Exposure to Interest Rate Risk around Monetary Policy Announcements

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Abstract

This paper tests a risk-based hypothesis of high excess returns around monetary policy announcements. The interest rate uncertainty is resolved by monetary policy announcements, and 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. Long-duration assets are more exposed to interest rate uncertainty since they receive their cash flows later. 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,

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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 is to identify the type of risk investors face and which assets are more exposed to.

This research shows a novel 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 resolution of interest rate uncertainty by monetary policy announcements (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 announcement premium literature, which focuses primarily on cash flow risk (Ai and Bansal, 2018; Wachter and Zhu, 2022).

Second, assets with different durations are expected to have different excess returns. In the event of an unanticipated increase in interest rates, investors devalue long-duration assets more by discounting future returns. Conversely, when the central bank announces 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. Short-duration assets are more sensitive to cash flow uncertainty, as monetary policy affects short-term cash flows, but have a neutral impact in the long run. An announcement resolves both risks; the central bank announces the short-term interest rate that 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, but not exposed to cash flow risk. Since long-duration bonds are more sensitive to discount rate changes, 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. Long-duration assets are more exposed to uncertainty about discount rates. When an announcement reduces uncertainty about the interest rate, the return on long-duration assets increases more than that of short-duration assets. 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, bonds with longer duration have higher expected returns. Treasury bonds with a maturity of 5 years 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 finding suggests that discount factor risk, which has been underemphasized in the literature, is as important as cash flow risk, which is the primary focus (Ai et al., 2022; Wachter and Zhu, 2022). Furthermore, this finding contrasts with the literature that observes a downward-sloping term structure of equity (Lettau and Wachter, 2011; Weber, 2018). This paper finds that the downward-sloping term structure does not hold on FOMC announcement days, as long-duration stocks are more exposed to interest rate risk and therefore have higher returns. The downward-sloping term structure holds only on non-FOMC announcement days,

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 premium. Savor and Wilson (2013) find that there is a high excess return of stocks and bonds on the days of macro announcements. Various empirical evidence of announcement premium has been studied in the empirical literature. [1].

Since the emergence of empirical evidence, the theoretical literature has developed a model for

[1] Lucca and Moench (2015) find that a high excess return is driven by a pre-announcement drift on FOMC announcement days. Other example includes Brusa et al. (2020); Neuhierl and Weber (2018); Cieslak et al. (2019); Mueller et al. (2017); Indriawan et al. (2021); Wachter and Zhu (2022)

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.

This paper differs from the literature by analyzing the discount factor risk because of interest rate uncertainty from theoretical and empirical perspectives, whereas the literature focuses mainly on uncertainty about future cash flow. Empirically, 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. Theoretically, Wachter and Zhu (2022) and Ai et al. (2022) models cash flow risk, where as my paper models both discount factor risk and cash flow risk.

Another difference from the literature is to focus on duration as cross-sectional heterogeneity in exposure to announcements. The 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. The literature assume that the parameters governing the cross-sectional sensitivity to monetary policy are exogenous, and they do not focus on why they are exposed differently [2]. This paper provides an interpretation of the cross-sectional sensitivity to monetary policy based on duration.

Second, this paper is in line with the literature on the importance of monetary policy uncertainty on asset prices. 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

[2] Other example is Ai et al. (2022). This paper provides empirical evidence that a firm's expected option-implied variance reduction on announcement days strongly predicts excess returns.

days and show that this measure is correlated with stock returns.

My contribution to this 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 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 on firm-level equity. 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 in this paper.

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

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.

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 constructs a model to present testable theoretical predictions about risk factors and expected returns on announcement days.

The model is based on Ai and Bansal (2018), with extensions that incorporate discount factor risk and cross-sectional heterogeneity across assets. 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 2, 3, and 4. It is important to note that an investor does not face any uncertainty about the cash flow on long-run assets. Ai and Bansal (2018) and Wachter and Zhu (2022) assume that the central bank announces uncertainty about cash flow. This paper generalizes their framework and incorporate discount rate risk.

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, an investor faces uncertainty about the discount factor. This can be understood as 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.[3]

[3]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.

