Exposure to Interest Rate Risk around Monetary Policy Announcements

Masayuki Okada*

September 29, 2023

Abstract

This paper tests a risk-based hypothesis of high excess returns around FOMC announcements. By announcing its decision on interest rates, FOMC resolves the interest rate uncertainty, but different assets have different exposures to it based on their durations. As the duration of an asset increases, its returns become more sensitive to both realized change and ex-ante interest rate uncertainty. Short-duration assets are less exposed to interest rate uncertainty since they receive their cash flows earlier, while long-duration assets are more exposed to uncertainty about interest rates. This relationship is applicable to both bonds and equities. The high excess returns on bonds and equities observed on FOMC announcement days are driven by interest rate uncertainty, which has been overlooked in previous research that has mainly focused on cash flow uncertainty.

1 Introduction

Monetary policy announcements are among the most important news for investors. They are typically released according to a set schedule. Due to Federal Reserve policy, Federal Open Market Committee (FOMC) participants are restricted from speaking publicly ten days before the FOMC

*Ph.D. student at New York University. Email: mo2192@nyu.edu. I thank, Kosuke Aoki, Jaroslav Borovička, Kei Ikegami, Teramoto Kazuhiro, Ricardo Lagos, Sydney Ludvigson, Martin Rotemberg, and Kenji Wada for helpful comments and suggestions.

meeting, creating uncertainty among investors about the content of monetary policy announcement. Since monetary policy has an impact on asset prices and investors face significant uncertainty about future asset prices before the announcements, risk-averse investors will likely demand a premium to hold assets during this period. In fact, stock market returns are significantly higher on the days of monetary policy announcements than on the other days (Savor and Wilson (2013), Lucca and Moench (2015), Ai and Bansal (2018)).The average daily return of the S&P 500 index is eight times higher on FOMC days (23.9 bps) than on non-FOMC days (3.1 bps).

A risk-based hypothesis explains the high excess return of stock observed on FOMC announcement days. Risk averse investors, who will be exposed to a higher degree of risk, demand a higher return before the announcement. To support this risk-based hypothesis about high return on announcement days, the cross-sectional heterogeneity of stocks is examined (Savor and Wilson (2014), Wachter and Zhu (2022), Ai et al. (2022)). Monetary policy announcements contain information about risks, and different stocks are heterogeneously exposed to the risks revealed by the announcements. Stocks with higher exposure on announcement days should be predictably higher than the return on less exposed equity. Savor and Wilson (2014) show that the expected return-beta relationship implied by the CAPM holds up well on macroeconomic announcement days.

A crucial question in this context is what type of uncertainty investors face before FOMC announcements and which stocks are more exposed to the monetary policy announcements. First, what type of uncertainty is resolved by the FOMC? Wachter and Zhu (2022) assume that macroeconomic announcements, including the FOMC, reveal the probability of a disaster that is about to occur in the economy. Ai et al. (2022) argue that FOMC announcements reveal information about the central bank's target rate of economic growth. However, it is reasonable to assume that monetary policy announcements have the most significant impact on uncertainty about the policy rate even though this type of uncertainty has been less studied. Second, what kind of assets are more exposed to monetary policy announcements and why are they more exposed? To the best of my knowledge, the literature makes an ad hoc assumption that there exists heterogeneity in the exposure of asset returns to monetary policy announcements, and it lacks a clear interpretation of the source of heterogeneity in monetary policy exposure.[1]. This paper analyzes the source of heterogeneity

[1] The only exception is Ai et al. (2022). They demonstrate that expected option-implied variance reduction measures the sensitivity of stock returns to monetary policy announcements. to monetary policy announcements. However, they

in monetary policy risk and gives a clearer interpretation of what drives the heterogeneity in the exposure to monetary policy announcements.

This study presents a novel approach to understanding 1. the type of risks and 2. the source of heterogeneity in exposure to in the monetary policy announcements. The main hypothesis is that 1. monetary policy announcements alleviate interest rate risk and 2. equity duration is the primary source of exposure heterogeneity. First, interest rate risk, as the main uncertainty resolved by monetary policy, is motivated by recent literature on the measurement of interest rate riks around monetary policy announcements(Lakdawala et al. (2021), Bauer et al. (2022)). The study observes a significant reduction in option-implied volatility of the Eurodollar future after monetary policy announcements, indicating a direct impact on interest rate risk. It is worth noting that while monetary policy announcements address various macroeconomic uncertainties, they primarily alleviate interest rate risk.

Second, equities of different durations are expected to demand varying excess returns when faced with interest-rate risk that leads to the heterogeneity in the risk exposure to interest rate risk. Specifically, in the event of an unanticipated rise in interest rates, investors tend to devalue long-duration equities more, discounting future returns. Conversely, when the central bank surprises by announcing a rate cut, investors highly value long-duration equities. Short-duration stocks, on the other hand, are less sensitive to interest rates because they pay more in the near term. Duration of assets can explain the heterogeneity in the exposure to interest rate risk.

I develop a simple asset pricing model that captures the risks associated with monetary policy announcements. A representative investor faces uncertainty regarding the monetary policy announcement. An announcement resolves two types of risks: the uncertainty about the cash flow and the uncertainty about the discount rates. The central bank initially declares the short-term interest rate, which the investor uses as a discount factor. Uncertainty about the discount rate is resolved by monetary policy announcements. The risk of cash flow is also addressed by the central bank, and it has been studied extensively in the literature (Ai and Bansal (2018) and Wachter and Zhu (2022)). This cash flow risk can be interpreted as the ”Fed information channel” of Nakamura and Steinsson (2018). The FOMC announcement reveals private information about its monetary target, which affects future economic growth. Since an investor does not know the hidden informa-

do not explain why some stocks have higher expected variance reduction on announcement days than other stocks.

tion about future economic growth before announcements, a premium is required to hold assets on announcement days[2].

An investor can trade two types of assets: short-duration assets and long-duration assets, which have different exposures to two risks. Short-duration assets provide a consumption claim in the near future while long-duration assets provide the claim in the distant future, making the latter more sensitive to the discount rate. Long-duration assets are more exposed to uncertainty about the discount rate. The price of long-duration assets should rise more when uncertainty about the discount rate is removed. Conversely, short-duration assets are more exposed to uncertainty regarding the cash flow. Monetary policy announcements have a transitory effect on cash flow and have no effect on cash flow in the distant future. Therefore, short-duration assets are more exposed to uncertainty about cash flow.

There are three theoretical predictions for the expected price changes on FOMC days for short-duration and long-duration assets. First, when uncertainty about the discount rate is more significant than uncertainty about cash flow, the expected price increase for long-duration stocks is greater than that for short-duration stocks. Conversely, the price increase for short-duration stocks is higher when uncertainty about the cash flow is greater than uncertainty about discount rate. For bonds, the return on long-duration bonds should be higher than that of short-duration bonds, as only the discount rate matters and bonds do not involve cash flow uncertainty. Second, when an announcement reduces uncertainty about the interest rate, the return on long-duration assets increases more than that of short-duration assets, as long-duration assets are more exposed to uncertainty about discount rates. Finally, when ex-ante uncertainty about the interest rate is high, the return on long-duration assets is higher than the return on short-duration assets.

I empirically test the three theoretical predictions for bonds and stocks. The duration of bonds is well defined using zero coupon bond yield data (Liu and Wu (2021)). The duration of equity is measured by the cash flow of firms based on Weber (2018). Firms with high earnings growth and low book value growth are defined as long-duration firms. The option implied volatility of the Eurodollar future is used as the interest rate uncertainty data (Bauer et al. (2022)).

The empirical results are consistent with the theoretical predictions. First, Treasury securities

[2] Another interpretation is that monetary policy has an impact on risk premium as extensively studied in the literature including Hanson and Stein (2015) and Miranda-Agrippino and Rey (2020).

with a maturity of 1 year have an average return of 0.7 bps, while those with a maturity of 20 years have a return of 10.0 bps on monetary policy announcement days. These empirical findings align with the theoretical results, which suggest that bonds are more exposed to discount rate uncertainty than to cash flow uncertainty, and that monetary policy announcements resolve the discount rate uncertainty. The return on long-maturity bonds tends to be higher. For stocks, stocks have an average return of 21.0 basis points with a maturity of 14 years and 18.7 basis points with a maturity of 22 years. The average return on short-duration and long-duration stocks are statistically indistinguishable. This implies that interest rate risk that has been overlooked in the literature is equally important as cash flow risk which is emphasized in the existing literature.

Second, I empirically the sensitivity of returns to a decline in interest rate uncertainty increases with duration for both bonds and stocks as suggested by the theoretical prediction. For stocks with a duration of 25 years, the elasticity of the return to interest rate uncertainty is 12.2, meaning the return increases by 12.2 percentage points when interest rate uncertainty decreases by 1% on announcement days. The elasticity for stocks with a duration of 7 years is lower at 8.0, indicating a considerably less responsive effect than that of long-duration equities. For bonds, the elasticity is 6.8 for 10-year maturities and 9.3 for 20-year maturities, indicating that the elasticity of long-duration bonds is higher than that of short-duration bonds.

The second empirical result contrasts with the first result. For both bonds and stocks, the elasticity of return to changes in interest rate uncertainty increases with duration. This is because the structure of discounting future cash flows is the same for both bonds and stocks. However, the first results show that the average return on FOMC days has a different term structure for bonds and equities. While stocks are exposed to cash flow uncertainty, bonds are not. Short-dated stocks are, on average, more exposed to monetary policy announcements.

Finally, the sensitivity of returns to a decline in interest rate uncertainty increases with duration. This holds true for both bonds and stocks. The elasticity of the return on stocks with a duration of 25 years to interest rate uncertainty is 1.37, which implies that the return increases by 1.37 percentage points when ex-ante interest rate uncertainty increases by 1% prior to the announcement days. For stocks with a duration of 7 years, the elasticity is 0.95. For bonds, the elasticity is 0.65 for a 10-year maturity and 1.45 for a 20-year maturity. The predicted return is higher for long-maturity bonds.

Related Literature

This paper relates to four strands of literature.

First, this paper relates to the literature on macro announcement premiums. Savor and Wilson (2013) find that there is a high excess return of stocks and bonds on the days of macro announcements, which can be explained by risks. Brusa et al. (2020) confirmed this in many countries. Savor and Wilson (2014) show that the CAPM holds up well on announcement days. Lucca and Moench (2015) find that a high excess return is driven by a pre-announcement drift on FOMC announcement days. Neuhierl and Weber (2018) show that the return drift depends on whether monetary policy is expansionary or contractionary. Cieslak et al. (2019) provide evidence on the stock market cycle over the FOMC announcement. Mueller et al. (2017) document that a trading strategy that short the US dollar and long other currencies has significantly larger excess returns around FOMC announcements. Indriawan et al. (2021) find a significant pre-announcement drift in the markets for government bonds. Wachter and Zhu (2022) shows that the excess return on announcement days is higher for long-maturity bonds.

Since the emergence of empirical evidence in the above papers, the theoretical literature has developed a model for the macroeconomic announcement premium. Ai and Bansal (2018) provide a revealed preference theory for the announcement premium. Wachter and Zhu (2022) show a model based on rare disasters and the success of the CAPM model on announcing days. Ai et al. (2022) develop a model in which risk compensation is required because FOMC announcements reveal the Fed's private information about its interest rate target and future economic growth rate. However, this paper differs from the literature by analyzing the impact of interest rate uncertainty on the macro announcement premium, whereas the literature focuses mainly on uncertainty about future cash flow. Lucca and Moench (2015) and Hu et al. (2022) find that the excess return is higher when the uncertainty about the aggregate cash flow, as measured by the VIX, declines more on the day of the FOMC announcement. In contrast to their study, I take into account interest rate uncertainty, not aggregate stock return uncertainty measured by VIX.

The macro announcement premium literature tests a risk-based hypothesis by examining the cross-sectional heterogeneity of assets. Savor and Wilson (2014) and Wachter and Zhu (2022) show that the relationship between market beta and expected returns is stronger on announcement days. Ai et al. (2022) provides empirical evidence that a firm's expected option-implied variance reduction on announcement days strongly predicts excess returns. They all assume that the parameters governing the cross-sectional sensitivity to monetary policy are exogenous, while I provide an unambiguous interpretation of the cross-sectional sensitivity to monetary policy based on duration.

Second, this paper is in line with the literature that highlights the importance of monetary policy uncertainty. A large body of literature has examined the effect of the first-moment change in the federal funds rate in event studies[3] However, the effect of monetary policy uncertainty on stock prices is another crucial aspect of the announcement that has been overlooked by the literature that focuses solely on the first-moment change. If the commonly used measure of the first-moment change in the federal funds rate does not move, but the uncertainty perceived by the market does, there may be a rise in stock prices. The stock price change driven by the second-moment change cannot be analyzed by literature that focuses only on the first-moment change in the federal funds rate. Bundick et al. (2017) estimates the positive effects of changes in short-term uncertainty on the term premium on announcement days. Bauer et al. (2022) finds effects of uncertainty reduction on asset prices that are distinct from the effects of conventional policy surprises. Lakdawala et al. (2021) show that the change in uncertainty affects the spillovers to global bond yields. Kroencke et al. (2021) identify a change in risk appetite on FOMC announcement days and show that this measure is correlated with stock returns. Mumtaz and Zanetti (2013) examine the impact of monetary policy volatility using an SVAR that allows for a time-varying variance of the monetary policy shock. Husted et al. (2020) uses the methodology of Baker et al. (2016). They estimate the aggregate impact of shocks by constructing an index of monetary policy uncertainty based on newspaper coverage. My contribution to this strand of the literature is to relate the high excess returns on FOMC announcement days to a measure of monetary policy uncertainty. The literature examines the causal impact of monetary policy uncertainty on financial and macroeconomic variables. The measure of monetary policy uncertainty is used for the first time to test the relationship with high excess returns on FOMC announcement days.

Third, my paper relates to the literature that studies the heterogeneous impact of monetary policy shocks on firm-level equity. Firm-level characteristics are associated with a heterogeneous

[3] See, e.g., Kuttner (2001), Bernanke and Kuttner (2005), Gürkaynak et al. (2004), Gertler and Karadi (2015), Hanson and Stein (2015), Nakamura and Steinsson (2018).

stock market response to monetary policy. Bernanke and Kuttner (2005) show that the response of stock returns varies across industries. Ippolito et al. (2018) find that stock prices of bank-dependent firms are more responsive to changes in the federal funds rate. Ozdagli (2018) and Chava and Hsu (2020) study the relationship between financially constrained firms and the return response after a monetary policy shock. Lagos and Zhang (2020) shows heterogeneity in stock turnover liquidity as a novel mechanism of monetary policy. Gürkaynak et al. (2022) shows that the stock price response to monetary policy depends on the maturity of debt issued by firms. Döttling and Ratnovski (2022) find that stock prices of firms with relatively more intangible assets respond less to monetary policy. My contribution to the literature is the study of the heterogeneous effect of the second moment of the policy rate on stocks. The literature focuses mainly on the change in the first moment of the federal funds rate. The heterogeneous effect of monetary policy uncertainty on firm stock prices is studied for the first time in this paper.

