Monetary Policy and the Term Structure of Equity Risk Premia*

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Abstract

Using high-frequency identification, we measure the impact of monetary policy shocks on dividend claims across different horizons. We estimate that 1% tightening of short-term interest rates decreases expected growth rates of dividends by 3.3% at the one-year horizon and increases risk premia by up to 1% at the nine-year horizon. Our estimates shows that dividend risk premia, particularly beyond the nine-year maturity, account for most of the effect of monetary policy on equity returns. Our findings can discipline models of monetary policy and risk premia.

Keywords: monetary policy, equity risk premia, term structure, dividend futures, high-frequency identification, FOMC announcements

JEL Classification: G12, G14, E52, E43, G13

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1 Introduction

Financial market participants closely follow monetary policy, and policy announcements often change asset prices. These prices can change due to two channels: expected cash flows or discount rates. Further, many important assets traded in an economy are long-lived assets that pay a stream of cash flows. Understanding the channels by which prices change allows us to distinguish different models of monetary policy. Some macroeconomic models allow monetary policy to impact long-term cash flows, while others do not. Similarly, some models allow for a relevant role for risk premia while others do not.

This paper quantitatively measures monetary policy's effects on expected cash flows and risk premia for the major US stock market index, the S&P 500, at different horizons. We show that monetary policy substantially affects stock prices through changes in risk premia that affect discount rates for long-term dividends. By long-term, we mean dividends that firms will pay beyond nine years. This channel explains roughly 75% of the total 7.6% drop in the stock market when monetary policy tightens by 1%. The remainder can be attributed to a change in the term structure of government bond interest rates, while cash flow expectations explain a negligible portion.

We document these findings with regressions of price changes from dividend swaps on monetary shocks that are measured using a high-frequency identification approach. A key contribution of our paper is the use of dividend swaps. These are financial instruments that trade claims on dividends that firms in the S&P 500 will deliver at different points in the future. From the prices of dividend swaps, we can extract a measure of equity yields for different maturities van Binsbergen, Hueskes, Koijen, and Vrugt (2013), a measure analogous to bond yields. While bonds have a deterministic payout at maturity, dividends are stochastic. Such a measure of equity yields contains information on expected dividend growth as well as risk premia on dividends. By combining this data with bond yield data, this instrument allows us to decompose changes in discount rates for risky dividends unrelated to the term structure of interest rates. Such a component contains information on the expected growth rate and risk premia for dividends at different horizons.

To further disentangle the effect of monetary policy on expected growth and risk premia, we perform two additional empirical exercises that measure the impact of monetary policy on the expected growth of cash flows. Both point towards the bulk of the effect of monetary policy on the stock market to come from risk premia, with a small contribution coming from the effect of monetary policy on expected cash flows. The first empirical exercise measures the effect of monetary policy on subjective expectations from the Institutional Brokers' Estimate System (I/B/E/S) professional forecasters' surveys of dividends and earnings growth constructed in De La O and Myers (2021). The second proxies expectations with a forecasting statistical model.

Our data only allows us to observe dividend futures prices up to the nine year horizon. In spite of this, we are able to bound from below the effect of monetary policy on longer unobserved dividend claim maturities. This is possible since the returns on the S&P 500 can be decomposed between return on government bonds and returns on dividend futures. From this decomposition, the only unobserved component are the dividend futures beyond the nine year horizon, which we backout residually.

Quantitatively, our main contributions are the following. A 1% tightening of short-term interest rates lowers one-year-ahead expected dividend growth by 3.3%, while risk premia on dividends three to nine years ahead rise by about 1%. We also estimate the annualized drop of risk premia of further maturities to 0.5%. Once the duration of these claims is considered, we obtain our headline result: long-horizon dividend claims explain 75% of the effect. It is important to emphasize that this is net of any effect through the term structure of interest rates and, therefore, beyond the already documented impacts on bond interest rates by Hanson and Stein (2015).

Related literature. We attempt to fully decompose the effect of monetary policy shocks across horizons as well as across default-free and dividend discount rates. Golez and Matthies (2022) construct dividend prices using options prices to measure the impact of monetary policy shocks. Their approach based on option-implied dividend prices limits the analysis to a maximum maturity of two years, while the dividend swaps we use are observed for up to nine years. Our dividend futures prices data show that evaluating monetary policy effects over a longer horizon is crucial and in fact is the largest contribution to the effect of monetary policy on the S&P 500.

Nagel and Xu (2024) perform a similar exercise and find that changes to the term structure of government bonds interest rates explain most of the variation in the stock market following a monetary shock. While our statistical bounds do not rule out that more than 50% of the effect comes from this channel, our point estimate indicates a statistically significant effect on dividend risk premia. Our results are robust to state-of-the-art measures of monetary policy shocks constructed in Gürkaynak, Sack, and Swanson (2005), Nakamura and Steinsson (2018) and Bauer and Swanson (2022), while admittedly weaker for the measure of monetary policy shock considered in Nagel and Xu (2024). We make minimal assumptions on risk-neutral expectations of dividends, by measuring them directly with futures prices. For unobserved maturities, we back out their price response from monetary policy shocks as a residual from a stock market response decomposition in terms of zero coupon bond and dividend future returns of different maturities.

Our paper directly connects to the literature that uses high-frequency identified shocks to measure the impact of monetary policy on different economic variables. The most common approach to identify monetary policy shocks is to look at high-frequency changes of either interest rates or interest-rate futures around the policy announcement Kuttner (2001); Cochrane and Piazzesi (2002); Gürkaynak, Sack, and Swanson (2005). Hanson and Stein (2015) and Nakamura and Steinsson (2018) document strong effects on long-term interest rates on nominal and real bonds. We use these policy shock measures to study their impact on dividend futures. Bauer and Swanson (2022) have put the high-frequency strategy under further scrutiny, showing that some measures of monetary policy shocks can be predicted. This puts the presumed exogeneity of these shock measures under doubt. To allay these concerns, they construct a new measure that orthogonalizes monetary shocks from its predictors. We use this as our baseline measure of monetary shock.

The decomposition we show in the paper highlights that risk needs to play a central role in monetary policy transmission into asset prices. These results support a growing theoretical literature on monetary policy effects on risk premia as in Caballero and Simsek (2020), Drechsler, Savov, and Schnabl (2018) and Kekre and Lenel (2022). Some papers try to understand why, in particular, FOMC announcements significantly impact prices. Pflueger and Rinaldi (2022) provide a New Keynesian model with habit preferences that can account for the market reaction after FOMC announcements. Alternatively, Ai and Bansal (2018) and Laarits (2022) provide a preference-over-news framework to understand this channel. While we do not tackle these theoretical explanations in this paper, we discuss how our additional empirical evidence regarding how and on which horizon monetary policy affects prices can be used as a new set of moments to quantify and discipline the quantitative and qualitative predictions that are made for changes to the equilibrium price of risk and co-movement of the stochastic discount factor with dividend growth. Our findings show that shocks to monetary policy affect equity yields (and therefore risk-neutral expected returns) at horizons far out into the future, beyond ten years. This can serve as a new quantitative moment to differentiate among a host of new models proposed in the literature to understand the response of risky claims to monetary policy.

Our results also build on the literature that measures how monetary policy can impact asset prices. The seminal paper by Bernanke and Kuttner (2005) show that the impact on the market is primarily through changes in risk premia. We show this prevails in an updated sample and that this channel is driven by dividend risk premia of long maturities. Lucca and Moench (2015) document positive excess equity returns in the 24 hours preceding scheduled FOMC announcements, while Liu, Tang, and Zhou (2022) use option prices to recover the FOMC risk premium and show that it varies across meetings. Our results show that dividend futures are also affected, reflecting changes to the risk-pricing in financial markets.

Other papers emphasize the role of monetary policy shocks in bond prices, particularly long maturities. Hanson and Stein (2015) emphasize that these effects also occur for bond prices with long maturities beyond the business cycle frequency. Brooks, Katz, and Lustig (2018) show that monetary policy shocks also affect long-term bond interest rates, even though the effect takes some days or months to incorporate into prices fully. For accounting for the response of the stock market to monetary policy, changes in bond interest rates are not the primary driver, but rather dividend risk premia.

Finally, we connect to the literature on the term structure of equity risk premia. van Binsbergen, Hueskes, Koijen, and Vrugt (2013) and van Binsbergen and Koijen (2017) show that, unconditionally, this term structure is negatively sloped, which is the opposite of what most macro-finance models would predict. More recently, Bansal, Miller, Song, and Yaron (2021) suggest that small samples and liquidity issues drive these results, while Giglio, Kelly, and Kozak (2022) construct synthetic dividend futures that have, on average, only a slightly negative term-structure slope over a much longer time series. We focus on a conditional, rather than unconditional, moment of the term structure of equity risk premia. Gormsen (2021) shows that the slope of equity risk premia is pro-cyclical—conditional on good times, it is positively sloped and negative otherwise. Our data replicate these findings. We further show that conditional on a monetary policy shock, long-term risk premia increase and the equity risk premium term structure steepens.

The rest of the paper proceeds as follows. In Section 2, we describe the data used, particularly the proprietary trading data on dividend swaps. Section 3 presents a standard asset pricing framework to explain what information is contained in dividend futures prices, which will clarify our empirical specifications. Section 4 contains our main results and decompositions. We conclude by discussing how our findings can discipline predictions of theoretical and quantitative models of monetary policy and risk premia.

2 Data

We utilize five distinct datasets for analyzing dividend swaps, market returns, monetary policy shocks, zero-coupon bond returns, and subjective dividend and earnings growth expectations.

The dividend swap prices are sourced from a proprietary dataset of a global bank that specializes in these financial instruments. The dataset has a daily frequency and covers 2004 to 2018. Additionally, we augment this dataset by incorporating dividend futures instruments from the Chicago Mercantile Exchange (CME) after 2018. [1] Whenever there is an overlap between the two datasets, the prices are virtually the same. We obtain this dataset through a Bloomberg terminal. Each of these swaps is tied to dividends paid over a single calendar year. For example, a contract referencing 2018 and traded in August 2017 is based on dividends paid from January through December 2018, not between August 2017 and August 2018. The contract settles at the end of 2018. To obtain prices for constant maturity instruments (that would trade dividends between August 2017 and August 2018 in the previous example) we apply linear interpolation to the dividend swap data, following the methodology of van Binsbergen and Koijen (2017). The returns on the S&P 500 are obtained from CRSP.

One possible issue with dividend swap data may be the lack of liquidity, especially for longer maturities. To investigate the liquidity of dividend swaps, we use CME data since 2017 to determine the number of contracts traded daily. In Appendix D, we demonstrate that dividend swaps are traded more frequently around scheduled FOMC meetings than on other days. Furthermore, in Appendix B.1, we show that our findings are robust to measuring the price changes in dividend swaps over different window lengths. Our findings are also robust if we use only publicly accessible data on exchange-traded instruments.

We obtain nominal bond yields from the parametrically estimated yield curves of Gürkaynak, Sack, and Wright (2007). To decompose the effects into expectations and risk premia, we use expectations data on dividends and earnings for the S&P 500 from De La O and Myers (2021), at maturities of one and two years as well as long-term growth.

We use the monetary policy shock measure from Bauer and Swanson (2022). Our results are robust to other measures. Appendix B shows results based on Nakamura and Steinsson (2018) and Gürkaynak, Karasoy-Can, and Lee (2019) who update the measure from Gürkaynak, Sack, and Swanson (2005). The main advantage of the measure constructed by Bauer and Swanson (2022) is that they address endogeneity concerns with prior monetary policy shock measures, which are correlated with and forecastable from macroeconomic data. They ensure the monetary policy shock is orthogonal to and unforecastable by publicly available macroeconomic data. We only consider scheduled meetings, and our baseline specification includes 128 scheduled announcements. Further, we focus on the effects of the level of short-term interest rates on the asset prices we use, so we use only the "target" factor of monetary policy shocks, the first principal component of changes in the term structure of the yield curve around monetary policy shock events.

