a computational linguistics approach. *The Quarterly Journal of Economics 133*(2), 801–870.

Hirshleifer, D. and J. Sheng (2021). Macro news and micro news: complements or substitutes? *Journal of Financial Economics*.

Jackwerth, J. C. and M. Rubinstein (1996). Recovering probability distributions from option prices. *The journal of Finance 51*(5), 1611–1631.

Jarocinski, M. and P. Karadi (2020). Deconstructing monetary policy surprises - the role of information shocks. *AEJ: Macroeconomics 12*(2), 1–43.

Karnaukh, N. and P. Vokata (2022). Growth forecasts and news about monetary policy. *Journal of Financial Economics 146*(1), 55–70.

Kuttner, K. N. (2001). Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of monetary economics 47*(3), 523–544.

Laarits, T. (2021). Pre-announcement risk. *NYU Stern School of Business*.

Lazarus, E. (2018). Horizon-dependent risk pricing: Evidence from short-dated options. *Available at SSRN 3436389*.

Li, Y. and C. Wang (2018). Rediscover predictability: Information from the relative prices of long-term and short-term dividends. *Working Paper*.

Lucca, D. O. and E. Moench (2015). The pre-fomc announcement drift. *The Journal of finance 70*(1), 329–371.

Lunsford, K. G. (2020). Policy language and information effects in the early days of federal reserve forward guidance. *American Economic Review* (9), 2899–2934.

McQueen, G. and V. V. Roley (1993). Stock prices, news, and business conditions. *The review of financial studies 6*(3), 683–707.

Melosi, L. (2017). Signalling effects of monetary policy. *The Review of Economic Studies 84*(2), 853–884.

Miller, S. (2020). The term structures of equity risk premia in the cross-section of equities. Technical report, Working Paper, Duke University.

Miranda-Agrippino, S. and G. Ricco (2021). The transmission of monetary policy shocks. *American Economic Journal: Macroeconomics 13*(3), 74–107.

Nakamura, E. and J. Steinsson (2018). High-frequency identification of monetary non-neutrality: the information effect. *The Quarterly Journal of Economics 133*(3), 1283–1330.

Neuhierl, A. and M. Weber (2019). Monetary policy communication, policy slope, and the stock market. *Journal of Monetary Economics 108*, 140–155.

Ozdagli, A. and M. Weber (2021). Monetary policy through production networks: Evidence from the stock market. Technical report, Working paper. Univeristy of Chicago.

Romer, C. D. and D. H. Romer (2000). Federal reserve information and the behavior of interest rates. *American Economic Review 90*(3), 429–457.

Song, D. (2017, 05). Bond Market Exposures to Macroeconomic and Monetary Policy Risks. *The Review of Financial Studies 30*(8), 2761–2817.

Song, Y. (2016). Dealer funding costs: Implications for the term structure of dividend risk premia. *Available at SSRN*.

Steyvers, M. and T. Griffiths (2007). Probabilistic topic models. *Handbook of latent semantic analysis 427*(7), 424–440.

Swanson, E. T. (2021). Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. *Journal of Monetary Economics 118*.

Ulrich, M., S. Florig, and C. Wuchte (2022). A model-free term structure of us dividend premiums. *Review of Financial Studies, forthcoming*.

Van Binsbergen, J., M. Brandt, and R. Koijen (2012). On the timing and pricing of dividends. *American Economic Review 102*(4), 1596–1618.

Van Binsbergen, J., W. Hueskes, R. Koijen, and E. Vrugt (2013). Equity yields. *Journal of Financial Economics 110*(3), 503–519.

Van Binsbergen, J. and R. Koijen (2010). Predictive regressions: A present-value approach. *The Journal of Finance 65*(4), 1439–1471.

Van Binsbergen, J. and R. Koijen (2017). The term structure of returns: Facts and theory. *Journal of Financial Economics 124*(1), 1–21.

Van Binsbergen, J. H., W. F. Diamond, and M. Grotteria (2022). Risk-free interest rates. *Journal of Financial Economics 143*(1), 1–29.

Weber, M. (2018). Cash flow duration and the term structure of equity returns. *Journal of Financial Economics 128*(3), 486–503.

9 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 (2023b). *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 spans 128 scheduled FOMC announcements.