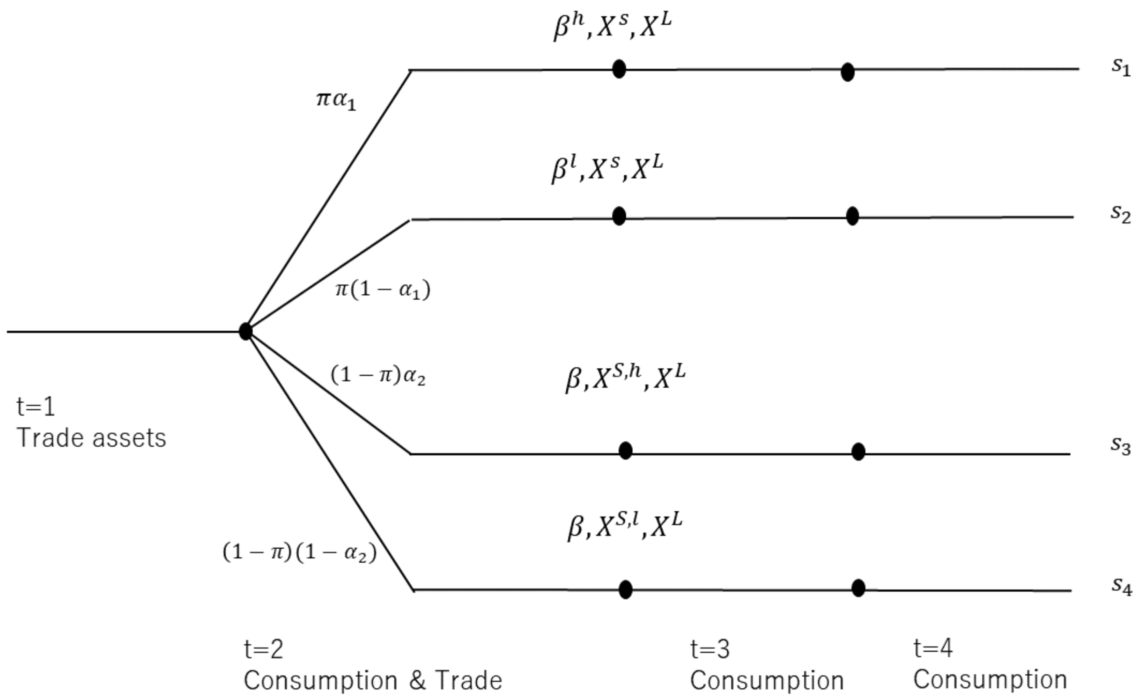


Figure 1: Model Overview

Second, 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

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

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

(2022).

such that

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

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.

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

where σ_1 and σ_2 represents a dispersion.

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 $\gamma > \frac{1}{\psi}$.*

$$P_1^S < E_1[P_2^S(s)], \quad P_1^L < E_1[P_2^L(s)],$$

Proof. See Appendix A.1. □

The expected return on announcement days is greater than one for both short- and long-duration assets. In the following analysis, I show (i) the comparative statistics on which asset's expected return is higher and (ii) the relationship between the expected return and the characteristic of monetary policy announcements.

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, $\pi = 1$. In this scenario, assets are not exposed to cash flow risk. Assets can be interpreted as bonds, as the cash flow on a bond remains constant regardless of economic conditions, at least in nominal terms. In this limiting case, the average announcement premium for a long-maturity bond is higher than that for a short-maturity bond.

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

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

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 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 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.

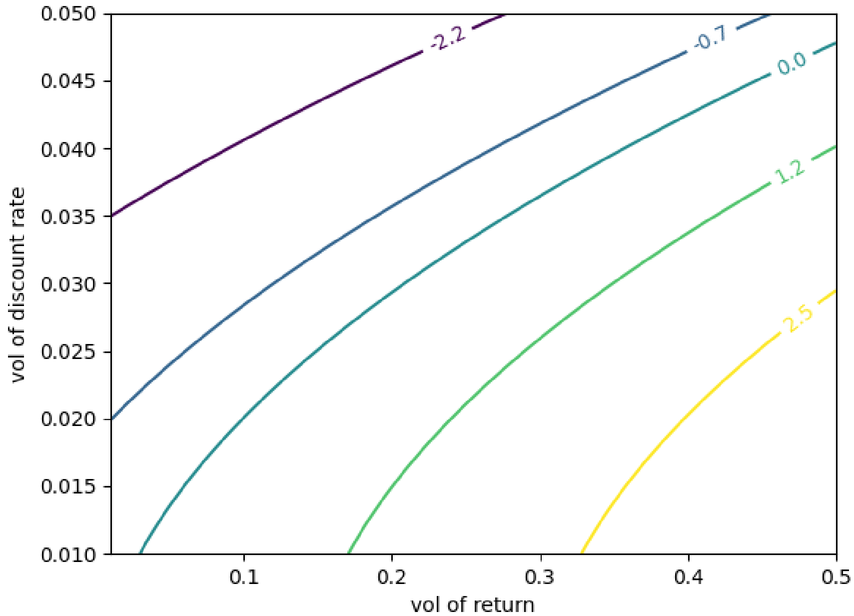


Figure 2: Numerical illustration.

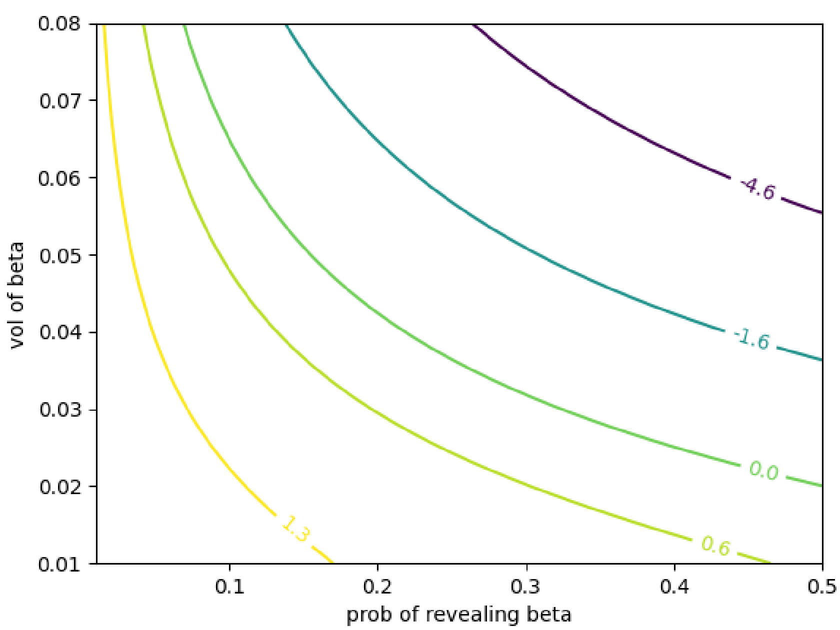


Figure 3: Numerical illustration.

