The Role of Firm Heterogeneity for Monetary Policy and Investment Decisions

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May 24, 2023

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Abstract

Monetary policy affects firms' capital investment through two distinct channels: the pure monetary channel, which operates through changes in interest rates, and the information channel, which operates through changes in investors' beliefs and sentiment about the economic outlook. I study how financial frictions impact the transmission of monetary policy to investment, considering the specific channel through which the policy is transmitted. I show that the role of financial frictions for monetary policy transmission hinges crucially on specific channel. Using Compustat data, I find that firms with high leverage are more sensitive to pure monetary shocks but are less sensitive to Fed information shocks. To shed light on the mechanism, I delve into the the nature of how Fed information affects investors beliefs. I document that the transmission channel of Fed information to firms' capital investment is primary non-fundamental, and empirically consistent with changes in investors sentiment in financial markets. Finally, I develop a dynamic general equilibrium model with firm idiosyncratic productivity and real and financial frictions to interpret the empirical results and quantify the distributional effects of monetary policy on investment.

JEL Codes: D21, D22, E22, E52.
Keywords: Monetary Policy, Firm Heterogeneity, Investment, Financial Frictions.

*Contact: Luigi Pollio, luigi.pollio@bc.edu. I would like to thank Marco Errico, Pietro Dall'Ara, Stephen Terry, Ryan Chahrour, Susanto Basu, Fabio Schiantarelli, Jaromir Nosal, Rosen Valchev, Danial Lashkari, Robert Ulbricht, François Gurio, Alexander Richter, Tarek Hassan, Pablo Guerron, Marco Brianti, Luca Gemmi, Simone Pesce and all participants at Boston College Dissertation Workshop and BC/BU Green Line Macro Meeting for the helpful comments. An earlier version of this paper circulated under the title "Financial Frictions and the Risk-Premium Channel of Monetary Policy.

1 Introduction

The transmission of monetary policy to firm investment decisions depends crucially on the presence of financial frictions. In the aftermath of the Global Financial Crisis, there has been considerable effort devoted to the understanding of how financial frictions influence the response of firms' capital investment to monetary policy interventions (Bernanke et al., 1999a; Ottonello and Winberry, 2018). Understanding the role of financial frictions in the transmission of monetary policy is crucial for policymakers aiming to enhance their understanding of how firms' financial conditions impact the effectiveness of monetary policy in stimulating aggregate demand.

In this paper, I investigate and quantify the role of financial frictions in the transmission of monetary policy to investment depending on the channel through which the policy is transmitted. Monetary policy has witnessed a profound evolution from the Keynesian theory to the new paradigm. In the standard Keynesian theory of monetary policy, central banks have the ability to influence firms' capital investment through changes in interest rates and the money supply, the "*pure monetary channel*". The new theory of monetary policy emphasizes the role of beliefs and expectations in shaping economic outcomes (Romer and Romer, 2000; Nakamura and Steinsson, 2018). Through non-monetary communication policies, central banks can influence firms' investment decisions by affecting investors' beliefs about the economic outlook, the "*information channel*".[1] By taking into account both channels, this paper aims to provide a more comprehensive understanding of how financial frictions interact with monetary policy to shape investment decisions.

I show that financial frictions play a different role in the transmission of monetary policy depending on the channel. I leverage the fact that during Federal Open Market Committee (FOMC) announcements, the Federal Reserve (Fed) discloses information about changes in policy rates as well as non-monetary information about the economic outlook. Using high-frequency data on interest rate expectations and stock market prices, and following the identification strategy proposed by Jarociński and Karadi (2020) I decompose monetary policy innovations into two orthogonal components: shocks that affect the economy through the pure monetary channel, the *pure monetary shocks*, and shocks that affect the economy through the information channel, the *Fed information shocks*. With this separation in hand,

[1]The information channel operates through the central bank's use of various communication tools, such as public statements, speeches, and press conferences, to convey information about their policy intentions, economic outlook, and assessments of future risks. The size of the information channel is not negligible in the data. Jarociński and Karadi (2020) shows that the Fed information channel explains about 30% of the effects of monetary policy innovations in the U.S. and up to 45% in Europe.

I examine how investment responses differ across firms with varying degrees of financial frictions to these policy shocks, utilizing Compustat data.

I find that firms that face a high level of financial frictions are relatively more responsive to pure monetary shocks, but less sensitive to Fed information shocks. I measure the degree of financial frictions using leverage as a proxy. Using Jordà (2005)'s Local Projection and instrumental variable approach, I estimate the dynamic heterogeneous response of capital accumulation to to both types of shocks across firms based on their past leverage. In response to a pure monetary policy shock resulting in a 1% increase in the average Tobin's Q, a firm with 10 pp more leverage before the shock accumulate around 0.03% more capital stock after 2 years. Conversely, in response to a Fed information shock leading to the same increase in average Q, a firm with 10 pp higher leverage before the shock accumulates around 0.03% less capital after approximately the same period of time. These findings show that financial frictions amplify the effects of pure monetary shocks on investment while dampening the effects of Fed information shocks.

To shed light on the mechanism, I investigate the channel through which Fed information affects firms' investment decisions. Previous research has showed that central banks' non-monetary communication influences firms' investment by changing investors' beliefs about the economy. However, there is limited research exploring whether this influence is related or unrelated to future fundamentals. The fundamental narrative underscores the significance of non-monetary communication as a source of new information regarding the fundamental state of the economy (Romer and Romer, 2000; Nakamura and Steinsson, 2018).[2] Conversely, the non-fundamental narrative posits that non-monetary communication primarily impacts investor sentiment and optimism, subsequently improving firms' financial conditions and borrowing capacity. I propose a test based on Tobin's Q to differentiate between the fundamental and non-fundamental narratives of Fed information.

I document that the transmission channel of Fed information to firms' capital investment is primary non-fundamental. I test the hypothesis that variations in investor sentiment in the financial markets play a dominant role in explaining the effects of Fed information on firms' investment. To test this, I study the relationship between Fed information and Tobin's Q, which captures the ability to generate dividends and the aggregate risk premium in the financial markets. I regress the change in the firm-level Q on the Fed information shock while controlling for common measures of market sentiment. In the baseline case, Fed information shocks positively predict an increase in firms' marginal value when not accounting

[2]For instance, if the Federal Reserve has superior information about the future level of productivity and communicates it in advance to agents, this new information influences agents' beliefs and expectations.

for aggregate sentiment. However, once I control for market sentiment, the effect of the Fed information shock on firm investment profitability becomes statistically insignificant. This suggests that changes in investor sentiment largely explain the observed impact on firms' investment decisions.

In order to interpret these empirical results and quantify the aggregate implication for monetary policy I develop a New-Keynesian dynamic general equilibrium heterogeneous firm model with idiosyncratic productivity and financial frictions. The model features a well-defined distribution of investment firms that are heterogeneous by idiosyncratic productivity. These firms produce a homogeneous wholesale good using a decreasing returns to scale technology, hire labor in a competitive labor market at the equilibrium wage and invest in new capital facing adjustment costs. Firms finance investment with internal and external funding, corporate bonds, and equity. Corporate bonds are issued at discount and priced by financial intermediaries. I introduce financial frictions by assuming the presence of quadratic equity issuance costs (Altınkılıç and Hansen, 2000). The monetary authority determines the nominal interest rate following a Taylor rule, and engages in non-monetary communication which affects investors sentiment within the financial markets.

The model helps to rationalize the empirical findings in the paper. A pure monetary shock increases the nominal interest rate and reduces the marginal benefit of capital through the stochastic discount factor. Because the return on future investment falls, firms find it optimal to reduce their capital stock over time. Firms with high levels of leverage are the most adversely affected by a pure monetary shock, as it increases their reliance on more expensive external financing sources. Consequently, highly leveraged firms are induced to invest relatively less as a result of an increase in their marginal cost of capital. Instead, a Fed information shock affects investment through the financial market by increasing the price of corporate bonds due to positive market sentiment. This leads to higher investment by firms, on average, as the improved future economic outlook enhances the marginal returns on capital. However, firms with high leverage are less responsive to these shocks as they have already reached their borrowing limits and have limited capacity to further increase investment.

Finally, I use the model to revisit the state dependent effects of monetary policy depending on a market response to a Fed communication. Previous literature focuses on studying the effect of monetary policy in a recession compared to normal times. In the model, a market pessimistic reaction to a Fed announcement increases the cost of debt making external financing more expensive. This in turn, reduces the effectiveness of conventional monetary policy interventions in a period of recession. Because of real and financial frictions, monetary policy interventions are state-dependent in the model. A TFP-induced recession produces two effects on the economy that may affect the potency of monetary policy. First, it increases the share of financially constrained firms that are more sensitive to Taylor rule shocks. Second, it increases the relative cost of capital financing due to the presence of fixed adjustment costs on investment, discouraging firms from investing in response to a positive shock. Using my calibrated model, I find that an expansionary Taylor rule shock without a negative market reaction is 12% more effective than in normal times. A negative market reaction to the same shock dampens the effectiveness of monetary policy by more than 20 percent compared to the case where there is no market response.

