Exposure to Interest Rate Risk around Monetary Policy Announcements

Masayuki Okada*

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Abstract

This paper tests a risk-based hypothesis of high excess returns around monetary policy announcements. By announcing its decision on interest rates, the interest rate uncertainty is resolved, but assets with different durations have different exposures to it. 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. 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. Uncertainty is created before announcements because Federal Open Market Committee (FOMC) participants are restricted from speaking publicly before the announcements. Risk-averse investors, who are exposed to this risk, demand a return (Ai and Bansal, 2018). As predicted by this risk-based theory,

*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.

the average return of the S&P 500 index is higher on monetary policy announcement days (23.9 bps) than on the other days (3.1 bps) (Savor and Wilson, 2013).

To further test this risk-based hypothesis, the cross-sectional heterogeneity of assets has been examined (Savor and Wilson (2014), Wachter and Zhu (2022), Ai et al. (2022)). Monetary policy announcements provide information about risk factors, and assets more exposed to these risks predictably yield higher returns. A crucial question in this context is to identify the type of risk investors face before announcements and which assets are more exposed to these announcements.

This research presents a novel approach to understanding (i) the type of risk resolved by monetary policy announcements and (ii) the source of heterogeneity across assets. The findings are that (i) monetary policy announcements reduce interest rate risk, and (ii) the main source of heterogeneity in exposure is the duration of assets.

First, interest rate risk is motivated by recent literature on the measurement of interest rate risk (Bauer et al., 2022). The paper finds a significant reduction in the option-implied volatility of interest rates following monetary policy announcements. This type of interest rate risk has been underemphasized in the literature, which primarily focuses on cash flow risk to explain the higher returns on announcement days (Ai and Bansal (2018) and Wachter and Zhu (2022)).

Second, assets with different durations are expected to have different excess returns. In the event of an unanticipated rise in interest rates, investors tend to devalue long-duration assets more, discounting future returns. Conversely, when the central bank surprises by announcing an interest rate cut, investors highly value long-duration assets. Short-duration assets, on the other hand, are less sensitive to interest rates because they pay more in the near term.

I develop a simple asset pricing model where a representative investor with a recursive preference faces risks. The investor can trade short-duration assets, which provide claims on consumption in the near future, and long-duration assets, which provide claims on consumption in the distant future. An investor faces two types of risk: cash flow risk and discount rate risk. An investor discount consumption in the future, but the discount factor is uncertain when trading assets. Additionally, the future cash flow of assets is uncertain. Long-duration assets are more exposed to discount rate risk, as their claims are in the distant future, while short-duration assets are more sensitive to cash flow uncertainty, given that monetary policy primarily affects short-term cash flows. An announcement resolves both types of risk. The central bank announces the short-term interest rate, which the investor uses as a discount factor, and the impact of monetary policy on future cash flows is revealed.

There are three theoretical predictions. The first prediction is about expected return on bonds and equities. Bonds with longer durations are expected to yield higher returns than short-duration bonds on announcement days. Bonds are exposed to discount rate risk and not exposed to cash flow risk. Since long-duration bonds are more sensitive to discount rate changes around announcement, they should have higher expected returns. In contrast, the relative expected returns for short- versus long-duration equities are ambiguous. When an announcement resolves discount rate risk more than cash flow risk, long-duration equities are expected to have higher returns.

The second prediction is about the contemporaneous relation between the realized change in interest rate uncertainty and expected return. 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. The third prediction is about the predictive relation between ex-ante interest rate uncertainty and expected return. 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 equities. 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). The option implied volatility of the Eurodollar future is used as the interest rate uncertainty data (Bauer et al., 2022).

First, Treasury bonds with a maturity of 5 year have an average return of 4.8 bps, while those with a maturity of 20 years have an average return of 10.0 bps on monetary policy announcement days. These empirical findings align with the theoretical results, which suggest that bonds are exposed to discount rate risk and long-duration bonds are more exposed to this risk. In contrast, equities do not show the positive relationship between duration and expected returns. Equities have an average return of 17.5 basis points with a maturity of 13 years and 17.3 basis points with a maturity of 22 years. The average return on short-duration and long-duration stocks are statistically indistinguishable. This implies that the discount factor risk, which has been overlooked in the literature, is equally important as cash flow risk, which is the primary focus in the existing literature (Ai et al., 2022; Wachter and Zhu, 2022).

Second, I empirically show that the elasticity of returns to a change in interest rate uncertainty increases with duration for both bonds and equities. For stocks with a duration of 25 years, the elasticity of the return to interest rate uncertainty is 12, meaning that the return increases by 12bps when interest rate uncertainty decreases by 1% on announcement days. For stocks with a duration of 7 years, the elasticity is lower at 8, indicating a considerably weaker response compared to long-duration equities. For bonds, the elasticity is 6 for 10-year maturities and 9 for 20-year maturities, indicating that the elasticity of long-duration bonds is higher than that of short-duration bonds.

Finally, the sensitivity of returns to ex-ante interest rate uncertainty increases with duration. For bonds, the elasticity is 0.65 for a 10-year maturity and 1.45 for a 20-year maturity. The predicted return for long-maturity bonds is 0.8 bps higher when ex-ante interest rate uncertainty increases by 1% prior to the announcement days.