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

	$\Delta\iota_t^s = MPS$			$\Delta\iota_t^s = OMPS$		
	ΔP^{180}	ΔP^{∞}	$\Delta P^{180} - \Delta P^{\infty}$	ΔP^{180}	ΔP^{∞}	$\Delta P^{180} - \Delta P^{\infty}$
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 our 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 (2023b) $OMPS_t$ at date t. ΔP_t^h is the change in the log asset price over the same window (P^{180} denotes the 180-day dividend strip and P^{∞} denotes the long-term asset). 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**

	$\Delta\iota_t^s = MPS$			$\Delta\iota_t^s = OMPS$		
	ΔP^{180}	ΔP^{∞}	$\Delta P^{180} - \Delta P^{\infty}$	ΔP^{180}	ΔP^{∞}	$\Delta P^{180} - \Delta P^{\infty}$
Panel A: 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
Panel B: Exclude most influential observations from Bauer and Swanson (2023a)						
$\Delta\iota_t^s$	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
Panel C: 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
Panel D: 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)
$Bid-ask_t$	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
Panel E: 60 minute window plus control for bid-ask spread						
$\Delta\iota_t^s$	0.298***	-0.093***	0.391***	0.189***	-0.076***	0.265***
	(0.095)	(0.019)	(0.103)	(0.067)	(0.013)	(0.072)
$Bid-ask_t$	1.832***	-0.320**	2.152***	1.138**	-0.117	1.256**
	(0.601)	(0.122)	(0.648)	(0.542)	(0.104)	(0.582)
Adj. R^2	0.118	0.205	0.158	0.098	0.285	0.148
Obs.	84	84	84	84	84	84
Panel F: 270-day short-term asset plus control for bid-ask spread						
$\Delta\iota_t^s$	0.176***	-0.071***	0.246***	0.150***	-0.072***	0.222***
	(0.063)	(0.019)	(0.070)	(0.044)	(0.012)	(0.047)
$Bid-ask_t$	0.609	-0.173	0.783	0.187	-0.013	0.200
	(0.457)	(0.136)	(0.507)	(0.406)	(0.112)	(0.438)
Adj. R^2	0.064	0.127	0.111	0.104	0.288	0.194
Obs.	84	84	84	84	84	84

This table presents the results from robustness tests of our main results from Table 2. In Panel A, variables are winsorized at 5% level. In Panel B, we exclude the most influential observations from Bauer and Swanson (2023a). In Panel C, we replace OLS standard errors with GMM standard errors. In Panel D, we add a control for options bid-ask spread. In Panel E, we use 60 minute (rather than 30 minute) windows to estimate short-term asset prices. In Panel F, we replace the 180-day maturity dividend strip with a 270-day maturity dividend strip. 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: **Predicting Economic Output**

	Real Dividend Growth						Real GDP Growth					
Horizon	1Q	2Q	3Q	4Q	5Q	6Q	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Univariate regressions												
ΔP^{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^{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)
Δi_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^{∞}	-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 Δi^s, the aggregate market announcement return ΔP^{∞}, and the change in the option implied volatility ΔIV. 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 Forecasting: Non-FOMC Days**

Horizon	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Real Dividend Growth						
ΔP^{180}	-0.043	-0.049	0.019	-0.092	-0.020	0.033
	(0.106)	(0.114)	(0.094)	(0.129)	(0.154)	(0.155)
Adj. R^2	-0.004	-0.004	-0.004	-0.003	-0.004	-0.004
Obs.	252	248	244	240	235	232
Panel B: Real GDP Growth						
ΔP^{180}	-0.036	-0.031	-0.033	-0.038	-0.020	-0.024
	(0.025)	(0.026)	(0.026)	(0.029)	(0.030)	(0.032)
Adj. R^2	0.000	-0.001	-0.001	0.001	-0.003	-0.003
Obs.	252	248	244	240	235	232

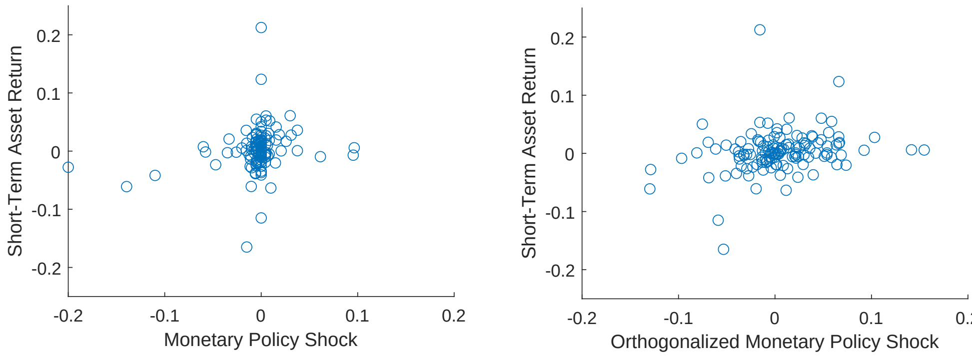
Panel A presents the results from the predictive regression of k-quarter ahead real dividend growth on the 180-day dividend strip return in the 30-minute window seven days before and seven days after the FOMC announcement:

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

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.