Literature. This paper contributes to several strands of the literature. First, it contributes to the literature that studies how the effect of monetary policy varies across firms with different balance sheet characteristics. This literature has investigated the excess sensitivity to a monetary policy innovation by looking at different metrics of the firms' performance and proxies for financial frictions. An earlier paper by Gertler and Gilchrist (1994) finds evidence that small firms are more sensitive than large firms to an interest rate tightening with respect to sales and inventories. Bahaj et al. (2019) study the role of financial frictions in the transmission of monetary policy to employment and found that younger, more-levered firms are most sensitive. Closer to my paper, two recent papers, Ottonello and Winberry (2018) and Jeenas (2018a), study the role of leverage in the transmission of monetary policy with respect to investment using Compustat data with contrasting results. Ottonello and Winberry (2018) find that firms with low default risk or low leverage accumulate relatively more capital after an interest rate cut. Jeenas (2018a) instead, find the opposite. High leverage firms display excess sensitivity to monetary policy interventions, but the result disappears once one controls for cash holdings. In light of this debate Cloyne et al. (2018) suggest measuring financial frictions by looking at dividend policy over the firm's life cycle and find that younger corporations paying no dividends are more responsive to monetary policy with respect to investment and borrowing decisions.[3] My paper contributes to this literature by showing that the role of financial frictions for monetary policy depends on the channel.[4]

Second, it contributes to the growing literature that studies the effect of the effect of Fed information on the economy. The idea that Fed announcements can convey information

[3] I discuss the differences between the results of those papers in the empirical analysis.

[4] Other papers in this literature study more generally the implication of heterogeneity in firm or industry behavior in response to monetary policy shocks Gaiotti and Generale (2002), Ehrmann and Fratzscher (2004), Peersman and Smets (2005).

about the future path of output and inflation beyond current and future monetary policy stance was put forth by Romer and Romer (2000) and formally developed in a model by Ellingsen and Söderström (2001). Campbell et al. (2012), Nakamura and Steinsson (2018), Jarociński and Karadi (2020) and Andrade and Ferroni (2021) shows that the presence of information effects can contaminate traditional estimates of monetary policy shocks that rely oh high-frequency identification and, it can change our conclusions of the effectiveness of monetary policy interventions.[5] My contribution to this literature is twofold. First, I show that pure monetary policy surprises have a significant effects on firm-level decisions and that, financial frictions, proxy by leverage amplifies the investment response. Second, I show that Fed information shocks affecting investors' beliefs are non-fundamental, and are consistent with the idea that central bank non-monetary information affects the level of sentiment in the economy.

Finally, it contributes to the theoretical literature that studies the role of credit market frictions in amplifying monetary policy disturbances. In a seminal paper, Bernanke et al. (1999a) embed the financial accelerator in a representative firm New Keynesian model with financial frictions and show that pro-cyclical firms' net worth amplifies monetary policy interventions. Ottonello and Winberry (2018) confirm the exact mechanism in a model with firms' heterogeneity and default risk. I contribute to this literature quantifying the distributional effects of monetary policy intervention allowing for the presence of a Fed information shock in an addition to a standard Taylor rule shock.

2 Empirical analysis

In this section, I show that the role of financial frictions on monetary policy transmission depends on the channel through which investment is affected by monetary policy. I begin by disentangling monetary policy innovations into two structural shocks, namely pure monetary shocks and Fed information shocks. Then, I discuss the dataset and measurement of financial frictions and investment in the data. Finally, I show that firms with high levels of financial frictions respond differently to monetary policy intervention, accumulating relatively more or less capital depending on the underlined shock.

[5] Jarociński and Karadi (2020), Andrade and Ferroni (2021) and Miranda-Agrippino and Ricco (2018) use market-based measures of interest rate expectations and economic fundamentals, combined with a sign-restriction approach to separate interest rate surprises. Other papers have proposed different identification strategies. Doh et al. (2020), Handlan (2020) and Acosta (2021) use machine-learning and text-based techniques applied to the Fed's alternative policy statements to identify interest rate surprises due to Fed information. Cai et al. (2021) and Lakdawala (2019) remove information effects from the Fed statement by controlling for the difference between the Fed's and the public's information.

2.1 Disentangling monetary policy shocks

I decompose monetary policy innovations into two structural shocks using the methodology proposed by Jarociński and Karadi (2020). I use high-frequency data and a set of sign restrictions on stock prices and interest rate expectations to disentangle market-based variations around Federal Open Market Committee (FOMC) announcements into two sets of shocks.[6] I leverage the fact that during the FOMC announcements, the Fed revels both information about the actual and future policy actions (i.e., monetary policy communication), as well as additional information about the state of the economy (i.e., non-monetary policy communication), Romer and Romer (2000), Nakamura and Steinsson (2018) and Campbell et al. (2012). Since financial market variables respond to both pure monetary policy communication and non-monetary policy communication, market-based variations surrounding FOMC statement provide a valid set of events to distinguish between the variations caused by the former and the variations caused by the latter.[7]

The empirical separation comes from identifying a shock that increases both stock market prices p_t and interest rate expectations Δi_t^e simultaneously, versus a shock that decreases p_t while increasing Δi_t^e in a 15-minutes window around an FOMC statement.[8] The first is a monetary policy shock that affects the economy through the interest rate, the *pure monetary shock* ε_t^{mps}; the second is a monetary policy shock that affects the economy by changing the investors' beliefs about the future economic outlook, the *Fed information shock* $\varepsilon_t^{\text{info}}$.[9]

$$\begin{pmatrix} \Delta i_t^e \\ \Delta p_t \end{pmatrix} = \begin{pmatrix} + & + \\ - & + \end{pmatrix} \times \begin{pmatrix} \varepsilon_t^{\text{mps}} \\ \varepsilon_t^{\text{info}} \end{pmatrix}$$

Sign restrictions are justified by economic theory. When the Fed announces a tightening of monetary policy, investors expect future policy rates to increase. This leads to a drop in stock market prices, as expected earnings decrease and the discount factor at which dividends are capitalized declines. Therefore, pure monetary communication typically results in a negative response of stock market prices and interest rate expectations. However, if stock

[6]Assuming that investors do not learn any additional information during this window, variations in financial market variables that arise around the FOMC policy announcements within a short time frame provide an exogenous proxy for the effect of monetary policy.

[7]Standard high-frequency identification approach is used in Ottonello and Winberry (2018), Jeenas (2018a), Cloyne et al. (2018) among others to identify monetary policy shocks.

[8]I measure interest rate expectations as the 3-month federal funds rate future as standard in the literature. If agents are risk-neutral, federal funds rate futures perfectly reflect the conditional expectations about future interest rates.

[9]Other approaches used in the literature to identify the two shocks and that are based on similar identifying assumptions are Miranda-Agrippino and Ricco (2018), and Acosta (2021).

prices increase in response to a positive interest rate surprise during the FOMC window, it indicates the presence of another component - non-monetary information - that is responsible for the positive correlation between stock prices and federal funds rate futures.

In my baseline specification, I employ a Bayesian structural VAR model with aggregate macroeconomic variables and monthly high-frequency financial variables to separate the two structural shocks.[10] Figure 9 in Appendix A illustrates the two series of monetary policy shocks identified using a sign restriction and a BVAR model.

2.2 Data and measurement

For the empirical analysis, I use firm-level data from the quarterly Compustat database which provides a reliable source of information on firms' financial statements and has been extensively used in previous research to study the effects of monetary policy on capital investment decisions.[11] I combine firm-level data with the pure and the Fed information shocks identified in the previous section and other aggregate variables. I sum the shocks at a quarterly level as in Cloyne et al. (2018). This results in a panel of 10,259 firms with quarterly financial information, spanning from 1990-Q1 to 2018-Q4.[12]

I study the heterogeneous response to monetary policy of capital stock accumulation instead of capital expenditure. Following the methodology of Ottonello and Winberry (2018), I use the perpetual inventory method to calculate the capital stock $k_{i,t}$ for each firm i at the end of the quarter t. Analyzing the dynamics of firms' capital stocks rather than investment expenditure is preferred due to measurement error issues, which make it difficult to precisely detect systematic responses in investment rates in the cross-section at the quarterly level Doms and Dunne (1998).

I use leverage $\text{lev}_{i,t}$ to proxy the level of financial frictions of a firm in a given quarter. I construct the variable leverage as the ratio between total debt and shareholders' equity. I choose this variable to measure the level of firms' financial frictions in the data because of two reasons. First, in a standard theoretical model with financial frictions, leverage can be interpreted as an inverse measure of firms' net worth.[13] Second, firms' leverage is 60%

[10] I use the co-movement between the high-frequency variations in the 3-month federal funds rate future and stock market prices in a 15-minutes window surrounding scheduled FOMC announcements summed up at monthly level.

[11] Around 50% of aggregate business investment in the US is accounted for by firm-level investment data from Compustat.

[12] Ottonello and Winberry (2018) aggregate the shocks at the quarterly level by taking a weighted average of the shocks calculated at the monthly level, and they find similar results.