The paper proceeds as follows. Section 2 shows data that motivates the cross-sectional heterogeneity is the exposure to monetary policy announcements. Section 3 shows a simple theory and presents the testable theoretical predictions. Section 4 explains the data and constructs the variables. Section 5 empirically tests the theoretical predictions for bonds. Section 6 empirically tests the theoretical predictions for equity.

Related Literature

This paper relates to three 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. 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. Zhang and Zhao (2023) also analyses the contemporaneous relation between uncertainty reduction and announcement premium, but the VIX is used to measure the uncertainty. 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[1] 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

[1] 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).

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 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.

2 Cross-sectional Heterogeneity in Exposure to Monetary Policy Announcement

This section shows the cross-sectional heterogeneity in the risk exposure of S&P 500 firms to monetary policy announcements. First, I compute the time-series average of daily returns on FOMC days for each of the 500 firms over the sample period (1990/1-2022/03). The firms were then ranked into five groups, from low to high, based on these time-series average returns. The mean and standard deviation of daily returns on FOMC and non-FOMC days for each group are reported in table 1. The results show significant variation in FOMC day returns across the five groups, with the highest group having an average return of 59.1 bps and the lowest group having an average return of 2.6 bps. While returns on FOMC day exhibit a heterogeneity, non-FOMC day returns are similar across all five groups, suggesting a variation in firms' exposure to monetary policy announcements.

Savor and Wilson (2013) find that the return on the S&P 500 Index is high on FOMC days. While their analysis does not address firm-level heterogeneity, table 1 shows that these higher returns are not uniform across all 500 firms, but rather are driven by a subset of firms. The underlying causes of this heterogeneity are explored in section 3, where a theoretical framework is presented to explain the differences between these groups.

3 Theory

This section shows a simple model to present testable theoretical predictions about risk factors and expected returns on announcement days.

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 mean and standard deviation of the S&P500 Index. Sample period is 1990/01/02-2022/03/31. Returns are expressed in basis points.

The model is 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: short-duration assets and long-duration assets. The short-duration assets give 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 risk: the discount factor risk and the cash flow risk of short-duration equity. The investor does not know the state of the economy in period 1. She believes that the discount rate is high (state s_1) with $\pi\alpha_1$ and it is low (state s_2) with $\pi(1-\alpha_1)$. The cash flow of short-duration equity is high (state s_3) with probability $(1-\pi)\alpha_2$ and the cash flow is low (state s_4) with probability $(1-\pi)(1-\alpha_2)$. The parameter π governs the probability of revealing the information about the discount rate. 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 cash flow on long-run assets.

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

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

There are two points to highlight. Firstly, why does an investor face uncertainty regarding the discount factir? This can be understood by taking into account the announcement of the risk-free short-term interest rate. The risk-free rate is used by investors to discount future 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.[2]

More importantly, it is assumed that only the uncertainty about the return on a short-duration asset is resolved through an announcement, while information about the cash flow of a long-duration asset is not revealed, resulting in an equal 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.

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

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

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

[2] 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).

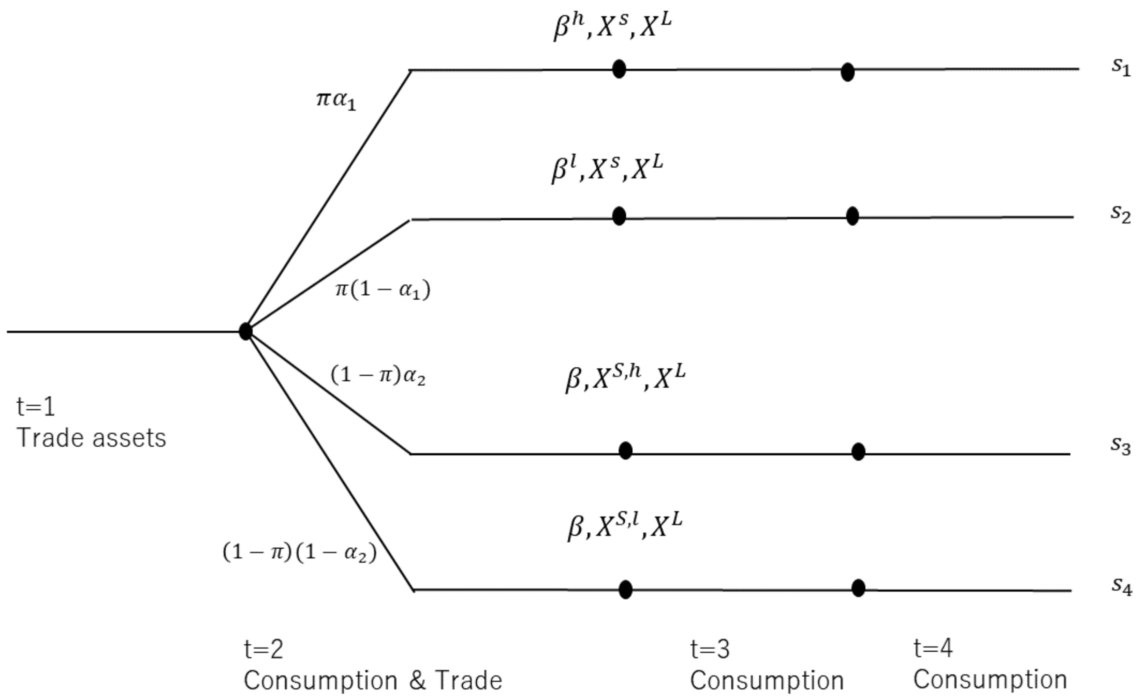

Figure 1: Model Overview

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, an investor knows the state of the economy as it is announced. 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 discount factor if $\gamma > \frac{1}{\psi}$ holds. 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 lower than the expected post-announcement price.