Figure 1: **Asset Announcement Return around Monetary Policy Shocks**

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



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

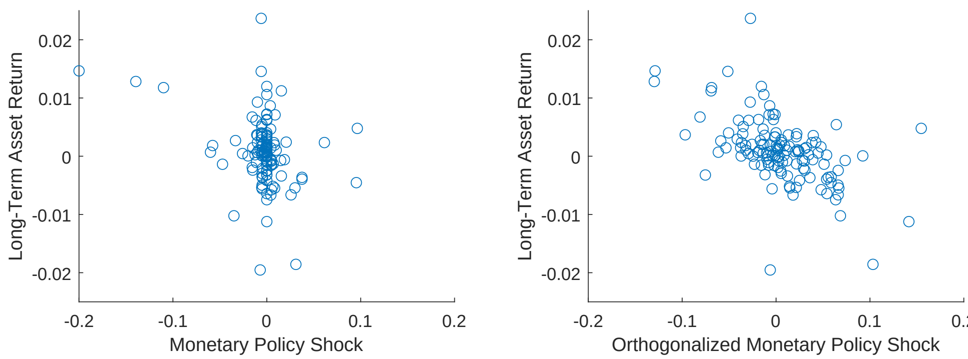


Figure 1 plots the scatter plots of asset return in the 30-minute window around the FOMC announcements versus the monetary policy shocks. In Panel A, we plot the short-term asset announcement returns versus either the monetary policy shock (left) or the orthogonalized monetary policy shock (right) from Bauer and Swanson (2023b). 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.

10 Appendix Tables & Figures

Table A.I: **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 A.II: **Asset Announcement Return on Monetary Policy Surprise: Full Sample**

	$\Delta\iota_t^s = MPS$			$\Delta\iota_t^s = OMPS$		
	ΔP^{180}	ΔP^{∞}	$\Delta P^{180} - \Delta P^{\infty}$	ΔP^{180}	ΔP^{∞}	$\Delta P^{180} - \Delta P^{\infty}$
Panel A: 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
Panel B: Exclude most influential observations from Bauer and Swanson (2023a)						
$\Delta\iota_t^s$	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
Panel C: 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
Panel D: 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
Panel E: 60 minute window plus control for bid-ask spread						
$\Delta\iota_t^s$	0.300***	-0.075***	0.375***	0.166***	-0.072***	0.237***
	(0.086)	(0.018)	(0.092)	(0.057)	(0.010)	(0.060)
$Bid-ask_t$	1.736***	-0.074	1.810***	1.377***	-0.005	1.382***
	(0.405)	(0.082)	(0.430)	(0.388)	(0.071)	(0.408)
Adj. R^2	0.142	0.115	0.158	0.120	0.266	0.153
Obs.	128	128	128	128	128	128
Panel F: 270-day short-term asset plus control for bid-ask spread						
$\Delta\iota_t^s$	0.176***	-0.058***	0.234***	0.146***	-0.068***	0.214***
	(0.065)	(0.016)	(0.070)	(0.043)	(0.010)	(0.045)
$Bid-ask_t$	0.569**	0.032	0.537*	0.487*	0.049	0.438*
	(0.262)	(0.065)	(0.281)	(0.252)	(0.056)	(0.264)
Adj. R^2	0.058	0.090	0.077	0.088	0.283	0.149
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. These specifications are the same as those reported in Table 3 in the manuscript which were run on the sample of FOMC announcements with non-zero monetary policy surprises. In Panel A, variables are winsorized at 5% level. In Panel B, we exclude the most influential observations from Bauer and Swanson (2023a). In Panel C, we replace OLS standard errors with GMM standard errors. In Panel D, we add a control for options bid-ask spread. In Panel E, we use 60 minute (rather than 30 minute) windows to estimate short-term asset prices. In Panel F, we replace the 180-day maturity dividend strip with a 270-day maturity dividend strip. Stars *, **, *** denote statistical significance at the ten, five, and one percent level.