[13] In a firm investment model with firm heterogeneity and financial frictions due to default risk or external equity financing, conditional to firms' size, higher level of debt predicts an higher marginal cost of capital.

correlated with measures of default risk, and leads to similar conclusions when studying the dynamic heterogeneous response to monetary policy shocks, Ottonello and Winberry (2018).

To test the robustness of my results, I consider alternative measures of financial frictions such as cash liquidity, size, age, distance to default and credit ratings. Appendix A provides further details on the construction of the variables and the cleaning.

2.3 Heterogeneity of investment response

Methodology. I estimate the dynamic heterogeneous response of investment to the two identified shocks separately using Jordà (2005)'s Local Projection with Instrumental Variable (LP-IV) as in Cloyne et al. (2018).[14] I prefer to use LP-IV instead of standard local projection for two reasons. First, it imposes a unit effect of normalization of the shocks in terms of a 1 unit change in the endogenous variable as explained in Stock and Watson (2018). Second, it is more efficient than the standard LP-OLS regression as it does not soffer of the generated regressor problem, Pagan (1984).

I use the one-quarter percentage change in the aggregate Tobin's Q, Δq_t, as the endogenous policy variable which is the log-difference of the average Q calculated across firms for each quarter. By choosing Δq_t as the endogenous variable, I normalize the two shocks to have an expansionary effect on capital investment, irrespective of their sign. This allows me to compare the results of the heterogeneous regression across multiple shocks, without estimating the average response of firms' capital investment.[15]

In the baseline specification, I regress the capital change h-period ahead $\Delta_h \log(k_{i,t+h}) = \log(k_{i,t+h}) - \log(k_{i,t-1})$ on the interaction between the average change in Q, Δq_t, and the variable leverage (in log), $\text{lev}_{i,t-4}$, lagged by four quarters:

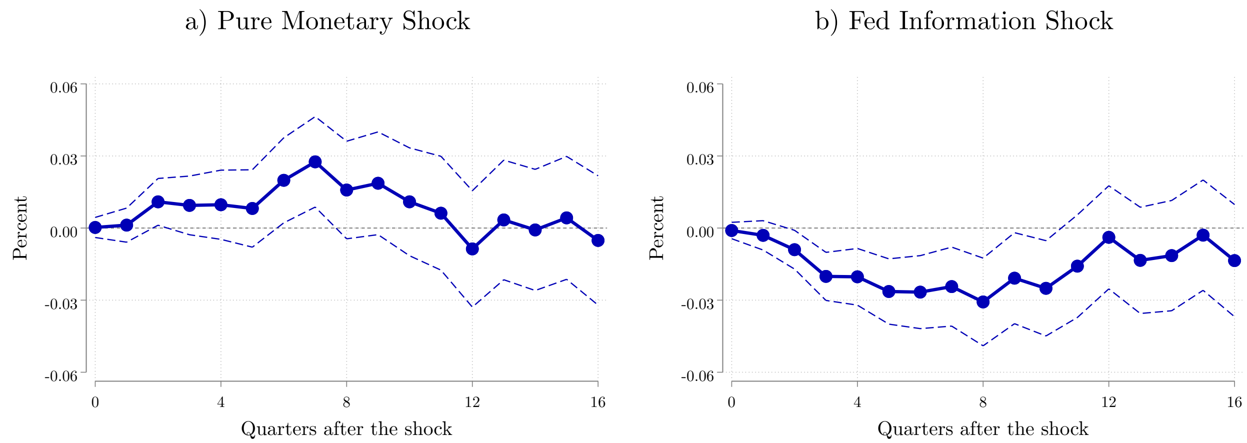
$$\Delta_h \log(k_{i,t+h}) = \alpha_{i,h} + \alpha_{t\times j,h} + (\beta_h^s \Delta q_t + \delta_h)\,\text{lev}_{i,t-4} + \Gamma_h' W_{i,t-1} + u_{i,t+h} \tag{1}$$

where h indexes the forecast horizon. I instrument the endogenous variable $\Delta q_t \cdot \text{lev}_{i,t-4}$ with the interaction between $\text{lev}_{i,t-4}$ and the exogenous disturbances ε_t^{mps} and $\varepsilon_t^{\text{info}}$ separately. I include firm fixed effects α_i to capture time-invariant differences in investment behavior across firms, sector-by-quarter fixed effects at the SIC-1 digit level $\alpha_{j\times t}$ to control for differences in

[14] Others papers, Ottonello and Winberry (2018), Ferrando et al. (2020), Jeenas (2018a) directly estimate the effect of the interact between the exogenous series of the shocks with the firm-level variable leverage on capital accumulation in a 1-stage regression. I checked that the results do not change qualitatively.

[15] Cloyne et al. (2018) uses the change in 1-year Treasury rate as endogenous policy variable following Gertler and Karadi (2015). However, since a pure monetary shock and a Fed information shock have opposite effects on investment given an increase in interest rates, using the interest rate as the endogenous variable complicates the interpretation of the results.

Figure 1: Heterogeneous response of investment



Notes: The figure illustrates the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms with a 10 percentage point difference in past leverage. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation 1 using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructued following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

how sectors respond to aggregate fluctuations, and firm size as a control variable, measured as the logarithm of past total assets. Finally, I include an interaction between firm size and the two shocks to capture heterogeneity in investment responsiveness due to differences in collateralizable assets.

The coefficients $\beta_h^s = \{\beta_h^{\text{mps}}, \beta_h^{\text{info}}\}$ measure how the cumulative response of investment h periods ahead to a pure monetary and a Fed information shock at time t depends on the firms' financial positions lev_{t-4} in quarter $t-4$. In particular, β_h^s is an estimate of the cumulative differential response of investment h periods ahead between two firms with a 1% difference in past leverage.[16] Hence, a positive value of β_h^s implies that high-leverage firms invest relatively more in response to an exogenous policy shock than low-leverage firms, suggesting that financial frictions may be amplify the effects of monetary policy. Conversely, if β_h^s is negative, it suggests that high-leverage firms invest relatively less than low-leverage firms in response to a policy shock, indicating that financial frictions dampen the response of investment to a policy intervention.

[16]Due to the linearity assumption in the interaction term, the heterogeneous effect of the shocks is independent of the level of past leverage.

Results. Figure (1) shows that sensitivity to monetary policy and hence, the role of financial frictions depends on the channel of transmission of monetary policy. In response to a pure monetary policy shock that increases the average Q by 1 pp, a firm with 10 pp more leverage before the shock accumulate around 0.03% more capital stock after 2 years. Conversely, in response to a Fed information shock that equally increases the average Q by 1 pp in a quarter, a firm with 10 pp more leverage before the shock accumulates around 0.03% less capital around 8 quarters after the shock occurred. Hence, financial frictions amplify the effects of pure monetary shocks on investment while dampening the effects of Fed information shocks.

Figure 11 in Appendix B shows that the heterogeneous sensitivity to the two shocks is primarily influenced by firms located at the tail end of the leverage distribution. I split firm-level observations into three leverage percentile bins: low, medium, and high. A firm is classified as low leverage if it falls within the 40th percentile of past year leverage, medium if it falls between the 40th and 80th percentile, and high if it is above the 80th percentile. I estimate the heterogeneous firm-level response to the two shocks relative to that of a low leverage firm. In response to a pure monetary shock, high leverage firms exhibit a significantly stronger sensitivity compared to medium leverage firms, accumulating 1.2 pp more capital than low leverage firms after 8 quarters from the shock, while medium leverage firms accumulate 0.9 pp more capital than low leverage firms. The opposite happens in response to a Fed information shock. Relative to low leverage firms, medium leverage firms do not display a statistically significant difference in their capital response. However, high leverage firms exhibit a significant decrease of around 1.6 pp in their capital relative to low leverage firms.[17]

Finally, Figure 12 in Appendix B quantifies the heterogeneous sensitivity of the non-linearity effects over the leverage distribution. I construct the average dynamic response of investment for each leverage group by combining the average response of capital for low-leverage firms with the differential response for medium and high-leverage firms. I then compare the average responses across the different groups. In the case of a pure monetary shock, a firm in the top 20% of the leverage distribution exhibits a 50% higher sensitivity compared to a firm in the bottom 40%. However, the same firm is 60% less sensitive than a firm in the bottom 40% when it comes to another factor.

Robustness. I undertake a series of robustness checks to ensure the consistency and robustness of the results shown in Figure 1. Specifically, I show that my results are robust

[17]These results are consistent with previous literature highlighting that firms within the first 40th percentile of the distribution and between the 40th and 80th percentile do not display significantly different riskiness profiles and balance sheet characteristics and thus, they respond similarly to aggregate shocks.

to different time periods, alternative shock identification approaches, and various model specifications. I defer the discussion of my results regarding different measures of financial frictions in relation to the prior literature to the subsequent section.