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 cash-flow is not announced ($s_i \in \{s_3, s_4\}$),

$$X^S(s_3) = X^S(s_4) = X^L \equiv \overline{X}.$$

Also, investors does not have upward or downward bias on the expected psot-announcement cash flow and discount factor. The average of realized high state and low state in post-announcement periods is equal to the average of expectation formed in pre-announcement periods.

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

where σ_1 and σ_2 represents a dispersion.

3.1 Bond as a No Cash Flow Uncertainty Case

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 cash flow on the bond does not depend on the state. The bond can be viewed as having no cash flow uncertainty, $\pi = 1$. 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. See Appendix A.2. □

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. See Appendix A.3. □

3.2 Equity as a Cash Flow Uncertainty Case

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 4, 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 discount rate (σ_1) the volatility of the cash flow (σ_2). The premium of short-duration equity is high when return volatility is high and discount rate volatility is low. The volatility of cash flow 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. When an announcement is about the discount 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.

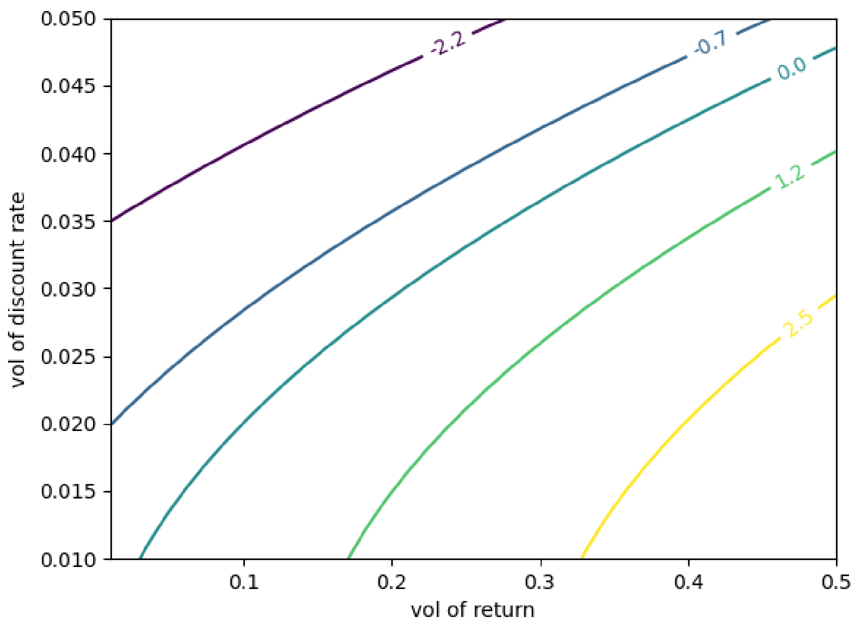

Figure 2: Numerical illustration.

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.

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.

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

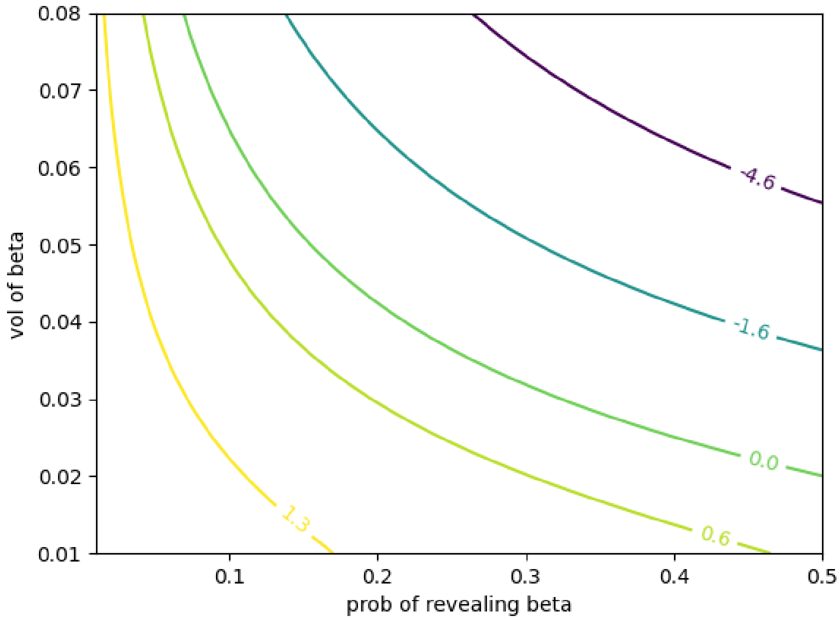

Figure 3: Numerical illustration.