Table A.III: **Predicting Economic Growth: 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^{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^{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)
$\Delta\iota_t^s$	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^{∞}	-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^s, the aggregate market announcement return ΔP^{∞}, and the change in the option implied volatility ΔIV. 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 A.IV: **Real Dividend and GDP Forecasting: Non-zero Shocks, Latest**

Horizon	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Real Dividend Growth						
ΔP^{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^{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 A.V: **Real Dividend and GDP Forecasting: FOMC and Non-FOMC Days**

Horizon	1Q	2Q	3Q	4Q	5Q	6Q
Panel A: Real Dividend Growth						
ΔP^{180}	-0.011	-0.051	0.002	-0.047	0.041	0.025
	(0.104)	(0.096)	(0.084)	(0.100)	(0.122)	(0.101)
$FOMC^{NZ}$	-0.005	-0.012	-0.014	-0.020***	-0.021**	-0.019*
	(0.008)	(0.009)	(0.009)	(0.008)	(0.009)	(0.010)
$\Delta P^{180} \times FOMC^{NZ}$	0.682**	0.925***	0.992***	1.250***	1.064***	1.013***
	(0.299)	(0.278)	(0.300)	(0.355)	(0.371)	(0.349)
Adj. R^2	0.005	0.016	0.023	0.039	0.034	0.026
Obs.	378	372	366	360	353	348
Panel B: Real GDP Growth						
ΔP^{180}	-0.031	-0.019	-0.023	-0.022	-0.005	-0.010
	(0.021)	(0.023)	(0.025)	(0.024)	(0.025)	(0.028)
$FOMC^{NZ}$	-0.002	-0.004**	-0.005***	-0.005***	-0.003**	-0.002
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
$\Delta P^{180} \times FOMC^{NZ}$	0.157**	0.190***	0.265***	0.176**	0.111*	0.055
	(0.068)	(0.072)	(0.082)	(0.083)	(0.064)	(0.046)
Adj. R^2	0.009	0.023	0.051	0.025	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 A.I: **Stylized Framework Timing**

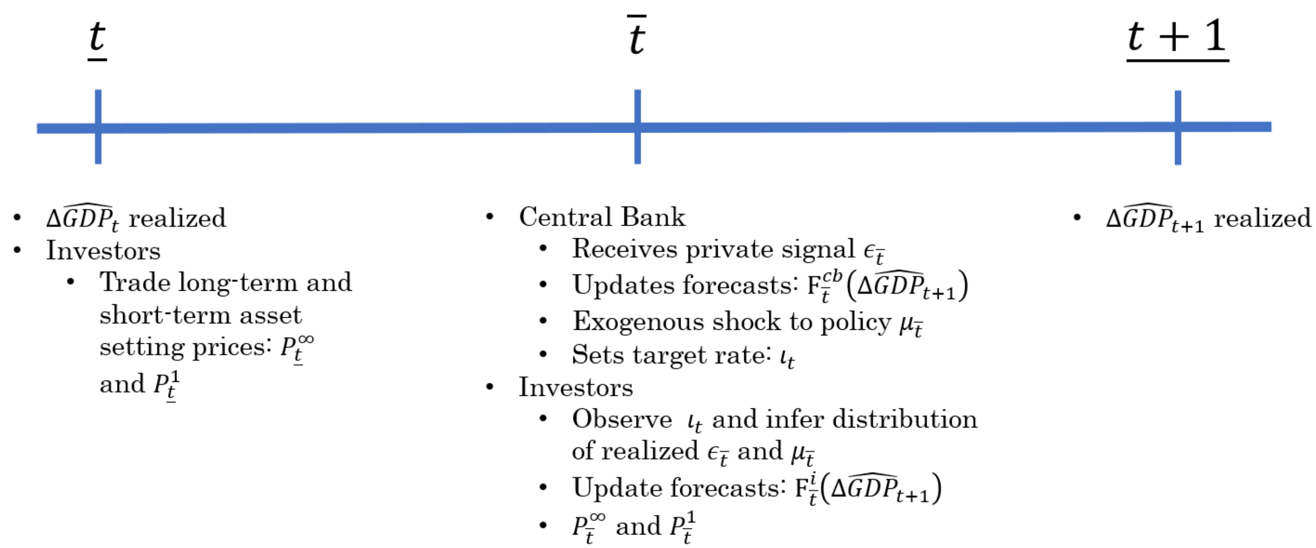
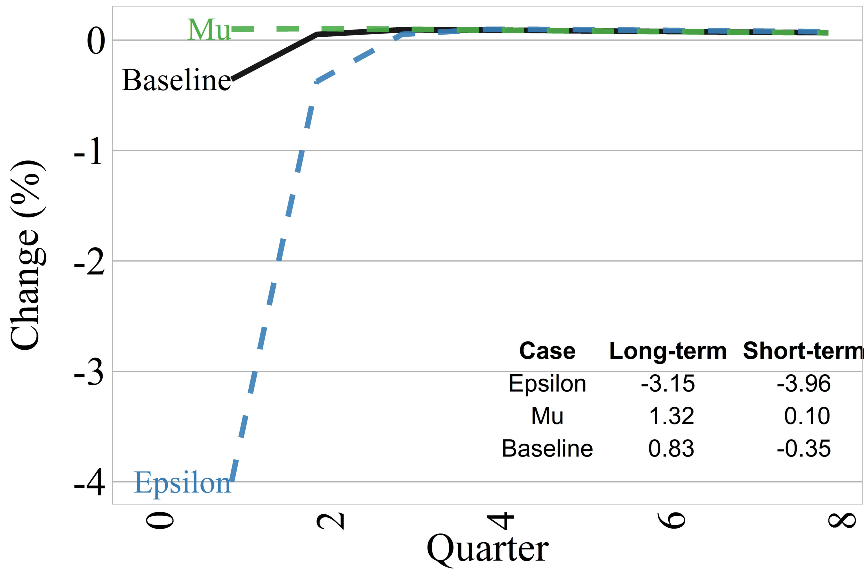