Figure 13 and 14 in Appendix B provide evidence of the robustness of the results to different time periods. To ensure the consistency of the findings, I re-estimate the main specification presented in Equation 1 using two distinct time periods. Firstly, I focus on the period from 1990 to 2008, excluding the period characterized by the zero lower bound and the financial crisis (Ottonello and Winberry, 2018). Secondly, I consider the interval from 1994 to 2018, excluding the period when the Federal Reserve did not provide additional information during the FOMC meetings, apart from changes in the policy rule.[18] Importantly, the results obtained from both alternative time periods are qualitatively and quantitatively consistent with the estimates presented in Figure 1.

Figure 15 in Appendix B presents the robustness of the results to different model specifications. Specifically, I estimate the heterogeneous response of capital to the monetary policy shocks without incorporating additional time or sector-time fixed effects (Cloyne et al., 2018). This enables an interpretation of the estimated coefficients that accounts for potential general equilibrium effects. Notably, the results remain consistent and unaffected by this alternative specification, further bolstering the robustness of the findings.

Finally, Figure 16 in Appendix B shows the robustness of the results to different shock identification procedures. Specifically, I differentiate between two types of monetary policy shocks by examining the co-movement between 3-month federal funds rate futures and stock market prices. I categorize shocks based on whether a positive interest rate surprise during the 30-minute FOMC window is accompanied by a decrease or increase in stock prices. A positive interest rate surprise accompanied by a decline in stock prices is classified as a pure monetary shock, whereas a positive surprise accompanied by an increase in stock prices is considered a Fed information shock.[19] I find that by using these series of shocks, the results align qualitatively with the ones in Figure 1.

2.4 Relating to prior literature

My study complements the existing literature by highlighting the importance of differentiating between channels when examining the role of financial frictions in investment and

[18] This exclusion is important for valid identification since the release of additional information around the FOMC announcement relies on the presence of other informational sources, such as the FOMC statement. As from 1990 to 1994 the Fed did not provide any communication during the FOMC meeting, it may impact the identification from high-frequency variables.

[19] This is what Jarociński and Karadi (2020) labels as the "Poorman" identification strategy.

monetary transmission. Previous studies, such as Ottonello and Winberry (2018), Cloyne et al. (2018) and Jeenas (2018a) among others, have explored the heterogeneous effects of monetary policy on investment but without explicitly separating the two channels. These studies have discussed the role of firms' financial frictions in the transmission of pure monetary shocks, employing various proxies for financial frictions and different model specifications.

Figure 21, and 22 in the Appendix C connect my results to the findings of Ottonello and Winberry (2018). Ottonello and Winberry (2018) find that firms with higher default risk or leverage, compared to their long-term average, are less responsiveness to monetary policy surprises, which they use as a proxy for pure monetary shocks. They argue that when financial variables, such as leverage or other proxies for financial frictions, are demeaned at the firm level, it can alter the predictions regarding heterogeneous sensitivity.[20] Figure 21 in the Appendix C shows that firms with a higher proximity to default are relatively more sensitive to exogenous pure monetary shocks, while displaying lower sensitivity to Fed information shocks, consistent with my findings. Figure 22 show that once, we split monetary policy surprises in two channels, the heterogeneous response to monetary policy are robust to demeaning leverage at the firm level.[21]

Figure 17, and 18 in Appendix C show that my results are also closely tightened to Jeenas (2018a). His findings are twofold. First, cash holdings are a more effective proxy for financial frictions compared to leverage. They show that after controlling for cash liquidity, the significance of past leverage diminishes in explaining the differential sensitivity to monetary policy shocks.[22] This suggests that cash liquidity serves as a comprehensive measure of financial frictions. Second, he shows that firms that have more cash display less responsiveness to monetary policy surprises. Figure 17 in Appendix C shows that once we split the channels of monetary policy, firms with lower cash liquidity are relatively less sensitive to exogenous pure monetary shocks, while they are relatively more sensitive to Fed information shocks, in line with the results of Jeenas (2018a) and the findings in Figure 1. Figure 18 shows that my results survive when controlling for an interaction between the shocks and cash liquidity.

Figure 19 in Appendix C connects to findings of Gertler and Gilchrist (1994). In their seminal paper, Gertler and Gilchrist (1994) and more recently Crouzet and Mehrotra (2020)

[20]The argument is that demeaning the right-hand side of the specification in equation (1) would allow controlling for permanent differences across firms that would otherwise be left in the error term and potentially bias the results.

[21]After demeaning leverage at the firm level, the heterogeneous response to Fed information shock is attenuated, indicating that the long-term component of leverage plays a crucial role in driving the observed heterogeneity.

[22]In this sense, cash liquidity is a sufficient statistic to measure the level of financial frictions.

investigate the heterogeneous response of investment to monetary policy shocks based on past sales growth. They find that small firms tend to be more sensitive to monetary policy shocks due to higher levels of financial frictions. To examine this further, I construct the size variable following the methodology of Gertler and Gilchrist (1994) using Compustat data. I then estimate the heterogeneous response of investment between small and large firms to the two shocks as in equation 1. Figure 19 in Appendix C shows that small firms are more responsive to pure monetary policy shocks and less sensitive to Fed information shocks.

Finally, Figure 23 in Appendix C connects with the findings of Whited (1992). Whited (1992) suggests using credit ratings as a measure of the level of financial frictions faced by firms. Credit ratings capture the likelihood of default more accurately than leverage and exhibit less volatility over time. In Figure 23, I present robust results by dividing the sample of firms into three groups based on their Standard & Poor's credit rating from Compustat. Firms with lower credit ratings, on average, display higher sensitivity to pure monetary shocks and lower sensitivity to Fed information shocks. This supports the hypothesis that credit ratings can serve as a reliable indicator of the impact of financial frictions on firms' response to different monetary policy channels.

2.5 The sentiment channel of Fed information

In this section, I show that the primary transmission channel of Fed information to firms' capital investment is primary non-fundamental. Previous studies have established that non-monetary communication from central banks influences real investment by shaping investors' beliefs about the state of the economy. However, there is limited research exploring whether this influence is related or unrelated to future fundamentals.[23]

The fundamental narrative is consistent with the idea that non-monetary communication from the central bank plays a vital role in providing new information about the fundamental state of the economy. This information is assimilated by market participants and the general public, who incorporate it into their existing beliefs and adjust their expectations accordingly. For example, if the central bank communicates positive information about aggregate productivity or labor market conditions, it can shape expectations and influence economic behavior, Romer and Romer (2000), Nakamura and Steinsson (2018). This can have implications for firms' capital investment decisions, as they may adjust their expenditures based on their revised outlook for future economic conditions.[24]

[23]The distinction between the fundamental and non-fundamental narratives is crucial for understanding the factors driving fluctuations in firms' capital investment in response to Fed information.

[24]The fundamental narrative emphasizes the role of non-monetary communication as a source of funda-

Instead, the non-fundamental narrative is in line with the idea that non-monetary communication from the central bank influences investor sentiment and the level of optmism in the economy. Investors do not learn any new information about the fundamental state of the economy from the FOMC announcements.[25] According to this perspective, when the central bank communicates a positive outlook for the future, it can foster increased optimism in the financial markets and improve the financial conditions of firms. Consequently, firms may respond by expanding their investment expenditures due to the improved borrowing capacity facilitated by positive investor sentiment.[26]

Q-Test for Fed information. I propose a test based on the marginal value of capital (or Tobin's Q) to differentiate between the fundamental and non-fundamental narratives of Fed information. The Tobin's Q serves as a comprehensive measure of a firm's investment profitability, and it depends on the ability of a firm to generate dividends for its shareholders, as well as by aggregate and firms' idiosyncratic financial conditions. Thus, by analyzing how the Tobin's Q responds to a Fed information shock $\varepsilon_t^{\text{info}}$, I can gain valuable insights into the underlying transmission mechanism.[27]

I test the hypothesis that variations in investor sentiment in the financial markets account for the majority of the effects of Fed information on firms' investment profitability. To show this, I study the relationship between the Fed information shock $\varepsilon_t^{\text{info}}$ and the firms' Q conditional to common measures of aggregate market sentiment. If the Fed information shock $\varepsilon_t^{\text{info}}$ influences investors' beliefs and is related to future fundamentals, conditioning the analysis on investor sentiment would result in the cov $\left(\varepsilon_t^{\text{info}}, Q_{j,t}\right)$ that is closer to the unconditional one. If $\varepsilon_t^{\text{info}}$ affects investors' beliefs while being unrelated to future fundamentals, conditioning to investor sentiment would lead the cov $\left(\varepsilon_t^{\text{info}}, Q_{j,t}\right)$ to be closer to zero.

To implement the test, I regress the one-period change in the firm-level Q on the Fed information shock $\varepsilon_t^{\text{info}}$, controlling for common measures of market sentiment in the financial market, λ_t:

$$\Delta \log Q_{i,t} = \alpha_i + \beta_0 \varepsilon_t^{\text{info}} + \beta_1 \lambda_t + \Gamma Z_{i,t-1} + u_{i,t} \tag{2}$$

mental news that impacts economic expectations and behavior.

[25] This is line with the macroeconomic of narratives of Flynn and Sastry (2022).