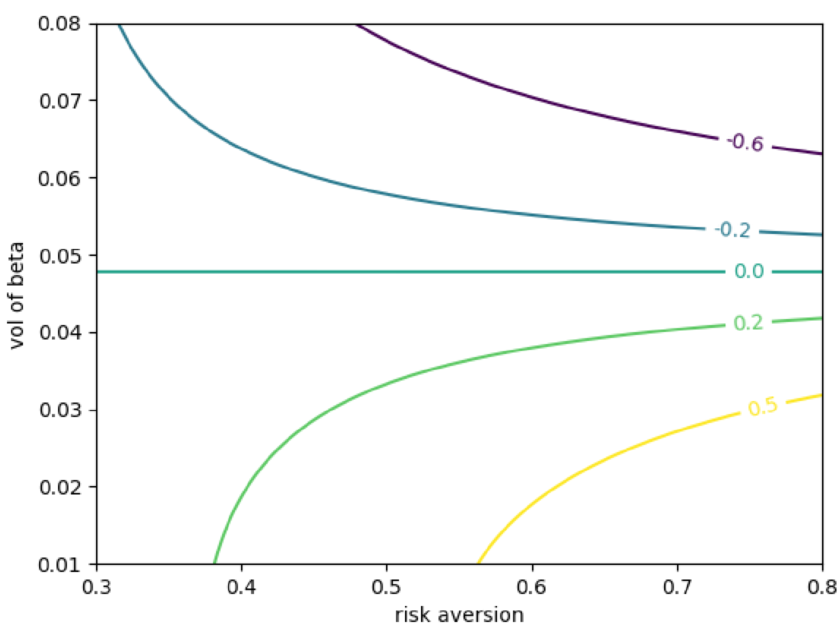

Figure 4: Numerical illustration.

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[3].

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.

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

4.1 Returns of Equity and Bond.

The sample period is 1990Q1-2019Q4. Table 2 shows summary statistics of the samples. The daily return of equity is defined as the $(\frac{p_t}{p_{t-1}} - 1) \times 10,000$ where p_t is the closing price of equity on announcement day and p_{t-1} is the price one day before announcement day.

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 zero coupon yield for U.S. Treasury bonds using nonparametric kernel-smoothing methods. 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 $\left(\frac{p_t(n)}{p_{t-1}(n)} - 1\right) \times 10,000$ where t is FOMC day.

4.2 The Equity Duration Measure

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 of this duration measure 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[4]. 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. In the appendix D.1, I use the book-to-market ratio as another measure of 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.

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

Figure 5 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.

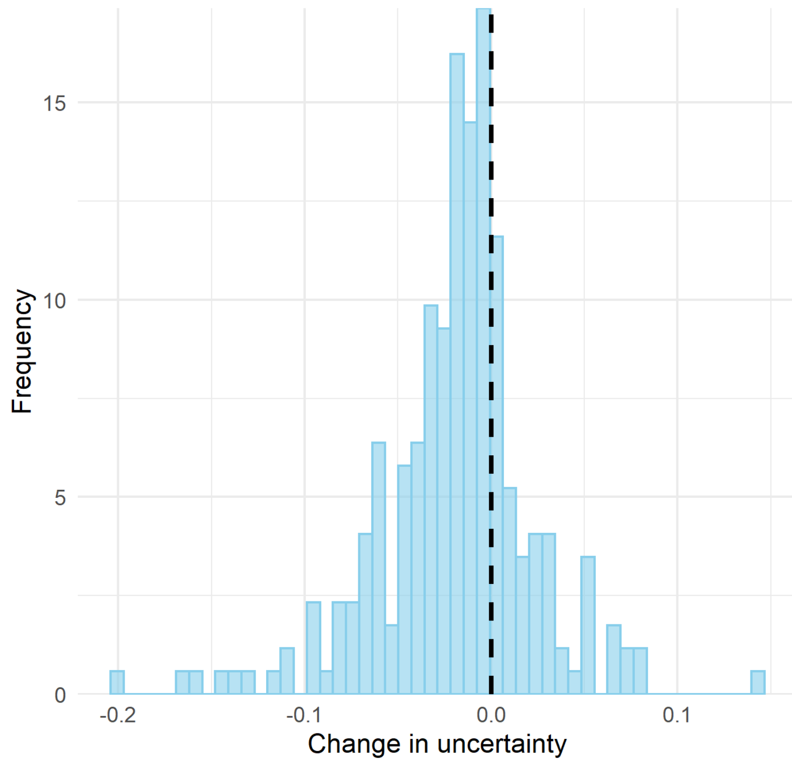

Figure 5: Histogram of change in interest rate uncertainty.

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

The proposition 2 states that the return on long-maturity bonds is higher than the return on short-maturity bonds. Figure 6 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 proposition 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 proposition 3. The return on long-maturity bonds should be more responsive to a change in interest rate uncertainty than the return on short-maturity bonds. I estimate the time-series regression of