[1] Trading in dividend derivatives initially developed in over-the-counter markets through dividend swaps intermediated by major dealers. Exchange-traded dividend futures were subsequently introduced, including EURO STOXX 50 contracts on Eurex in June 2008 and S&P 500 contracts on CME in November 2015.

In Figure 1, we show the time series of the baseline monetary policy shock we use in this paper. The shocks tend to be around 5 to 10 basis points in absolute terms. The largest shock in the sample is around 15 basis points during the global financial crisis. The plot indicates that our sample has relevant negative and positive shocks. Another notable feature is that the shocks' variance decreased after the global financial crisis. To address the impact of the global financial crisis and any potential change of regime that could affect our results, we show in Appendix B.2 that our results are robust to the exclusion of the event both before and after it happens.

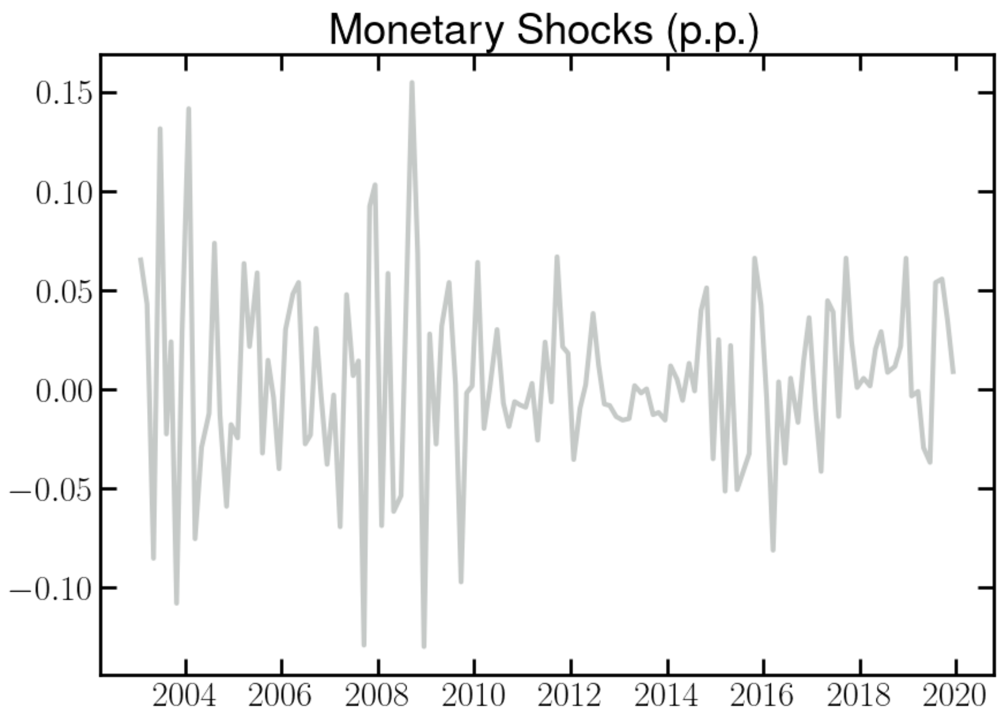


Figure 1: Time series for the high-frequency identified monetary policy shocks from Bauer and Swanson (2022). This shock time-series ensures they are orthogonal to publicly available macroeconomic data. The sample runs from 2004 to 2020.

3 Pricing of Dividend Claims

The spot price[2] $P_t^{(n)}$ of a dividend claim to be paid at $t+n$ is:

$$P_t^{(n)} = E_t\left[M_{t,t+n}D_{t+n}\right] \tag{1}$$

where D_{t+n} is the dividend paid out at $t+n$ and $M_{t,t+n}$ is the stochastic discount factor

[2]The spot price is the price paid today for a dividend claim to be received in the future.

that prices dividends paid at $t+n$.[3] Assuming the same stochastic discount factor prices both dividend claims and government bonds, we can rewrite Equation (1) as

$$P_t^{(n)} = \exp(-n(\theta_t^{(n)} + i_t^{(n)} - g_t^{(n)}))D_t \tag{2}$$

where $i_t^{(n)}$ is the nominal government bond yield for maturity n and $g^{(n)}$ is the average growth rate of dividends. A common stochastic discount factor is consistent with evidence that financial intermediaries price risk across government bonds and derivatives markets (He et al. (2017)). We define $\theta^{(n)}$ as the risk premium required to hold a dividend claim of maturity n, capturing the discounting of expected dividends beyond the nominal government bond yield. Maturity is measured in years, so $t+n$ denotes n years ahead.

Instead of using spot prices, we work with futures prices[4] $F_t^{(n)}$ which relates to spot prices through the no-arbitrage condition:

$$F_t^{(n)} = P_t^{(n)} \exp\left(n i_t^{(n)}\right) \tag{3}$$

Combining Equations (2) and (3) shows that futures prices do not depend on government bond yields: the futures price of a dividend strip contains only information about growth expectations and risk premia.

$$F_t^{(n)} = \exp(-n(\theta^{(n)} - g^{(n)}))D_t \tag{4}$$

Equation (4) shows that dividend futures prices reflect risk-premia and expected dividend growth. This clarifies that measuring the effect of monetary policy on these prices do not reflect any effect of monetary policy on the term-structure of interest rates for government bonds. It is helpful to define the forward equity yield of maturity n to be $m_t^{(n)}$, as in van Binsbergen, Hueskes, Koijen, and Vrugt (2013).

$$m_t^{(n)} := \theta_t^{(n)} - g^{(n)} \tag{5}$$

The equity yield is analogous to bond yields, except that it applies to a maturity specific claim with a stochastic terminal payout, as opposed to the deterministic payout of government bonds. The time-series properties of $m_t^{(n)}$, which we show below in Figure 2, reveal that the forward equity yield $m_t^{(n)}$ decreases in good times and increases during bad times, which can be more clearly seen during the two big recessions in the sample period, the 2008

[3]Formally, D_{t+n} is a random variable measurable with respect to $\mathcal{F}_{t+n}$, the sigma-algebra generated at $t+n$.

[4]The futures price is the price agreed today for an exchange in the future. In this case, the price to be paid at date $t+n$ to receive D_{t+n}.

financial crisis and the COVID-19 pandemic: expected growth rates tumble in bad times and risk premia spike. Further, the term structure of the forward equity yield tends to be upward-sloping in good times while reversing during bad times, a pattern visible again over the two big recessions. Still, on average, the term structure is positively sloped. Our baseline specification will explore the variation of monetary policy shocks over the time-series, as well as maturity variation over different dividend futures contracts.

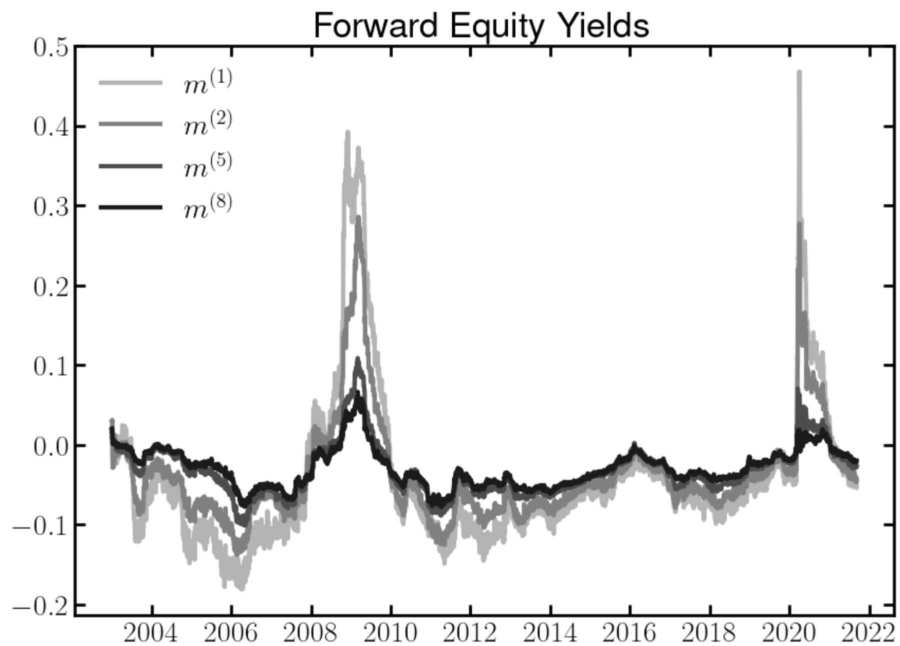


Figure 2: Time series of the forward equity yields for maturities of one, two, five, and eight years from 2003 to 2022. Forward equity yields of maturity n are the difference between the risk premium at the equivalent maturity and the average log expected growth up to maturity, as given by Equation (5). Data are at a daily frequency.

4 Monetary policy shock impacts on asset prices

This paper aims to decompose the impact of monetary policy shocks on different term structures: expected growth, risk-free rates and dividend risk premia. This section shows our main results, which document this decomposition. The effect of monetary policy on the term-structure of risk-premia, in particular long-maturity risk-premia, accounts for most of the effect on the stock market.

Our first exercise is to measure the impact of monetary policy shocks on forward equity yields of different maturities. As shown in the previous section, we define a forward equity yield of maturity n as the difference between the risk premium of the cash flow with maturity n and the average expected growth until maturity. We run regressions of each forward equity yield on monetary policy shocks to estimate the effect on short- and long-term claims. Next, we show that either survey- or model-based expected growth is affected only at the one-year horizon. After that, all the effects on long-term dividend claims are due to changes in dividend risk premia. Finally, we show that these shocks' impact on the market returns is driven primarily by long-term changes in the dividend prices, not bond returns.

4.1 Impact on forward equity yields

In our first set of results, we report the impact of monetary policy shocks on forward equity yields. While we cannot disentangle expected growth and risk premia effects solely with these regressions, we can show whether monetary policy can affect the price of cash flows with different maturities. To do that, we regress changes in forward equity yields on monetary policy shocks for all maturities we can observe (up to nine years), as defined by the equation below.

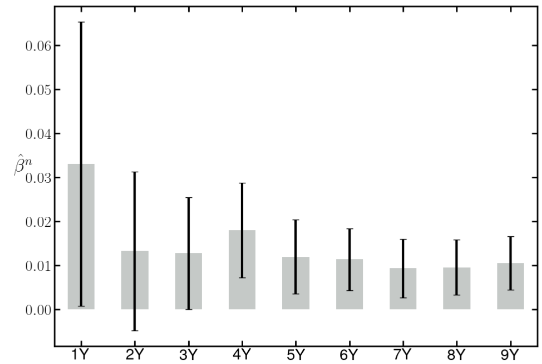
$$\Delta m_t^{(n)} = \alpha^n + \beta^n f_t + \epsilon_t^{(n)},\ n = 1, \ldots, 9 \tag{6}$$

In this main specification, Δ is the change from closing price between time $t+1$ and $t-1$, and f_t is the monetary policy shock measured at announcement t. A 2-day window is relatively large in the spectrum of high-frequency identification strategies. This is our preferred baseline since it allows enough time to incorporate information into dividend futures prices. These instruments are not as liquid as S&P 500 futures or interest rate futures, but the window is not so long that it removes power from our regressions. Our results are robust to this window choice, and we report alternative specifications in Appendix B.