[26] The non-fundamental narrative highlights the significance of non-monetary communication in shaping investor sentiment and influencing firms' investment decisions through the enhancement of their financial environment (Alimov and Mikkelson (2012), Arif and Lee (2014), Li et al. (2022)).

[27] Regardless of the narrative, the Fed information shock $\varepsilon_t^{\text{info}}$ is expected to be positively related with the firm' marginal value $Q_{i,t}$. In the case of news, the positive correlation between $\varepsilon_t^{\text{info}}$ and $Q_{i,t}$ arises primarily due to higher expected future dividends, whereas in the case of the non-fundamental, this correlation is primarily due to an improvement in investor sentiment.

Table 1: Results of the Q-test for Fed information

	No Sentiment	With Sentiment
	(1)	(2)
Fed Information Shock	1.431***	0.253
	(0.486)	(0.334)
Pure Monetary Shock	-1.353***	-0.972**
	(0.481)	(0.383)
Fixed Effects	Firm	Firm
Controls	Size, Trend	Size, Trend
Period	1990-2018	1990-2018
Observation	339268	336555

Notes: The table reports panel OLS estimates of the coefficients of a regression of the change in the Tobin's Q on the monetary policy shocks. Average Tobin's Q is the ratio of total assets, the market value of equity from CRSP, minus the book value of equity and deferred taxes to total assets. Pure and Fed information shocks are identified using Jarociński and Karadi (2020) approach. Variations in investor sentiment are proxy by the change in volatility index (VIX). The dataset runs from 1990-Q1 to 2018-Q4. Standard errors, clustered two-way at the firm and quarter level, are reported in parentheses. $* = 10\%$ level, $** = 5\%$ level, and $*** = 1\%$ level. See Appendix A for additional information on variables construction.

where α_i controls for firm-fixed effects, $Z_{i,t-1}$ controls for firms' size and firms' time trend. I use the change in the Volatility Index (VIX) as my baseline measure of investor sentiment.

Table (1) provides evidence supporting the non-fundamental narrative of Fed information. Column (1) shows that Fed information shocks positively predict an increase in the firms' marginal value when not controlling for aggregate measure of sentiment.[28] Column (2) shows that, after accounting for market sentiment, the Fed information shock ($\varepsilon_t^{\text{info}}$) does not show any significant effect in on firm investment profitability. The effect of $\varepsilon_t^{\text{info}}$ on $Q_{i,t}$ becomes statistically insignificant, confirming the hypothesis that Fed information influencing investors' beliefs is non-fundamental.

Table 3 and 4 in Appendix D provide additional robustness checks to validate the results. Table 3 shows that the results are robust to alternative measures of market sentiment: the excess bond premium (EBP) from Gilchrist and Zakrajšek (2012), which captures the risk premium in the bond market; the 1-year horizon macro uncertainty index proposed by Jurado et al. (2015); and the global risk aversion index from Bekaert et al. (2022), used as a proxy for the price of risk on households. Table 4 shows that the results remain consistent even after including additional controls in the regression specified in Equation 2.[29]

[28] In contrast, tightening pure monetary shocks negatively affect firms' profitability, in line with the standard monetary policy theory.

[29] These additional controls account for the fact that the average Q is used as a proxy for the marginal

Finally, Appendix D provides additional evidences in favor of the non-fundamental hypothesis of Fed information.

3 Quantitative model

In order to interpret these empirical results and quantify the aggregate implication for monetary policy, I develop a general equilibrium New-Keynesian model with heterogeneous firms, idiosyncratic productivity, and real and financial frictions. The presence of idiosyncratic productivity allows me to study the distributional effects of firms' characteristics more precisely by capturing the rich heterogeneity we observe in the firm-level data. Because those effects tend to be highly non-linear, standard macroeconomic models that do not incorporate this heterogeneity would fail to capture the distributional effects of leverage.[30]

The theoretical part of this paper is organized into three sections. In section 3, I describe the main elements of the model and the estimation of the parameters. The key actors in the model are a set of firms that make investments and are heterogeneous because of idiosyncratic productivity. They finance investment with internal and external source of funds, corporate bond, and equity issuance (Gomes, 2001).[31] Real frictions arise from adjustment costs in capital accumulation, while financial frictions are introduced through an equity financing premium and leverage-dependent interest rates on bonds. Both types of frictions are important for matching the data.

Section 4 of the paper comprises the calibration of the model and the validation of its predictions on the data. Given the parametrization of the model, I show that on simulated data, the average and heterogeneous dynamic response of investment to the represented policy shocks in the model are consistent with the empirical findings and provide an intuition of the mechanism. Finally in section 5, I present the aggregate implications of the heterogeneity for monetary policy. I show that the aggregate effects of monetary policy may depend on the distribution of leverage, which varies over the business cycle, and the effect that Fed communication has on market sentiment.

value of capital. Typical controls utilized in the literature include leverage, cash liquidity (to capture the presence of financial frictions), past sales growth, and the sales-to-capital ratio.

[30] However, modeling firms' heterogeneity increases computational complexity. That entails the disadvantage of modeling Fed information shocks in a reduced form to keep the model computationally tractable.

[31] This is different from Ottonello and Winberry (2018), who assume that firms can endogenously default in equilibrium and exit from the market.

3.1 Heterogeneous firms

Time is discrete and the horizon is infinite. In each period there is a unit mass of firms indexed by j with a well-defined distribution $\Gamma_t = \Gamma(\varepsilon_{j,t}, K_{j,t}, B_{j,t})$ over idiosyncratic productivity $\varepsilon_{j,t}$, capital $K_{j,t}$ and debt $B_{j,t}$. Firms are owned by a representative household. Firms produce an homogeneous wholesale good $Y_{j,t}$ in the economy which is purchased by retailers at the equilibrium price p_t^w. After producing, paying taxes and investing in new capital, firms decide either to distribute dividends to the household or to issue equity paying a premium.

Production and investment. Firms produce an homogeneous wholesale good $Y_{j,t}$ using capital $K_{j,t}$ and labor $N_{j,t}$ with a decreasing return to scale technology: $Y_{j,t} = Z_t \varepsilon_{j,t} K_{j,t}^{\alpha} N_{j,t}^{\nu}$ where $\alpha + \nu \leq 1$ is the degree of return to scale. The decreasing return to scale assumption guarantees the existence of an optimal firm size. Firms' technology is subject to an aggregate shock Z_t common to all firms, and a firm specific shock $\varepsilon_{j,t} \in \mathcal{E} \equiv \{\varepsilon_1, \varepsilon_2, ..., \varepsilon_N\}$ which follows a discrete time first-order stationary Markov chain with $P(\varepsilon_{j,t+1} = \varepsilon_s | \varepsilon_{j,t} = \varepsilon_i) \equiv \pi_{is} \geq 0$, and $\sum_s^N \pi_{is} = 1, \forall i$.[32]

Each period, firms hire labor in a competitive labor market at the equilibrium wage w_t, invest in new capital $K_{j,t+1}$ and issue one period debt $B_{j,t+1}$. Because firms do not face any frictions in adjusting labor, the optimal labor policy $N_{j,t}^*$ solves the static problem:

$$N_{j,t}^* = \underset{N_{j,t} \geq 0}{\arg\max} \left\{ p_t^w Z_t \varepsilon_{j,t} K_{j,t}^{\alpha} N_{j,t}^{\nu} - w_t N_{j,t} \right\} = \left(\frac{\nu p_t^w Z_t \varepsilon_{j,t}}{w_t} \right)^{\frac{1}{1-\nu}} K_{j,t}^{\frac{\alpha}{1-\nu}}$$

After hiring labor and producing, firms decide the investment policy in physical capital, given that the existing capital stock depreciates at the rate δ. In equilibrium, capital accumulation follows the standard law motion for capital $K_{j,t+1} = (1-\delta)K_{j,t} + I_{j,t}$, where $I_{j,t}$ is the amount of new investment in capital stock. I assume that the price of investment is fixed and it is normalized to 1. To generate a more realistic firm size distribution I assume that firms face adjustment costs whenever they invest or divest in new capital:

$$\mathcal{G}\left(K_{j,t+1}, K_{j,t}\right) = c_0 \left(\frac{K_{j,t+1} - (1-\delta)K_{j,t}}{K_{j,t}} \right)^2 K_{j,t} + c_1 Y_{j,t} \mathbb{1}_{I_{j,t} \neq 0}, \tag{3}$$

where $\mathbb{1}_{\mathrm{I}_{j,t} \neq 0}$ is an indicator that equals one if firm investment is different from zero and c_0

[32] The aggregate productivity shock follows an auto-regressive process in logs and it is used to generate a TFP-induced recession in the model.

and c_1 are two parameters controlling the strength of the adjustment costs. The functional form $\mathcal{G}$ is made up of two terms. The first term is a quadratic adjustment cost which generates slow convergence to the optimal firm size implied by the decreasing returns to scale assumption and idiosyncratic productivity. The second term adds a non-convex adjustment cost component which introduces periods of inaction in the firms' investment choices, Doms and Dunne (1998).