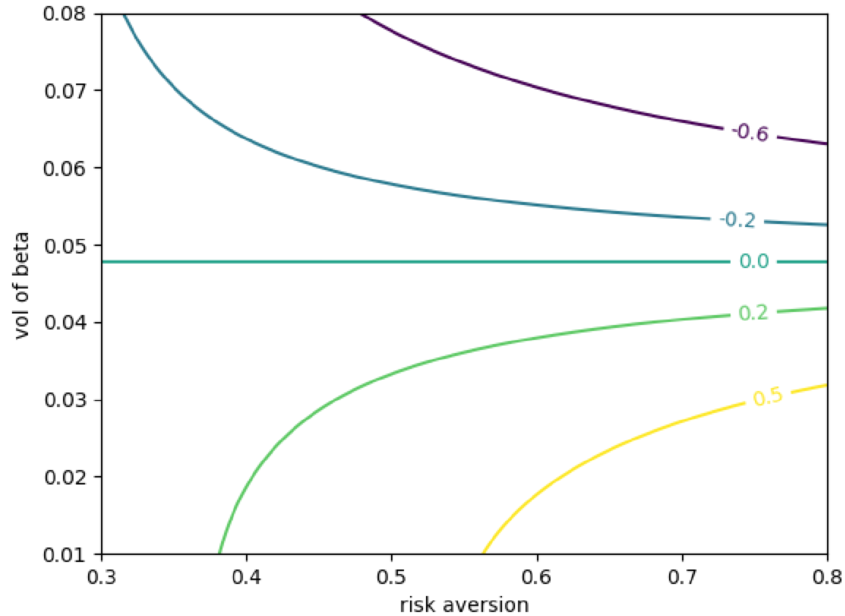


Figure 4: Numerical illustration.

4 Data

This section explains the construction of the main variables: bond and equity returns, equity duration, and interest rate uncertainty. For bonds, US Treasury bonds are used. For stocks, U.S. public companies included in both of CRSP and Compustat are used. The description of the data source can be found in the appendix B. The sample period is 1990Q1-2019Q4.

4.1 Returns of Equity and Bond.

The daily return of the assets on the announcement days is expressed in basis points; $(\frac{p_t}{p_{t-1}} - 1) \times 10,000$. For equities, p_t is the closing price on announcement day and p_{t-1} is the price one day before announcement day. The price for each equities is obtained from CRSP.

For Treasury bonds, the returns on bonds are constructed using the Treasury bond price data from Gürkaynak et al. (2007). This data constructs daily data about zero coupon yield of U.S. Treasury bonds for various maturities. The price of bonds, p_t, is given by $p_t(n) = \frac{1}{(Y_t(n))^n}$ where $Y(n)$ is the annualized yield of maturity n years at time t and obtained from the data.

4.2 The Duration of Assets

To examine the heterogeneous exposure to assets with different durations, it is necessary to measure the duration of the assets. For bonds, duration is directly observed. If a Treasury bond matures in n years, I use n as its duration.

For equities, the duration is not directly observed. I followed Weber (2018) to construct the duration of each equity. Weber (2018) is based on the timing of the cash flows. The measure is similar to Macaulay duration, 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 future cash flow is forecasted using future forecasted return on equity and growth in book equity using clean surplus accounting,

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

Returns on equity and growth in equity are modeled to follow an autoregressive process. The parameters in the autoregressive process are estimated using the pooled CRPS-Compustat firms. The details of this duration measure are described in Appendix C.

Table 2 reports the summary statistics for duration. The average payoff horizon implied by the stock prices is 17.8 years. The standard deviation of duration is 5.9 years, so there is considerable heterogeneity in the data. Public (19.8 years) and transportation (18.0 years) industries have longer durations on average, while utilities (16.3 years) and wholesale (16.8 years) industries have shorter durations.

Panel B shows that duration is strongly negatively correlated with the book-to-market ratio, which is often used as an alternative measure of duration in the literature (Lettau and Wachter, 2007). In the following sections, I use the book-to-market ratio as an alternative measure of duration for robustness checks.

Table 2: Summary statistics

	Dur	BM	Size	Prof	Lev
	Panel A. Means and SD				
Mean	17.7	1.38	5.5	0.02	0.23
SD	5.0	1.5	2.2	0.06	0.2
	Panel B. Correlations				
Dur		-0.40	-0.05	-0.12	-0.03
BM			0.20	-0.10	-0.15
Size				0.19	0.18
Prof					0.06

Note: This table reports time series averages of cross-sectional means and standard deviations for firm characteristics in Panel A and correlations of these variables in Panel B. DUr is cash-flow duration; BM is the book-to-market ratio; Size is long of assets; Prof is profit devided by assets; Lev is a leverage ratio. Financial statement data com from Compustat. The sample period is 1990Q1-2019Q4.

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, $\sqrt{\mathrm{Var}(\mathrm{ED}_{t+\tau}|I_t)}$. The methodology provides a model-free estimate of the conditional standard deviation, given the prices of futures and options.

Figure 5 shows the histogram of the two-day window change in interest rate uncertainty on FOMC announcement days (246 days); $log(mpu_{t+1}) - log(mpu_{t-1})$ where t is the FOMC day. The average change in the uncertainty measure is -0.021. Its t-value is -7.12, suggesting that, on average, the monetary policy announcement significantly reduces interest rate uncertainty.

The standard deviation is 0.047. The variation in the resolution of interest rate uncertainty is closely related to a specific change in the Federal Reserve's forward guidance (Lakdawala et al., 2021). For example, the largest decrease occurred in August 2011; monetary policy uncertainty decreases by 29%, shown in the left tail of the histogram in figure 5. Before the meeting, the FOMC stated that interest 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 significantly reduces interest rate uncertainty.