We present the results of the regressions in Figure 3. Our analysis shows that monetary policy impacts forward equity yields of all maturities, including the short-term. The impact is largest for the one-year-ahead period, but the nine-year forward equity yield is also affected significantly. The magnitudes of the impacts are economically significant for all maturities. A 100-basis-point monetary policy tightening shock in short-term interest rates leads to a 330-basis-point increase in the one-year forward equity yield. This shock increases the nine-year forward equity yield by 105 basis points. These measures are yearly, so we still need to compound each dividend future by its duration to evaluate their impact on the aggregate stock, as we do in Section 4.4.

n	$\hat{\beta}^{(n)}$	t-stat	R^2
1Y	0.0330	1.9973	0.0312
2Y	0.0132	1.4409	0.0165
3Y	0.0127	1.9567	0.0300
4Y	0.0179	3.2729	0.0795
5Y	0.0119	2.7980	0.0594
6Y	0.0113	3.0918	0.0716
7Y	0.0093	2.7521	0.0576
8Y	0.0095	2.9621	0.0661
9Y	0.0105	3.3470	0.0829

(A)



(B)

Figure 3: Baseline specification results for the monetary policy shocks, f_t, effects on changes in forward equity yields $m_t^{(n)}$, for yearly maturities one to nine years ahead. The regression is defined by $\Delta m_t^{(n)} = \alpha^n + \beta^n f_t + \epsilon_t^{(n)}$, $n = 1, \ldots, 9$. Along with the point estimates, we provide t-statistics and R^2s for each of the nine regressions. Monetary policy shocks are from Bauer and Swanson (2022). The window size is one day after versus one day before the FOMC scheduled announcements. In Panel B, we show a 95% confidence interval.

In light of the decomposition of Equation (5), either nine-year nominal expected dividend growth falls by 105 basis points, or the nine-year dividend risk premium rises by 105 basis points, or some combination of the two occurs. In the following sections, we explore this decomposition empirically by dissecting how much of these effects are due to changes in expectations versus dividend risk premia.

We are not the first to document such non-neutrality for long-maturity assets; other examples include Hanson and Stein (2015) and Leombroni, Vedolin, Venter, and Whelan (2021), which show how both the Federal Reserve and the European Central Bank can strongly affect long interest rates up to 20 years ahead. The key difference here is that, by construction of the decomposition of Equation (5), the assets we consider contain no effect through the term structure of interest rates, only expected growth and risk premia. Thus, it must either be the case that monetary policy affets dividend growth expectations or risk-premia. In addition, looking at different maturities allows us to tell specifically at which horizon the stock market dividends fall the most following a monetary shock. We further explore these decompositions in the later sections.

4.1.1 Dividend swaps liquidity

One possible issue with dividend swap data may be the lack of liquidity, especially for longer maturities. To investigate the liquidity of dividend swaps, we use CME data since 2017 to determine the number of contracts traded daily. In Appendix D, we demonstrate that dividend swaps are traded more frequently around scheduled FOMC meetings than on other days in a month. Furthermore, in Appendix B.1, we show that our findings are robust to measuring the price changes in dividend swaps over different window lengths. Our findings are also robust if we use only publicly accessible data on exchange-traded instruments.

4.2 Impact on expectations and risk premia

In this section, we break down the effects we observe on dividend futures between expectations and risk premia. We do this using two approaches to measure expectations.

The first approach uses a statistical-based measure of expected growth based on the term structure of forward equity yields. We closely follow van Binsbergen, Hueskes, Koijen, and Vrugt (2013) to estimate the implied expected growth for all maturities up to nine years ahead.

The second approach employs subjective growth expectations by using surveys of dividend and earnings expectations for the S&P 500, which are constructed in De La O and Myers (2021) and based on I/B/E/S professional forecasts. For this method, we present the results for expected dividend growth one and two years ahead and long-term earnings growth. We use earnings rather than dividend growth for long-term horizons because the coverage of I/B/E/S survey data is much lower for dividends than for earnings.

4.2.1 Statistical measure of dividend growth expectations

We model dividend growth as being driven by a set of factors. Following van Binsbergen et al. (2013) we use equity yields of maturity two and five.

$$\Delta d_{t+252} = \psi_0 + \psi_1^\top x_t + \nu_t \tag{7}$$

$$x_t = \mu + \Gamma x_{t-1} + \epsilon_t \tag{8}$$

We show in Appendix A.1 the model's estimates. For arbitrary maturity n, we can calculate expected yearly dividend growth as the following:

$$E_t[\Delta d_{t+252n}] = \psi_0 + \psi_1^\top \left(\left[\sum_{i=0}^{n-2} \Gamma_A^i \right] \mu_A + \Gamma_A^{(n-1)} X_t \right) \tag{9}$$

$$\mu_A \equiv \sum_{i=0}^{251} \Gamma^i \mu,\ \Gamma_A \equiv \Gamma^{252} \tag{10}$$

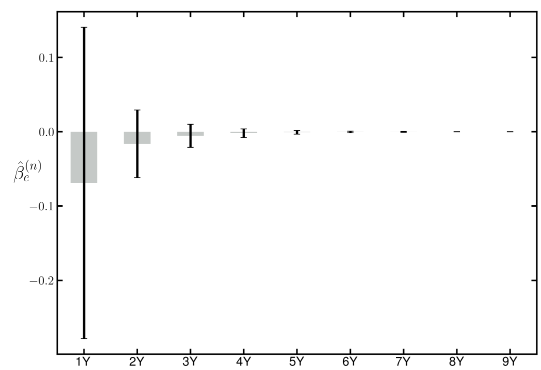
where d_t is the log dividend, and we assume 252 trading days in a year. To measure the impact of monetary policy shocks on expected growth, we run the analogous specification on monetary shocks, replacing the observed forward equity yields with the model-implied changes in expected growth, $\Delta E_t[\Delta^{252} d_{t+252n}]$, as shown by the equation below.

$$\Delta E_t[\Delta^{252} d_{t+252n}] = \alpha^n + \beta^n f_t + \epsilon_t^{(n)},\ n = 1, \ldots, 9 \tag{11}$$

In Figure 4, we show the results of this regression. The first thing to notice is that the coefficients are noisier than those obtained with observed forward equity yields. We find no statistically significant results. However, the point estimates show that monetary policy has some economically relevant effect in reducing dividend growth rate expectations up to two years ahead. After that, the effects quickly converge to zero. Although weak, we take this as evidence that monetary policy can only affect expected growth for up to a two-year horizon, but not after that.

n	$\hat{\beta}^{(n)}$	t-stat	R^2
1Y	−0.0689	−0.6450	0.0060
2Y	−0.0163	−0.7019	0.0071
3Y	−0.0054	−0.6828	0.0067
4Y	−0.0020	−0.6731	0.0065
5Y	−0.0008	−0.6697	0.0065
6Y	−0.0004	−0.6687	0.0064
7Y	−0.0002	−0.6683	0.0064
8Y	−0.0001	−0.6682	0.0064
9Y	−0.0000	−0.6682	0.0064

(A)



(B)

Figure 4: Results for the monetary policy shocks, f_t, effects on the change in statistical dividend growth expectations at horizon n, for yearly maturities one to nine years ahead. We run the regression $\Delta E_t[\Delta^{252} d_{t+252n}] = \alpha^n + \beta^n f_t + \epsilon_t^{(n)}$, $n = 1, \ldots, 9$. We provide the point estimates, t-stats, and R^2s for each of the nine regressions. Monetary policy shocks are from Bauer and Swanson (2022). The window size is one day after versus one day before the FOMC scheduled announcements. Panel B shows 95% confidence intervals.

4.2.2 Subjective measures of dividend growth expectations

An alternative to the statistical measures of expected growth implied by the forward equity yields term structure are the subjective beliefs reported by market participants. We take the expected dividend growth data from De La O and Myers (2021). These are bottom-up aggregated dividend expectations for each stock in the S&P 500 index. The data are from I/B/E/S, which reports median estimates of professional analysts. For expectations one year ahead, the coverage (i.e., the number of firms that are part of the S&P 500 for which there are median forecasts at each point) is very high. However, the dividend coverage declines significantly for longer maturities, especially beyond two years ahead, whereas earnings coverage is still very high. Therefore, we proxy our long-term dividend growth metric using the median earnings forecasts. The implicit assumption is that earnings and dividend growth should reflect similar information in the long run.

The main challenge in incorporating measured expectations into the analysis is that these are measured on a lower frequency than monetary shocks, since professional forecaster expectations are reported in irregular frequency. To circumvent this we aggregate up the expectations to monthly frequency. While using daily monetary shocks with a monthly expectations outcome variable would not bias any estimates in our baseline specification, they introduce a significant amount of noise, making it much harder to identify non-zero effects. To address this issue, we follow Mertens and Ravn (2013) and Gertler and Karadi (2015) by using monetary shocks as external instruments in a vector autoregression (VAR) that includes these subjective expectations. This method allows us to use a high-frequency shock as an instrument for the actual underlying shocks identified in a structural VAR estimated at a lower frequency, which, in our case, are the monthly expected growth rates of earnings at different horizons.

More specifically, and following as closely as possible Gertler and Karadi (2015), we include in the VAR five variables: one-year nominal interest rate, consumer price index, industrial production, excess bond premium and subjective expectations. We run three different VARs, each containing a measurement of expectations: one-year dividend expectations, two-year dividend expectations, and expectations for the long-term growth of earnings (LTG). Below, we report the impact value coefficient of the impulse response function to a monetary shock for the variables of interest. More details about the VAR and the complete set of dynamic impulse response functions are reported in Appendix A.2.

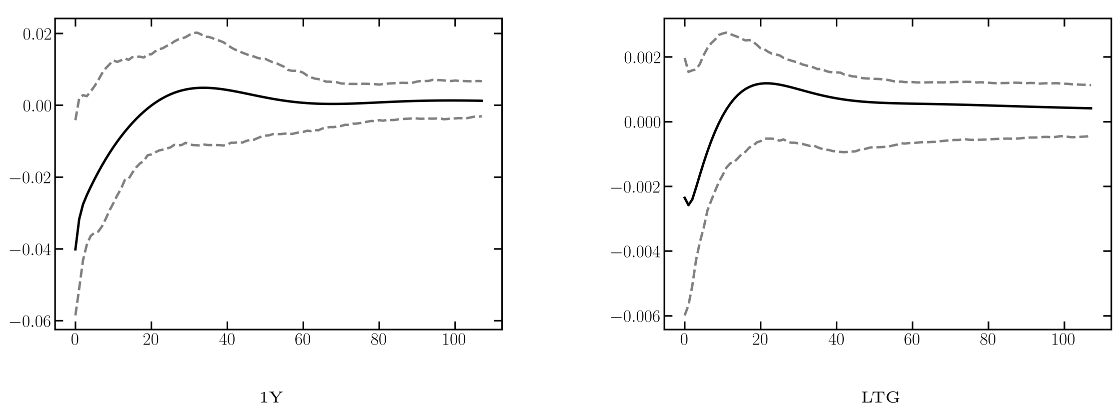


Figure 5: Effect of monetary policy shocks on the subjective dividend growth expectation one year ahead and on the long-term earnings growth (LTG) measure. We use a VAR specification as in Gertler and Karadi (2015) to be able to calculate these impacts. 95% confidence interval constructed with the wild bootstrap following Gertler and Karadi (2015).