The presence of adjustment costs brings two advantages to the model. First, allow imperfect correlation between firm size and idiosyncratic shocks by introducing the desire to smooth firms' investment in the model. In a world without adjustment cost, the optimal choice of capital would only depend on the conditional expectations of firms' future productivity, making firms continuously adjust capital every period, at odds with the firms' behavior in the data. Second, it introduces a forward-looking component in investment choice by creating a positive correlation between investment and expected marginal-Q, which is missing in the absence of real frictions.

Financial frictions. Each firm jointly decides the capital to buy for the next period and its financing policy. As a means of financing investment, firms rely on both internal and external funds, which are represented by corporate bonds $B_{j,t}$ offered at a discount and new equity issuance. Firms prefer debt over equity financing because of a tax advantage[33]. The corporate tax rate is denoted by τ. Internal financing is represented by the cash flows generated from production net of debt repayment and tax saving and, it is the preferred source of firms' financing in the model because of the absence of transaction costs. The total source of internal financing available to a firm after production, debt repayment and taxes at the beginning of every period is:

$$\Pi = (1-\tau) \max_{N_{j,t} \geq 0} \left\{ p_t^w Z_t \varepsilon_{j,t} K_{j,t}^{\alpha} N_{j,t}^{\nu} - w_t N_{j,t} \right\} - \eta - B_{j,t} + \tau \left(\delta K_{j,t} + i_t B_{j,t} \right) \tag{4}$$

The first term is the after taxes operating profits gross of the cost of debt; the second term is the amount that firms have to repay to the bondholders at the beginning of every period t; the last term is the tax rebate from issuing debt and depreciating capital. The parameter η is a fixed cost of production introduced in the model to match the cross-sectional moments in the data.

Beyond internal funds, firms have access to the bond market. Firms can finance investments

[33] Because of tax advantage, Modigliani-Miller's theorem does not hold and firms choose to finance investment by issuing debt over equity.

by issuing one-period corporate bonds at discount. The price of debt is $\mathcal{Q}$ and it is firm-specific and determined in equilibrium by a financial intermediary.[34] Because debt is risk-free, bondholders require firms to be able to repay their debt in every state of the world, Hennessy and Whited (2007). This is guaranteed by introducing a ceiling on the maximum amount of resources that firms can collect on the bond market for financing investment. I follow Jeenas (2018b) and Buera and Moll (2015), I assume that debt is constrained to be less than a fixed fraction of the future capital stock.[35]

$$\mathrm{B}_{j,t+1} \leq \theta_k \mathrm{K}_{j,t+1} \tag{5}$$

This linearity in the ceiling on debt introduces two elements. First, it directly limits the maximum leverage that a firm can achieve next period at value θ_k. Second, as explained in DeAngelo et al. (2011), the presence of a forward-looking variable in the ceiling constraint adds value to the financial flexibility in the future. This effect will affect the firms' optimal decision for capital and debt in the model.

Finally, firms can raise funds by issuing new equity shares. Equity issuance is more expensive than debt financing and arises just when current investment opportunities justify the additional cost. To introduce that, I first define dividends in the model. The amount of dividends paid to the shareholders after issuing debt and investing in new capital is:

$$\mathcal{D} = \Pi(\varepsilon_{j,t}, K_{j,t}, B_{j,t}) - \mathcal{G}\left(K_{j,t+1}, K_{j,t}\right) - I_{j,t} + \mathcal{Q}B_{j,t+1} \tag{6}$$

If $\mathcal{D}$ is positive it means that firm distributes positive dividends to the shareholders while if it is negative, it means that firm is collecting external resources from the household by issuing new equity. However, to ensure that equity issuance is infrequent in the model, I assume firms incur additional costs when raising new equity funds. I assume that the firm pays a quadratic cost to raise external equity funds, which is as follows:

$$\mathcal{H}\left(\mathcal{D}\right) = \left(a_0 + a_1 \mathcal{D}_{j,t}^2\right) \mathbb{1}_{\mathcal{D}_{j,t}<0} \tag{7}$$

The cost of external finance is zero if a firm decides to distribute dividends. At the same time, it is positive, and it marginally increases in the amount of new issuance if a firm is receiving

[34] Since I do not restrict debt to be positive, $\mathrm{B}_{j,t}$ can take both positive or negative values, with a positive value denoting debt and a negative value denoting cash.

[35] In Hennessy and Whited (2007) debt is collateralized by the following period operating profits to guarantee that firms always can repay their debt. In contrast, in Khan and Thomas (2013) the maximum debt is constrained to a fraction of the value of current capital, which resembles the idea that smaller firms can borrow less today.

injections of funds from the shareholders, consistent with the empirical findings in Altınkılıç and Hansen (2000). The parameters a_0 and a_1 control the degree of financial friction[36]. The equity payout left to the shareholders is equal to the dividends net of equity issuance cost.

3.2 Financial intermediary

The household owns a representative, perfectly competitive financial intermediary. The financial intermediary transfers household deposits to firms in the form of zero-coupon bonds. To introduce a premium on the corporate bond, I assume that the intermediary charges a premium Φ above the safe-interest rate on the cost of borrowing $\mathcal{R}_t^b$ which is $\mathcal{R}_t^b = (1 + i_t)\,\Phi$. The premium Φ is subject to an exogenous shock $\varepsilon_t^{\text{sent}}$ that captures an exogenous change in the investors' sentiment in the financial markets. A positive shock to $\varepsilon_t^{\text{sent}}$ improves investors' sentiment which decreases the premium on holding bond assents pushing firms to increase borrowing (Li et al., 2022).

Additionally, I introduce the assumption that the shock has heterogeneous effects on the price of debt among firms. Specifically, when a positive shock $\varepsilon_t^{\text{sent}}$ occurs, the premium charged by intermediaries decreases in proportion to firms' leverage. This assumption aims to capture the notion that as market sentiment improves, highly leveraged firms derive less benefit from it due to their limited borrowing capacity being already utilized (Whited, 1992). I specify a functional form for Φ in the calibration section and estimate its' parameters to match the heterogeneous response of investment observed in the data.

3.3 The New-Keynesian block

Retailers. There is a unit continuum of retailers indexed by i. Retailers purchase the homogeneous good $Y_{j,t}$ produced by the wholesale heterogeneous firms at price p_t^w and transform it into a differentiated good $\tilde{Y}_{i,t}$ using a linear technology $\tilde{Y}_{i,t} = Y_{j,t}$. Retailers are subject to Rotemberg quadratic adjustment costs and set the prices $p_{i,t}$ for the differentiated good $\tilde{Y}_{i,t}$ in a monopolistic competitive market.

Final good producers. There is a unit mass of perfectly competitive final good producers. Final good producers buy a basket of differentiated goods $\tilde{Y}_{i,t}$ from the retailers at price $p_{i,t}$ and aggregate into a final consumption good using a standard CES aggregator production

[36] In the literature, it is common to introduce also a fixed cost of equity issuance as in Hennessy and Whited (2007). In the calibration, I set the fixed cost of equity issuance to zero to avoid a jump in the value function.

function. The retailers and the final good producers aggregate to derive the standard New Keynesian Phillips curve

$$\log \Pi_t = \frac{\theta - 1}{\phi_p} \log \frac{p_t^w}{p} + \beta \mathbb{E}_t \log \Pi_{t+1} \tag{8}$$

which links gross inflation today Π_t to the expected future path of the retailer marginal cost p_t^w. A complete derivation of the equation (8) is in the Appendix.

3.4 Monetary authority

To introduce a role for the monetary authority, I assume that the central bank sets the nominal interest rate i_t following a standard Taylor rule, that is:

$$\log(1 + i_t) = \log(1 + \bar{i}) + \phi_\pi \log \left(\frac{1 + \pi_t}{1 + \bar{\pi}} \right) + \varepsilon_t^{\text{mps}} \tag{9}$$

where, $\bar{i}$ is the stationary value for the interest rate, and $\bar{\pi}$ is the inflation target. The parameter ϕ_π measures the response of monetary policy to deviations in inflation from its targeted values. Under this assumption, a change in the nominal rate can occur endogenously, if the central bank sees inflation increasing, or exogenously if the central bank deviates temporarily from the systematic Taylor rule.

To map the model to the data I assume that a shock to the Taylor rule $\varepsilon_t^{\text{mps}}$ proxies a pure monetary shock while, a shock to the investor sentiment $\varepsilon_t^{\text{sent}}$ proxies a Fed information shock. proxies a Fed information shock. This captures the idea that, as the monetary authority engages in non-monetary communication, it affects firms' investment primary through the willingness to take risks and the price of debt in the bond market.