The most closely related work in this area of research is that of Ozdagli and Velikov (2020). It constructs a parsimonious index of monetary policy exposure based on firm characteristics, including financial constraints, cash, and cash flow duration. Stocks whose prices are more sensitive to an expansionary monetary policy shock earn lower average returns. Using the second moment of the interest rate instead of the first moment used in Ozdagli and Velikov (2020), I demonstrate that monetary policy exposure increases with cash flow duration. My measure of monetary policy exposure is closely tied to the monetary policy announcement premium.

Fourth, my paper relates to the literature on the term structure of equity (Dechow et al. (2004), Lettau and Wachter (2007), Lettau and Wachter (2011), Van Binsbergen et al. (2012), Weber (2018), Mohrschladt and Nolte (2018), Gonçalves (2021), and Chen (2022)). A downward-sloping term structure of stock returns is observed. Van Binsbergen et al. (2012) use options data and show that short-term dividend strips have high excess returns. Dechow et al. (2004) and Weber (2018) use earnings, market capitalization, and a book value of equity to estimate the time series of future firm cash flows. This paper also finds that the term structure of stock returns on FOMC days is downward sloping but less steep than returns on non-FOMC days.

2 Cross-sectional heterogeneity in exposure to monetary policy

This section shows cross-sectional heterogeneity in risk exposure of S&P500 firms to monetary policy announcements. Table 1 shows the heterogeneity in returns on FOMC days for these firms. Daily data on stock returns are used for this analysis. First, I construct a time series average of returns on FOMC days for the 500 firms over the sample period. Next, I rank firms into five groups based on the time-series average return from low to high. The mean and standard deviation of daily returns on FOMC and non-FOMC days within each group are reported in Table 1. The results indicate that there is a significant difference in FOMC day returns across the five groups, with the highest group experiencing an average return of 59.1 bps and the lowest group experiencing an average return of 2.6 bps. Although FOMC day returns are significantly heterogeneous, non-FOMC day returns are similar across all five groups, suggesting significant heterogeneity in exposure to monetary policy announcements.

Savor and Wilson (2013) and Lucca and Moench (2015) find that the return of the S&P 500 Index is significantly higher on FOMC days. The return on the S%P 500 on FOMC days is 23.9 basis points. Table 1 indicates that the high return is not universal among the 500 companies, but rather driven by groups 4 and 5. The reason for the difference between these groups is explored in section 3 through the presentation of a theoretical framework.

3 Theory

In this section, I show a simple model to explain high return round announcements based on Ai and Bansal (2018).

There is a representative investor with four periods. Periods 1 and 2 are trading periods. Periods 2, 3, and 4 are consumption periods. The investor trades two types of assets: long-duration stocks and short-duration stocks. The short-duration stock gives a claim of consumption in period 3, while the long-duration stock gives a claim in period 4.

An investor in period 1 faces two sources of uncertainty: the discount rate and the cash flow of short-duration equity. The investor does not know the state of the economy in period 1. She believes that the cash flow of short-duration equity is high ($X^{S,h}$) with probability $(1-\pi)\alpha_2$ and

Table 1: Cross-sectional heterogeneity in monetary policy exposure

	S&P500	Group				
	Index	1	2	3	4	5
Mean on FOMC	23.9	2.6	17.1	26.7	36.4	59.1
Mean on Non-FOMC	3.1	6.5	6.4	6.9	6.7	8.3
SD on FOMC	114	239	223	258	283	350
SD on Non-FOMC	113	228	214	241	271	330

Note: "Mean on FOMC" is the average stock return on FOMC day. "Mean on Non-FOMC" is the average return of stock excluding FOMC day. "SD" denotes the standard deviation. The categorization of firms is based on the average return on FOMC day, computed by taking the time-series average of returns on FOMC days for each of the 500 firms. The firms are then assigned ranks from one to five, based on the time-series average, and the average returns on FOMC days and Non-FOMC days are calculated for each group. "S&P500 Index" is the daily index return. Sample period: 1990/01/02-2022/03/31. Sample uses S&P 500 firms. Returns are expressed in basis points.

the cash flow is low ($X^{S,l}$) with probability $(1-\pi)(1-\alpha_2)$. The discount rate is high (β^h) with $\pi\alpha_1$ and the discount rate is low (β^l) with $\pi(1-\alpha_1)$. At the beginning of period 2, announcements are made to reveal the state of the economy (s_1, s_2, s_3, s_4). Agents know the state of the economy in periods 3 and 4. It is important to note that an investor does not face any uncertainty about the return on long-run equity.

In the first period, the market for assets opens, where short-duration equity is traded at a price of P_1^S and long-duration equity is traded at P_1^L. The second asset market opens in period 2 after the announcement resolves the uncertainty. In periods 3 and 4, the investor consumes the return on investment, with consumption financed solely by stocks.

The equilibrium condition is that aggregate consumption is exogenously given. Consumption in period 2 cannot depend on the state s. Then prices are determined.

There are two points to highlight. Firstly, why does an investor face uncertainty regarding the discount rate? This can be understood by taking into account the announcement of the risk-free short-term interest rate by the central bank. The risk-free rate is used by investors to discount future

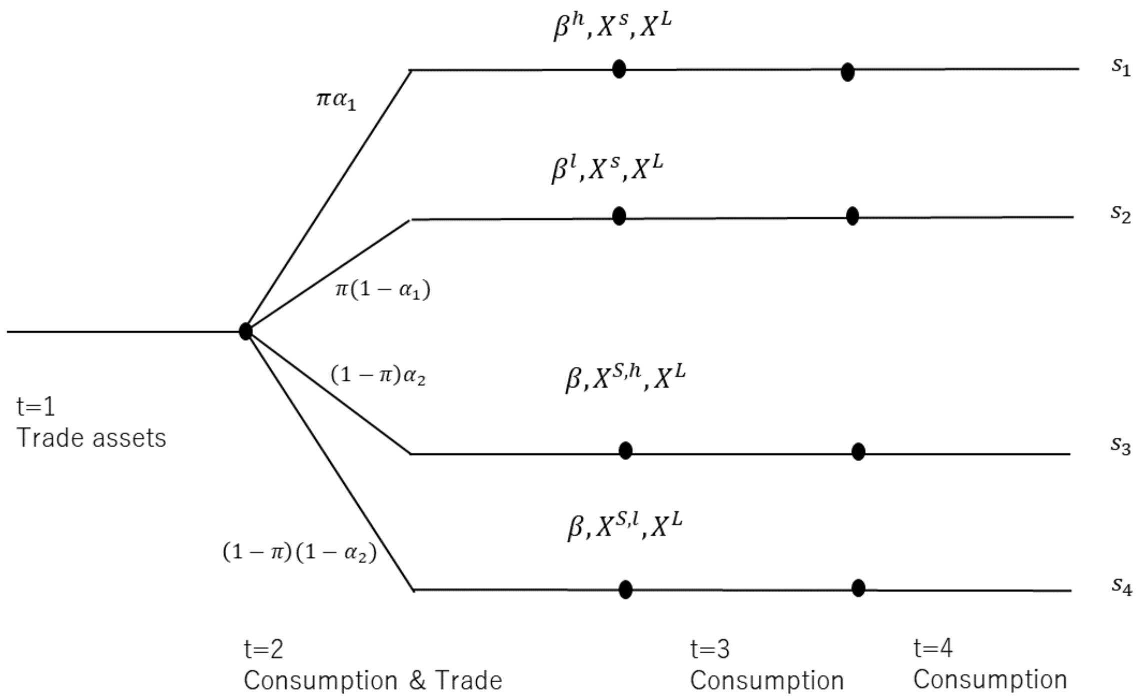

Figure 1: Model Overview

cash flows since it represents a payoff without risk. Before the announcement of the risk-free rate, investors are uncertain about it, and, therefore, uncertain about how to discount the future.[4]

More importantly, it is assumed that only the uncertainty about the return on short-duration equity is resolved through an announcement, while uncertainty about long-run equity remains unresolved, resulting in a return of X^L in all states. The reason for resolving only the uncertainty about the return on short-duration equity is that monetary policy's effects are often temporary in empirical analyses (Christiano et al. (2005), Ramey (2016)). It is reasonable to assume that the central bank announcement contains no information about the distant future return but some information about the near future return. Therefore, before the central bank announces, an investor faces uncertainty about the return on short-term equity that is resolved by the announcement.

[4]This argument assumes that the real interest rate is equal to the nominal interest rate. Recent literature shows that the long-term real interest rate varies in response to monetary policy. See Hanson and Stein (2015) and Bianchi et al. (2022).

Figure 1 shows an overview of the model. The investor maximizes

$$\max_{\theta_1^S,\theta_1^L,\theta_2^S,\theta_2^L} \quad \left\{ E_1 \left[\left(C_2(s)^{1-\frac{1}{\psi}} + \beta(s) V_3(s)^{1-\frac{1}{\psi}} \right)^{\frac{1-\gamma}{1-\frac{1}{\psi}}} \right] \right\}^{\frac{1}{1-\gamma}}$$

$$V_3(s) = \left[C_3(s)^{1-\frac{1}{\psi}} + \beta(s) C_4(s)^{1-\frac{1}{\psi}} \right]^{\frac{1}{1-\frac{1}{\psi}}}$$

such that

$$\begin{aligned}
e &= P_1^L \theta_1^L + P_1^S \theta_1^S + S_1, \\
S_1 &= C_2(s) + P_2^L(s)\theta_2^L(s) + P_2^S(s)\theta_2^S(s), \quad s \in \{s_1, s_2, s_3, s_4\} \\
C_3(s) &= X^S(s)(\theta_1^S + \theta_2^S(s)), \quad s \in \{s_1, s_2, s_3, s_4\} \\
C_4(s) &= X^L(\theta_1^L + \theta_2^L(s)), \quad s \in \{s_1, s_2, s_3, s_4\}
\end{aligned}$$

In period 2, the announcement reveals the state. Thus, the asset price is given by the CRRA case. Consumption in period 2 does not depend on the state due to the market clearing condition.

$$P_2^S(s_i) = \beta(s_i) \left(\frac{C_3(s_i)}{C_2} \right)^{-\frac{1}{\psi}} X^S(s_i), \quad s_i \in \{s_1, s_2, s_3, s_4\}$$

$$P_2^L(s_i) = \beta^2(s_i) \left(\frac{C_4(s_i)}{C_2} \right)^{-\frac{1}{\psi}} X^L, \quad s_i \in \{s_1, s_2, s_3, s_4\}$$

The prices in period 1 are given by

$$P_1^S = \frac{E_1 \left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s) V_3(s)^{1-\frac{1}{\psi}} \right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} \beta(s) C_3(s)^{-\frac{1}{\psi}} X^S(s) \right]}{E_1 \left[\left(C_2^{1-\frac{1}{\psi}} + \beta(s) V_3(s)^{1-\frac{1}{\psi}} \right)^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} \right] C_2^{-\frac{1}{\psi}}}$$

$$P_1^L = \frac{E_1 \left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s) V_3(s)^{1-\frac{1}{\psi}} \right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} \beta^2(s) C_4(s)^{-\frac{1}{\psi}} X^L \right]}{E_1 \left[\left(C_2^{1-\frac{1}{\psi}} + \beta(s) V_3(s)^{1-\frac{1}{\psi}} \right)^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} \right] C_2^{-\frac{1}{\psi}}}$$

In the CRRA case, $\frac{1}{\psi} = \gamma$, the price in period 1 is equal to the expected price in period 2. However, if risk aversion is sufficiently high, the price rises on average after the announcement.

Proposition 1. *The expected price in period 2 is higher than the price in period 1 for short- and long-duration stock if and only if* $\gamma > \frac{1}{\psi}$.

$$P_1^S < E_1[P_3^S(s)], \quad P_1^L < E_1[P_3^L(s)],$$

Proof. See Appendix A.1. □

The intuition is as follows. The pre-announcement price is calculated using the pessimistic probability that overweights a low-utility state and underweights a high-utility state. This is clear from

$$\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}$$

is decreasing with state if $\gamma > \frac{1}{\psi}$ holds. The higher the utility state ($C_4(s)$), the more an investor discounts the states. The investor gives more weight to low states with lower returns and less weight to high states with higher returns. Therefore, the pre-announcement price is low.

When the utility function is separable ($\gamma = \frac{1}{\psi}$), the announcement premium is equal to one. The prices of pre-announcement and post-announcement are

$$P_2^S(s) = \beta(s)\left(\frac{C_3(s)}{C_2}\right)^{-\frac{1}{\psi}} X^S(s)$$

$$P_1^S = \frac{E_1[\beta(s)C_3^{-\frac{1}{\psi}}(s)X^S(s)]}{C_2^{-\frac{1}{\psi}}}$$

Therefore,

$$E_1\left[\frac{P_2^S(s)}{P_1^S}\right] = 1$$

holds.

In the following analysis, I assume there is no consumption growth, $C_3(s_i) = C_4(s_i)$, for $s_i \in \{s_1, s_2, s_3, s_4\}$, and the return of long-duration equity is the same as the return of short-duration equity when return is not announced,

$$X^S = X^L \equiv \overline{X}.$$

Also, I assume that the average of high return and low return is equal to the return when nothing is announced.

$$\beta^h = \beta\left(1+\sigma_1\left(\frac{1}{\alpha_1}-1\right)\right),$$
$$\beta^l = \beta\left(1-\sigma_1\right),$$
$$X^{S,h} = \overline{X}\left(1+\sigma_2\left(\frac{1}{\alpha_2}-1\right)\right),$$
$$X^{S,l} = \overline{X}\left(1-\sigma_2\right),$$

where σ_1 and σ_2 represents a dispersion.

3.1 Bond

In this section, theoretical predictions are presented for the case where the probability of revealing the discount rate is equal to one, which is equivalent to bonds. The return on the bond is fixed after the announcement, and hence the bond can be viewed as having no return volatility, $\pi = 1$. In this limiting case, the average announcement premium of a bond with a long maturity is higher than that of a bond with a short maturity.