Mapping the shocks in our baseline specification to that in the VAR is non-trivial since they are effectively different measures of monetary shocks. In order to make estimates comparable, we scale the shock in the VAR so that the impact response of the one-year bond yield is the same as what we observe when we regress the one-year yield on our measure of the monetary shock. We find that a 1% increase in interest rates causes one-year yields to increase by 0.4%.

Figure 5 shows that monetary policy has an economically large and statistically significant effect on expectations of one-year dividends. At the same time, the estimates for long-term earnings are small in magnitude and insignificant. This is qualitatively similar to what we find with the statistical expectations, suggesting that most of the responses in long-term equity yields are due to the effects of monetary policy on risk premia, not on long-term growth expectations.

4.3 Statistical bounds on risk premia

Armed with estimates of expectations, we can place bounds on the estimated effects of monetary policy on risk premia. This section aims to obtain confidence intervals on the effects of risk premia in equity yields. The effect on risk premia can be estimated by

$$\hat{\beta}_{\theta^{(n)}} = \hat{\beta}_{m^{(n)}} + \hat{\beta}_{g^{(n)}} \tag{12}$$

We can obtain a conservative upper bound on the standard error of this estimate by assuming that both the estimators for the effect on equity yield and the effect on growth expectations are perfectly correlated. With the obvious notation, the variance of the estimator of the effect of monetary policy on risk-premia is

$$\text{Var}\left(\hat{\beta}_{\theta^{(n)}}\right) = \text{Var}\left(\hat{\beta}_{m^{(n)}}\right) + \text{Var}\left(\hat{\beta}_{g^{(n)}}\right) + 2\text{Corr}\left(\hat{\beta}_{m^{(n)}}, \hat{\beta}_{g^{(n)}}\right)\sqrt{\text{Var}\left(\hat{\beta}_{m^{(n)}}\right)\text{Var}\left(\hat{\beta}_{g^{(n)}}\right)} \tag{13}$$

$$\leq \text{Var}\left(\hat{\beta}_{m^{(n)}}\right) + \text{Var}\left(\hat{\beta}_{g^{(n)}}\right) + 2\sqrt{\text{Var}\left(\hat{\beta}_{m^{(n)}}\right)\text{Var}\left(\hat{\beta}_{g^{(n)}}\right)} \tag{14}$$

where the last inequality assumes conservatively that the estimates are perfectly positively correlated; in this conservative approach, we find that effects on risk premia for long-maturity dividends are significant at the 10% level. We use the impact coefficient in the VAR approach of Section 4.2.2 on expectations for long-term earnings growth. We map this to the response coefficient of the nine-year equity yield, using (12) to find a point estimate of the response of the risk premium. The standard errors are the same as in Section

4.2.2 and are computed using the wild bootstrap.

4.3.1 Summarizing the impacts on the term-structure of risk-premia

To summarize the evidence, we find that expected growth drives most of the effect in the short term (one-year horizon), but after that, most of the effect is due to dividend risk-premium effects. These imply that the term structure of equity risk premia steepens following a monetary shock.

Figure 6 shows the resulting impact on the slope of the term structure of equity risk premia by removing the impact on expected growth from the forward equity yield estimates for all maturities. We use the average effects on subjective beliefs and statistical measures to give a sense of the steepening, which is around 105 - (- 140) = 245bps, accounted for by a drop in equity risk premia at the one-year horizon and an increase of around 100bps at the nine-year horizon. We obtain the drop in risk premia implied for the one-year horizon since we estimated expected dividend growth to drop by more than our estimate of the impact rise in forward equity yields.

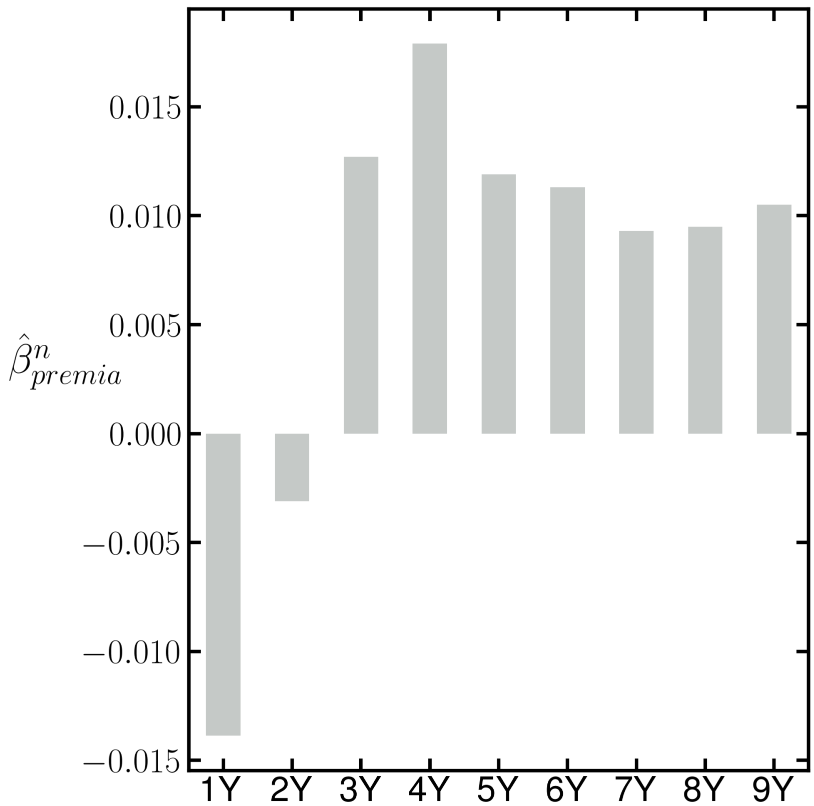


Figure 6: Measure of the impact of monetary policy shocks on the risk-premium component of the forward equity yields of maturity n, where n is based on yearly maturities from one to nine years ahead. To do this exercise, we take the point estimates from Figure 3 and remove the changes in expected growth. To construct the latter metric, we average the effect on the statistical and subjective measures of expected growth.

4.4 Decomposing market returns

So far, we have shown that monetary policy can affect the dividend claims prices of all maturities. In particular, beyond the one-year horizon the impact comes only through the risk-premia channel and not through changes in expected growth. In this section, we discuss how our results map into stock market returns. It is informative to do so since the S&P 500 is a long-duration asset. Therefore, it can mechanically be affected by changes in bond prices. By decomposing the market returns into the return of dividend futures and bonds of different maturities, we can quantitatively assess the relative importance of these two term structures on risky claims.

Most of the papers that discuss the impact of monetary policy on asset prices focus either on the aggregate stock market Nakamura and Steinsson (e.g., 2018) or on interest rates Hanson and Stein (e.g., 2015). Therefore, it is unclear if markets are affected by changes in bond prices, including changes in long-term bond interest rates, or through the future dividend components.

First, we map our results on forward equity yields to returns on the dividend futures contracts. We show in Appendix C that the following relationship holds between equity yields and return on dividend futures R_t^F:

$$\Delta m_t^{(n)} = \frac{1}{n}\left(\ln\left(\frac{D_{t+\Delta}}{D_{t-\Delta}}\right) - \ln R_{t,n}^F\right) \tag{15}$$

where Δ is the window around the monetary policy shock and D_t are observed dividends.

Firms determine their dividend payouts before monetary policy meetings, so payouts should remain unchanged around an announcement, implying $\ln(D_{t+\Delta}/D_{t-\Delta}) = 0$. Consistent with this prediction, regressions of daily dividend payouts on monetary policy shocks do not reject the null of a zero effect.

Next, we decompose the return on the market as a sum of a weighted portfolio of zero-coupon government bonds and dividend futures returns, closely following van Binsbergen and Koijen (2017) and defined by the equation below. Up to a first-order approximation, we can write the realized return on the S&P 500 as the return on a portfolio of bonds and dividend claims.

$$\underbrace{R_t^M}_{\text{return on the S\&P 500}} \approx \underbrace{\sum_{n=1}^{\infty} w_{t-1,n} R_{t,n}^F}_{\text{return on a portfolio of dividend futures}} + \underbrace{\sum_{n=1}^{\infty} w_{t-1,n} R_{t,n}^B}_{\text{return on a portfolio of zero-coupon bonds}} \tag{16}$$

where the weights are given by the price of each dividend claim relative to the sum of all dividends:

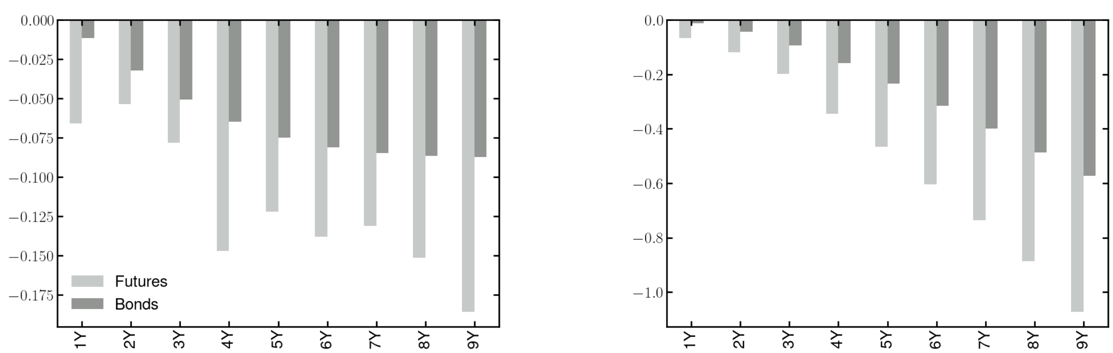
$$w_{t-1,n} = \frac{P_{t-1}^{(n)}}{S_t} \tag{17}$$

We have three main goals here. First, we quantitatively estimate how much of the impact of monetary policy on the market can be attributed to each of the first nine dividend future returns versus the equivalent maturity bond returns. Second, we explore how, under certain assumptions, we can calculate the residual unobserved contribution of dividends and bonds beyond the maturities we observe in the data. Finally, we revisit the seminal result of Bernanke and Kuttner (2005): most of the effect of monetary policy on the market is due to risk premia. On top of providing a different angle from which to estimate the impact of risk premia on the stock, we add to this result along two dimensions: i) we can disentangle whether bond or dividend risk premia, and ii) whether short- or long-term risk premia, matter most. As shown in previous sections, changes in long-term dividend-futures returns are driven only by changes in risk premia. Thus, if monetary policy affects market returns primarily by changing long-term dividend futures, long-term dividend risk premia are the most relevant driver.

To calculate the impact on market returns, we run a similar regression to the baseline for forward equity yields but using returns as an outcome. We find that a 100-basis-point increase in the short-term level of interest rates causes a drop of 7.6% in the market. Next, we run the same regression for each of the dividend futures and bonds of equivalent maturities.

$$\Delta R_{t,j}^{(n)} = \alpha_j^n + \beta_j^n f_t + \epsilon_{t,j}^n,\ n = 1, \ldots, 9,\ j = F, B \tag{18}$$

Multiplying the results of this regression by the average weight of each contract, we can estimate the impact of each maturity on the overall market. Figure 7 shows the result of this calculation for dividend futures and bond returns over the first nine maturities. In total, the first nine maturities account for 165 basis points of the 760 basis-point drop in the market following a monetary policy tightening shock of 1%. Of these 165 basis points, 110 basis points come from dividend futures and 55 basis points from bond returns. Moreover, the impact on long-term dividend-futures returns is stronger than the short-term impact.