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-duration bonds is higher than the return on short-duration bonds. Figure 6 shows the average return on the FOMC day across various durations. Standard errors follow Newey and West (1987). The return on long-duration bonds is higher than that on short-duraiton bonds. While the average return on one-year Treasury bond is 0.62 bp, the average return on twenty-nine-year Treasury bond is 10.22 bp. The result is consistent with the proposition 2. Since interest rate uncertainty is reduced on FOMC days, and long-duration bonds

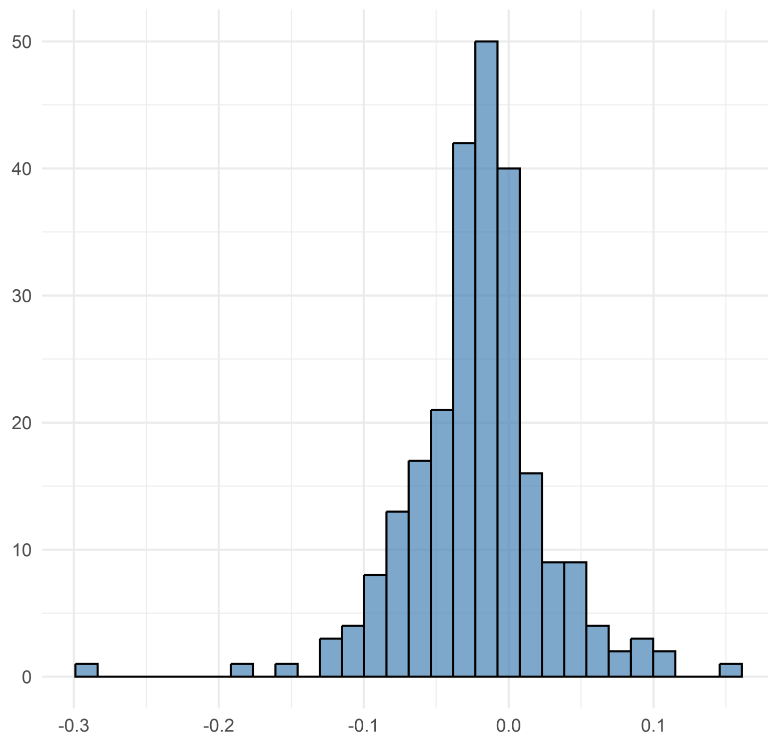


Figure 5: Histogram of change in interest rate uncertainty.

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.

are more exposed to the announced interest rate level, investors demand a higher premium for long-duration bonds on average.

Although the average yield increases monotonically with duration, the long-duration bond has a larger standard error. This is also observed in Wachter and Zhu (2022). Since the price is given by $p_t(n) = \frac{1}{(Y_t(n))^n}$, a longer duration, n, results in a larger price fluctuation.

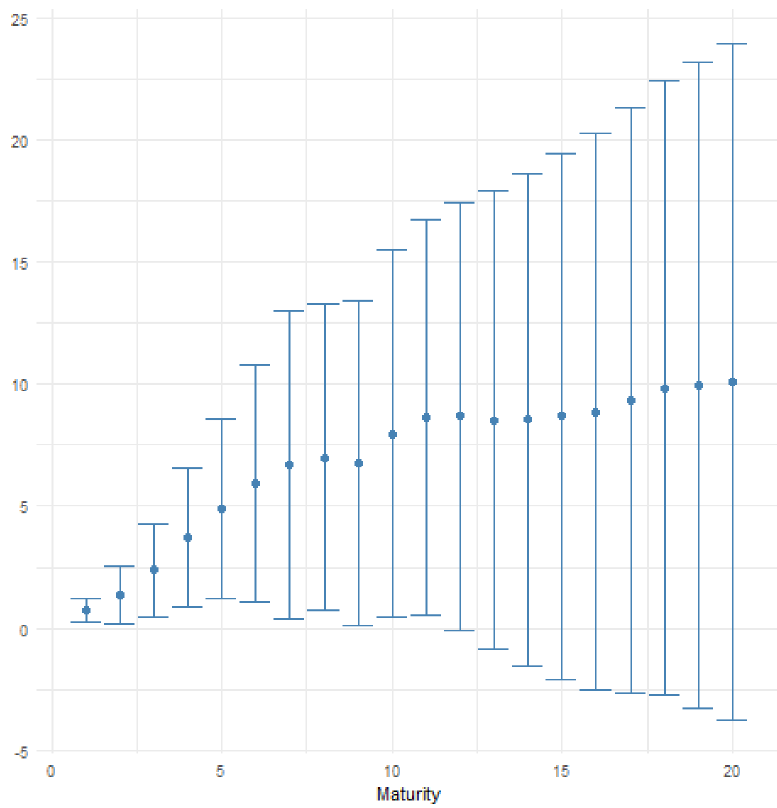


Figure 6: Average return on Treasury on FOMC days.

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 $\frac{p_t(n)}{p_{t-1}(n)} - 1$, where $p_t(n)$ is the price of Treasury bond with n-years maturity on FOMC days and p_{t-1} is price on one day before FOMC days. The price is given by $p_t(n) = \frac{1}{(Y_t(n))^n}$, where $Y_t(n)$ is the annualized yield on Treasury bonds with n years maturity. The return is expressed in basis points. The band represents the two standard error bands according to Newey and West (1987).

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.

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).