Figure A.I shows the timing of the stylized framework from Section 2.

Figure A.II: **Propagation of Monetary Policy Surprise: Easing**

(a) Change in Expected GDP Growth



(b) Change in Expected Target Rate

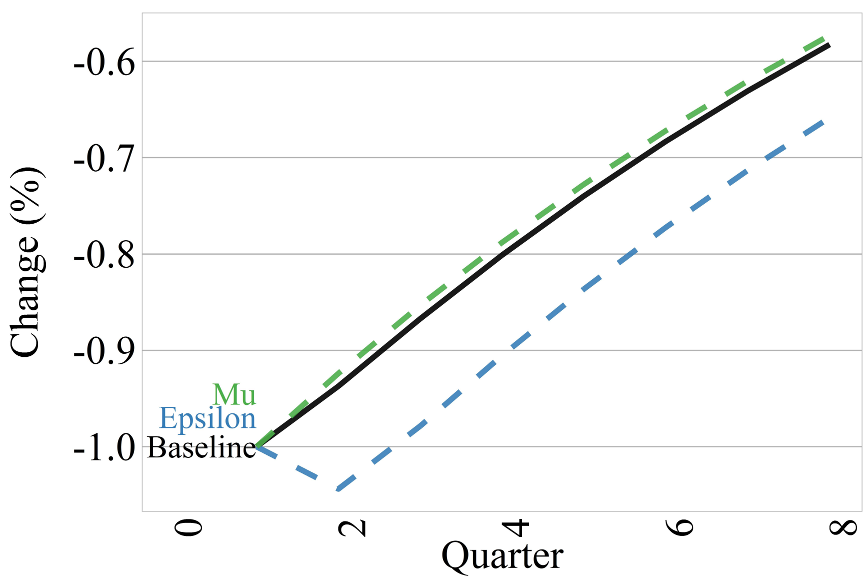
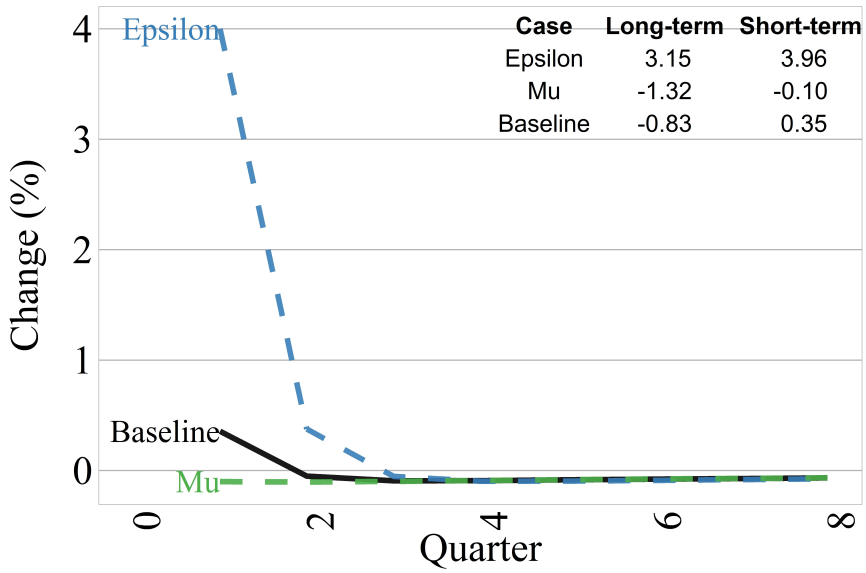


Figure A.II plots the model-implied change in expectations across the term structure following a monetary policy surprise of -1% (unexpected easing). Panel A shows the change in expected quarterly economic growth where the x-axis indicates the number of quarters ahead (the monetary policy surprise occurs 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 shocks, ϵ and μ, 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 does not observe the shocks directly.