Panel A: Per-maturity effect

Panel B: Cumulative effect

Figure 7: Decomposition of the effects of monetary policy shocks, f_t, on dividend futures and bond returns for yearly horizons from one to nine years. We run the regression $\Delta R_{t,j}^{(n)} = \alpha_j^n + \beta_j^n f_t + \epsilon_{t,j}^n$, $n = 1, \ldots, 9$, $j = F, B$ and multiply by the average weights of each of these maturities, $w_{t-1,n} = \frac{P_{t-1}^{(n)}}{S_t}$, to calculate the impact on the market. Panel A shows the impact of each maturity, while Panel B shows the cumulative impact.

To measure the contribution beyond nine years we run regression (18) on bond returns for maturities up to 30 years, which are observable. From the decomposition (16), this allows us to place a bound on the contribution of non-observable dividend futures, the single non-observed component of the decomposition.

Figure 8 shows the response of bond returns with 95% confidence intervals for maturities of 1 to 30 years. We stop at the 30-year maturity since this is the last maturity observed in the data.[5] Regressions are the equivalent of Equation (18) but only for bonds and for maturities beyond nine years. Bonds' return response has a hump shape, peaking at around ten years and reaching zero around the 25-year maturity. This suggests that the longer maturity bonds should account for relatively even less than dividend futures, compared to what is observed in the first nine years. Taking into account these estimated response of bond yields and assuming no effect beyond the 30 year bond, we find that around 75% of the total effect is accounted by dividends beyond the nine years. Details are provided in Appendix E.

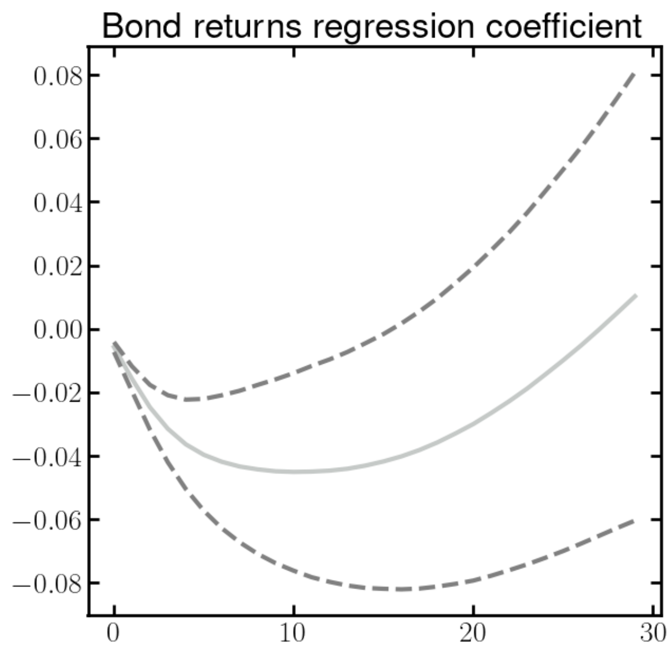


Figure 8: Decomposition of the effects of monetary policy shocks, f_t, on bond returns for yearly horizons from 1 to 30 years. We run the regression $\Delta R_{t,j}^{(n)} = \alpha_j^n + \beta_j^n f_t + \epsilon_{t,j}^n$, $n = 1, \ldots, 30$, $j = B$.

5 Conclusion

We show that monetary policy significantly affects the stock market through long-term risk premia. A shock of 100bps to the short-term level of interest rates causes the S&P 500 to drop by 7.6% and 75% of this can be attributed to effects on long-term dividend risk premia, in particular for those beyond the nine-year maturity. Dividend futures of long maturities drive most of this result, not short-term dividend risk premia, expected dividend growth,

[5] Even if we use a parametric yield curve, relying only on it for observed maturities is advisable, as warned in Gürkaynak et al. (2007).

bond interest rates, or bond term premia.

Our new set of stylized moments helps shed light on the underlying mechanisms of monetary policy on the pricing of risk in financial markets. The identified moments we document place restrictions on the joint movement of the equilibrium price of risk and dividends following a monetary shock. Understanding these mechanisms is important for better calibrating models of monetary policy and evaluating their counterfactuals. Rationalizing these responses is left for future work.

APPENDIX

A Measures of expected growth

A.1 Statistical model

In Table 1 we report our estimates for the parameters for the daily model estimation of expected dividend growth implied by forward equity yields following van Binsbergen, Hueskes, Koijen, and Vrugt (2013).

Parameter	Value
ψ_0	0.039
$\psi_{1,1}$	1.343
$\psi_{2,1}$	-0.548
μ_1	0.000
μ_2	0.000
$\Gamma_{1,1}$	0.993
$\Gamma_{1,2}$	0.009
$\Gamma_{2,1}$	0.000
$\Gamma_{2,2}$	0.997

Table 1: Parameters of the model to calculate implied dividend growth for different maturities, closely following van Binsbergen, Hueskes, Koijen, and Vrugt (2013) estimation. More specifically, we estimate the VAR(1) model $x_{t+1} = \mu + \Gamma x_t + \epsilon_{t+1}$, where $x_t = (m_t^{(2)}, m_t^{(5)})$, on a daily level to be able to back out the implied measure of expected growth for all the horizons.

A.2 VAR with high-frequency shocks

In particular, in this section we describe how we implement the VAR model to calculate impulse response functions of monthly/quarterly variables using shocks identified at high frequency. This allows us to use high-frequency shocks to measure the effects of monetary policy on monthly variables while imposing only one sign restriction.

Let f_t be the high-frequency measured monetary shock and let u_t^f denote the reduced form residual for the variable where we shall impose the sign restriction. First, we need to estimate the reduced form VAR of the monthly variables, $\mathbf{Y}_t$, based on the specification below:

$$\mathbf{Y}_t = \sum_{j=1}^{p} \mathbf{B}_j \mathbf{Y}_{t-j} + \mathbf{u}_t \tag{19}$$

We define $\mathbf{u}_t = \mathbf{S}\boldsymbol{\varepsilon}_t$ as a linear combination of the structural shocks $\boldsymbol{\varepsilon}_t$ as usual.

Second, we need to estimate the ratio $\mathbf{s}^q/s^f$. We do that by two-stage least squares using f_t as an instrument for u_t^f. We closely follow Mertens and Ravn (2013) and Gertler and Karadi (2015). These papers show that an estimate of the reduced-form variance matrix, the ratio $\mathbf{s}^q/s^f$, and a sign restriction on s^f are sufficient to identify the effects of the structural shock ε^f on all the variables of the VAR. The sign restriction we impose is the same as in Gertler and Karadi (2015): a positive shock to the one-year interest rate must increase the one-year rate.

In the figures below we show the impulse response functions for the one- and two-year-ahead dividend growth expectations, along with the model for long-term earnings growth.

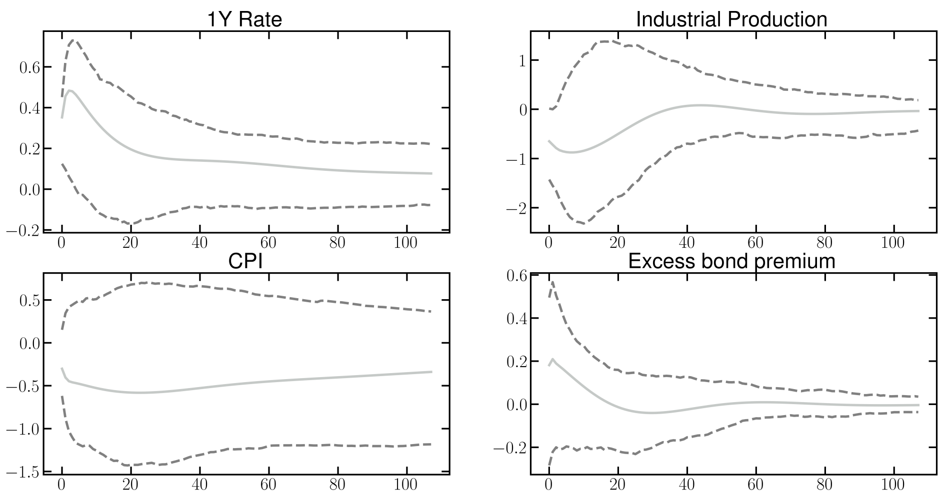


Figure 9: Impulse response functions for the VAR estimations using the method of Gertler and Karadi (2015) that allows us to combine high-frequency shocks, in this case, defined by Bauer and Swanson (2022), to lower frequency data. In this specification we have one-year interest rates, inflation (CPI), industrial production and the one-year-ahead dividend growth expectations from De La O and Myers (2021).

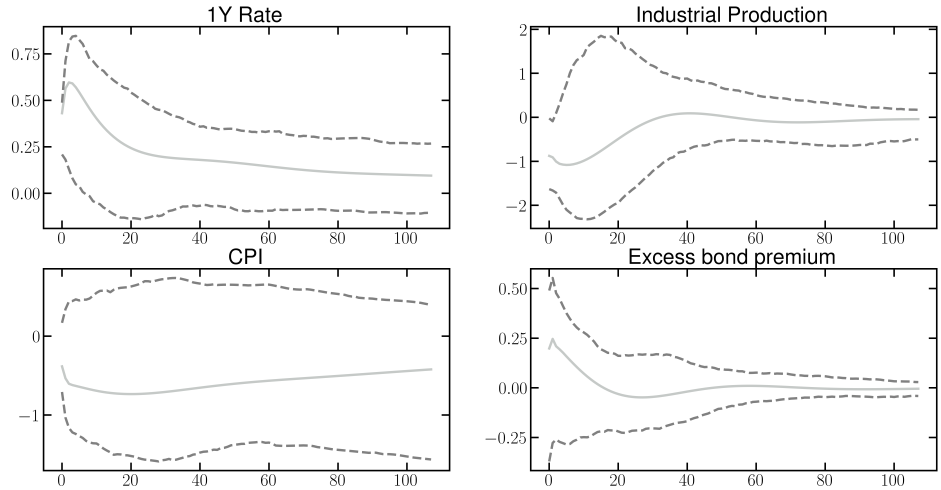


Figure 10: Impulse response functions for the VAR estimations using the method of Gertler and Karadi (2015) that allows us to combine high-frequency shocks, in this case, defined by Bauer and Swanson (2022), to lower frequency data. In this specification we have one-year interest rates, inflation (CPI), industrial production and the two-year-ahead dividend growth expectations from De La O and Myers (2021).

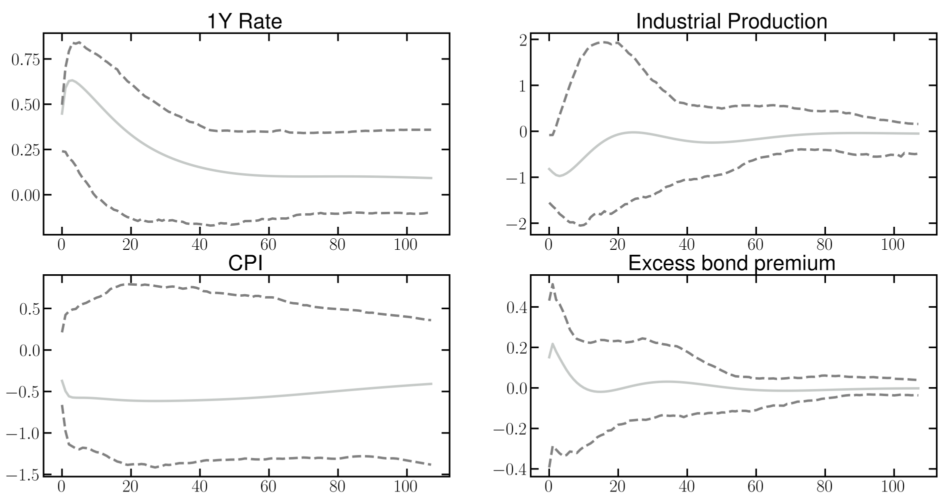


Figure 11: Impulse response functions for the VAR estimations using the method of Gertler and Karadi (2015) that allows us to combine high-frequency shocks, in this case, defined by Bauer and Swanson (2022), to lower frequency data. In this specification we have one-year interest rates, inflation (CPI), industrial production and long-term earnings growth expectations from De La O and Myers (2021).