Proposition 2. *The average announcement premium of a long-maturity bond is higher than that of a short-maturity bond if and only if* $\gamma > \frac{1}{\psi}$.

$$E_1\left[\frac{P_2(s)^L}{P_1^L}\right] > E_1\left[\frac{P_2(s)^S}{P_1^S}\right].$$

Proof. The announcement premium of long-maturity bonds and short-maturity bonds is given by

$$\begin{aligned} & E_1\left[\frac{P_2(s)^S}{P_1^S}\right] - E_1\left[\frac{P_2(s)^L}{P_1^L}\right] \\ & = \alpha_1(1-\alpha_1)\beta^l\beta^h C(s_1)^{-\frac{1}{\psi}} C(s_2)^{-\frac{1}{\psi}}\overline{X}^2 \\ & \times \left(\left[C_2^{1-\frac{1}{\psi}} + \beta(s_1)V_3(s_1)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} - \left[C_2^{1-\frac{1}{\psi}} + \beta(s_2)V_3(s_2)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\right)(\beta^h - \beta^l) \end{aligned}$$

The average announcement premium of a long-maturity bond is higher than that of a short-maturity bond. Note that

$$\left[C_2^{1-\frac{1}{\psi}} + \beta(s_1)V_3(s_1)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} - \left[C_2^{1-\frac{1}{\psi}} + \beta(s_2)V_3(s_2)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}$$

is negative if and only if $\gamma > \frac{1}{\psi}$. □

Intuitively, the discount factor is only the source of uncertainty for bonds. Long-maturity bonds are more exposed to monetary policy announcements. If $\gamma < \frac{1}{\psi}$ holds, the investor gives more weight to good states and less weight to bad states. The announcement premium of both bond maturities is less than one because assets are less exposed after the announcement. Since the long-maturity bond is a riskier asset, the price of the long-maturity bond falls more than the price of the short-dated bond.

The impact of volatility on the premium is also larger for a long-maturity bond.

Proposition 3. *Consider the volatility of discount factor increases keeping $\beta^h \beta^l$ constant. The announcement premium of a long-maturity bond increases more than that of short maturity bond if and only if $\gamma > \frac{1}{\psi}$*

$$\frac{\partial E_1\left[P_2^L(s)/P_1^L\right]}{\partial(\beta^h - \beta^l)} > \frac{\partial E_1\left[P_2^S(s)/P_1^S\right]}{\partial(\beta^h - \beta^l)}$$

Proof. The announcement premium of long-maturity bonds and short-maturity bonds is given by

$$\begin{aligned}
&E_1\left[\frac{P_2(s)^S}{P_1^S}\right] - E_1\left[\frac{P_2(s)^L}{P_1^L}\right] \\
&= \alpha_1(1-\alpha_1)\beta^l\beta^h C(s_1)^{-\frac{1}{\psi}} C(s_2)^{-\frac{1}{\psi}} \overline{X}^2 \\
&\times \left(\left[C_2^{1-\frac{1}{\psi}} + \beta(s_1)V_3(s_1)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} - \left[C_2^{1-\frac{1}{\psi}} + \beta(s_2)V_3(s_2)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\right)(\beta^h - \beta^l) > 0
\end{aligned}$$

The last inequality holds because

$$\left[C_2^{1-\frac{1}{\psi}} + \beta(s_1)V_3(s_1)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} - \left[C_2^{1-\frac{1}{\psi}} + \beta(s_2)V_3(s_2)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}$$

is negative if and only if $\gamma > \frac{1}{\psi}$. $\square$

3.2 Equity

This section provides theoretical predictions for equity, which is characterized by $\pi < 1$. This means that a central bank announcement reveals information about the future cash flow, which is uncertain before the announcements. The analysis compares the announcement premium of short-duration equity and long-duration equity.

$$E_1\left[\frac{P_2(s)^S}{P_1^S}\right] - E_1\left[\frac{P_2(s)^L}{P_1^L}\right]$$

The sign of the difference between the announcement premiums of short-duration equity and long-duration equity depends on the values of the parameters. While there is an analytical expression for this difference, determining whether the premium for long-duration equity is higher or lower than that for short-duration equity cannot be done through simple conditions. To illustrate numerically, I present figures 2 through 5, which show the difference between $E_1\left[\frac{P_2^S(s)}{P_1^S}\right]$ and $E_1\left[\frac{P_2^L(s)}{P_1^L}\right]$, with each line representing a contour. The figures demonstrate the parameter values for which the premium is higher for short-duration equity.

In summary, when σ_1 is low, σ_2 is high and π is low, the premium of short duration is higher. Figure 2 shows the relationship between the volatility of the return (σ_2) and the volatility of the discount rate (σ_1). The premium of short-duration equity is high when return volatility is high and discount rate volatility is low. The volatility of return measures the exposure of short-duration stocks to an announcement. Long-duration equity exposure is measured by discounted volatility.

Figure 3 shows the relationship between discount rate volatility (σ_1) and discount rate disclosure probability (π). The premium of short-term equity is higher when π is low. The argument of Theorem 4 provides intuition for this.

Figure 4 displays a contour depicting the relationship between the discount rate volatility and the degree of risk aversion (γ). The premium for short-duration equity increases as the level of risk aversion increases, given that the volatility of the discount rate is low. Intuitively, when the volatility of the discount rate is low, the premium for short-duration equity exceeds that of long-duration equity. The risk aversion amplifies the differences between premiums, leading to an increase in the premium for short-duration equity. Conversely, when the volatility of the discount rate is high, the premium for long-duration equity increases with risk aversion since the premium for long-duration equity is higher.

Figure 5 shows the relationship between the volatility of the discount rate (σ_1) and the volatility of aggregate consumption [5]. Figure 5 is similar to 4. A bad state gets worse, and a good state gets better as aggregate consumption fluctuates more. Agents with a recursive preference overweight a bad state and underweight a good state. When the variance of aggregate consumption is high, investors overweight bad states more, resulting in the same effect as increasing the risk-averse parameter. The premium of long-duration equity is higher when the volatility of the discount rate is

[5] This is given by $C_h - C_l$. I assume that $C_h \equiv C(s_1) = C(s_3) > C(s_2) = C(s_4) \equiv C_l$.

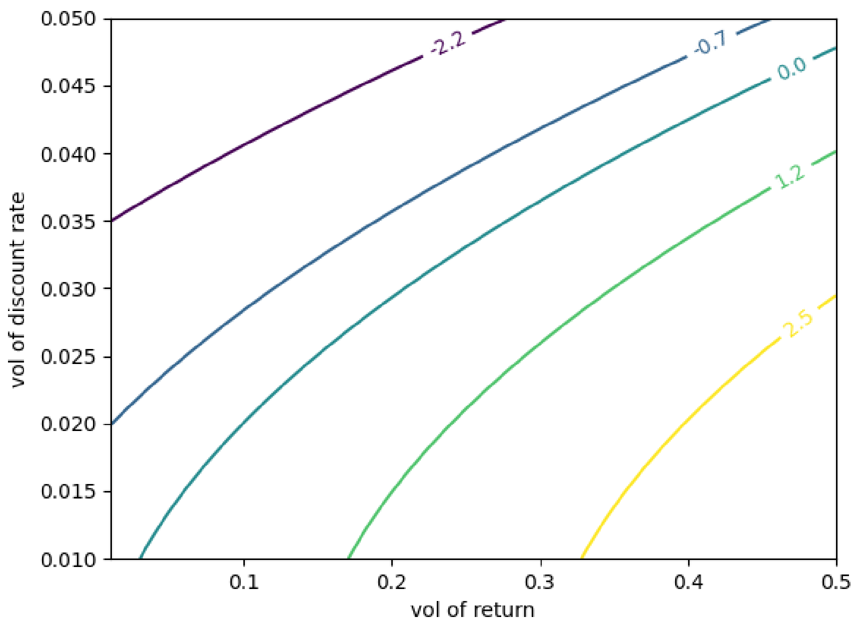

Figure 2: Numerical illustration.

high. The long-duration minus short-duration premium increases with consumption volatility. In contrast, when the volatility of the discount rate is low, the difference decreases with consumption volatility.

In summary, the announcement premium of short-duration equity can be higher or lower than that of long-duration equity. The short duration is higher when return volatility is high, risk aversion is high, consumption volatility is high, and the probability of discount rate announcement is low.

What happens when the central bank reveals more information about the discount rate? The long-duration premium increases, but the short-duration premium decreases when an announcement contains more information about the discount rate (as π increases).

Proposition 4. *As π increases, the premium of short-duration minus the premium of long-duration decreases.*

$$\frac{\partial E_1\left[\frac{P_2(s)^S}{P_1^S}\right] - E_1\left[\frac{P_2(s)^L}{P_1^L}\right]}{\partial \pi} < 0.$$

Proof. See appendix A.2. □

The intuition behind this theorem is as follows. When an announcement is about the discount

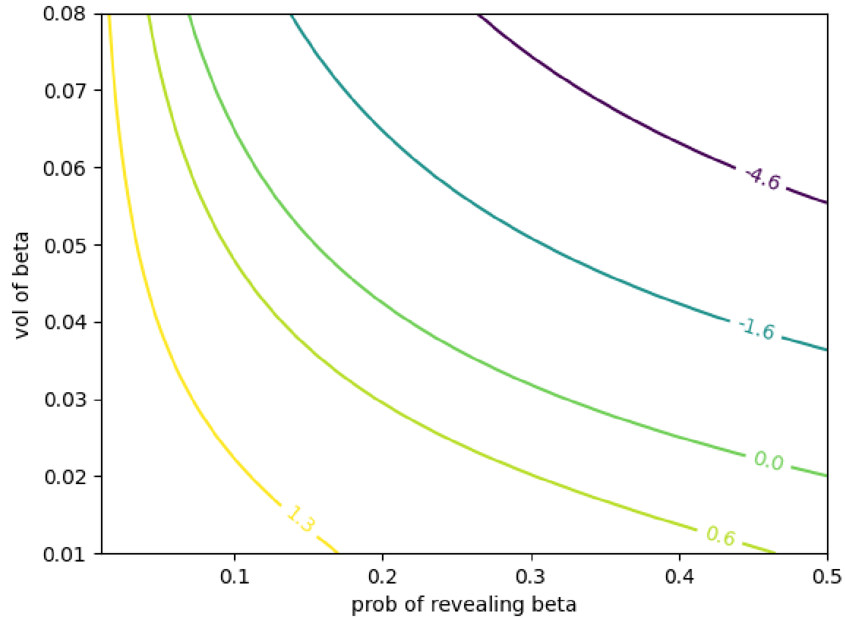

Figure 3: Numerical illustration.

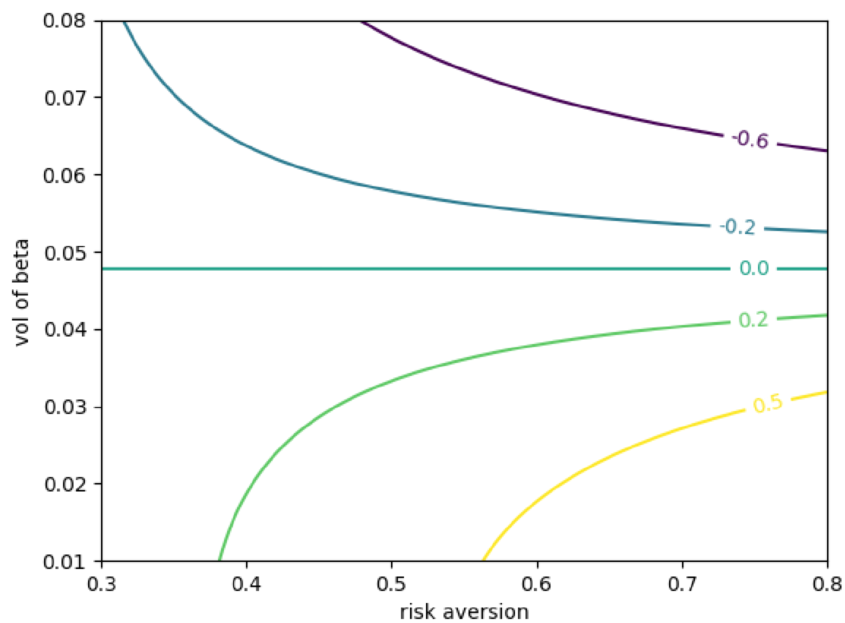

Figure 4: Numerical illustration.

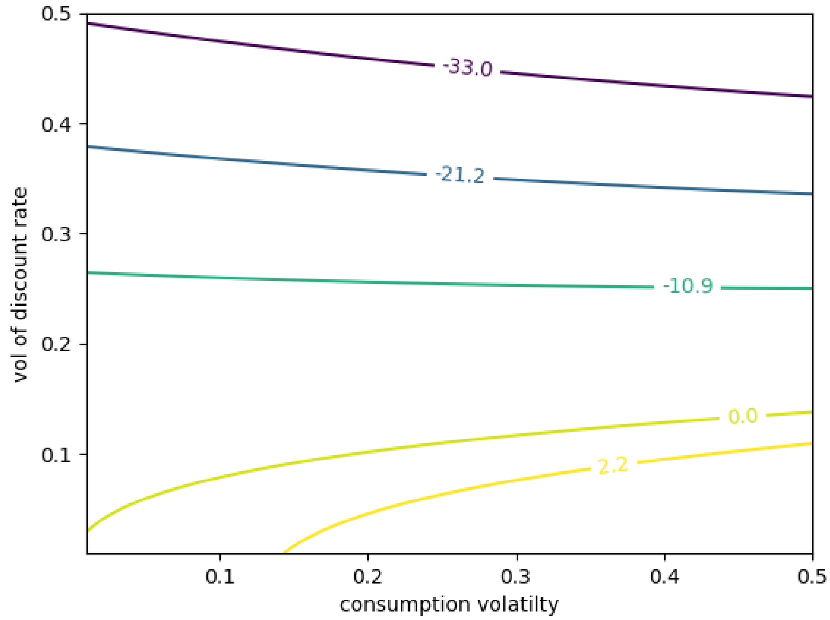

Figure 5: Numerical illustration.

rate, the premium for long duration is higher than that for short duration. When an announcement is about yield, the short-duration premium is higher. When π increases, an announcement is more likely to be about the discount rate. The long-duration premium increases with π.

Proposition 5. *As the volatility of the discount rate (σ_1) increases, the premium of short-duration minus the premium of long-duration decreases.*

$$\frac{\partial E_1\left[\frac{P_2(s)^S}{P_1^S}\right] - E_1\left[\frac{P_2(s)^L}{P_1^L}\right]}{\partial \sigma_1} < 0.$$

Proof. See Appendix A.3. □

Intuitively, when the volatility of the discount rate is large, the long-duration equity is more exposed. Its premium gets higher.

To summarize, I make three theoretical predictions for bonds and stocks. First, bonds have an upward sloping yield curve. For stocks, it can be upward-sloping or downward-sloping. It depends on the uncertainty about returns and the discount rate. Second, the price increase of long-dated assets is larger than that of short-dated assets when an announcement removes more uncertainty about the discount rate. For both bonds and stocks, this prediction holds. It is illustrated by the contemporaneous relationship between the realized change in the uncertainty level and the realized return on the asset. Finally, the price increase is larger for long-duration assets than for short-duration assets when ex ante uncertainty about the discount rate is high. This prediction holds for both bonds and equities. This relationship is predictive.

Discussion

One theory in the literature assumes that the central bank announces uncertainty about the rate of return, but I assume that uncertainty about the discount rate is also resolved. Why is this distinction important? Different types of uncertainty resolution affect the return on short- and long-term equities differently. Disclosure about the discount rate strongly affects the return on long-duration equity. Announcement about the stock return affects the return on short-duration equity more. A natural question is what is an announcement about the stock return? One interpretation is that monetary policy affects risk appetite. Prior to the announcement, an investor faces uncertainty about how much risk is being taken in the economy as a whole. They do not know the future risk premia. At the announcement, the central bank announces monetary policy and aggregate risk appetite is determined. Previous empirical research documents the significant effect of monetary policy on risk premia[6].