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

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

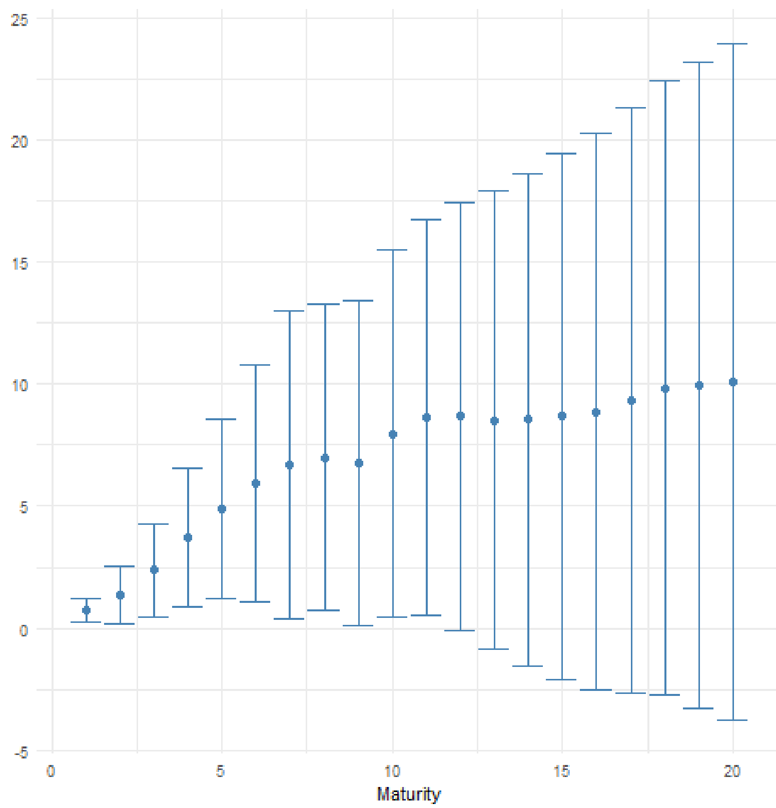

Figure 6: Average return on Treasury on FOMC days.

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).

today is the tth FOMC day. I estimate β^m_{iru} separately for different maturities m. Figure 7 shows the estimated result of equation (1). It shows the monotonically downward sloping curve that is consistent with the proposition 3. The standard error is Newey and West (1987). The estimated β_{iru} for a 10-year maturity bond is -6.8, which means that when the implied volatility of interest rate over a one-year horizon decreases by 1% on announcement days, the expected return on 10-year maturity bond increases by 0.68%. The coefficients are significantly negative for all horizons.

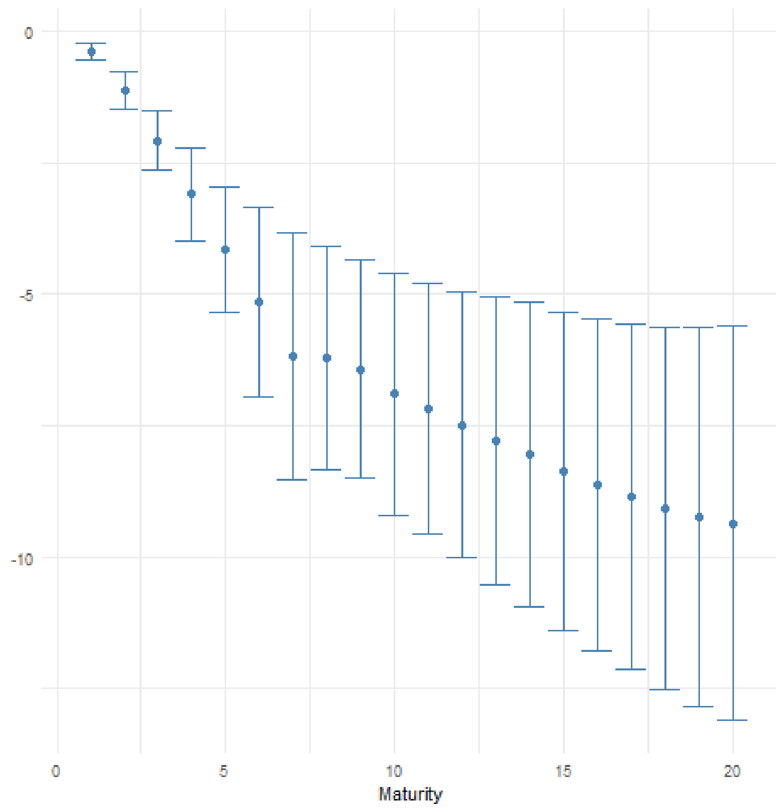

Figure 7: Sensitivity of return to change in interest rate uncertainty.

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).

To see that the decline of interest rate uncertainty mainly drives the high return on bonds, I also show the contemporaneous relationship between VIX and Treasury. The literature (Lucca and Moench (2015), and Hu et al. (2022)) uses VIX as a major source of uncertainty that is reduced by the announcements. I estimate

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

Figure 8 shows the estimated β_{vix}^m. The coefficients are not significantly different from zero and do not show monotonicity. This figure suggests that the Treasury is not exposed to risks that VIX captures, although VIX is intensively used in the literature. Hillenbrand (2021) studies the high return on Treasury bonds and rejects the risk-based hypothesis by showing that the contemporaneous relation between the return on Treasury and the decline of VIX is statistically insignificant. However, a significant relationship between change in uncertainty and high return is observed if interest rate uncertainty is focused.

5.3 Interest Rate Uncertainty and Predictive Regression.

I also estimate the predictive relationship between interest rate uncertainty and Treasury returns. I estimate

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

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 9 shows the results. When ex-ante interest rate uncertainty is high, a long-short investment strategy is predictably high. Ex-ante uncertainty predicts the Treasury yield on FOMC days. Second, predictability increases with maturity.