5.2 Interest Rate Uncertainty and Contemporaneous Regression.

This section shows that the return on bonds with longer duration is more responsive to a change in interest rate uncertainty than that with shorter duration bonds. This hypothesis is consistent with proposition 3. A theoretical prediction is given by the proposition 3. I estimate the time-series regression of

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

where t is the tth FOMC announcement, y_t^m is the return on Treasury bonds with duration m. ΔIRU_t is a logarithm of today's interest rate uncertainty minus yesterday's interest rate uncertainty when today is the tth FOMC day. I separately estimate β_{iru}^m for different maturities m. Figure 7-(a) shows the estimated result of equation (2). It shows a 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 duration 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 duraiton bond increases by 0.68%. In contrast, when the maturity is 5 years, the estimated coefficient is -4.1. Shorter duration bonds are less responsive to change in interest rate uncertainty.

The literature focuses on the resolution of uncertainty about cash flow (Lucca and Moench, 2015; Hu et al., 2022). To demonstrate that the high return on bonds is primarily driven by a decline in interest rate uncertainty, rather than uncertainty about aggregate cash flow, I also examine the contemporaneous relationship between the VIX and Treasury bonds. I estimate

$$y_t^m = \beta_{vix}^m \Delta\text{VIX}_t + \beta_{capm}^m (R_t^M - r^f) + \epsilon_t. \tag{3}$$

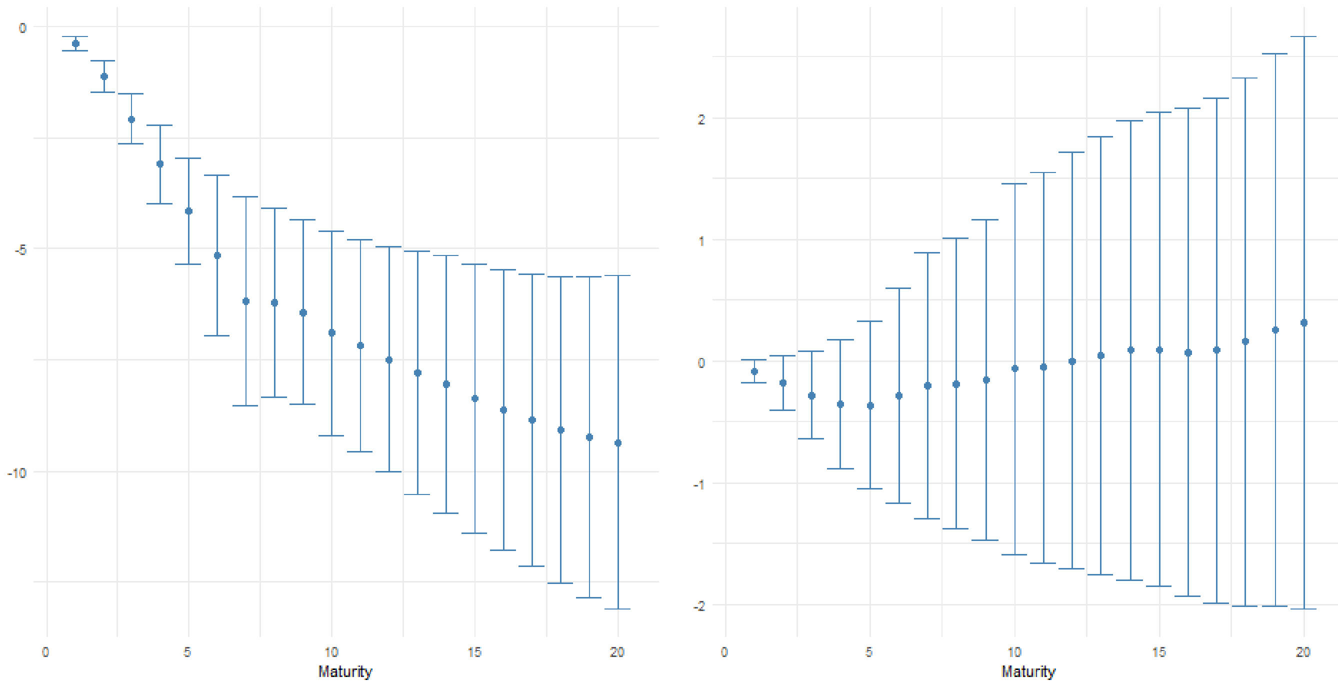
Figure 7-(b) displays the estimated values of β_{vix}^m. The coefficients are not significantly different from zero and do not exhibit a monotonic increase with duration. For instance, the estimated coefficient for a 5-year bond is -0.9, while for a 10-year bond, it is -0.1. These results suggest that Treasury bonds are not significantly exposed to the risks captured by the VIX, despite its use in the literature. Instead, the resolution of interest rate uncertainty appears to be the primary driver of bond returns.

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

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



(a) Interest Rate Uncertainty

(b) VIX

Figure 7: The sensitivity of return to uncertainty

Note: This figure Treasury Return Sensitivity to a change in (a) interest rate uncertainty and (b) VIX. I regress the Treasury return on a change in uncertainty measure,

$$y_t^m = \beta^m \Delta \text{Unc}_t + \beta^m_{capm}(R_t^M - r^f) + \epsilon_t, \tag{4}$$

where Unc_t is interest rate uncertainty in panel (a) and VIX in panel (b). This figure plots the coefficients β^m for each maturity m, and its two standard error bands. Interest rate uncertainty is taken from Bauer et al. (2022).

where m is the duration of the bonds, y_m is the Treasury yield with duration 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 duration and selling the one-year duration. The level of interest rate uncertainty is detrended using the HP filter. Figure 8 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 durationy.