3.5 Household and government

Household. There is a representative household that owns all the firms in the economy. The representative household supplies labor in the market N_t, consumes the output produced C_t, and saves in one-period deposits D_t. Household maximizes the discounted sum of the future utility, taking the wage w_t and the interest rate i_t as given. The household utility function is additive and separable in consumption and labor. The household problem is as follows:

$$\max_{\{C_t, N_t, B_t\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{1-\gamma} - 1}{1 - \gamma} - \kappa N_t \right\} \tag{10}$$

such that

$$C_t + D_t = w_t N_t + \frac{1 + i_{t-1}}{1 + \pi_t} D_{t-1} + \mathcal{D}_t + \mathcal{D}_t^R + \mathcal{D}_t^F + G_t \tag{11}$$

where $\mathcal{D}_t$, $\mathcal{D}_t^R$ and $\mathcal{D}_t^F$ are respectively the dividends payed by the wholesale heterogeneous firms, retailers and final good producers and G_t is the government transfer from firms taxes. The first order conditions of the household problem pin down the Euler equation for consumption, the labor supply and the stochastic discount factor $\Lambda_{t,t+1} = \beta \mathbb{E}_t \left[\frac{C_t}{C_{t+1}} \right]$.

Government. I close the model by assuming that there is a government that run a balanced budget constraint every period. For simplicity, I assume that the collected taxes from the firms are rebated to the household in a lump-sum fashion

$$G_t = \int \tau \left(p_t^w Y_{j,t} - w_t N_{j,t} \right) - \tau \left(\delta K_{j,t} + i_t B_{j,t} \right) d\Gamma \tag{12}$$

Ricardian equivalence holds in the model, so the precise financing path of the given stream of government expenditure is irrelevant.

3.6 Calibration and estimation

I calibrate the model parameters following the literature. A set of parameters are calibrated based on previous works. In contrast, I estimate the parameters governing real and financial frictions to match the cross-sectional moments of the model's stationary equilibrium to the averages observed in the data. I calculate the average moments to target in the data at the quarterly level as in Jeenas (2018a).

Calibrated parameters. I set the household discount factor $\beta = 0.98$ which implies a roughly 2% nominal interest rate in the stationary equilibrium consistent with the long-term average of the 1-year Treasury yield used in the empirical analysis. I set the depreciation rate $\delta = 0.01$ to match the cross-sectional average of the firms' investment rate in the data at quarterly frequency.[37] I calibrate the firms' production function and the idiosyncratic technological process parameters following Gilchrist et al. (2014) and Jeenas (2018b). I set the capital share $\alpha = 0.255$ and the labor share $\nu = 0.595$ which imply a decreasing returns to scale of 0.85 as commonly used in the literature.

[37] Other papers calibrate $\delta = 0.025$ based on the quarterly measure of capital depreciation from the U.S national income and product accounts (NIPA).

I assume that the idiosyncratic productivity ε follows an AR(1) log-normal process $\log \varepsilon_{i,t} = \rho_\varepsilon \log \varepsilon_{i,t-1} + u_{i,t}$, with $u_{i,t} \sim N(0, \sigma_\varepsilon^2)$. I discretize the stochastic process for the logarithm of idiosyncratic productivity using the Tauchen (1986) method. I set the auto-correlation parameter $\rho_\varepsilon = 0.785$ and the standard deviation $\sigma_\varepsilon = 0.125$ which are close to the parameters estimates in Gilchrist et al. (2014) on Compustat firms. I follow Bordalo et al. (2021) to calibrate the corporate tax rate $\tau = 0.2$.[38] The maximum leverage parameter θ_k instead is set to guarantee that the next period cash on hand is sufficient to repay the financial intermediaries given the amount of debt chosen. I also use the parameter θ_k as the upper bound of the variable leverage when discretizing the leverage choice.

I set the CRRA parameter σ in the representative household utility function to 1 to have a logarithm in consumption. I calibrate the parameters governing the New-Keynesian block following Ottonello and Winberry (2018) instead. I calibrate the elasticity of goods θ to 10, and the price adjustment coefficient cost $\phi_p = 90$, which implies a mark-up in the steady-state equal to 11%. I set ϕ_π, the coefficient on the inflation gap, at 1.25, values in line with those used in the New Keynesian literature. I fix the disutility of labor parameter k to 1.5 to have a value of hours worked in the steady-state close to 0.6. For the quantitative exercise, I set the function $\Phi^{-1} = 1 + \varepsilon_t^{\text{risk}} e^{-\theta_l \frac{\mathrm{B}'}{\mathrm{K}'}}$ so that in the steady state the price of debt is the same across firms. I estimate the parameter θ_l to 1.5 to produce a differential response of firm-level investment to a Fed information shock of approximately 1% consistent with figure (1).[39] Finally, I calibrate the parameters of the aggregate shocks to match the persistence and the effect of the dynamic response observed in the data. A summary of the calibrated parameters used in the model is in the table (2.A).

Estimated parameters. The parameters $(\eta, c_0, c_1, a_0, a_1)$ governing the fixed cost of production, the real and the degree of financial frictions are estimated using simulated method of moments to match a set of empirical moments drawn from Compustat. I choose the moments to target based on the previous works in the literature and perform a sensitivity analysis before estimation to ensure that the target moments are informative about the structural parameters.

I target the average leverage, as defined earlier in the empirical analysis, the average return on capital[40] at the quarterly frequency as in Hennessy and Whited (2007) which are

[38] They estimate the corporate tax rate based on the (CBO) (2017) data. Other papers in the literatue have calibrated τ in an interval between 0.15 and 0.35, Graham (2000), Begenau and Salomao (2019).

[39] Alternatively, one could estimate θ_l in the model to match the heterogeneous response observed in the data after simulation. I avoid this procedure as it is intensive computationally.

[40] I calculate the average return on capital in Compustat as the ratio of total dividends, cash dividends

Table 2: Summary of the parameters in the model

Parameters	Description	Value	Target
A. Calibrated			
β	Discount factor	0.98	2% risk-free rate
δ	Depreciation rate	0.01	Average investment rate
α	Capital share	0.255	Jeenas (2018)
ν	Labor share	0.595	Jeenas (2018)
τ	Corporate tax	0.2	Bordalo et al. (2021)
κ	Labor disutility	1.5	SS Labor ≈ 0.6
σ	CRRA coefficient	1	Log Utility Consumption
ρ_ε	Productivity persistence	0.785	Gilchrist et al. (2014)
σ_ε	Productivity dispersion	0.125	Gilchrist et al. (2014)
θ	Goods substitutability	10	Ottonello, Winberry (2018)
ϕ_p	Price adjustment cost	90	Ottonello, Winberry (2018)
ϕ_π	Taylor rule inflation coefficient	1.25	Ottonello, Winberry (2018)
B. Estimated			
η	Fix cost of production	0.054	Average leverage
c_0	Non-convex adjustment cost	0.125	Average dividends/total assets
c_1	Quadratic adjustment cost	4.9	Inaction rate
a_0	Fix issuance cost	0	
a_1	Quadratic issuance cost	12.54	Frequency equity issuance
θ_k	Max leverage	0.988	Maximum leverage

Notes: I report the calibrated and the estimated parameters of the model in panel A and panel B. The values of the targeted moments are calculated at quarterly frequency from Compustat data.

informative about the fixed cost of production and the degree of quadratic adjustment cost. I also target the inaction rate of investment, defined as the percentage of the firms with an investment rate lower, in absolute value, than one-tenth of the average investment rate in the data as in Khan and Thomas (2013). The rate of inaction is informative about the real friction parameters and, in particular, about the fixed cost component of investment, and it is a common target in the investment literature. Finally, I target the percentage of firms that issue equity in the data which is the share of firms that report having raised funds from the issuance of common and preferred stock in Compustat as in Hennessy and Whited (2007) and Begenau and Salomao (2019). This moment is informative to pin down the structural parameters governing the degree of financial frictions in the model. Intuitively, an increase in the equity issuance component a_1 raises the firms' cost of equity financing, and therefore, it reduces the share of financially constrained firms in the model[41].

plus equity repurchases, and total assets.

[41] Hennessy and Whited (2007) target this moment along with the first and second moments of the ratio of equity issuance to assets, the frequency of negative debt, and the co-variance between equity issuance and

The estimation procedure returns the following estimated parameters: the quadratic adjustment cost parameter $c_0 = 4.9$, the non-convex adjustment cost parameter $c_1 = 0.125$, the fix cost of production $\eta = 0.054$ and the quadratic issuance cost $a_1 = 12.54$. These estimates are in line with other papers in the literature. The table (2.B) reports a summary of the parameters that are estimated and the target moments.

4 Mechanism and validation

This section validates the mechanisms at play in the model. Section 4.1 discusses the mechanism and the role of financial frictions within the model. Section 4.2 presents the aggregate impulse response function to various monetary policy surprises in the model. Section 4.3 tests the model's heterogeneous sensitivity and provides an explanation of the underlying mechanism.