6 Empirical Analysis of Equity

In this section, I empirically test the theoretical predictions for the expected return on equity.

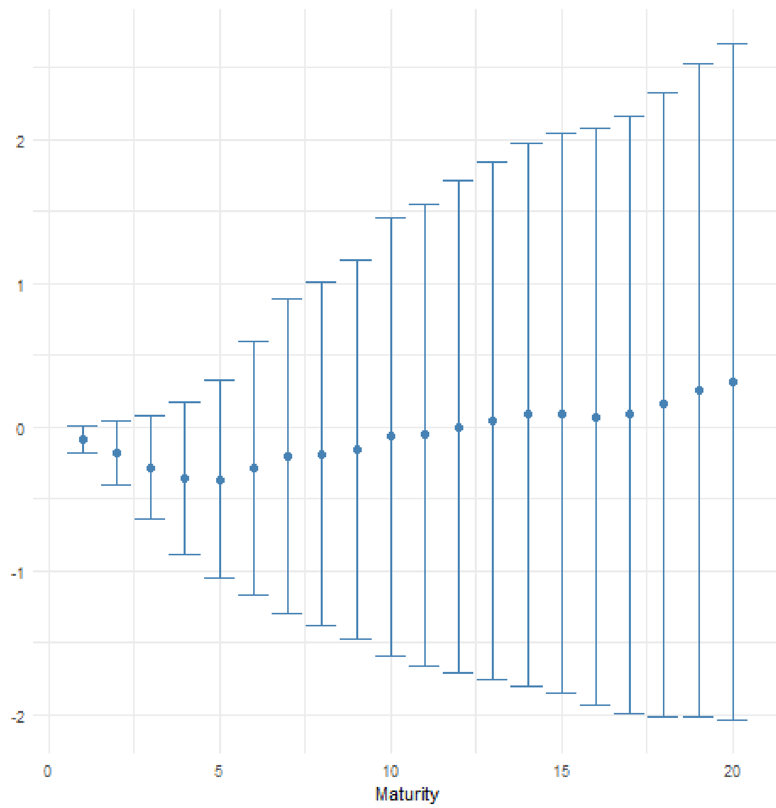

Figure 8: Treasury return sensitivity to change in VIX.

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).

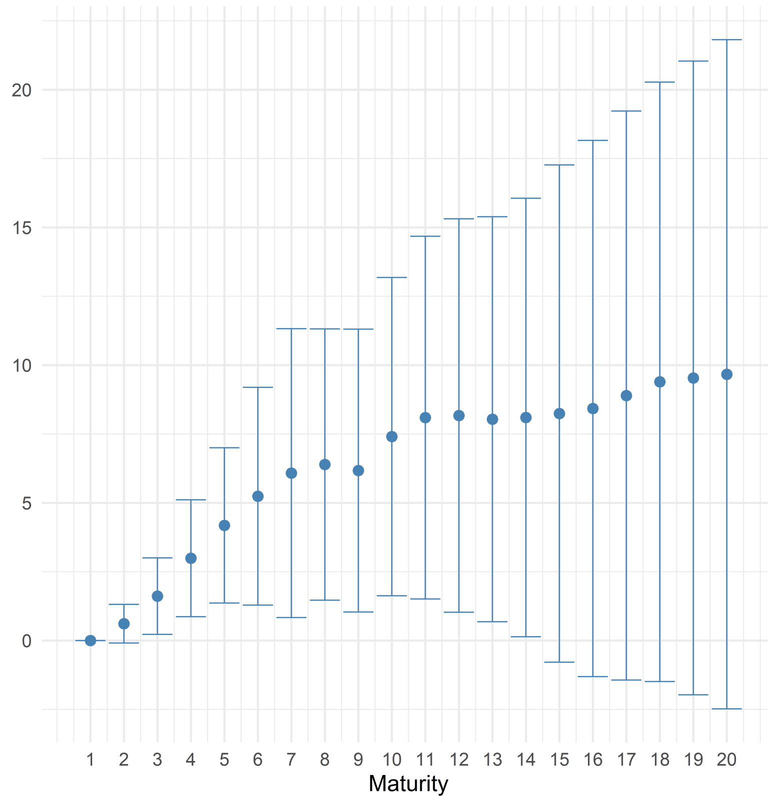

Figure 9: Treasury return sensitivity to ex-ante interest rate uncertainty.

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).

6.1 Average Return on FOMC days

First, I empirically test whether short- or long-term stocks have a higher return on the announcement day. Figure 10 shows the average return conditional on duration. The horizontal axis is equity duration. I divide the firms into ten groups from low to high based on duration, and then calculate the average return on FOMC days in the groups. The vertical line is the average return. The average returns on short-duration equity and long-duration equity are statistically indistinguishable even though the longest-duration portfolio takes a smaller value. The theoretical prediction suggests that if monetary policy has a transitory effect on cash flow and this effect is larger than the effect of the discount rate, the return on short-duration equity will be higher. If the discount factor risk is resolved by the announcement, the expected return on long-duration equity is higher. Figure 10 shows discount factor risk that has been overlooked in the literature is equally important as the cash flow risk that is the main focus in the literature for equity return.