4 Data

The main data variables are explained in this section. Important variables are the equity duration measure, interest rate uncertainty, and equity and bond returns. The description of the data source is in Appendix B.

4.1 Equity and bond returns.

Balance sheet information is available in Compustat. The sample period is 1990Q1-2019Q4. Table 2 shows summary statistics of the samples. The daily return of equity is defined as the

[6] See Bekaert et al. (2013), Hanson and Stein (2015),Gertler and Karadi (2015), Gilchrist et al. (2015), Miranda-Agrippino and Rey (2020) among others.

$(\frac{p(t)}{p(t-1)} - 1) \times 10,000$ where $p(t)$ is the closing price of equity.

Table 2: Summary statistics

Statistic	N	Mean	Pctl(25)	Median	Pctl(75)	St. Dev.
Excess return	1,769,760	15.564	−127.523	−2.200	140.385	508.214
Duration	651,088	17.828	15.857	18.991	21.240	5.962
Size	860,854	5.152	3.328	5.085	6.951	2.541
Leverage	836,206	0.296	0.060	0.233	0.397	0.485
Profitability	775,385	0.006	0.005	0.027	0.044	0.251
Market-to-book ratio	736,996	2.198	0.775	1.137	1.940	28.473

Note: This table reports summary statistics for excess return on FOMC days and firm characteristics in data. ”Pctl(25)” and ”Pctl(75)” represent 25th and 75th percentile. The number of observations for excess return is daily and for firm characteristics is quarterly. Excess return is expressed in basis points. Duration is from Weber (2018) and expressed in years. Size is log of asset. Leverage us debt over asset. Profitability is capital income over asset. Market-to-book ratio is the sum of the market value of equity and debts as a fraction of assets.

Daily Treasury data is used as the return of bonds. Data are from Liu and Wu (2021), which constructs a yield curve using nonparametric kernel-smoothing methods. As a robustness check, appendix D.4 uses data from Gürkaynak et al. (2007). Liu and Wu (2021) provides the yield of zero coupon bonds. The price of bonds is given by $p_t(n) = \frac{1}{(Y_t(n))^n}$ where $y(n)$ is the yield of maturity n years at time t. The return of bonds on FOMC day is given by $(\frac{p_t(n)}{p_{t-1}(n)} - 1) \times 10,000$ where t is FOMC day.

4.2 The equity duration measure

Firm-level balance sheet variables are from quarterly Compustat. The measure of duration is based on cash flow (Weber, 2018). In the appendix D.1, I use the book-to-market ratio as another measure of duration.

The measure of duration in Weber (2018) is based on the timing of the cash flows. The measure is similar to Macaulay duration for bonds, which reflects the weighted average time to maturity of cash flows. Duration is defined as

$$\text{Duration}_{it} = \frac{\sum_{s=1}^{T} s \times \text{CF}_{i,t+s}/(1+r)^s}{P_{it}},$$

where Duration_{it} is the duration of firm i at time t, $\text{CF}_{i,t+s}$ is the cash flow at time $t+s$, P_{it} is the price of current equity, r is the risk-free rate. The details are described in the appendix C.1.

Which firms in the data have long durations? Cash flow is decomposed into two terms; income and change in book value[7]. When firms have higher income, cash flow becomes larger and its duration is long. When the book value of firms increases, less cash flow is distributed and its duration is short. For example, equity in the financial industry has a long duration.

4.3 Interest rate uncertainty data

The data on interest rate uncertainty comes from Bauer et al. (2022). They construct the standard deviation of the Eurodollar future one year ahead, conditional on the current information, $\sqrt{\text{Var}(\text{ED}_{t+\tau}|I_t)}$. The methodology provides a model-free estimate of the conditional standard deviation, given the prices of futures and options. The change in interest rate uncertainty is measured in the two-day window around FOMC announcements.

This measure of uncertainty is closely tied to a specific change in the Federal Reserve's forward guidance (Lakdawala et al., 2021). For example, the second largest decline occurred in August 2011. Prior to the meeting, the FOMC stated that rates would be kept low "... for an extended period". At the August meeting, the FOMC explicitly signaled that rates would remain low "at least through mid-2013". The market was able to interpret the statement with less uncertainty about future interest rates. The central bank's clear statement greatly reduces interest rate uncertainty.

Figure 6 shows the histogram of the change in interest rate uncertainty on FOMC announcement days (246 days). The sample period is 1990/01/02-2020/09/30. The average change in the uncertainty measure is -1.9 basis points. Its t-value is -7.12.

[7] Cash flow + book value = income + lagged book value.

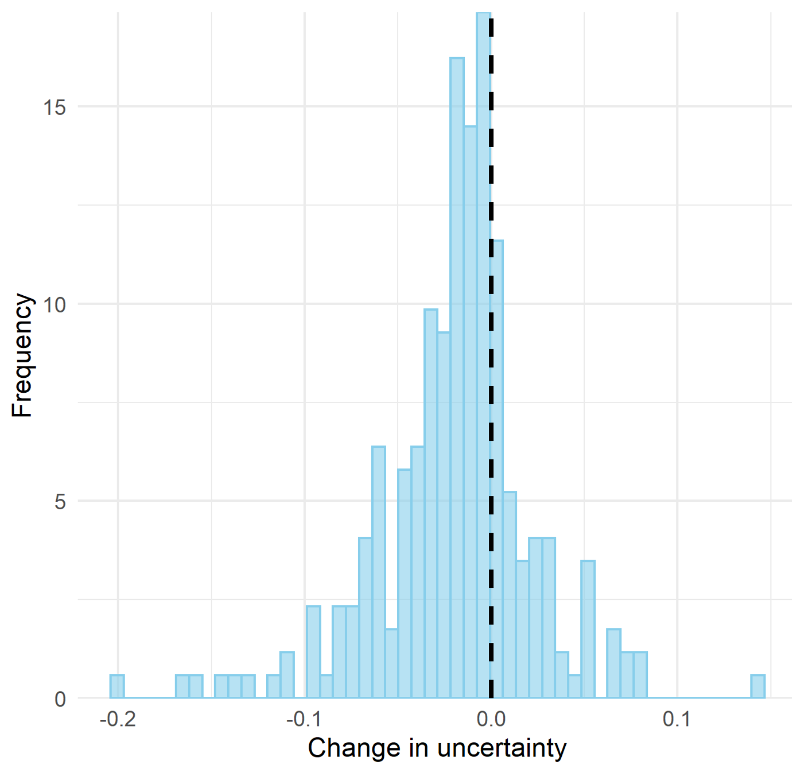

Figure 6: Histogram of change in interest rate uncertainty.

Notes: Histogram of one-day change in interest rate uncertainty on FOMC days. Interest rate uncertainty uses a risk-neutral standard deviation of the three-month LIBOR rate at a one-year horizon, estimated from Eurodollar futures and options. Data is obtained from Bauer et al. (2022). Each sample represents one FOMC meeting. The sample period is 1990/1-2019/12. A dotted line represents zero.

5 Empirical Analysis of Bonds

In this section, I empirically test the theoretical implications for bonds.

5.1 Average Return on FOMC days

Theorem 2 states that the return on long-maturity bonds is higher than the return on short-maturity bonds. Figure 7 shows the average yield on the FOMC day across maturities. Standard errors follow Newey and West (1987). The return on long-maturity bonds is higher than that on short-maturity bonds. While the average return on one-year Treasury securities is 0.62 bp, the average return on twenty-nine-year Treasury securities is 10.22 bp. The result is consistent with the theorem 2. Since interest rate uncertainty is significantly reduced on FOMC days, and long-maturity bonds are more exposed to the announced interest rate level, investors demand a higher premium for long-maturity bonds.

Although the average yield increases monotonically with maturity, the long-maturity bond has a larger standard error, and the difference is not statistically significant. This is because yield data is used to construct the return. Since the price is given by $p_t(n) = \frac{1}{(Y_t(n))^n}$, a larger n results in a larger price fluctuation. This is also observed in Wachter and Zhu (2022).

Table 3 shows the average return on FOMC days and non-FOMC days. To save space, I present the returns on Treasury securities with maturities of 1, 5, 10, 15, and 20 years. On average, a long-short portfolio earns 9.3 bps on a FOMC announcement day. I also report CAPM alphas and betas. Risk-adjusted returns, as measured by alphas, increase monotonically from short to long maturities. In contrast, the return on non-FOMC days is significantly lower than the return on FOMC days.

5.2 Interest rate uncertainty and contemporaneous regression.

The purpose of this section is to understand the differential response of the yield on bonds of different maturities to a change in interest rate uncertainty. A theoretical prediction is given by the theorem 3. The return on long-maturity bonds should be more responsive to a change in interest

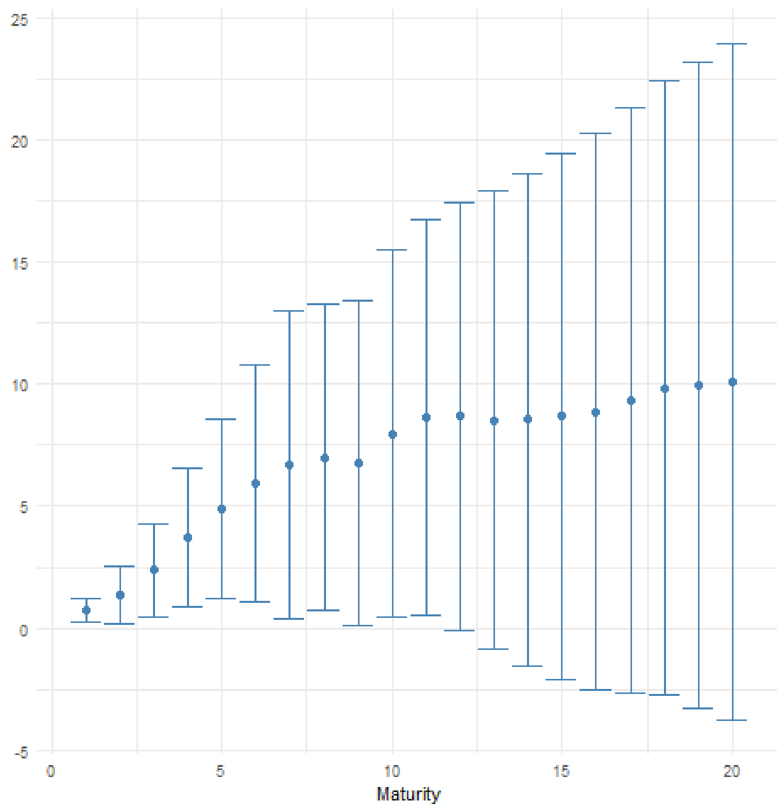

Figure 7: Average return on Treasury on FOMC days.

Notes: Average return on Treasury securities of different maturities on FOMC days. The sample period is 1990/1-2021/12. The Treasury return is given by $\frac{p_t^m}{p_{t-1}^n} - 1$, where p_t is the daily Treasury price and p_{t-1} is its lagged price. The return is expressed in basis points. The band represents the two standard error bands according to Newey and West (1987). Treasury yields are taken from Liu and Wu (2021).

Table 3: Return of Treasury

	Maturity						
	1	5	10	15	20	20-1	t(20-1)
	Panel A:FOMC days						
Average Return	0.7	4.8	7.9	8.7	10.0	9.3	1.42
α_{capm}	0.7	4.2	7.5	8.4	10.9	10.2	1.44
β_{capm}	0.1	2.5	2.0	1.0	-3.1	-3.2	-0.36
	Panel B:Non-FOMC days						
Average Return	0.06	0.3	0.7	1.3	1.8	1.7	1.79
α_{capm}	0.08	0.4	1.0	1.7	2.3	2.2	2.17
β_{capm}	-0.8	-6.6	-11.8	-16.6	-20.3	-19.4	-5.18

Notes: This table reports the returns of Treasury for different maturities on FOMC days. The return of treasury is defined as $\frac{p(n)_t}{p(n)_{t-1}}$ where $p(n)_t$ is daily price of Treasury with maturity m. ”Return on FOMC days” is an adjusted return. α_{capm} and β_{capm} are from the CAPM model. Maturity is in years. Returns are stated in basis points. The t-statistic is based on standard errors following Newey and West (1987).

rate uncertainty than the return on short-maturity bonds. I estimate the time-series regression of

$$y_t^m = \beta_{iru}^m \Delta \mathrm{IRU}_t + \beta_{capm}^m (R_t^M - r^f) + \epsilon_t, \tag{1}$$

where t is the tth FOMC announcement, y_{mt} is the return on Treasuty with maturity m. $\Delta\mathrm{IRU}_t$ is a logarithm of today's interest rate uncertainty minus yesterday's interest rate uncertainty if today is the tth FOMC day. I estimate β_{iru}^m separately for different maturities m. Figure 8 shows the estimated result of equation (1). It shows the downward sloping curve that is consistent with the result of the maturity. This is consistent with theorem 3. The standard error is Newey and West (1987).

To see that interest rate uncertainty is the main uncertainty resolved by monetary policy announcements, I also show the contemporaneous relationship between VIX and Treasury. Lucca and Moench (2015), Hillenbrand (2021), and Hu et al. (2022) use VIX as a measure of uncertainty to test risk-based explanations for high excess returns. The VIX is a natural choice for testing. I estimate

$$y_t^m = \beta_{vix}^m \Delta \mathrm{VIX}_t + \beta_{capm}^m (R_t^M - r^f) + \epsilon_t. \tag{2}$$

Figure 9 shows the estimated β_{vix}^m. The coefficients are not significantly different from zero and do not have a monotonically decreasing slope. This figure suggests that interest rate uncertainty is important for the high excess return on FOMC days.