Figure A.III: **Propagation of Monetary Policy Surprise: Tightening**

(a) Change in Expected GDP Growth



(b) Change in Expected Target Rate

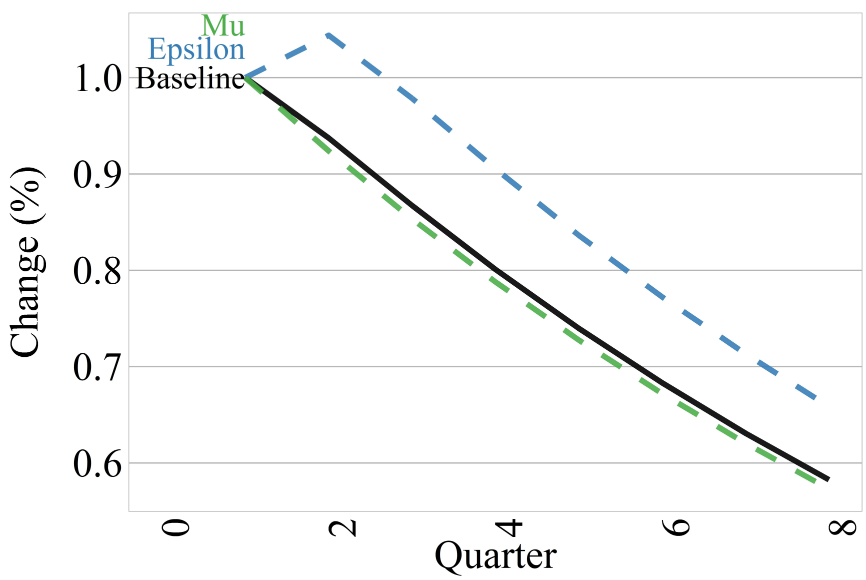
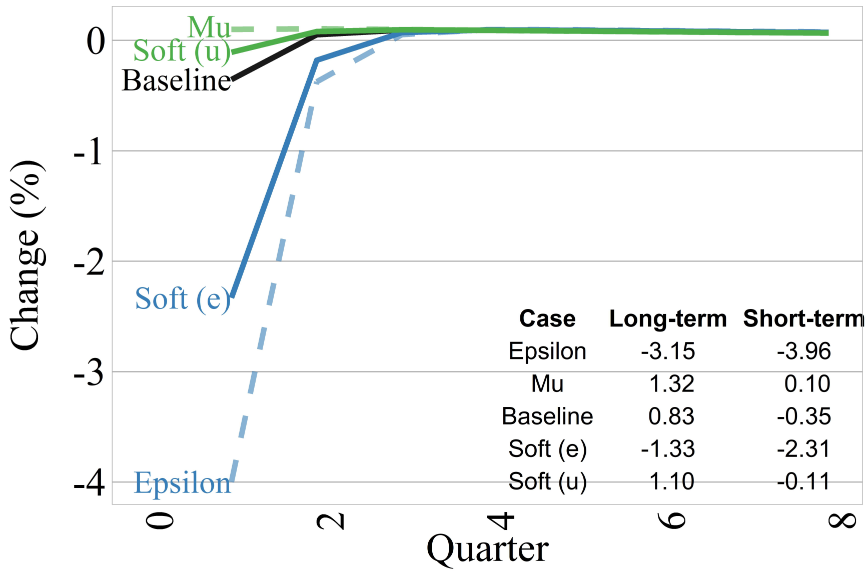


Figure A.III plots the model-implied change in expectations across the term structure following a monetary policy surprise of 1% (unexpected tightening). Panel A shows the change in expected quarterly economic growth where the x-axis indicates the number of quarters ahead (the monetary policy surprise 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 shocks, ϵ and μ, 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 does not observe the shocks directly.

Figure A.IV: **Propagation of Monetary Policy Surprise: Soft Information**

(a) Change in Expected GDP Growth



Case	Long-term	Short-term
Epsilon	-3.15	-3.96
Mu	1.32	0.10
Baseline	0.83	-0.35
Soft (e)	-1.33	-2.31
Soft (u)	1.10	-0.11