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. Panel A shows the excess return on FOMC days of each portfolio. Monotonically upward or downward term-structure is not observed even though the return on first and second portfolio is higher than others and the return on ninth and tenth portfolio is lower than others.

Panel B shows the average return on equities with different durations on non-FOMC announcement days. Interestingly, the excess return on Non-FOMC days has a clear downward slope curve that shows a clear contrast with the average return on FOMC days. This patter is consistent with the literature on the term structure of equity (Van Binsbergen et al. (2012), Weber (2018)). A term structure of returns on FOMC days is flatter than on non-FOMC days. This suggests that the discount factor risk pushes the term structure up on FOMC days, which also supports this paper's

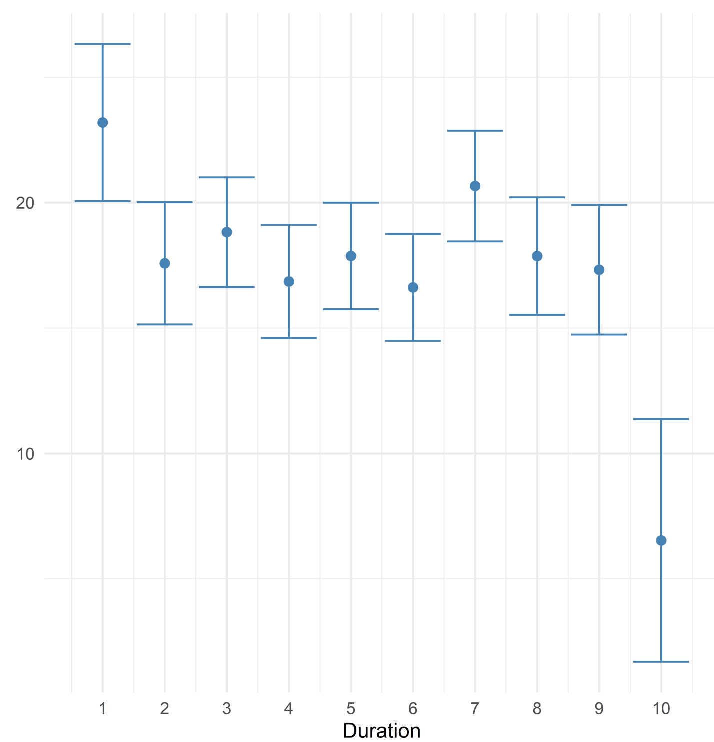

Figure 10: Average return on FOMC day

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.

main message that the discount factor risk should not be overlooked on FOMC days.

Table 4: Uncertainty resolution and exposure

Portfolio	1	2	3	4	5	6	7	8	9	10
	Panel A: FOMC days									
Duration	7.4	13.5	15.5	16.8	17.9	18.9	19.8	20.8	21.8	24.9
FOMC return	23.1	17.5	18.8	16.8	17.8	16.6	20.6	17.8	17.3	6.5
FF3 α	11.4	4.4	1.2	-0.8	-2.1	-0.5	-0.6	-3.1	-4.4	-9.7
FF5 α	11.2	4.3	1.2	-0.8	-2.2	-0.6	-0.6	-2.9	-4.1	-9.1
	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
FF3 α	13.0	6.9	4.8	3.4	2.4	1.8	1.4	0.4	0.3	0.6
FF5 α	12.8	6.5	4.4	3.0	2.1	1.6	1.6	0.9	1.7	1.9

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 short to long. The t-statistic follows Newey and West (1987).

6.2 Interest Rate Uncertainty and Contemporaneous Regression.

This section employs a firm-level event study approach with panel data to examine the impact of interest rate uncertainty on the cross-section of equity[5]

I test the theoretical prediction 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

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

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

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. The theoretical prediction 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 5 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. The appendix D.1 analyzes the same prediction using the other measure of duration for robustness check. The appendix D.2 employs a portfolio-level event study for robustness.

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 5: 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. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

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Appendix A Proof

A.1 Proposition 1

The expected announcement premium for short-duration stock is

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

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 Proposition 2

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

$$\begin{aligned}
&E_1\left[\frac{P_2(s)^S}{P_1^S}\right] - E_1\left[\frac{P_2(s)^L}{P_1^L}\right] \\
&= \frac{E\left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\right] E\left[\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]}{E\left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]} \\
&- \frac{E\left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\right] E\left[\beta^2(s)C_4(s)^{-\frac{1}{\psi}}X^L(s)\right]}{E\left[\left[C_2^{1-\frac{1}{\psi}} + \beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\beta^2(s)C_4(s)^{-\frac{1}{\psi}}X^L(s)\right]}
\end{aligned} \tag{5}$$

Denote

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

The equation 5 is written as

$$\begin{aligned}
&E_1\left[\frac{P_2(s)^S}{P_1^S}\right] - E_1\left[\frac{P_2(s)^L}{P_1^L}\right] \\
&= \left(E\left[A(s)\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right] E\left[A(s)\beta^2(s)C_4(s)^{-\frac{1}{\psi}}X^L(s)\right]\right)^{-1} E[A(s)] \\
&\times \left(E\left[\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right] E\left[A(s)\beta^2(s)C_4(s)^{-\frac{1}{\psi}}X^L(s)\right]\right. \\
&\left. - E\left[A(s)\beta(s)C_4(s)^{-\frac{1}{\psi}}X^S(s)\right] E\left[\beta^2(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]\right)
\end{aligned}$$