5.3 Interest rate uncertainty and predictive regression.

I also estimate the predictive relationship between interest rate uncertainty and Treasury returns. Theorem 3 shows that the yield on FOMC days increases with ex-ante interest rate uncertainty. I estimate

$$y_t^m - y_t^1 = \beta_{iru}^m \mathrm{IRU}_{t-2} + \beta_{capm}^m (R_t^M - r^f) + \epsilon_t,$$

where m is the maturity of the bonds, y_m is the Treasury yield with maturity m, and IRU_{t-2} is the level of interest rate uncertainty two days before FOMC day. The left-hand side is the return of the long-short strategy of buying the m maturity and selling the one-year maturity. The level of interest rate uncertainty is detrended using the HP filter. Figure 10 shows the results. First, when ex-ante

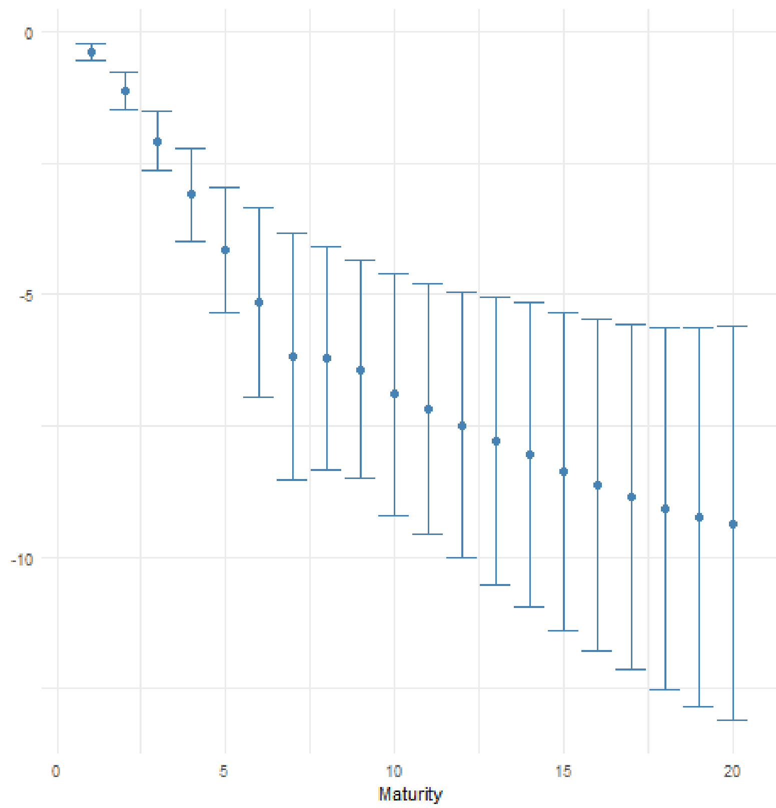

Figure 8: Sensitivity of return to change in interest rate uncertainty.

Notes: Treasury Return Sensitivity to a Change in Interest Rate Uncertainty. This figure plots the return sensitivity to a change in interest rate uncertainty for Treasury securities of different maturities. I regress the Treasury return on a change in interest rate uncertainty on FOMC announcement days, controlling for market excess returns. A change in interest rate uncertainty is the leading uncertainty minus the lagged uncertainty. This figure plots the coefficients on the change in interest rate uncertainty and its two standard error bands. Interest rate uncertainty is taken from Bauer et al. (2022).

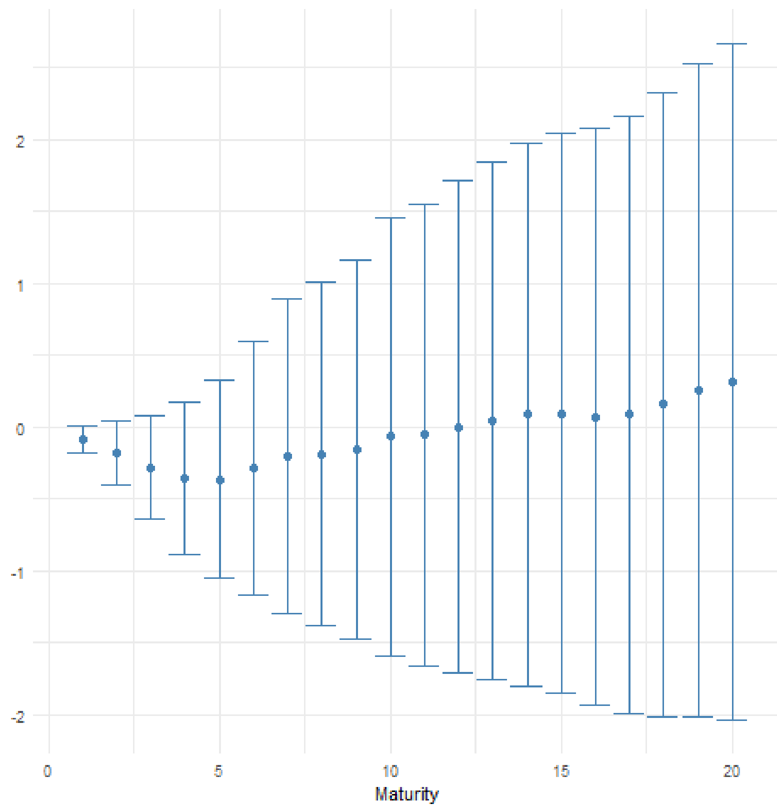

Figure 9: Treasury return sensitivity to change in VIX.

Notes: Treasury Return Sensitivity to a Change in the VIX. This figure plots the return sensitivity to a change in interest rate uncertainty for Treasury securities of different maturities. I regress the Treasury return on a change in the VIX on FOMC announcement days, controlling for market excess returns. This figure plots the coefficients on the change in interest rate uncertainty and its two standard error bands. Interest rate uncertainty is taken from Bauer et al. (2022).

interest rate uncertainty is high, a long-short investment strategy is predictable, although there is no predictability for maturities longer than 15 years. Ex-ante uncertainty predicts the Treasury yield on FOMC days. Second, predictability increases with maturity, as suggested by theorem 3.

6 Empirical Analysis of Equity

In this section, I empirically test the theoretical predictions.

6.1 Average Return on FOMC days

First, I empirically test whether the premium for short-duration equity is higher than that for long-duration equity. I show the average return on FOMC day conditional on duration. Figure 11 shows the average return. The horizontal axis is equity duration. I divide the firms into ten groups from low to high based on duration. Then I calculate the average return on FOMC days in the groups. The vertical line is the average return. The short-duration stock has a higher excess return on the FOMC day. The theoretical prediction suggests that if monetary policy has a transitory effect on returns and this effect is larger than the effect of the discount rate, the return on short-duration stocks will be higher.

A portfolio approach is used to assess the impact of duration on returns on FOMC day. Stocks are sorted into decile portfolios based on the previous quarter's duration measure. Table4 shows the average returns on FOMC day for equally weighted portfolios and portfolio alphas using the Fama and French factor model.

$$y_t^m = \alpha^m + \beta^m \text{Fama French Factors} + \epsilon_{it}, \tag{3}$$

where $m \in \{1, \cdots, 10\}$ represents the portfolio based on duration. Control variables include Fama and French's three factors or five factors. A long-short strategy in low and high duration portfolios returns 15.9 basis points on an FOMC announcement. Since there are eight FOMC meetings in a year, the return is 1.53%. This premium is significantly negative using the standard error according to Newey and West (1987). Panel B shows the average return on equities with different durations on non-FOMC announcement days. It also shows a clear downward slope, consistent with the

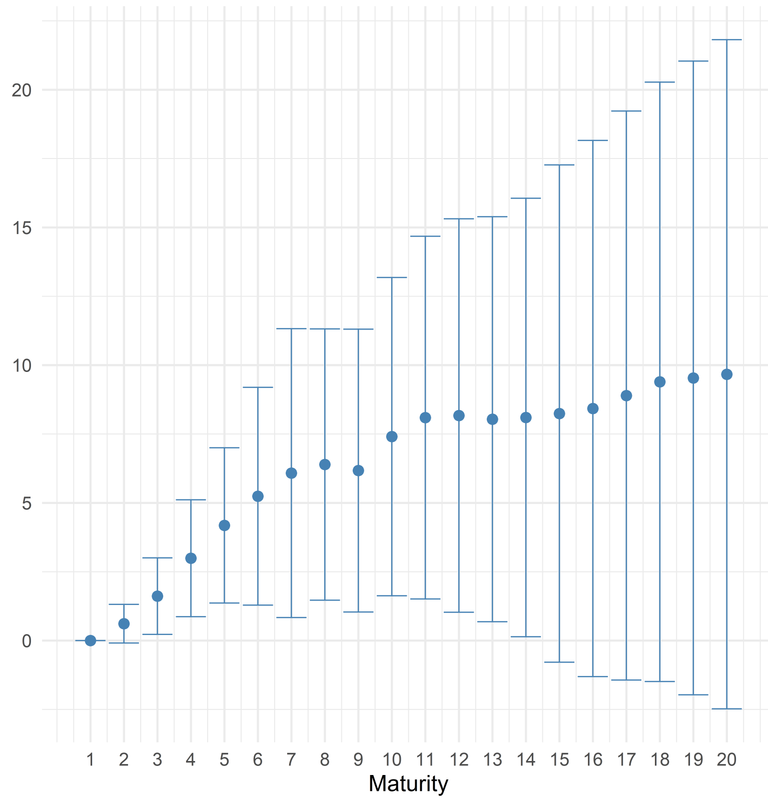

Figure 10: Treasury return sensitivity to ex-ante interest rate uncertainty.

Notes: Treasury Return predictability by ex-ante Level of Interest Rate Uncertainty. This figure plots the predictability of Treasury returns by the ex ante level of interest rate uncertainty at different maturities. I regress Treasury long-short returns on the lagged level of interest rate uncertainty on FOMC announcement days, controlling for market excess returns. Long-short strategy is the return of a long-short strategy that buys maturities of m years and sells maturities of one year. The level of interest rate uncertainty is detrended with a HP filter. The lagged value is taken two days before the FOMC announcement days. This figure plots the coefficients of the lagged level of interest rate uncertainty and the 95% confidence interval. The interest rate uncertainty is taken from Bauer et al. (2022).

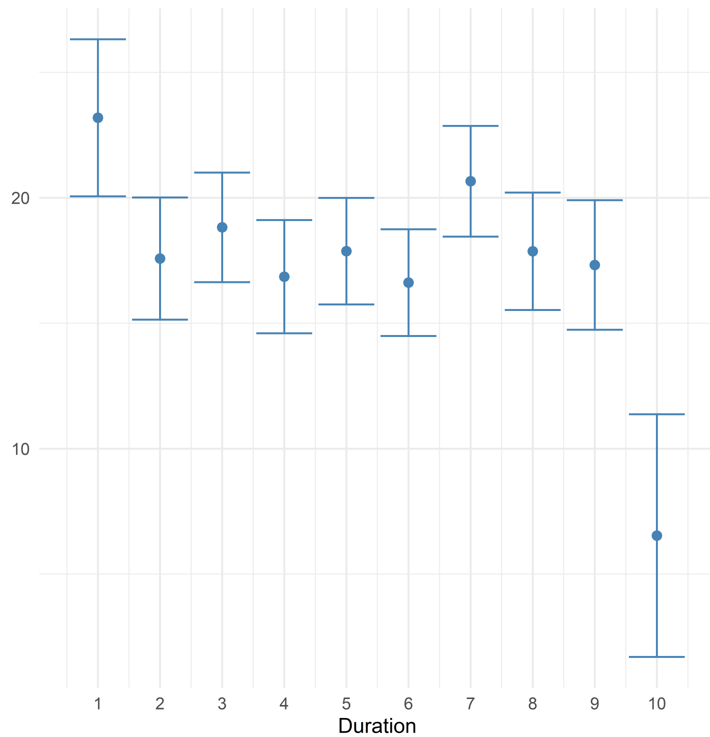

Figure 11: Average return on FOMC day

Notes: This figure plots the time-series average of portfolio returns on FOMC days. I divide the companies into ten groups from low to high based on duration and take an average within the groups. The portfolio is rebalanced quarterly.

literature on the term structure of equity (Van Binsbergen et al. (2012), Weber (2018)). A term structure of returns on FOMC days is less monotonic than on non-FOMC days. This suggests that some factors push the term structure up on FOMC days. The next section shows that interest rate uncertainty removed by FOMC days moves a term structure upward.

Table 4: Uncertainty resolution and exposure

	1	2	3	4	5	6	7	8	9	10	10-1	t(10-1)
	Panel A: FOMC days											
Duration	7.2	14.1	16.1	17.4	18.4	19.3	20.2	21.1	22.1	24.9		
FOMC return	25.5	21.0	19.0	19.0	18.2	19.8	19.7	18.5	18.7	9.6	-15.9	-3.41
FF3 α	11.4	4.4	1.2	-0.8	-2.1	-0.5	-0.6	-3.1	-4.4	-9.7	-21.0	-5.26
FF5 α	11.2	4.3	1.2	-0.8	-2.2	-0.6	-0.6	-2.9	-4.1	-9.1	-20.3	-6.24
	Panel B: Non-FOMC days											
Non-FOMC return	15.8	9.8	7.8	6.4	5.5	4.8	4.4	3.3	3.3	3.5	-12.3	-11.5
FF3 α	13.0	6.9	4.8	3.4	2.4	1.8	1.4	0.4	0.3	0.6	-12.5	-15.5
FF5 α	12.8	6.5	4.4	3.0	2.1	1.6	1.6	0.9	1.7	1.9	-10.9	-16.3

Notes: The sample period is 1981/1-2021/12. The table shows the time series average of the portfolio returns. "FOMC days" is the $\frac{p(t)}{p(t-1)} - 1$, where t is the FOMC day. "Non-FOMC days" is the average daily return excluding FOMC days. "FF3 α" and "FF5 α" report alphas from the three-factor model of Fama and French (1992) and the five-factor model of Fama and French (2015). Alphas and returns are in basis points. "1"-"10" represents the portfolio from low to high. The t-statistic follows Newey and West (1987).

In addition to the portfolio sorts, I also run a Fama-MacBeth regression to show that the significant return predictability of duration on FOMC days is not captured by common cross-sectional return differences. Tale 5 shows the results of Fama-MacBeth regression.

As shown in section 5.1, while the term structure of bonds is upward sloping on FOMC days, that of stocks is flat. Why is that? The key difference is uncertainty about the cash flow and uncertainty about the discount rates. The return on short-term equities is more uncertain than the return on long-term equities because of monetary non-neutrality. If the volatility of future cash flow is equally important as the volatility of discount rate, the term structure of equity is flat. However,

Table 5: Uncertainty resolution and exposure

	(1)	(2)	(3)
Intercept	0.26	0.15	0.60
	(3.98)	(3.47)	(1.99)
Duration	-0.004	-0.004	-0.03
	(-1.97)	(-2.34)	(-3.38)
CAPM β		0.08	0.08
		(2.16)	(1.32)
Book to market			-0.26
			(-2.10)
Market capital			0.03
			(3.46)

Notes: This table reports Fama-MacBeth-regression estimated. The dependent variable is the daily excess return on FOMC days. The explanatory variables are given in the first column. The sample covers 1990/1-2021/12. The t-statistics follows Newey and West (1987).

the return on the bond is fixed, so the return on the short-duration bond is not more exposed. The only uncertainty is the discount rate, so long-duration bonds are, on average, more exposed to monetary policy.

6.2 Interest rate uncertainty and contemporaneous regression.

This section employs a portfolio-level event study and a firm-level event study approach with panel data to examine the impact of interest rate uncertainty on the cross-section of equity[8].

6.2.1 Firm-level approach

I test the theorem empirically 4. The theorem states that the return on long-duration equities is more sensitive to changes in interest rate uncertainty than is the return on short-duration equities. I estimate

$$\text{Return}_{i,t} = \beta_1 \Delta IRU_t + \beta_2 \text{Duration}_{it} + \beta_3 \Delta IRU_t * \text{Duration}_{it} + \gamma X_{it} + \epsilon_{it} \tag{4}$$

where i is the index of the firm, t is the tth FOMC. Also, Return_{it} is the stock return of firm i at the tth FOMC, ΔIRU_t is the measured change in uncertainty caused by the tth FOMC, and Duration_{it} is the measured duration of firm i at the tth FOMC. X_{it} are control variables. Theorem 4 states that a firm that is more exposed to uncertainty will have a higher stock return if the announcement resolves more uncertainty. This implies that β_3 is negative. When the duration is higher, the effect of an increase in uncertainty on the stock return is more negative.