(b) Change in Expected Target Rate

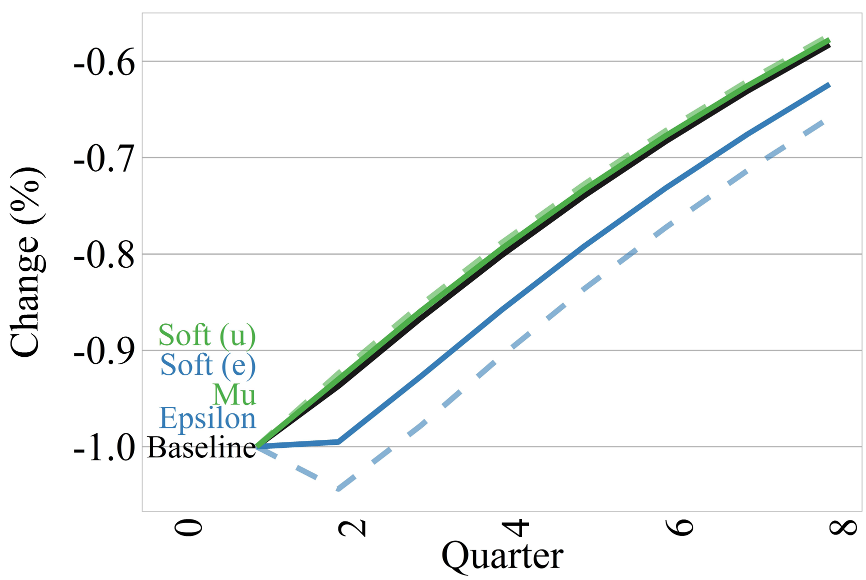
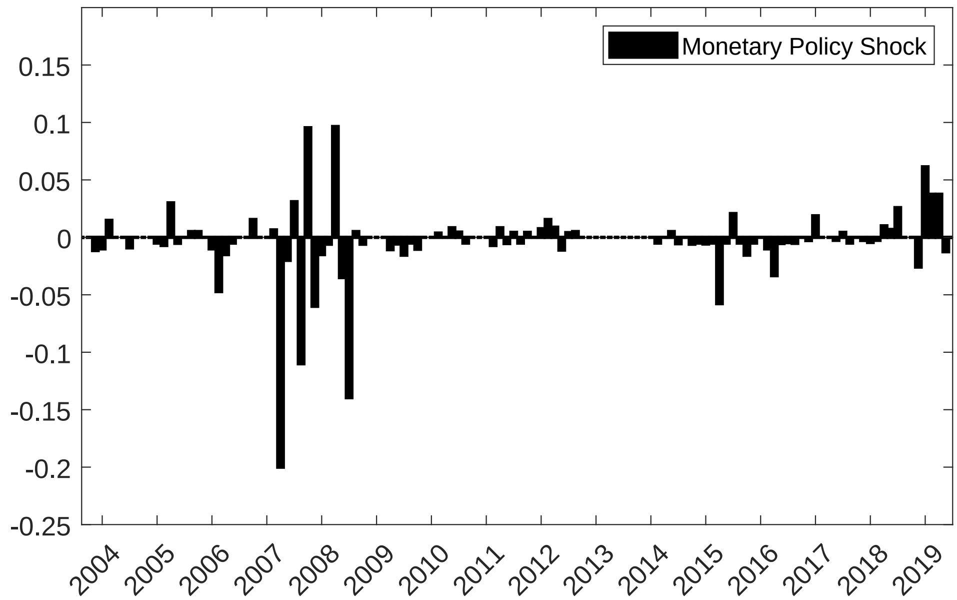


Figure A.IV plots the model-implied change in expectations across the term structure following a monetary policy surprise of -1% (unexpected easing). Panel A shows the change in expected quarterly economic growth where the x-axis indicates the quarters ahead (the monetary policy shock occurs at quarter 0). Panel B shows the change in expected target rate 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 A.V: **Monetary Policy Shock**

Panel A: Monetary Policy Shock (*MPS*)



Panel B: Orthogonalized Monetary Policy Shock (*OMPS*)