The cash-flow of bonds is the same for the states and maturities. Also, I have assumed that the consumption in period three and four are the same in all state, $C_3(s_i) = C_4(s_i)$. The sign of this equation is equal to

$$
\begin{aligned}
&\Big(E\left[\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]E\left[A(s)\beta^2(s)C_4(s)^{-\frac{1}{\psi}}X^L(s)\right] \\
&- E\left[A(s)\beta(s)C_4(s)^{-\frac{1}{\psi}}X^S(s)\right]E\left[\beta^2(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]\Big) \\
&= (1-\alpha)\beta(s_2)C_3(s_2)^{-\frac{1}{\psi}}\alpha A(s_1)\beta^2(s_1)C_4(s_1)^{-\frac{1}{\psi}}\overline{X} \\
&+ \alpha\beta(s_1)C_3(s_1)^{-\frac{1}{\psi}}(1-\alpha)A(s_2)\beta^2(s_2)C_4(s_2)^{-\frac{1}{\psi}}\overline{X} \\
&- (1-\alpha)A(s_2)\beta(s_2)C_4(s_2)^{-\frac{1}{\psi}}\alpha\beta^2(s_1)C_4(s_1)^{-\frac{1}{\psi}}\overline{X} \\
&- \alpha A(s_1)\beta(s_1)C_4(s_1)^{-\frac{1}{\psi}}(1-\alpha)\beta^2(s_2)C_4(s_2)^{-\frac{1}{\psi}}\overline{X} \\
&= \alpha(1-\alpha)\beta(s_1)\beta(s_2)C(s_1)^{-\frac{1}{\psi}}C(s_2)^{-\frac{1}{\psi}}(A(s_1)-A(s_2))(\beta(s_1)-\beta(s_2))
\end{aligned} \tag{6}
$$

The difference between the discount factor in two states are positive, $\beta(s_1) = \beta^h > \beta(s_2) = \beta^l$. Also,

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

is true if and only if $\gamma > \frac{1}{\psi}$. Therefore, the equation 6 is negative, and the expected return on the long-maturity bond is higher than the short-maturity bonds.

A.3 Proposition 3

Appendix B Data Sources and Descriptions

1. FOMC dates are obtained from the website of the Board of Governors of the Federal Reserve System[6].

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 $sprtrn$.

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

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[7]. 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
     - 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

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

  - 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[8]. Employment Situation announcement days are from the U.S. Bureau of Labor Statistics[9]. GDP announcement days are from the U.S. Bureau of Economic Analysis[10].

10. Daily Treasury data is from Gürkaynak et al. (2007) and Liu and Wu (2021). I obtain data from Gurkaynak's homepage[11] and Wu's homepage[12].

Appendix C Constructin of Duration Measure

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

[8] https://www.bls.gov/bls/news-release/ppi.htm

[9] https://www.bls.gov/bls/news-release/empsit.htm

[10] https://apps.bea.gov/histdata/histChildLevels.cfm?HMI=7

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

Federal Reserve updates weekly at

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

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

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.

$$\begin{aligned} \text{CF}_{i,t+s} &= \text{E}_{i,t+s} - (\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}) \\ &= \text{BV}_{i,t+s-1}\left[\frac{\text{E}_{i,t+s}}{\text{BV}_{i,t+s-1}} - \frac{\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}}{\text{BV}_{i,t+s-1}}\right] \end{aligned} \tag{7}$$

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 [13]. Return on equity has an AR(1) coefficient of 0.67 and growth in book equity of 0.18.

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

[13] 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).

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 (7).

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

$$\text{Return}_{i,t} = \beta_1 \Delta IRU_t + \beta_2 \text{Duration}_{it} + \beta_3 \Delta IRU_t * \text{Duration}_{it} + \gamma X_{it} + \epsilon_{it}. \tag{8}$$

The book-to-market ratio is lagged by six months. Table 6 shows that value firms have smaller sensitivity to change in interest rate uncertainty.

Table 6: Return sensitivity to interest rate uncertainty

Dependent Variable:		excess return	
Model:	(1)	(2)	(3)
Variables			
IRU	-7.658***	-3.246	-2.954
	(2.116)	(3.004)	(2.781)
Duration × IRU	1.394**	1.471**	1.603**
	(0.6148)	(0.5899)	(0.5760)
Size × IRU		-0.6671	-0.8955*
		(0.5584)	(0.4576)
Profit × IRU		15.76	20.91
		(16.22)	(14.05)
leverage × IRU		-3.971	-3.181
		(4.967)	(4.670)

Clustered (industry & Year) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

D.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, ΔIRU 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}	-7.1	-7.2	-8.6	-9.4	-9.0	-8.9	-9.8	-10.3	-10.3	-11.2	-4.1	-2.7
	Panel B: CAPM											
β_{iru}	0.56	0.43	0.20	-0.24	0.04	0.45	-0.47	-0.97	-1.03	-2.02	-2.58	-2.06
β_{capm}	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.19

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).

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 8 shows the estimated β_3. In some specifications, it is significantly negative. That is consistent with the theory.

Table 8: 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. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.