Control variables include firm and quarter fixed effects, size, profitability, market-to-book ratio, leverage, and the interaction of balance sheet variables with the change in interest rate uncertainty. Balance sheet variables are lagged by one quarter. Robust standard errors clustered at firms are used in reporting t-statistics. Table 6 reports the results. The coefficient on β_3 is significantly negative. When interest rate uncertainty decreases on FOMC days, the return on long-duration equities is higher than that on short-duration equities.

[8] See Chava and Hsu (2020), Lagos and Zhang (2020), and Ozdagli (2018) for an example of a firm-level event study approach.

Table 6: Return sensitivity to interest rate uncertainty

Dependent Variable:	excess return		
Model:	(1)	(2)	(3)
Variables			
IRU	-4.003***	2.419***	1.811*
	(0.8403)	(0.9273)	(0.9333)
Duration × IRU	-0.2310***	-0.2122***	-0.2192***
	(0.0478)	(0.0577)	(0.0587)
Size × IRU		-1.520***	-1.119***
		(0.1072)	(0.1154)
Profit × IRU		30.80***	23.69***
		(4.606)	(4.456)
Market book × IRU		0.0481	-0.0323
		(0.1269)	(0.1246)
leverage × IRU		1.704*	0.4476
		(1.015)	(0.9967)
Fit statistics			
Observations	738,808	656,418	656,418
R^2	0.00480	0.00643	0.01159
Within R^2			0.00450

Notes: This table reports coefficient estimates from the panel regression. Column 1 reports the results when a change in interest rate uncertainty, duration, and their interaction term are the dependent variables. ”IRU” represents a change in interest rate uncertainty on FOMC days. A change in interest rate uncertainty is the leading uncertainty minus the lagging uncertainty. Column 2 adds size, profitability, leverage, market-to-book, and their interaction with a change in interest rate uncertainty to the dependent variables. Robust standard errors clustered at firms are used in reporting t-statistics. Column 3 adds firm and quarter fixed effects. Heteroskedasticity robust standard errors are used. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

6.2.2 Portfolio event study

Next, a portfolio approach is applied. I estimate

$$y_t^m = \beta_{iru}^m \Delta \text{IRU}_t + \beta_{capm}^m (R_t^M - r^f) + \epsilon_t,$$

where m is the portfolio sorted by duration, y_m is the return on equity in portfolio m on the FOMC day, IRU_{t-2} is the level of interest rate uncertainty two days before the FOMC day. Table 7 shows the results.

Table 7: Uncertainty resolution and exposure

	Low	2	3	4	5	6	7	8	9	High	10-1	t(10-1)
	Panel A: Interest rate uncertainty											
β_{iru}	-8.0	-9.6	-9.3	-9.7	-9.3	-9.4	-9.4	-10.3	-10.8	-12.2	-4.2	-2.84
	Panel B: CAPM											
β_{iru}	-0.4	-1.1	-0.5	-0.7	-0.2	-0.2	-0.3	-1.0	-1.1	-3.5	-3.1	-2.31
β_{capm}	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	0.1	-1.18

Notes: This table shows the return sensitivity of the portfolio to a change in interest rate uncertainty. The portfolio is sorted by duration measure. A change in interest rate uncertainty is measured by leading uncertainty minus lagged uncertainty. Panel A regresses excess returns on a change in interest rate uncertainty. Panel B regresses a change in interest rate uncertainty on market excess returns. The t-statistic follows Newey and West (1987).

6.3 Interest rate uncertainty and predictive regression.

This section tests the theorem 5. The theorem states that when ex-ante interest rate uncertainty is high, the return on long-duration equity is predictably higher than that on short-duration equity. A firm-level event study approach is used. I estimate

$$\text{Return}_{i,t} = \beta_1 IRU_{t-2} + \beta_2 \text{Duration}_{it} + \beta_3 IRU_{t-2} * \text{Duration}_{it} + \gamma X_{it} + \epsilon_{it} \tag{5}$$

where i is the index of the firm, t is the tth FOMC. Also, Return_{it} is the stock return of firm i at the tth FOMC, IRU_{t-2} is the interest rate uncertainty two days prior to FOMC days, and Duration_{it} is the measured duration of firm i at the tth FOMC. X_{it} are control variables. Interest rate uncertainty is detrended with the HP filter. Table8 shows the results. The estimated β_3 is significantly positive. When ex-ante interest rate uncertainty is high, the return on long-duration equity is predictably higher than the return on short-duration equity.

7 Conclusion

This paper provides empirical evidence and a simple model for cross-sectional returns on FOMC announcement days. In particular, this paper focuses on to determine what specific type of uncertainty is resolved by FOMC announcements and the factors that contribute to the heterogeneity of stock returns. The findings of this study align with existing literature that emphasizes risk-based explanations for the elevated excess returns observed on FOMC announcement days. However, instead of cash flow uncertainty, the analysis highlights the significance of interest rate uncertainty in driving these returns. To assess the importance of interest rate uncertainty, the study formulates theoretical predictions regarding announcement returns based on the duration of assets and subsequently provides empirical evidence that supports these theoretical expectations.

Table 8: Return sensitivity to interest rate uncertainty

Dependent Variable:	excess return		
Model:	(1)	(2)	(3)
Variables			
IRU	0.8447***	0.8971***	0.9075***
	(0.0600)	(0.3124)	(0.3222)
Duration × IRU	0.4504**	0.4592*	0.4750**
	(0.1990)	(0.2382)	(0.2421)
Size × IRU		0.0546	0.1180***
		(0.0419)	(0.0408)
Profit × IRU		0.0239	-0.2702
		(2.003)	(1.982)
Market book × IRU		-0.0492	-0.0292
		(0.0541)	(0.0570)
leverage × IRU		-1.381***	-1.291***
		(0.3803)	(0.3817)
Fit statistics			
Observations	738,808	656,418	656,418
R^2	0.00044	0.00091	0.00825
Within R^2			0.00114

Notes: This table reports coefficient estimates from the panel regression. Column 1 reports the results when a change in interest rate uncertainty, duration, and their interaction term are the dependent variables. ”IRU” represents ex-ante interest rate uncertainty. ”Duration” is a dummy variable that takes one if larger than the median. Column 2 adds size, profitability, leverage, market-to-book, and their interaction with a change in interest rate uncertainty to the dependent variables. Robust standard errors clustered at firms are used in reporting t-statistics. Column 3 adds firm and quarter fixed effects. Heteroskedasticity robust standard errors are used. *p<0.1; **p<0.05; ***p<0.01.

References

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

H. Ai, L. J. Han, X. N. Pan, and L. Xu. The cross section of the monetary policy announcement premium. *Journal of Financial Economics*, 143(1):247–276, 2022.

S. R. Baker, N. Bloom, and S. J. Davis. Measuring economic policy uncertainty. *The quarterly journal of economics*, 131(4):1593–1636, 2016.

M. D. Bauer and E. T. Swanson. A reassessment of monetary policy surprises and high-frequency identification. Technical report, National Bureau of Economic Research, 2022.

M. D. Bauer, A. Lakdawala, and P. Mueller. Market-based monetary policy uncertainty. *The Economic Journal*, 132(644):1290–1308, 2022.

G. Bekaert, M. Hoerova, and M. L. Duca. Risk, uncertainty and monetary policy. *Journal of Monetary Economics*, 60(7):771–788, 2013.

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

F. Bianchi, M. Lettau, and S. C. Ludvigson. Monetary policy and asset valuation. *The Journal of Finance*, 77(2):967–1017, 2022.

F. Brusa, P. Savor, and M. Wilson. One central bank to rule them all. *Review of Finance*, 24(2): 263–304, 2020.

B. Bundick, T. Herriford, and A. Smith. Forward guidance, monetary policy uncertainty, and the term premium. *Monetary Policy Uncertainty, and the Term Premium (July 2017)*, 2017.

S. Chava and A. Hsu. Financial constraints, monetary policy shocks, and the cross-section of equity returns. *The Review of Financial Studies*, 33(9):4367–4402, 2020.

Z. Chen. Inferring stock duration around fomc surprises: Estimates and implications. *Journal of Financial and Quantitative Analysis*, 57(2):669–703, 2022.

L. J. Christiano, M. Eichenbaum, and C. L. Evans. Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of political Economy*, 113(1):1–45, 2005.

A. Cieslak, A. Morse, and A. Vissing-Jorgensen. Stock returns over the fomc cycle. *The Journal of Finance*, 74(5):2201–2248, 2019.

P. M. Dechow, R. G. Sloan, and M. T. Soliman. Implied equity duration: A new measure of equity risk. *Review of Accounting Studies*, 9(2):197–228, 2004.

R. Döttling and L. Ratnovski. Monetary policy and intangible investment. *Journal of Monetary Economics*, 2022.

E. F. Fama and K. R. French. The cross-section of expected stock returns. *the Journal of Finance*, 47(2):427–465, 1992.

E. F. Fama and K. R. French. A five-factor asset pricing model. *Journal of financial economics*, 116(1):1–22, 2015.

M. Gertler and P. Karadi. Monetary policy surprises, credit costs, and economic activity. *American Economic Journal: Macroeconomics*, 7(1):44–76, 2015.

S. Gilchrist, D. López-Salido, and E. Zakrajšek. Monetary policy and real borrowing costs at the zero lower bound. *American Economic Journal: Macroeconomics*, 7(1):77–109, 2015.

A. S. Gonçalves. The short duration premium. *Journal of Financial economics*, 141(3):919–945, 2021.

R. Gürkaynak, H. G. Karasoy-Can, and S. S. Lee. Stock market's assessment of monetary policy transmission: The cash flow effect. *The Journal of Finance*, 77(4):2375–2421, 2022.

R. S. Gürkaynak, B. P. Sack, and E. T. Swanson. 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 (November 2004)*, 2004.

R. S. Gürkaynak, B. Sack, and J. H. Wright. The us treasury yield curve: 1961 to the present. *Journal of monetary Economics*, 54(8):2291–2304, 2007.

S. G. Hanson and J. C. Stein. Monetary policy and long-term real rates. *Journal of Financial Economics*, 115(3):429–448, 2015.

S. Hillenbrand. The fed and the secular decline in interest rates. *Available at SSRN 3550593*, 2021.

G. X. Hu, J. Pan, J. Wang, and H. Zhu. Premium for heightened uncertainty: Explaining pre-announcement market returns. *Journal of Financial Economics*, 145(3):909–936, 2022.

L. Husted, J. Rogers, and B. Sun. Monetary policy uncertainty. *Journal of Monetary Economics*, 115:20–36, 2020.

I. Indriawan, F. Jiao, and Y. Tse. The fomc announcement returns on long-term us and german bond futures. *Journal of Banking & Finance*, 123:106027, 2021.

F. Ippolito, A. K. Ozdagli, and A. Perez-Orive. The transmission of monetary policy through bank lending: The floating rate channel. *Journal of Monetary Economics*, 95:49–71, 2018.

T. A. Kroencke, M. Schmeling, and A. Schrimpf. The fomc risk shift. *Journal of Monetary Economics*, 120:21–39, 2021.

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

R. Lagos and S. Zhang. Turnover liquidity and the transmission of monetary policy. *American Economic Review*, 110(6):1635–72, 2020.

A. Lakdawala, T. Moreland, and M. Schaffer. The international spillover effects of us monetary policy uncertainty. *Journal of International Economics*, 133:103525, 2021.

M. Lettau and J. A. Wachter. Why is long-horizon equity less risky? a duration-based explanation of the value premium. *The Journal of Finance*, 62(1):55–92, 2007.

M. Lettau and J. A. Wachter. The term structures of equity and interest rates. *Journal of Financial Economics*, 101(1):90–113, 2011.

Y. Liu and J. C. Wu. Reconstructing the yield curve. *Journal of Financial Economics*, 142(3): 1395–1425, 2021.

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

S. Miranda-Agrippino and H. Rey. Us monetary policy and the global financial cycle. *The Review of Economic Studies*, 87(6):2754–2776, 2020.

H. Mohrschladt and S. Nolte. A new risk factor based on equity duration. *Journal of Banking & Finance*, 96:126–135, 2018.

P. Mueller, A. Tahbaz-Salehi, and A. Vedolin. Exchange rates and monetary policy uncertainty. *The Journal of Finance*, 72(3):1213–1252, 2017.

H. Mumtaz and F. Zanetti. The impact of the volatility of monetary policy shocks. *Journal of Money, Credit and Banking*, 45(4):535–558, 2013.

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

A. Neuhierl and M. Weber. Monetary momentum. Technical report, National Bureau of Economic Research, 2018.

W. K. Newey and K. D. West. A simple, positive semi-definite, heteroskedasticity and autocorrelationconsistent covariance matrix. *Econometrica*, 55(3):703–708, 1987.

P. Ottonello and T. Winberry. Financial heterogeneity and the investment channel of monetary policy. *Econometrica*, 88(6):2473–2502, 2020.

A. Ozdagli and M. Velikov. Show me the money: The monetary policy risk premium. *Journal of Financial Economics*, 135(2):320–339, 2020.

A. K. Ozdagli. Financial frictions and the stock price reaction to monetary policy. *The Review of Financial Studies*, 31(10):3895–3936, 2018.

V. A. Ramey. Macroeconomic shocks and their propagation. *Handbook of macroeconomics*, 2: 71–162, 2016.

P. Savor and M. Wilson. How much do investors care about macroeconomic risk? evidence from scheduled economic announcements. *Journal of Financial and Quantitative Analysis*, 48(2): 343–375, 2013.

P. Savor and M. Wilson. Asset pricing: A tale of two days. *Journal of Financial Economics*, 113 (2):171–201, 2014.

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

J. A. Wachter and Y. Zhu. A model of two days: Discrete news and asset prices. *The Review of Financial Studies*, 35(5):2246–2307, 2022.

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

Appendix A Proof

A.1 Theorem 1

The expected announcement premium for short-duration stock is

$$
\begin{aligned}
&E\left[\frac{P_2^S(s)}{P_1^S}\right] \\
&= \frac{E\left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\right] E\left[\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]}{E\left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]} \\
&= 1 - \frac{\text{cov}\left(\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}, \beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right)}{E\left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]}
\end{aligned}
$$

Focusing on post-announcement price, $P_3(s)$ is higher when $X(s)$ is high. Then,

$$\beta^h C_3(s_1)^{-\frac{1}{\psi}} \overline{X}^S > \beta^l C_3(s_2)^{-\frac{1}{\psi}} \overline{X}^S$$

$$\beta C_3(s_3)^{-\frac{1}{\psi}} X^{S,h} > \beta C_3(s_4)^{-\frac{1}{\psi}} X^{S,l}$$

holds. In this case, the covariance is negative if and only if $\gamma > \frac{1}{\psi}$ holds. This is because

$$\left[C_2^{1-\frac{1}{\psi}} + \beta(s_2)V_3(s_2)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} > \left[C_2^{1-\frac{1}{\psi}} + \beta(s_1)V_3(s_1)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}$$

$$\left[C_2^{1-\frac{1}{\psi}} + \beta(s_4)V_3(s_4)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}} > \left[C_2^{1-\frac{1}{\psi}} + \beta(s_3)V_3(s_3)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}$$

holds. The expected announcement premium is higher than one. The same argument applies for long-duration stock.