B Robustness

In this Appendix we show the robustness of our results to different window specifications, what our results look like before and after the Global Financial Crisis, and alternative shock measures.

B.1 Window specifications

Our main result is based on regression specification (6), which shows the impact of monetary policy shocks on each available maturity of the forward equity yields. In the main text, we provide results for the change in these forward equity yields from one day before to one day after the shock. In this section, we explore additional window specifications.

B.1.1 Placebo windows

First, we show that our results pass a simple placebo window. We pick windows of the same size but on random dates between meetings. In Figure 12 we show that the effect is zero with large confidence intervals.

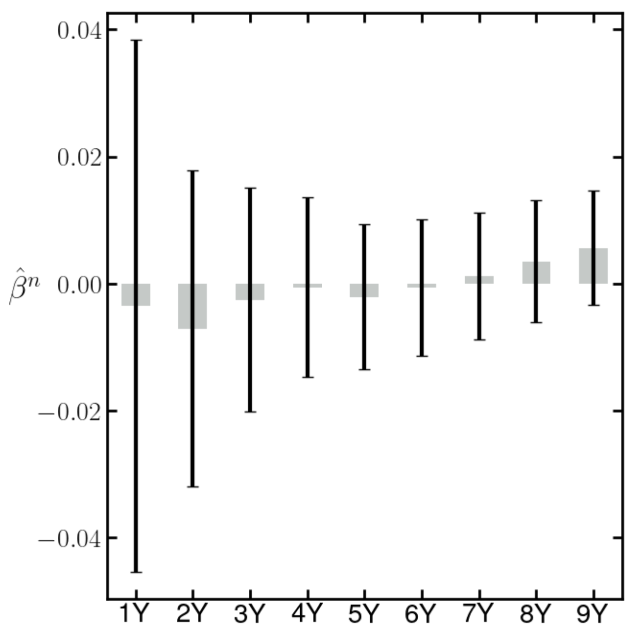


Figure 12: Point estimates and 95% confidence interval for the placebo specification regression results, which show the effects of monetary policy shocks, f_t, on change of forward equity yields of maturities, $m_t^{(n)}$, of yearly maturities one to nine years ahead. The regression is defined by $\Delta m_t^{(n)} = \alpha^n + \beta^n f_t + \epsilon_t^{(n)}$, $n = 1, \ldots, 9$. Monetary policy shocks are from Bauer and Swanson (2022). The window size is one day, but instead of taking the baseline one day after versus one day before the FOMC scheduled announcements, we pick the one day variation in random dates in between meetings.

B.1.2 Window sizes

Next, we run the same baseline specification but change the size of the windows. In particular, we show results for windows covering all combinations of days from two days before the FOMC meeting to two days after. In other words, we consider windows that start two days before and end zero, one, or two days after, and so forth. In Figure 13, we show that most window sizes lead to results similar to those from the baseline window. Of course, as we increase the window sizes, we introduce noise to forward equity yields and, consequently, confidence intervals widen. However, point estimates are robust along this dimension. Point estimates move closer to zero when the window involves a zero lag in one of the legs of the window definition.

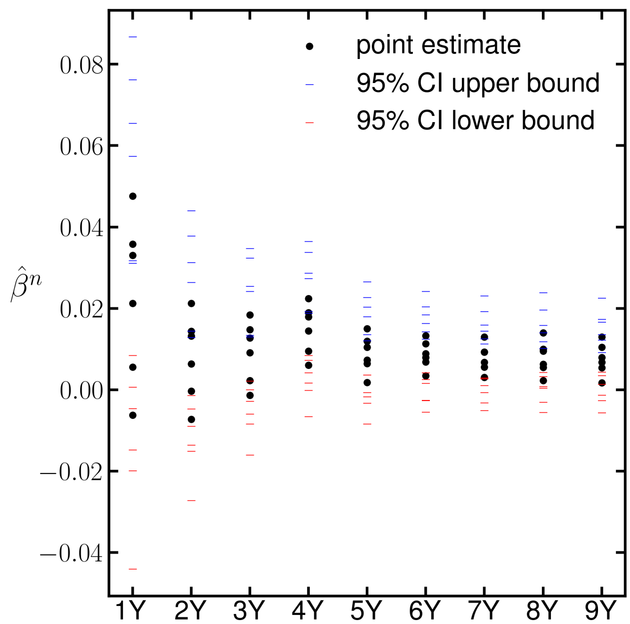


Figure 13: Point estimates and 95% confidence interval for the regression results, which show the effects of monetary policy shocks, f_t, on change of forward equity yields of maturities, $m_t^{(n)}$, of yearly maturities one to nine years ahead. The regression is defined by $\Delta m_t^{(n)} = \alpha^n + \beta^n f_t + \epsilon_t^{(n)}$, $n = 1, \ldots, 9$. Monetary policy shocks are from Bauer and Swanson (2022). The window size is defined by all the combinations of plus-two and minus-two days intervals. Confidence intervals are taken from the lower and upper bound of these different window combinations cases.

B.2 Before and after the Global Financial Crisis

Here we show that our results are also robust to different time-series slices. In particular, we test if our results are due mostly to effects that accrue during the Global Financial Crisis. In order to do so, we split the data into two periods: before January 2008 and after December 2009.

Figure 14 shows the results for the first part of the sample and before the Global Financial Crisis. Results are quantitatively and qualitatively similar to the baseline full-sample results, albeit with wider confidence intervals as the number of observations decreases by a large margin.

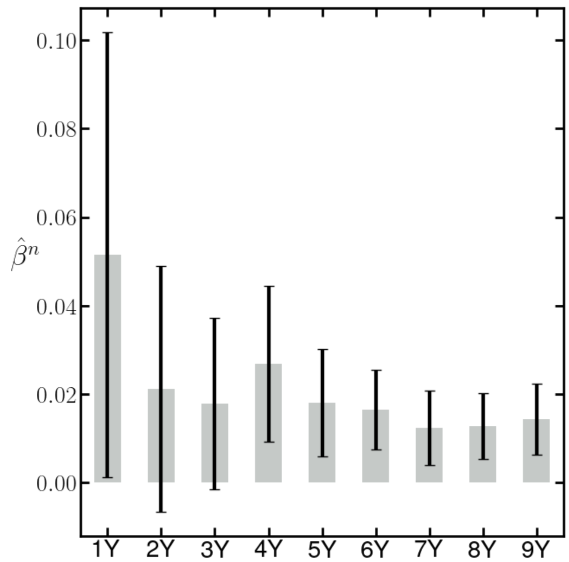


Figure 14: Point estimates and 95% confidence interval for the pre-Global Financial Crisis specification regression results, which show the effects of monetary policy shocks, f_t, on change of forward equity yields of maturities, $m_t^{(n)}$, of yearly maturities one to nine years ahead. The regression is defined by $\Delta m_t^{(n)} = \alpha^n + \beta^n f_t + \epsilon_t^{(n)}$, $n = 1, \ldots, 9$. Monetary policy shocks are from Bauer and Swanson (2022). The window size is one day after versus one day before the FOMC scheduled announcements. We only consider data prior to January 2008 in our sample.

After the crisis, confidence intervals also increase significantly, as shown in Figure 15. While the point-estimates for the longer maturities are relatively the same as in the baseline, the strong short-term effect, particularly one year ahead, decreases to only about 1%. However, the confidence interval goes from -4% to 6%.

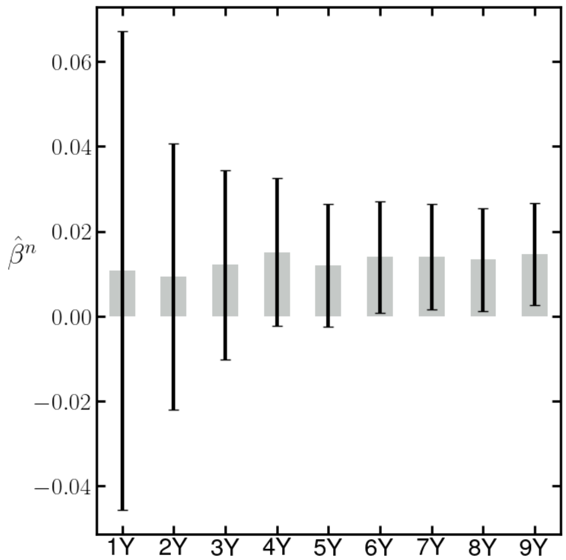


Figure 15: Point estimates and 95% confidence interval for the after-Global Financial Crisis specification regression results, which show the effects of monetary policy shocks, f_t, on change of forward equity yields of maturities, $m_t^{(n)}$, of yearly maturities one to nine years ahead. The regression is defined by $\Delta m_t^{(n)} = \alpha^n + \beta^n f_t + \epsilon_t^{(n)}$, $n = 1, \ldots, 9$. Monetary policy shocks are from Bauer and Swanson (2022). The window size is one day after versus one day before the FOMC scheduled announcements. We only consider data after December 2009 in our sample.

Therefore, we find qualitatively and quantitatively similar results for long-maturity claims. However, short-term prices are affected. We cannot determine whether this difference is due to different channels of monetary policy across these two time periods or simply to noisier data. We leave the exploration of how zero-lower-bound constraints and quantitative easing or other monetary policy channels affect short- versus long-term claims for future research.

B.3 Shocks

In the baseline result, we use the shocks from Bauer and Swanson (2022). Their specification takes a similar approach to Gürkaynak, Sack, and Swanson (2005) but strips out the predictable component of this measure using economic news surprises. In this section, we show that our results are robust to the choice of shock, confirming and extending the finding in Bauer and Swanson (2022) that this predictable component does not affect regressions of stock prices on monetary policy shocks. To do so, we take an updated version of Gürkaynak, Sack, and Swanson (2005) from Gürkaynak, Karasoy-Can, and Lee (2019) and run the same baseline regression. Figure 16 confirms that the results are identical.

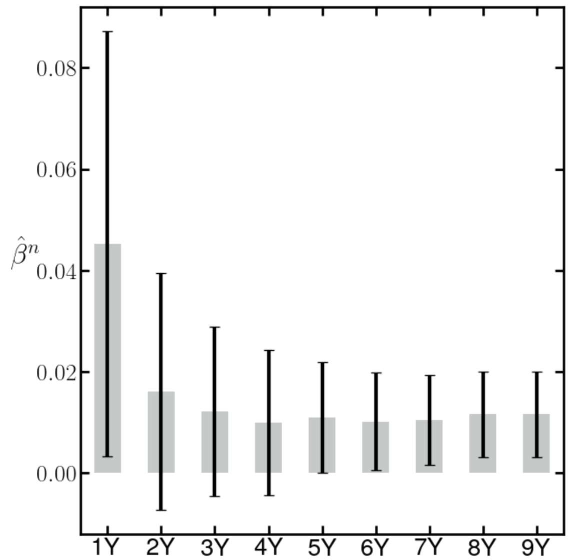


Figure 16: Point estimates and 95% confidence interval for the alternative shock specification regression results, which show the effects of monetary policy shocks, f_t, on change of forward equity yields of maturities, $m_t^{(n)}$, of yearly maturities one to nine years ahead. The regression is defined by $\Delta m_t^{(n)} = \alpha^n + \beta^n f_t + \epsilon_t^{(n)}$, $n = 1, \ldots, 9$. Monetary policy shocks are from Gürkaynak, Karasoy-Can, and Lee (2019). The window size is one day after versus one day before the FOMC scheduled announcements.