6 Empirical Analysis of Equities

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

6.1 Average Return on FOMC days

First, I empirically test whether short- or long-term stocks have a higher return on the announcement days. Figure 9-(a) shows the average return conditional on duration. The horizontal axis is the duration of equities. I divide the firms into ten groups from low to high based on duration. I rebalance the portfolio for every announcement. Then I calculate the average return on FOMC days in each group. The vertical line is the average return on announcement days.

The average returns on short-duration equity and long-duration equity are statistically indistinguishable even though the longest-duration portfolio takes a smaller value. This empirical patter shows a contrast to that of Treasury bonds where long-duration bonds give a higher return.

The theoretical prediction suggests that if resolution of cash flow uncertainty is as large as discount rate uncertainty, the return on short-duration equities will be as high as that on long-duration equities. Figure 9-(a) 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.

$$y_t^m = \alpha^m + \beta^m \text{Fama French Factors} + \epsilon_{it}, \tag{5}$$

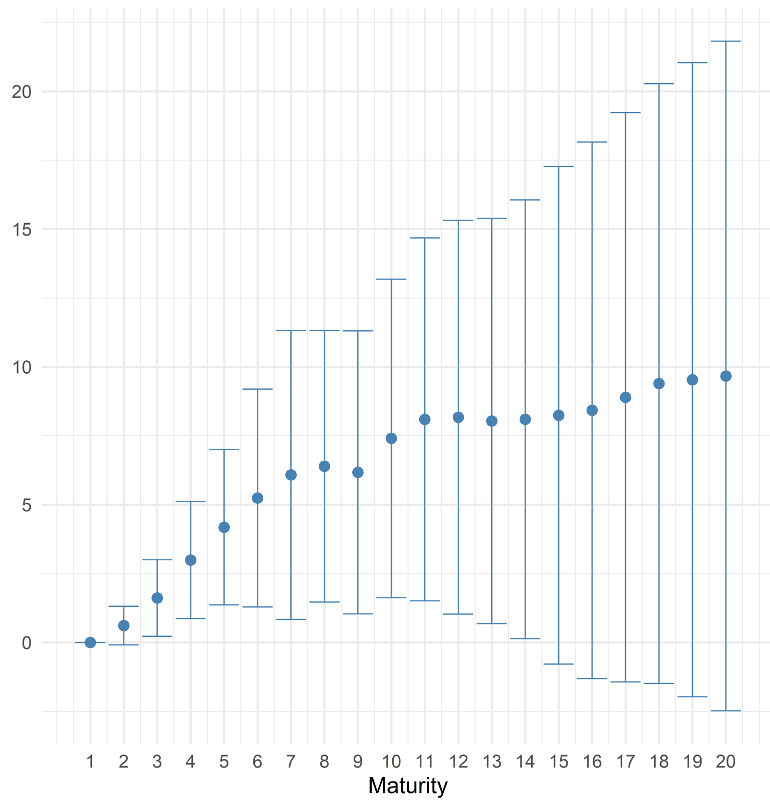
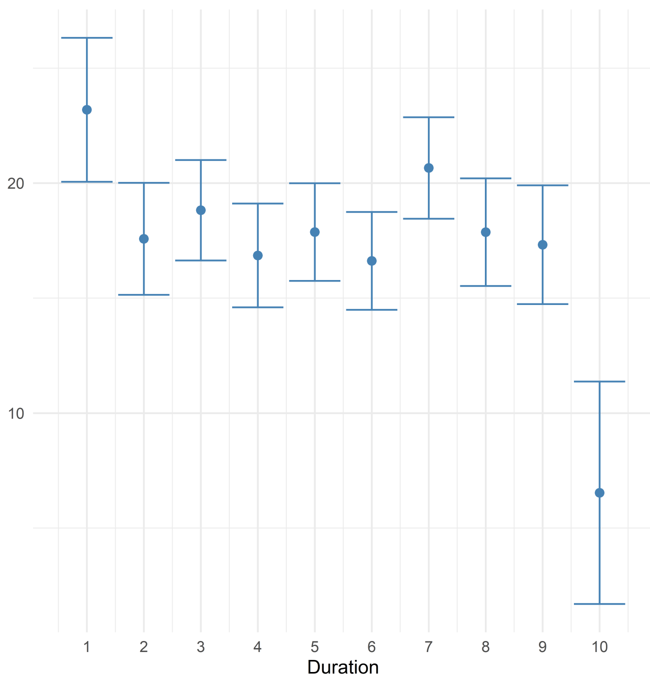
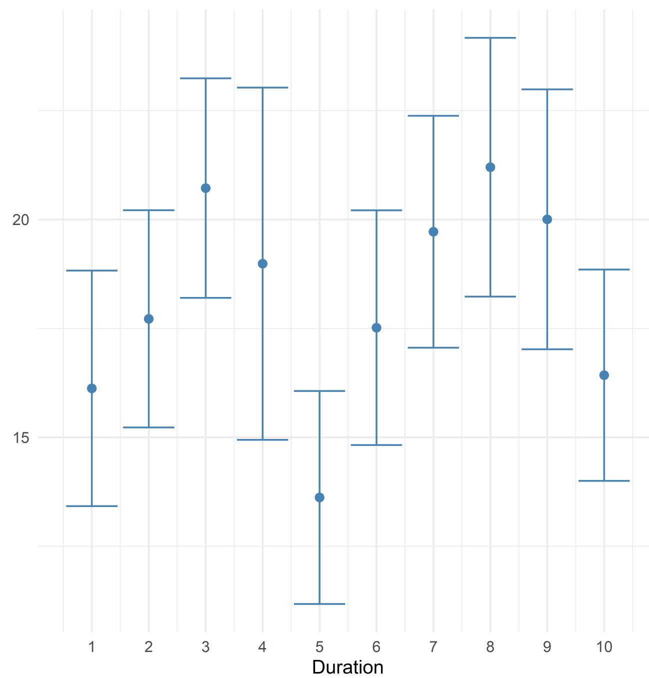


Figure 8: Treasury return sensitivity to ex-ante interest rate uncertainty.