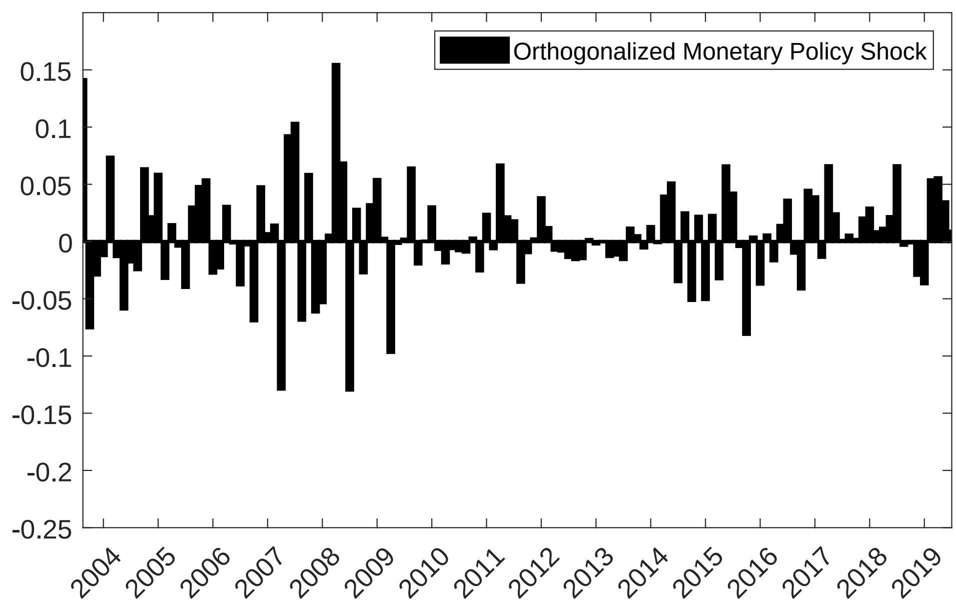
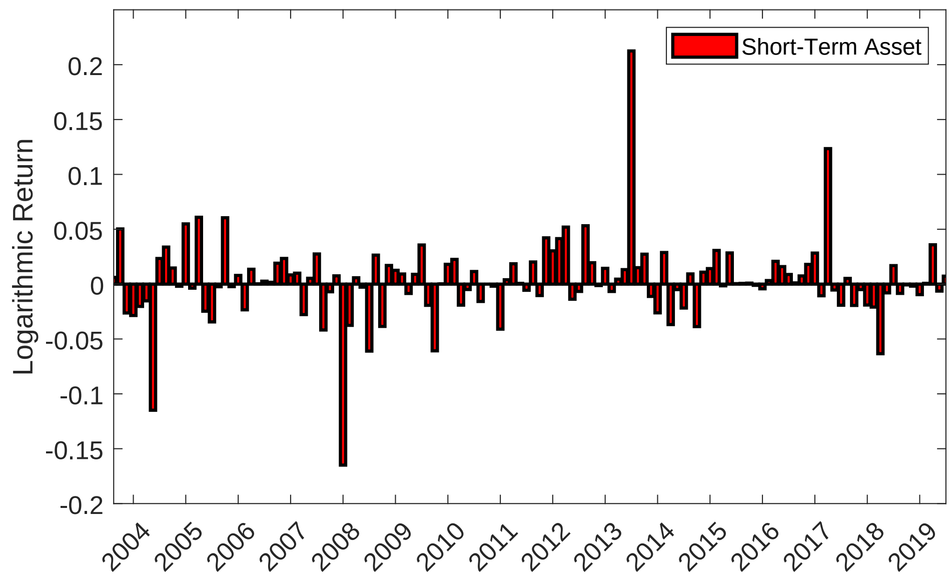


Figure A.V plots the time-series of monetary policy shocks (Panel A) and orthogonalized monetary policy shocks from Bauer and Swanson (2023b) (Panel B). The time period is January 2004 through December 2019.

Figure A.VI: **Asset Return**

Panel A: Short-term Asset (180-day Dividend Strip)



Panel B: Long-term Asset (Aggregate Market)

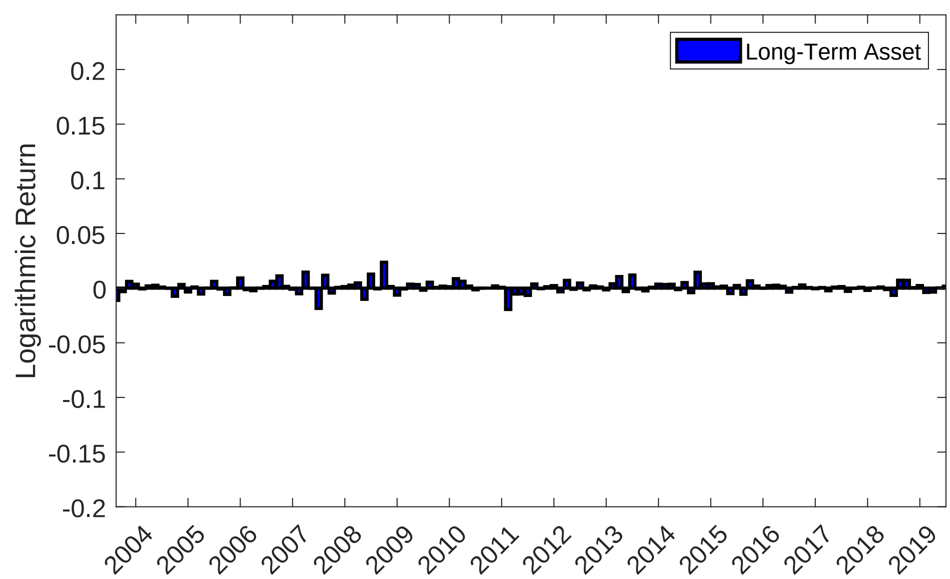


Figure A.VI plots the time-series of short-term returns over the 30-minute window around each FOMC announcement (Panel A) and the corresponding long-term asset return (Panel B). The time period is January 2004 through December 2019.