Below we present robustness with respect to the Nakamura and Steinsson (2018) shock.

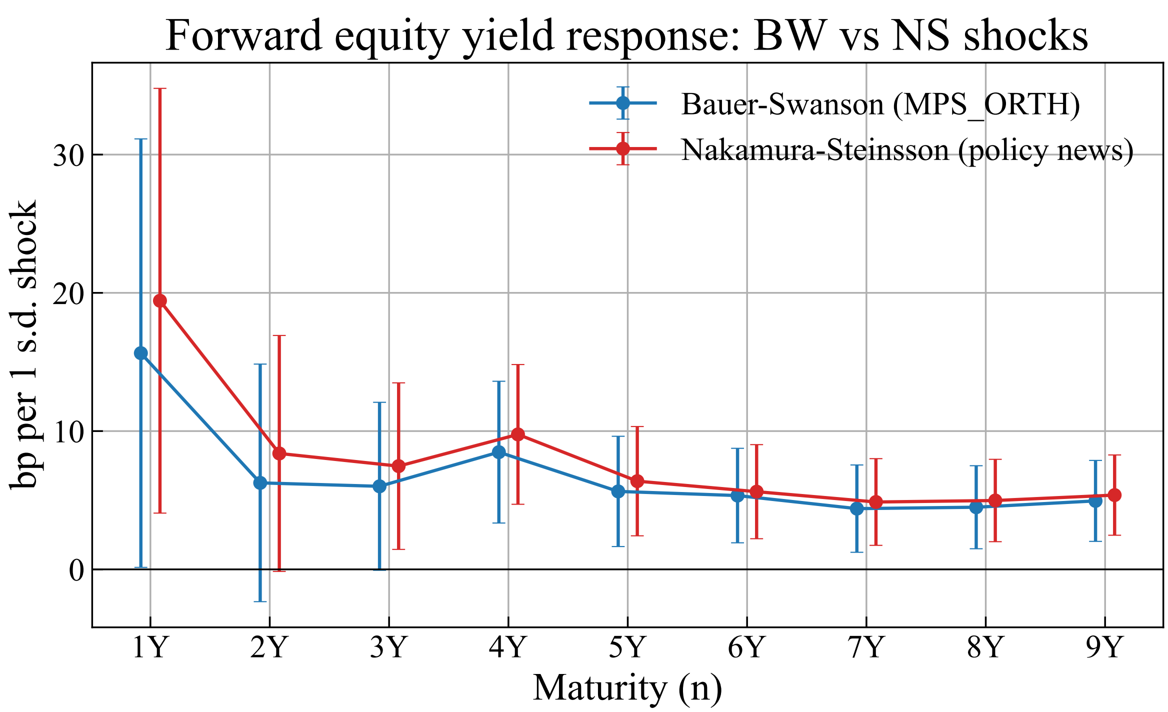


Figure 17: Forward equity yield responses to monetary policy shocks: comparison of the shocks from Bauer and Swanson (2022) and Nakamura and Steinsson (2018).

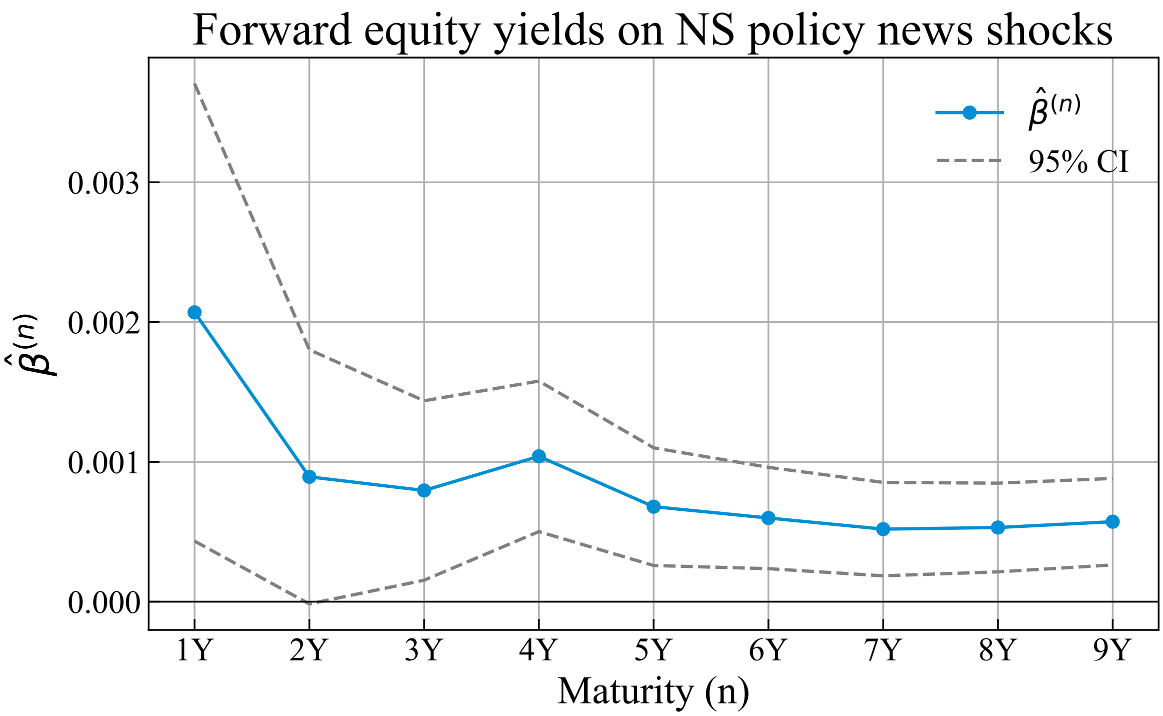


Figure 18: Forward equity yield responses to monetary policy shocks from Nakamura and Steinsson (2018).

B.4 Exchange-Traded Sample

Figure 19 plots the time series of the publicly available equity yields based on exchange-traded instruments.

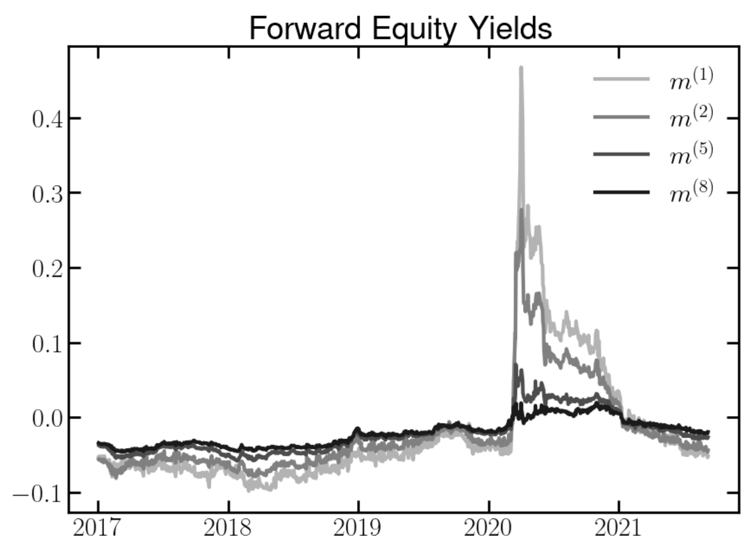


Figure 19: Time series of forward equity yields constructed from publicly available exchange-traded dividend futures.

Figure 20 reports the baseline specification estimated on the publicly available sample. From the above sample we only include data up to 2019.

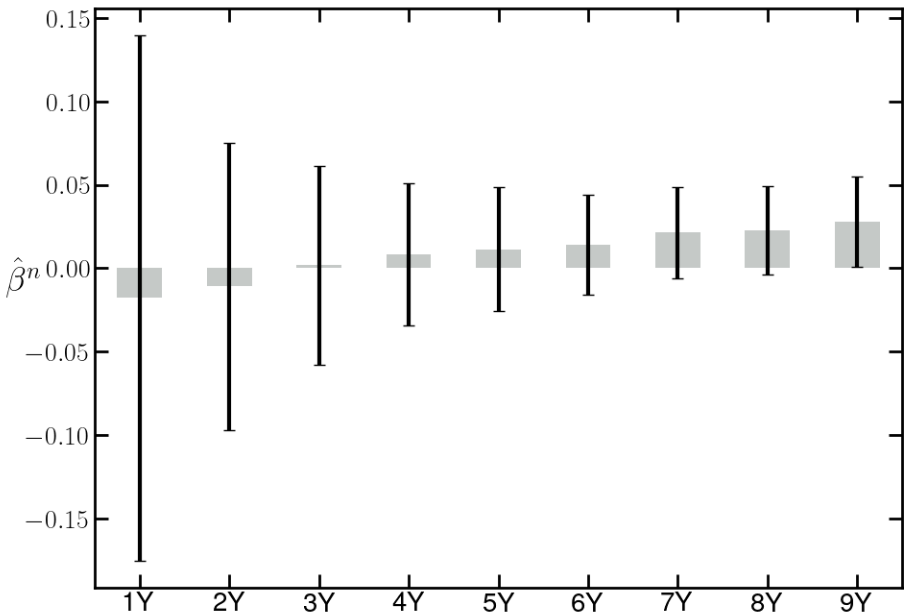


Figure 20: Point estimates and 95% confidence interval for the baseline specification estimated on the publicly available exchange-traded sample, for yearly maturities one to nine years ahead.

In spite of the noisier estimates due to the smaller sample, the main result that the equity yields of long-term dividend claims increase is still statistically significant.

C From forward equity yields to returns

In this section we show how to map the impact of forward equity yield changes to returns. To see that, note that forward equity yields are defined as:

$$m_t^{(n)} = -\frac{1}{n} \ln \left(\frac{F_t^{(n)}}{D_t} \right) \tag{20}$$

Therefore, the first difference yields

$$\Delta m_t^{(n)} = \frac{1}{n} \left(\ln \left(\frac{D_{t+\Delta}}{D_{t-\Delta}} \right) - \ln R_{t,n}^F \right) \tag{21}$$

If monetary policy shocks do not affect $\ln \left(\frac{D_{t+\Delta}}{D_{t-\Delta}} \right)$, which is a reasonable assumption since dividend payments are decided well in advance, then:

$$\Delta m_t^{(n)} = -\frac{1}{n} \ln R_{t,n}^F \tag{22}$$

And the impacts can then be mapped from forward equity yields to dividend future returns.

D Dividend swaps liquidity

Illiquidity in dividend swaps has been emphasized by Bansal, Miller, Song, and Yaron (2021) and Gomes and Ribeiro (2018). One potential concern is that this illiquidity biases our results, potentially towards zero. However, there are a few things to take into account. First, the S&P 500 is very liquid, and we find a strong and relatively similar effect of monetary policy in long-term forward equity yields. Second, short-term dividend swaps are more liquid than long ones and should be less affected by this issue. However, with the exception of the one-year-ahead dividend swap, we find a strong and relatively similar effect across all other maturities.

Third, while we do not have access to the bid-ask spreads, we can see the trading volumes for 2016 and later data that come from CME. We then test whether the trading volumes of these instruments are significant around FOMC meetings. To do so, first we calculate the daily share of total monthly volume and check if there are spikes around monetary policy announcements. Figure 21 aggregates all maturities and shows that, on average, two days after FOMC announcements around 7% of the total monthly trade volume of dividend swaps is traded. In general, there are spikes three days before the meeting, suggesting a positioning to the meeting effect, and then a spike in the trading volume one and two days after the announcement. Therefore, we believe that our baseline windows are well designed.