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).



(a) Cash flow duration



(b) Book-to-market ratio

Figure 9: Average returns conditional on duration

Note: This figure plots the time-series average of portfolio returns on FOMC days. The horizontal axis represents the duration of portfolio form short (one) to long (ten). The vertical axis represents the average return on FOMC days for each portfolio. I divide the equities into ten groups from low to high based on duration and take an average within the groups. The portfolio is rebalanced every quarter. Figure (a) uses cash flow duration in Weber (2018) to form a portfolio. Figure (b) use book-to-market ratio.

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.

This paper contributes to the literature on the term structure of equity. Weber (2018) finds that the term structure of equity returns is downward sloping. This finding is for average returns including FOMC days and non-FOMC announcement days. This paper finds that the term structure is not downward sloping on FOMC days, but it is on non-FOMC announcement days. Panel B shows this finding. The average return of the shortest duration portfolio is 15.8 bps. The average return of the longest duration portfolio is 3.5 bps.

The average return on long-duration assets increases on FOMC days if uncertainty about discount rate risk is more resolved on FOMC days compared to non-FOMC days. This provides a plausible explanation, and the next section tests this hypothesis by comparing the sensitivity of returns to interest rate uncertainty for long- and short-duration equities.

Robustness check Since the cash flow duration is not directly observed in data, I did robustness check by using another measure for duration. I use book-to-market ratio as an alternative measure for duration because Hansen et al. (2008) and Lettau and Wachter (2007) study the timing of cash flow through the lens of book-to-market-sorted portfolios. The book-to-market ratio and cash flow duration are sometimes used interchangeably. A negative linear relationship exists under some assumptions as shown in Appendix C.1. Equities with higher book-to-market ratio is considered as shorter-duration equities.

Figure 9-(b) shows the average returns for each portfolio based on book-to-market ratio. The portfolio is rebalanced from low ratio to high ratio. The return on portfolio with low book-to-market ratio and high ratio is statistically indistinguishable. This finding is also consistent with the case where cash-flow duration is used as duration measure.

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 examines the impact of resolution of interest rate uncertainty on the return on equities with different duration. 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

$$\text{Return}_{i,t} = \beta_1 \Delta IRU_t + \beta_2 \text{Duration}_{it} + \beta_3 \Delta IRU_t \times \text{Duration}_{it} + \gamma X_{it} + \epsilon_{it} \tag{6}$$

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. Control variables include firm and quarter fixed effects, size, profitability, 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.

The theoretical prediction states that β_3 is negative; a firm that is more exposed to uncertainty will have a higher stock return if the announcement resolves more uncertainty. Table 5 reports the results. The coefficient on β_3 is -0.23 in the baseline specification and significantly negative. The interpretation of this coefficient says that when the duration of equities is one-year longer, the elasticity of return to the change in interest rate uncertainty decreases by 0.23 basis points. The elasticity of return to change in interest rate uncertainty increases with duration in absolute terms.

Robustness check I estimate an equation (6) by replacing $\text{Duration}_{i,t}$ with the book-to-market ratio. Table 6 shows the estimated results. The coefficient of interest is on the interaction term of book-market-ratio and IRU. The estimated coefficient is significantly positive. Equities with lower book-to-market ratio are more responsive to interest rate uncertainty. Since equities with lower book-to-market ratio is considered as short-duration equities, estimated result is consistent with the results that use cash-flow uncertainty as a duration measure.

Table 5: Return sensitivity to interest rate uncertainty

Dependent Variable:	excess return		
Model:	(1)	(2)	(3)
Variables			
IRU	-2.363***	4.392***	3.946***
	(0.7751)	(0.8536)	(0.8601)
Duration × IRU	-0.3099***	-0.3219***	-0.3390***
	(0.0450)	(0.0443)	(0.0454)
Size × IRU		-1.289***	-0.9193***
		(0.0808)	(0.0842)
Profit × IRU		21.84***	16.30**
		(7.203)	(7.184)
leverage × IRU		0.7782	-0.1409
		(0.9053)	(0.8970)
Fit statistics			
Observations	839,208	787,971	787,971
R^2	0.00495	0.00600	0.01173
Within R^2			0.00396

Clustered (firm) standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

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.

Table 6: Return sensitivity to interest rate uncertainty

Dependent Variable:	excess return		
Model:	(1)	(2)	(3)
Variables			
IRU	-9.125***	-2.316***	-3.074***
	(0.2049)	(0.5829)	(0.5851)
Book-to-Market × IRU	0.7805***	1.361***	1.330***
	(0.0861)	(0.0983)	(0.0985)
Size × IRU		-1.539***	-1.165***
		(0.0823)	(0.0841)
Profit × IRU		20.75***	15.51***
		(5.312)	(5.289)
leverage × IRU		2.087**	1.767**
		(0.8529)	(0.8348)
Fit statistics			
Observations	916,334	859,316	859,316
R^2	0.00453	0.00563	0.01119
Within R^2			0.00366

Clustered (firm) standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

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.