A.2 Theorem 4

In a simplified case of $\alpha_1 = \alpha_2 = \frac{1}{2}$, $C(s_1) = C(s_3) = C_h$, there is an analytical solution. To save space, I denote

$$S_i = \left[C_2^{1-\frac{1}{\psi}} + \beta(s_i)V_3(s_i)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}$$

where $s_i \in \{s_1, s_2, s_3, s_4\}$.

$$\begin{aligned}
&E\left[\frac{P_2(s)^S}{P_1^S}\right] - E\left[\frac{P_2(s)^L}{P_1^L}\right] \\
&= \pi^2 \frac{1}{4}\beta^l\beta^h C(s_1)^{-\frac{1}{\psi}} C(s_2)^{-\frac{1}{\psi}} \overline{X}^2 \beta 2\sigma_1 (S_1 - S_2) \\
&+ (1-\pi)^2 \frac{1}{4}\beta^3 C(s_3)^{-\frac{1}{\psi}} C(s_4)^{-\frac{1}{\psi}} \overline{X}^2 (S_4 - S_3) 2\sigma_2 \\
&+ \pi(1-\pi)\frac{1}{4}(\overline{X}\beta)^2 \Big\{\beta^l C_l^{\frac{-1}{\psi}} C_h^{\frac{-1}{\psi}} (\sigma_2 - \sigma_1 - \sigma_1\sigma_2)(S_2 - S_3) \\
&+ \beta^h C_l^{\frac{-1}{\psi}} C_h^{\frac{-1}{\psi}} (\sigma_2 - \sigma_1 + \sigma_1\sigma_2)(S_4 - S_1) \\
&+ \beta^h C_h^{\frac{-2}{\psi}} (\sigma_1 + \sigma_2 + \sigma_1\sigma_2)(S_1 - S_3) \\
&+ \beta^l C_l^{\frac{-2}{\psi}} (\sigma_1 + \sigma_2 - \sigma_1\sigma_2)(S_4 - S_2)\Big\}
\end{aligned}$$

The derivative with respect to π is given by

$$\frac{\partial E\left[\frac{P_2(s)^S}{P_1^S}\right]-E\left[\frac{P_2(s)^L}{P_1^L}\right]}{\partial\pi}$$
$$=\frac{1}{4}\overline{X}^2\beta(C_lC_h)^{-\frac{1}{\psi}}\Big\{2\pi\beta^h\beta^l 2\sigma_1(S_1-S_2)-2(1-\pi)\beta^2 2\sigma_2(S_4-S_3)$$
$$+(1-2\pi)\beta\left(\beta^l(S_2-S_3)(\sigma_2-\sigma_1-\sigma_1\sigma_2)+\beta^h(S_4-S_1)(\sigma_2-\sigma_1+\sigma_1\sigma_2)\right)\Big\}$$
$$+(1-2\pi)\frac{1}{4}(\overline{X}\beta)^2\Big\{\beta^hC_h^{\frac{-1}{\psi}}(\sigma_1+\sigma_2+\sigma_1\sigma_2)(S_1-S_3)+\beta^lC_l^{\frac{-1}{\psi}}(\sigma_1+\sigma_2-\sigma_1\sigma_2)(S_4-S_2)\Big\}$$

I assume that $S_1=S_3<S_2=S_4$ and $\beta^h\beta^l=\beta^2$. I denote $S\equiv S_2-S_1$. Then, the last line is equal to zero. The derivative is equal to

$$\frac{\partial E\left[\frac{P_2(s)^S}{P_1^S}\right]-E\left[\frac{P_2(s)^L}{P_1^L}\right]}{\partial\pi}$$
$$=-S\sigma_1(4\pi\beta^h\beta^l+(1-2\pi)\beta(\beta^l+\beta^h))-S\sigma_2(4(1-\pi)\beta^2-(1-2\pi)\beta(\beta^l+\beta^h))$$
$$+(1-2\pi)\beta S(-\beta^l+\beta^h)\sigma_1\sigma_2$$
$$=-S\sigma_1(4\pi\beta^2+(1-2\pi)2\beta^2)-S\sigma_2(4(1-\pi)\beta^2-(1-2\pi)2\beta^2)+(1-2\pi)\beta S2\sigma_1^2\sigma_2$$
$$=\beta S(-\sigma_1 2\beta-\sigma_2 2\beta+(1-2\pi)\sigma_1^2\sigma_2)$$

The last term inside the bracket is a quadratic function of σ_1. It can be shown that this is negative. Therefore, the derivative is negative.

A.3 Theorem 5

I assume that $S_1=S_3<S_2=S_4$ and $\beta^h\beta^l=\beta^2$. I denote $S\equiv S_2-S_1$.

$$\frac{\partial E\left[\frac{P_2(s)^S}{P_1^S}\right]-E\left[\frac{P_2(s)^L}{P_1^L}\right]}{\partial\sigma_1}$$
$$=\frac{1}{4}(\overline{X}\beta)^2(C_lC_h)^{\frac{-1}{\psi}}\left\{\pi^2 2(S_1-S_2)+\pi(1-\pi)\left(\beta^l(S_2-S_3)(-1-\sigma_2)+\beta^h(S_4-S_1)(-1+\sigma_2)\right)\right\}$$
$$=\frac{1}{4}(\overline{X}\beta)^2(C_lC_h)^{\frac{-1}{\psi}}S\left(-2\pi^2+\pi(1-\pi)\left(\beta^l(-1-\sigma_2)+\beta^h(-1+\sigma_2)\right)\right)$$

The last term is negative.

Appendix B Data Sources and Descriptions

1. FOMC dates are obtained from the website of the Board of Governors of the Federal Reserve System[9].

2. Daily SP 500 return is obtained from CRSP through WRDS. CRSP - Annual Update - Index/SP 500 Indexes - Index File on SP 500. Return on SP composite Index is item $sprtrn$.

3. Daily return on the Center for Research in Security Prices (CRSP) value-weighted NYSE / NASDAQ / AMEX is from CRSP-Annual Update - Stock-Version 2-Daily Stock Market Indexes.

4. High-frequency change in SP500 around FOMC announcement is taken from Michael Bauer's web page[10]. Data is used for Bauer and Swanson (2022). It is based on a 30-minute window around the FOMC announcement.

5. VIX data is from Chicago Board Options Exchange through WRDS. I use "CBOE S&P500 Volatility Index - Close" (item is vix).

6. Monetary policy uncertainty measure is from Daily market-based data in Bauer et al. (2022) is from Michael Bauer's web page..

7. Daily stock returns of individual firms are from CRSP.

8. Firm characteristics are from Compustat. I use Compustat - North America - Fundamental Quarterly. The usage of each item is based on Ottonello and Winberry (2020) and Gürkaynak et al. (2022).

    -

    - Cash is chq. This item represents any immediately negotiable medium of exchange or any instruments normally accepted by banks for deposit and immediate credit to a customer's account. This item is not available for banks.

        - Bank and finance company receivables

[9] https://www.federalreserve.gov/monetarypolicy/fomc_historical_year.htm

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

- Bank drafts
- Bankers' acceptances
- Cash on hand (including foreign currency)
- Certificates of deposit included in cash by the company
- Checks (cashier's or certified)
- Demand certificates of deposit
- Demand deposits
- Letters of credit
- Money orders

- Short-term investment is $ivst$. This item includes, for example, commercial paper, marketable securities, money market funds, repurchase agreements, and treasury bills listed as short-term.
- Liquid asset ratio is defined as $cheq/atq = (chq + ivst)/atq$.
- Sales are $saleq$. Capital is $ppentq$. Leverage is $dlcq + dlttq/atq$. Size is $\log(asset)$.
- Profitability is operating income before depreciation ($oibdpq$) as a fraction of total assets(atq).
- Market to book ratio is the sum of the market value of equity and total debts ($prccq * cshoq + dlcq + dlttq$) as a fraction of total assets (atq.)
- Credit rating is S&P quality ranking ($spcrsc$).

I used firms that satisfy 1. asset is positive. 2. Capital is positive. 3. Sales are positive.

9. PPI announcement days are from the U.S. Bureau of Labor Statistics[11]. Employment Situation announcement days are from the U.S. Bureau of Labor Statistics[12]. GDP announcement days are from the U.S. Bureau of Economic Analysis[13].

[11] https://www.bls.gov/bls/news-release/ppi.htm
[12] https://www.bls.gov/bls/news-release/empsit.htm
[13] https://apps.bea.gov/histdata/histChildLevels.cfm?HMI=7

10. Daily Treasury data is from Gürkaynak et al. (2007) and Liu and Wu (2021). I obtain data from Gurkaynak's homepage[14] and Wu's homepage[15].

[14] http://refet.bilkent.edu.tr/research.html

Federal Reserve updates weekly at

https://www.federalreserve.gov/data/nominal-yield-curve.htm

[15] https://sites.google.com/view/jingcynthiawu/yield-data?authuser=0

Appendix C Constructin of Duration Measure

In this section, I describe the construction of duration measures.

C.1 Cash flow duration

This subsection describes the cash flow duration based on Dechow et al. (2004) and Weber (2018). This measure reflects the weighted average time to maturity of cash flow.

$$\text{Duration}_{it} = \frac{\sum_{s=1}^{T} s \times \text{CF}_{i,t+s}/(1+r)^s}{P_{it}},$$

where Duration_{it} is the duration of firm i at time t, $\text{CF}_{i,t+s}$ is the cash flow at time $t+s$, P_{it} is the price of current equity, r is the risk-free rate. A risk-free rate is common across time and firms.

Equities do not have a well-defined finite maturity, so I split the duration formula into a finite period and an infinite terminal value.

$$\text{Duration}_{it} = \frac{\sum_{s=1}^{T} s \times \text{CF}_{i,t+s}/(1+r)^s}{P_{it}} + (T + \frac{1+r}{r}) \times \frac{P_{it} - \sum_{s=1}^{T} \text{CF}_{i.t+s}/(1+r)^s}{P_{it}}$$

Since cash flow is not known in advance, it is approximated by the AR(1) process.

$$\begin{aligned} \text{CF}_{i,t+s} &= \text{E}_{i,t+s} - (\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}) \\ &= \text{BV}_{i,t+s-1} \left[\frac{\text{E}_{i,t+s}}{\text{BV}_{i,t+s-1}} - \frac{\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}}{\text{BV}_{i,t+s-1}} \right] \end{aligned} \tag{6}$$

Future return on equity $(\frac{\text{E}_{i,t+s}}{\text{BV}_{i,t+s-1}})$ and growth in book equity $(\frac{\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}}{\text{BV}_{i,t+s-1}})$ follows autoregressive one process with mean reversion.

$$\frac{\text{E}_{i,t+s}}{\text{BV}_{i,t+s-1}} = (1-\rho_1)\overline{\frac{\text{E}}{\text{BV}}} + \rho_1 \frac{\text{E}_{i,t+s-1}}{\text{BV}_{i,t+s-2}},$$

$$\frac{\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}}{\text{BV}_{i,t+s-1}} = (1-\rho_2)\overline{\text{BVG}} + \rho_2 \frac{\text{BV}_{i,t+s-1} - \text{BV}_{i,t+s-2}}{\text{BV}_{i,t+s-2}},$$

where $\overline{\frac{\text{E}}{\text{BV}}}$ is average cost of equity and $\overline{\text{BVG}}$ is average growth in book equity [16]. Return on equity has an AR(1) coefficient of 0.67 and growth in book equity of 0.18.

[16] They are set to 0.03 and 0.015, respectively. The risk-free rate is set to 0.03. A termination period, T, is set to 60 quarters. They are all from Weber (2018).

The procedure to get cash flow ($\text{CF}_{i,t+1}$) in one period ahead given $\frac{\text{E}_{i,t+s}}{\text{BV}_{i,t+s-1}}$ and $\frac{\text{BV}_{i,t+s}-\text{BV}_{i,t+s-1}}{\text{BV}_{i,t+s-1}}$ is

1. Compute $\frac{\text{BV}_{i,t+s+1}-\text{BV}_{i,t+s}}{\text{BV}_{i,t+s}}$ with AR(1) process.
2. Compute $\frac{\text{E}_{i,t+s+1}}{\text{BV}_{i,t+s}}$ with AR(1) process.
3. Compute $\text{CF}_{i,t+1}$ with equation (6).
4. Update $\text{BV}_{i,t+1}$ with

$$\text{BV}_{i,t+1} = \left(1 + \frac{\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}}{\text{BV}_{i,t+s-1}}\right)\text{BV}_{i,t+s-1}$$

This is a recursive procedure, so the future cash flow is obtained in the same way. Duration is measured with the future cash flow.

I use quarterly Compustat as a dataset. BV is an item *ceqq* (common/ordinary equity) minus item *pstkq* (Preferred/Preference Stock). Return on equity is an item *ibq* (Income after all expenses) divided by lagged BV. P_{it} is an item *prccq* (equity price close) multiplied by an item *cshoq* (common shares outstanding).

Appendix D Additional Analysis

D.1 Other measures of duration

In this appendix, I use other measures of duration and empirically test the main results. In the main text, I used the measure of duration based on firm cash flow.

I also use the book-to-market ratio, which relates a firm's book equity to its market equity. Firms with high (low) book-to-market ratios are called value (growth) firms, so a high ratio leads to a shorter duration. I estimate

$$\text{Return}_{i,t} = \beta_1 \Delta IRU_t + \beta_2 \text{Duration}_{it} + \beta_3 \Delta IRU_t * \text{Duration}_{it} + \gamma X_{it} + \epsilon_{it}. \tag{7}$$

The book-to-market ratio is lagged by six months. Table 9 shows that value firms have smaller sensitivity to change in interest rate uncertainty.

Table 9: Return sensitivity to interest rate uncertainty

Dependent Variable:	excess return		
Model:	(1)	(2)	(3)
Variables			
IRU	-7.656***	-1.903	-1.591
	(2.116)	(3.256)	(3.001)
Duration $\times$ IRU	1.397**	1.255*	1.299**
	(0.6155)	(0.5911)	(0.5750)
Size $\times$ IRU		-1.294**	-1.444***
		(0.4418)	(0.3389)
Profit $\times$ IRU		26.45**	28.27**
		(11.02)	(9.723)
leverage $\times$ IRU		0.2792	0.9895
		(5.627)	(5.350)

Notes: This table reports coefficient estimates from the panel regression. Column 1 reports the results when a change in interest rate uncertainty, duration, and their interaction term are the dependent variables. ”IRU” represents a change in interest rate uncertainty on FOMC days. A change in interest rate uncertainty is the leading uncertainty minus the lagging uncertainty. Column 2 adds size, profitability, leverage, market-to-book, and their interaction with a change in interest rate uncertainty to the dependent variables. Robust standard errors clustered at firms are used in reporting t-statistics. Column 3 adds firm and quarter fixed effects. Heteroskedasticity robust standard errors are used. *p<0.1; **p<0.05; ***p<0.01.