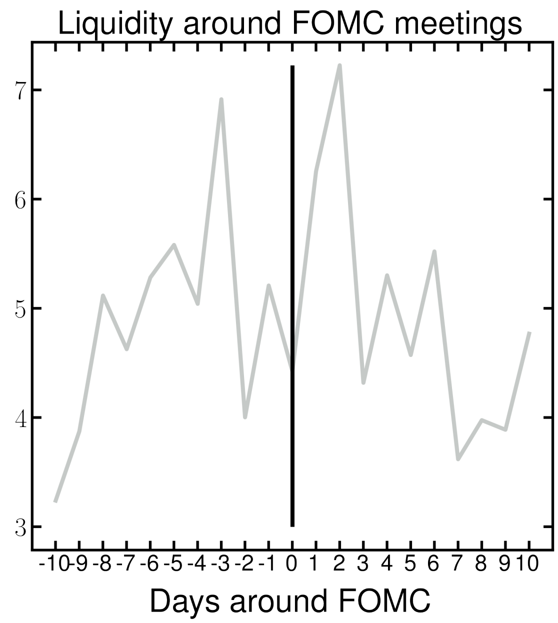


Figure 21: Daily share of the total monthly dividend futures contracts traded 10 days before and up to 10 days after the FOMC announcements.

Fourth, we also show the time series of the total number of contracts for each of the dividend swaps. Figure 22 plots the 2017 and 2018 dividend swaps contracts trading volumes. The message is the same as in the previous plot—there are spikes around FOMC announcements. We view this as suggestive evidence that investors trade around these meetings, so that we can use these prices to recover the market's expectations and risk-premium estimates.

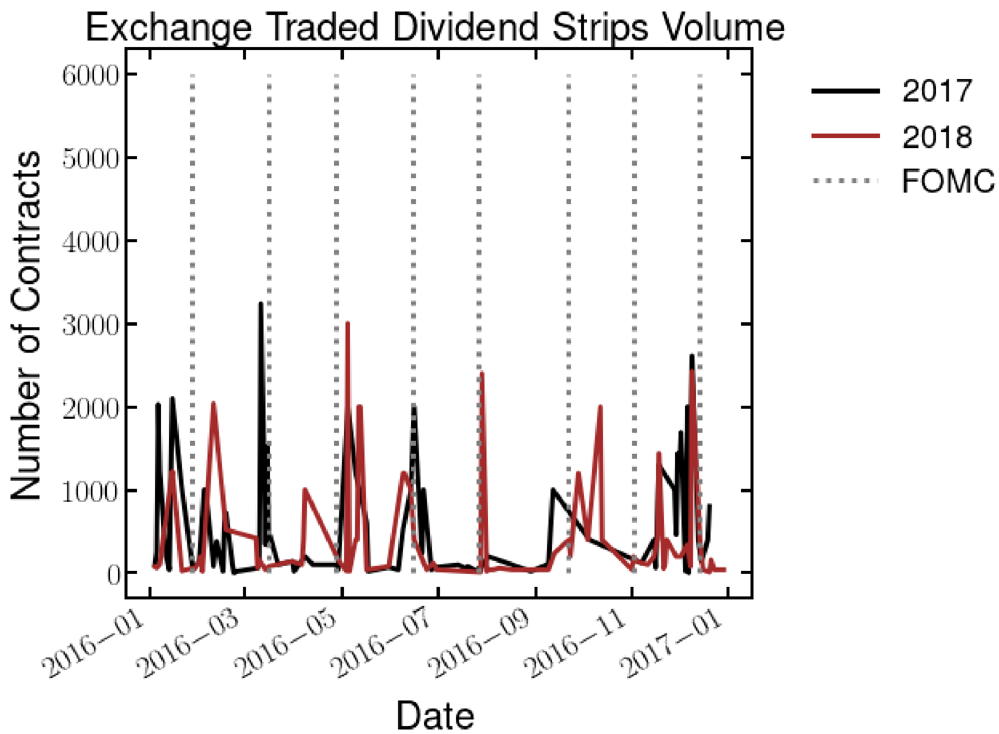


Figure 22: Daily time-series of the number of contracts traded for two different expiration maturities of dividend futures: one expiring in 2017 and another in 2018. Data are from January 2016 to January 2017. Dotted lines represent the FOMC meetings.

E Bounding Residual Dividend Claim Response

We can approximate the residual dividend claim beyond the observed data. Using (16), we can define the return on the non-observed dividend residual claim as the following:

$$\left(1 - \sum_{n=1}^{9} w_{t-1,n}\right) R_t^{res} := R_t^M - \sum_{n=1}^{9} w_{t-1,n} R_{t,n}^F - \sum_{n=1}^{\infty} w_{t-1,n} R_{t,n}^B \tag{23}$$

The last term in (23), the portfolio of bonds, poses a problem since it is also non-observed. To deal with this, we will approximate it with a zero-coupon bond of fixed maturity. This is justified on the grounds that, as estimated in van Binsbergen (2020), the duration of the stock market can be bounded to be between 14 and 28 years. Concretely, we estimate the residual claim duration, H_t, for different market duration assumptions, D.

$$\hat{R}^{res}_{t,H_t} = \frac{1}{\hat{w}_{t-1,H}} \left(R^M_t - \sum_{n=1}^{9} w_{t-1,n} R^F_{t,n} - \sum_{n=1}^{9} w_{t-1,n} R^B_{t,n} - \hat{w}_{t-1,H} R^B_{t,H_t} \right) \tag{24}$$

$$H_t \text{ such that } \hat{w}_{t-1,H} H_t + 2 \sum_{n=1}^{9} w_{t-1,n} n = D, \; D = 14, \ldots, 28 \tag{25}$$

$$\hat{w}_{t-1,H} = 1 - \sum_{n=1}^{9} w_{t-1,n} \tag{26}$$

Figure 23 shows the contribution of the residual claim to the aggregate effect on the market for the different implied residual durations, H_t. Therefore, this is an extension of the left panel of Figure 7, but focusing only on the unobserved portion of the dividend portfolio. In Appendix E.1, we show the results when we map the residual results back to the forward equity yields dimension.

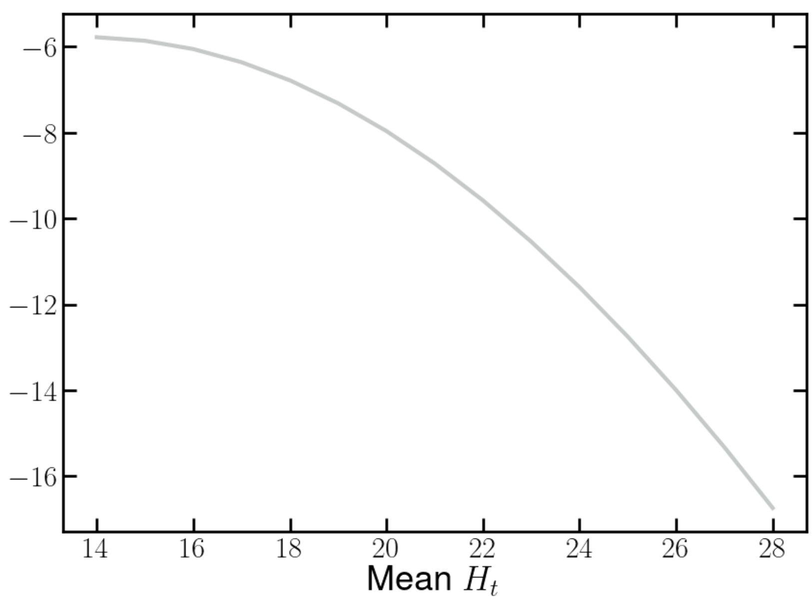


Figure 23: Decomposition of the effects of monetary policy shocks, f_t, on the residual dividend futures portfolio for different implied duration H_t. We run the regression $\Delta \hat{R}^{res}_{t,H_t} = \alpha^{res}_j + \beta^{res}_j f_t + \epsilon^{res}_t$ and multiply by the average weight of the residual maturity, $\hat{w}_{t-1,H} = 1 - \sum_{n=1}^{9} w_{t-1,n}$, to calculate the impact on the market.

Overall, the effect of monetary policy shocks on the residual dividend portfolio monotonically decreases with the implied duration H_t. Even for the lowest possible residual duration, the impact on the market would be around 570bps, and therefore only around 30bps would be due to the residual bond portfolio. To sum up, around 75% of the total effect on the market would be due to the residual, long-term dividend portfolio.

Since long-term forward equity yields are not driven by changes in expected growth, changes in risk premia are the main channel in play following FOMC announcements. Therefore, we confirm the result of Bernanke and Kuttner (2005) that most market movements following monetary policy shocks are due to risk premia. On top of that, we add that long-term dividend risk premia are the most important channel.

E.1 Revisiting the Residual Forward Equity Yields

We can use the map between returns and forward equity yields to calculate the impact of monetary policy on the residual forward equity yields.

In Figure 24 we plot an extension of Panel B of Figure 3, but only focusing on the residual forward equity yield for different values of implied residual duration of the dividend portfolio H_t, along with 95% confidence interval bands and for different duration assumptions. The magnitude is slightly smaller than what we estimated for the nine-year maturity—here a 100bps shock to the interest rate increases the residual claim forward equity yield by around 40–60bps. These effects, though, are still substantial, especially given that they are compounded by the estimated duration of the claim (as per equation (25), which, as we see from the x-axis in each graph, varies from 15 years to 32.5 years). This would also imply that the impact on the term structure of forward equity yields is positive when including frequencies beyond nine years.

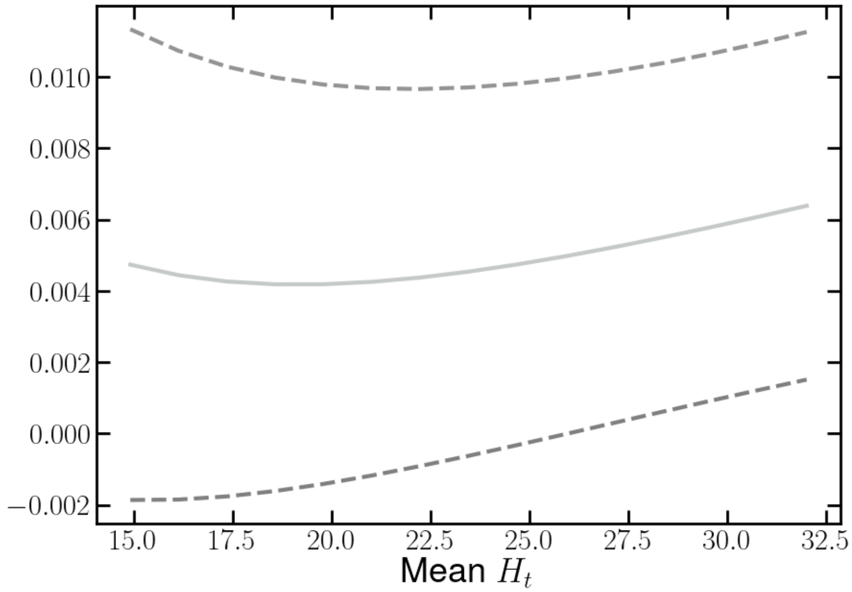


Figure 24: Effects of monetary policy shocks on the residual claim forward equity yield of the market after taking into account all the observed dividend strips. We show the results for different numbers of average duration of the residual claim H_t.

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