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Appendix A Proof

A.1 Proposition 1

The expected announcement premium for short-duration stock is

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

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 Proposition 2

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

$$
\begin{aligned}
& E_1\left[\frac{P_2(s)^S}{P_1^S}\right]-E_1\left[\frac{P_2(s)^L}{P_1^L}\right] \\
& =\frac{E\left[\left[C_2^{1-\frac{1}{\psi}}+\beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\right]E\left[\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]}{E\left[\left[C_2^{1-\frac{1}{\psi}}+\beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]} \\
& -\frac{E\left[\left[C_2^{1-\frac{1}{\psi}}+\beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\right]E\left[\beta^2(s)C_4(s)^{-\frac{1}{\psi}}X^L(s)\right]}{E\left[\left[C_2^{1-\frac{1}{\psi}}+\beta(s)V_3(s)^{1-\frac{1}{\psi}}\right]^{\frac{\frac{1}{\psi}-\gamma}{1-\frac{1}{\psi}}}\beta^2(s)C_4(s)^{-\frac{1}{\psi}}X^L(s)\right]}
\end{aligned} \tag{7}
$$

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 7 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

$$
\begin{aligned}
&\Big(E\left[\beta(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]E\left[A(s)\beta^2(s)C_4(s)^{-\frac{1}{\psi}}X^L(s)\right]\\
&-E\left[A(s)\beta(s)C_4(s)^{-\frac{1}{\psi}}X^S(s)\right]E\left[\beta^2(s)C_3(s)^{-\frac{1}{\psi}}X^S(s)\right]\Big)\\
&=(1-\alpha)\beta(s_2)C_3(s_2)^{-\frac{1}{\psi}}\alpha A(s_1)\beta^2(s_1)C_4(s_1)^{-\frac{1}{\psi}}\overline{X}\\
&+\alpha\beta(s_1)C_3(s_1)^{-\frac{1}{\psi}}(1-\alpha)A(s_2)\beta^2(s_2)C_4(s_2)^{-\frac{1}{\psi}}\overline{X}\\
&-(1-\alpha)A(s_2)\beta(s_2)C_4(s_2)^{-\frac{1}{\psi}}\alpha\beta^2(s_1)C_4(s_1)^{-\frac{1}{\psi}}\overline{X}\\
&-\alpha A(s_1)\beta(s_1)C_4(s_1)^{-\frac{1}{\psi}}(1-\alpha)\beta^2(s_2)C_4(s_2)^{-\frac{1}{\psi}}\overline{X}\\
&=\alpha(1-\alpha)\beta(s_1)\beta(s_2)C(s_1)^{-\frac{1}{\psi}}C(s_2)^{-\frac{1}{\psi}}(A(s_1)-A(s_2))(\beta(s_1)-\beta(s_2)) \qquad (8)
\end{aligned}
$$

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 8 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[4].

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

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

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

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

7. Firm characteristics are from Compustat. I use Compustat - North America - Fundamental Quarterly.

8. PPI announcement days are from the U.S. Bureau of Labor Statistics[5]. Employment Situation announcement days are from the U.S. Bureau of Labor Statistics[6]. GDP announcement days are from the U.S. Bureau of Economic Analysis[7].

9. Daily Treasury data is from Gürkaynak et al. (2007) and Liu and Wu (2021). I obtain data from Gurkaynak's homepage[8] and Wu's homepage[9].

Appendix C Constructin of Duration Measure

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

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.

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

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

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

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

Federal Reserve updates weekly at

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

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

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.

$$\begin{aligned} \text{CF}_{i,t+s} &= \text{E}_{i,t+s} - (\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}) \\ &= \text{BV}_{i,t+s-1} \left[\frac{\text{E}_{i,t+s}}{\text{BV}_{i,t+s-1}} - \frac{\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}}{\text{BV}_{i,t+s-1}} \right] \end{aligned} \tag{9}$$

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 [10]. 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

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 (9).
4. Update $\text{BV}_{i,t+1}$ with

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

[10] 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).

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).

C.1 Negative relationship between cash flow duration and book-to-market

In section 6.2, I use book-to-market ratio for alternative measure of duration as a robustness check. In this subsection, a linear relationship between cash flow duraiton and book-market ratio exist under some assumptions.

The cash flow duration is defined as

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

and with the accounting identity, net cash distribution is given by

$$\text{CF}_{i,t+s} = \text{BV}_{i,t+s-1} \left[\frac{\text{E}_{i,t+s}}{\text{BV}_{i,t+s-1}} - \frac{\text{BV}_{i,t+s} - \text{BV}_{i,t+s-1}}{\text{BV}_{i,t+s-1}} \right]$$

If we assume that the growth in the book value of equity is zero for all finite periods ($\text{BV}_{i,t+s-1} = \text{BV}_{i,t+s}$) and the return on equity is constant over periods ($\frac{\text{E}_{i,t+s}}{\text{BV}_{i,t+s-1}} = \frac{\text{E}_{i,t}}{\text{BV}_{i,t-1}}$), then $\text{CF}_{i,t+s} = \text{E}_{i,t}$. Under this assumption, cash flow duration can be written as

$$\text{Duration}_{it} = T + \frac{1+r}{r} - \frac{E_{i,t}T}{rP_{i,t}}$$

Also assume that the return on equity is always equal to the cost of capital, $\frac{E_{i,t}}{BV_{i,t-1}} = r$.Then, duration can be written as

$$\text{Duration}_{it} = T + \frac{1+r}{r} - \frac{BV_{i,t}T}{P_{i,t}}$$

In this special case, there exists a linear and negative relationship between duration and book-to-market ratio.