D.2 Other macroeconomic announcements

Savor and Wilson (2013) and Hu et al. (2022) analyze other macroeconomic announcements and state that stock return on announcement days is high. Table 10 describes the average return of S&P500 on other major macroeconomic announcement days.

EMPL/NFP is a monthly announcement of the employment situation by the U.S. Bureau of Labor Statistics. PPI is a monthly announcement of the producer price index by BLS. GDP is a quarterly announcement by the U.S. Bureau of Economic Analysis.

I choose the PPI announcement, instead of the CPI announcement because PPI is almost always announced a few days ahead of CPI. Arguably CPI announcement is less informative.

GDP announcement has three stages; advance, preliminary, and final. I use only advance announcements.

The stock return on employment announcement days is four times higher than on non-announcement days though it is not statistically significant. There is no announcement premium on PPI and GDP announcement days.

Table 10: Summary Statistics

	FOMC	EMPL/NFP	PPI	GDP	No announce
Observations	256	336	336	78	7092
Mean	0.23%	0.12%	-0.007%	-0.13%	0.03%
t-statistic	2.85	1.28	-0.68	0.17	2.41
Standard deviation	1.14	1.19	1.31	1.11	1.12

Note: "FOMC" is the stock return of SP500 on FOMC day. "EMPL/NFP" is the employment situation announced by BLS. "PPI" is the producer price index announced by BLS. The sample period of the employment situation and PPI is 1994/01-2021/12. The sample period of GDP is 2002Q2-2021Q4. t-statistic is computed by the White standard error.

While FOMC directly announces the interest rate, the employment situation announcement is not directly related to the interest rate. Although the stock return on both FOMC and the employment situation is high, the channel of interest rate uncertainty and duration should be less clear on employment situation announcement day.

I estimate

$$\text{Return}_{i,t} = \beta_1 \Delta UNC_t + \beta_2 \text{Duration}_{it} + \beta_3 \Delta UNC_t * \text{Duration}_{it} + \gamma X_{it} + \epsilon_{it}.$$

I use only employment situation announcement days. If the mechanism of interest rate uncertainty and duration is missing, estimated β_3 is insignificant.

Table11 shows the estimated β_3 using only the employment announcement days. They do not consistently show negative coefficients. The mechanism of interest rate uncertainty and duration is missing on employment situation announcement days. Although the return of the index (S&P500) is high on both FOMC and employment situation announcement days, a different mechanism drives the high announcement premium.

Table 11: Uncertainty resolution and exposure

	Dependent variable:			
	Stock return on employment announcement.			
	(1)	(2)	(3)	(4)
Duration(CF)*IRU	-0.232^{***}		0.026	
	(0.024)		(0.028)	
Duration(BE)*IRU		0.089^{**}		0.044
		(0.043)		(0.046)
Controls	No	No	Yes	Yes
Note:		*p<0.1; **p<0.05; ***p<0.01		

D.3 Monetary policy shock and duration

In this section, I analyze the impact of an unexpected change in the interest rate on equity prices with different duration. Theoretically, when the central bank unexpectedly raises the interest rate, the discount factor gets larger, and the price of equity with a long duration should decrease. I empirically test this prediction.

Monetary policy shock is identified by the high-frequency change in federal fund future (Bernanke and Kuttner, 2005), the first principal component of high-frequency changes in interest rate (Nakamura and Steinsson, 2018), and the residual of regressing the first principal component on macro announcement (Bauer and Swanson, 2022).

The empirical specification is

$$\text{Return}_{i,t} = \beta_1 \text{MPS} + \beta_2 \text{Duration}_{it} + \beta_3 \text{MPS} * \text{Duration}_{it} + \epsilon_{it},$$

where MPS is monetary policy shock. Table 12 shows the estimated β_3. In some specifications, it is significantly negative. That is consistent with the theory.

D.4 Treasury with different data

This section uses data of Gürkaynak et al. (2007) for empirical analysis for bonds. Gürkaynak et al. (2007) uses Treasury quotes provided by the Federal Reserve Bank of New York since December 1987. It employs a parametric yield curve specification to fit the data. Liu and Wu (2021) uses the CRSP daily Treasury data, which provides end-of-day quotes on all outstanding Treasury securities. It constructs a new yield curve using a non-parametric kernel-smoothing method.

Figure 12 shows the average return of the Treasury on FOMC days. The upward term strucutre is also observed in this data.

Table 12: Return sensitivity to interest rate uncertainty

Dependent Variable:	excess return		
Model:	(1)	(2)	(3)
Variables			
MP shock	-3.190	-0.0741	-0.5948
	(1.846)	(1.692)	(1.628)
Duration × MP shock	-0.1064	-0.1233*	-0.1002
	(0.0665)	(0.0667)	(0.0648)
Size × MP shock		-0.7716**	-0.6270*
		(0.3216)	(0.3225)
Profit × MP shock		9.556	8.732
		(6.197)	(5.033)
Market book × MP shock		0.2382	0.1503
		(0.1692)	(0.1439)
leverage × MP shock		2.623*	1.744
		(1.211)	(1.454)

Notes: This table reports coefficient estimates from the panel regression. Column 1 reports the results when a change in interest rate uncertainty, duration, and their interaction term are the dependent variables. "IRU" represents a change in interest rate uncertainty on FOMC days. A change in interest rate uncertainty is the leading uncertainty minus the lagging uncertainty. Column 2 adds size, profitability, leverage, market-to-book, and their interaction with a change in interest rate uncertainty to the dependent variables. Robust standard errors clustered at firms are used in reporting t-statistics. Column 3 adds firm and quarter fixed effects. Heteroskedasticity robust standard errors are used. *p<0.1; **p<0.05; ***p<0.01.

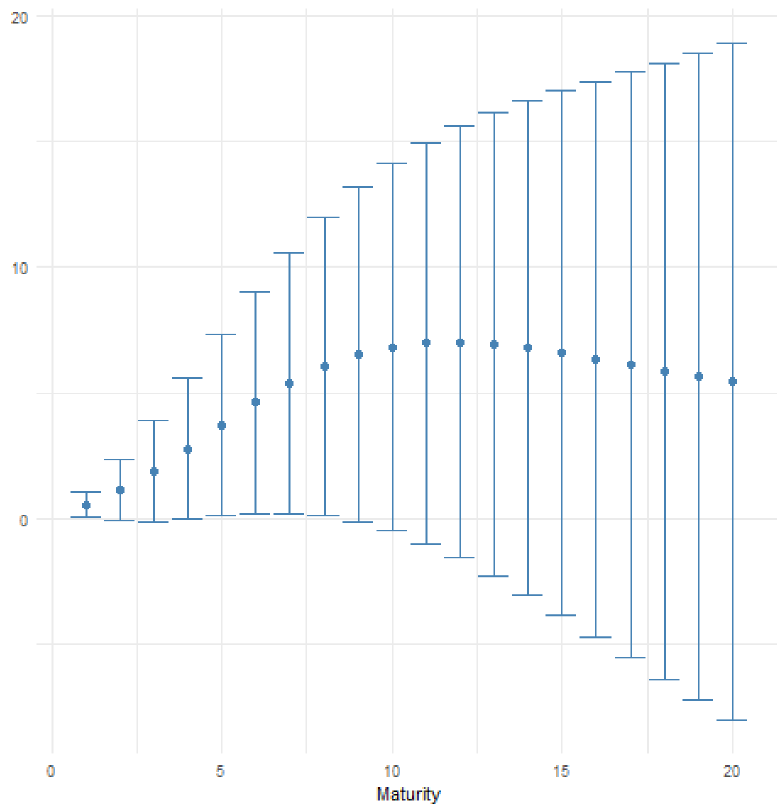

Figure 12: Average return on Treasury on FOMC days.

Notes: Average return on Treasury securities of different maturities on FOMC days. The sample period is 1990/1-2021/12. The Treasury return is given by $\frac{p_t^m}{p_{t-1}^n} - 1$, where p_t is the daily Treasury price and p_{t-1} is its lagged price. The return is expressed in basis points. The band represents the two standard error bands according to Newey and West (1987). Treasury yields are taken from Liu and Wu (2021).

I estimate the time-series regression of

$$y_t^m = \beta_{iru}^m \Delta \text{IRU}_t + \beta_{capm}^m (R_t^M - r^f) + \epsilon_t, \tag{8}$$

where t is the tth FOMC announcement, y_{mt} is the return on Treasuty with maturity m. ΔIRU_t is a logarithm of today's interest rate uncertainty minus yesterday's interest rate uncertainty if today is the tth FOMC day. I estimate β_{iru}^m separately for different maturities m. Figure 13 shows the return sensitivity of the Treasury to a change in interest rate uncertainty. The return sensitivity increases with maturity.

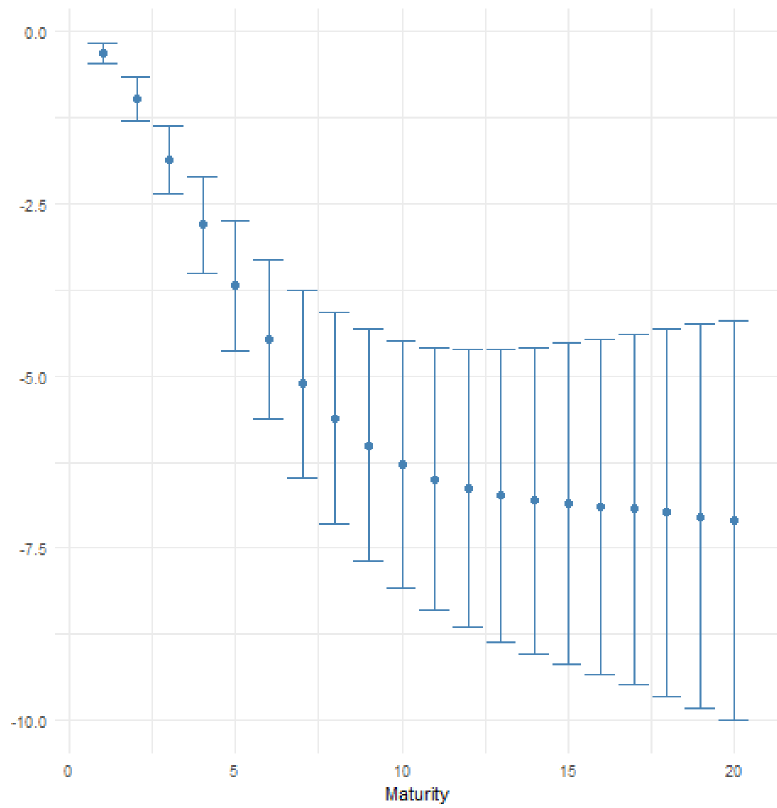

Figure 13: Elasticity of return to interest rate uncertainty.

Notes: Treasury Return Sensitivity to a Change in Interest Rate Uncertainty. This figure plots the return sensitivity to a change in interest rate uncertainty for Treasury securities of different maturities. I regress the Treasury return on a change in interest rate uncertainty on FOMC announcement days, controlling for market excess returns. A change in interest rate uncertainty is the leading uncertainty minus the lagged uncertainty. This figure plots the coefficients on the change in interest rate uncertainty and its two standard error bands. Interest rate uncertainty is taken from Bauer et al. (2022).

I estimate

$$y_t^m = \beta_{iru}^m \mathrm{IRU}_{t-2} + \beta_{capm}^m (R_t^M - r^f) + \epsilon_t,$$

where m is the maturity of the bonds, y_m is the Treasury return with maturity m, and IRU_{t-2} is the level of interest rate uncertainty two days prior to FOMC day. The level of interest rate uncertainty is detrended using the HP filter. Figure 14 shows the return sensitivity of the Treasury on predicted interest rate uncertainty. The return sensitivity increases with maturity.

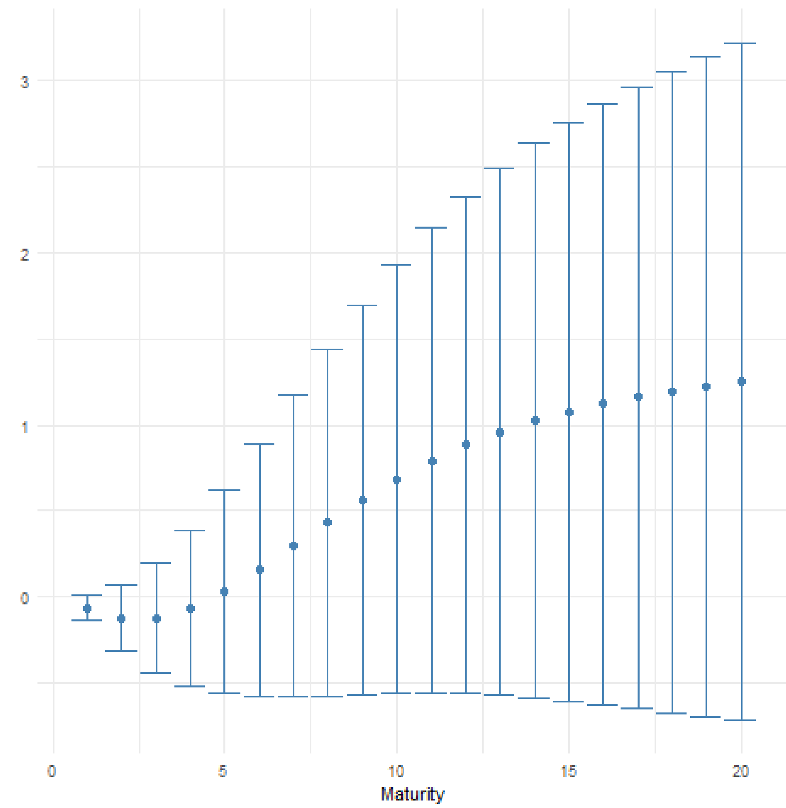

Figure 14: Elasticity of return to interest rate uncertainty.

Notes: Treasury Return Sensitivity to the Lagged Level of Interest Rate Uncertainty. This figure plots the return sensitivity of the Treasury to the lagged level of interest rate uncertainty at different maturities. I regress the Treasury returns on the lagged level of interest rate uncertainty on FOMC announcement days, controlling for market excess returns. The level of interest rate uncertainty is detrended with an HP filter. The lagged value is taken two days prior to the FOMC announcement days. This figure plots the coefficients of the lagged level of interest rate uncertainty and its two standard error bands. The interest rate uncertainty is taken from Bauer et al. (2022).