4.1 Firms' problem and financial frictions

In the model, firms make two substantial choices. They choose the amount of capital to buy for the next period K' and the amount of debt B' to issue for financing investment. I denote with $\{\varepsilon, S\}$ the set of state variables $\{\varepsilon, K, B\}$ for a firm j and with a $'$ a variable tomorrow. At the beginning of every period t, each firm solves the following dynamic profit maximization problem subject to a set of constraints:

$$V(\varepsilon, S) = \max_{K', B'} \left\{ \mathcal{D}(\varepsilon, S, S') - (a_0 + \frac{a_1}{2}\mathcal{D}^2)\mathbb{1}_{\mathcal{D}<0} + \Lambda_{t,t+1} \sum_{\varepsilon'} \pi\left(\varepsilon'|\varepsilon\right) V'\left(\varepsilon', S'|\varepsilon\right) \right\} \tag{13}$$

subject to:

$$\mathcal{D}(\varepsilon, S, S') = \Pi(\varepsilon, S) - c_0 \left(\frac{K'}{K} - 1 + \delta\right)^2 K + c_1 Y \mathbb{1}_{I \neq 0} - K' + (1-\delta)K + \mathcal{Q}B' \tag{14}$$

$$\Pi(\varepsilon, S) = \max_{N \geq 0} (1-\tau)(p_t^w Y - w_t N - \eta) - B + \tau\left(\delta K + i_t B\right) \tag{15}$$

$$B' \leq \theta_k K' \qquad (\lambda') \tag{16}$$

$$\mathcal{Q}\left(S'\right) = \frac{1 + \varepsilon_t^{\text{risk}} e^{-\theta_l \frac{B'}{K'}}}{1 + i_t} \tag{17}$$

investment to pin down the level, the slope and the curvature of equity issuance costs in a similar model to mine.

where $V(\varepsilon, S)$ is the value of a firm at the beginning of the period, $\Pi(\varepsilon, S)$ is the cash on hand available to finance investment, $\mathcal{D}(\varepsilon, S, S')$ are the dividends to the shareholders, and λ' is the multiplier associate to the non-binding constraint on debt.

The presence of equity issuance cost is the main source of financial frictions in the model. I define the level of financial friction faced by a firm based on their dividend policy.[42] At the beginning of every period, firms are distinct by the internal funds available to finance investment. I define a firm as *financially unconstrained* (or, with low level of financial friction) if it has accumulated enough internal resources to finance new investment through only cash on hand and new debt issuance. Unconstrained firms never issue equity since it is costly and find it optimal to pay dividends to the shareholders by raising debt. I define a firm as *financially constrained* (or, with high level of financial friction) instead if at the optimum it does not have accumulated enough resources to buy capital K' through debt and cash, and they find optimal to issue equity to forego investment. Constrained firms never distribute dividends to the shareholders and pay an external premium to raise funds through equity.[43]

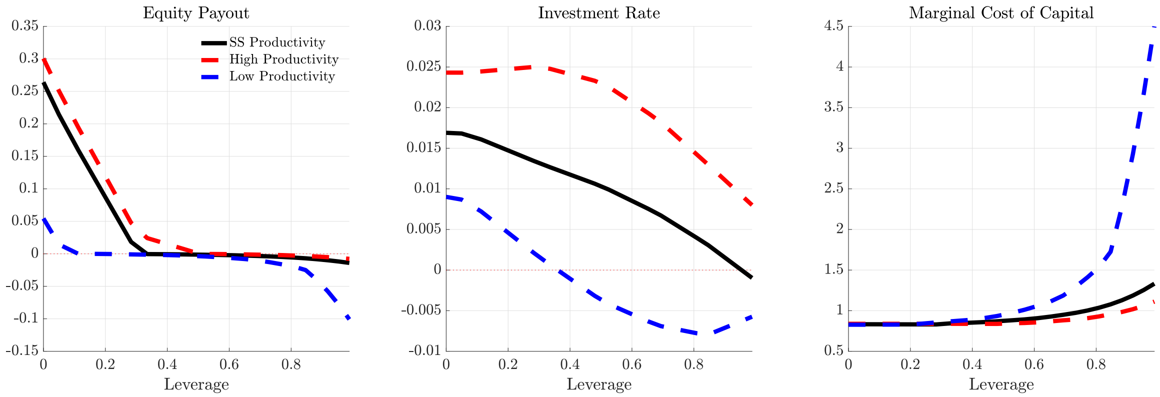
The steady-state policy functions for capital and equity issuance along the leverage dimension shows a linkage between firms' leverage, and financial frictions in the model. Figure 2 shows two main facts. First, given a fixed amount of capital, high leverage firms are more likely to be financially constrained (first column). In the stationary equilibrium, low leverage firms are more likely to pay dividends to the shareholders while high leverage firms are more likely to issue equity to finance investment. The intuition is that firms with a high level of debt are not generating enough resources via debt and internal resources, and so they find optimal financing investment by issuing equity. Whereas firms with a low level of debt can sustain their optimal investment policy without relying on equity issuance and thus, distribute dividends to the shareholders. Second, firms' financing decisions and investment choices are intimately connected (second column). Investment rates are decreasing in the amount of leverage, given a fixed amount of capital. This is because, as firms with a high level of debt are more likely to raise funds through equity, high leverage firms would find raising one additional unit of capital more costly (third column) and thus, they optimally reduce their size in equilibrium.

Figure 27 in Appendix F shows that model steady-state policy predictions are consistent with the equivalent in the data. I construct actual steady-state policy in the data computing the long-term averages of leverage, equity issuance, dividends payout and investment rates

[42]This distinction is the same as in Rojas (2018) which defines the financing gap of a firm as the difference between resources needed to operate and invest minus the resources available to do so.

[43]This definition is similar to the one of Ottonello and Winberry (2018) and Jeenas (2018a)

Figure 2: Dividend policy and the marginal cost of capital in the steady state.



Notes: I plot the average shareholder payout, investment rate (in percentage points) and the cost of capital (marginal cost of capital divided by capital) function in the stationary equilibrium along the leverage dimension. The idiosyncratic productivity is fixed at the steady state level and, for all three plots, I average the policy functions across firms that weight in the population distribution for more then 1% of total capital. For each subplot, I add a linear fitted line (red line).

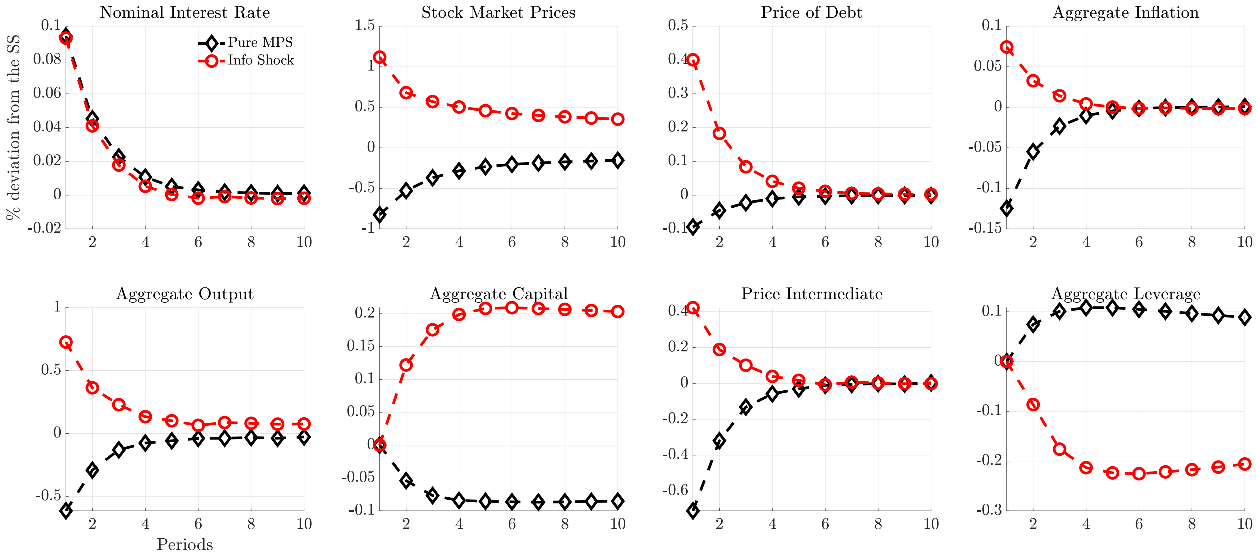
for each firm in my dataset from 1990 to 2018. I plot the cross-sectional correlation between firms' leverage and dividends payout, equity issuance, and investment rates. The data shows a very strong relationship between firms' leverage, payout policy and equity issuance in the long run. Specifically, firms with high leverage tend to exhibit lower dividend payouts to shareholders, lower investment rates, and a higher likelihood of issuing equity to finance their activities. These findings align with prior studies in Fazzari et al. (1987), which emphasize the importance of leverage in determining firms' financial decisions and investment behavior.

4.2 Aggregate impulse response in the model

The model can qualitatively match the aggregate impulse responses observed in the data. To do that, I study the aggregate effects of different interest rate surprises along the perfect foresight transition path back to the steady-state. At time t a policy shock arises and the economy temporary departs from its steady state and slowly comes back to equilibrium as in Jeenas (2018a) and Ottonello and Winberry (2018). The impulse response function are obtained simulating a transition path back to the steady state after 100 periods.[44] In order to have comparable results across simulations, I calibrate the standard deviation and the persistence parameters of the two exogenous components to increase the nominal interest rate at impact by roughly 0.1% and to induce a temporary fluctuations for around eight

[44]More details of the algorithm are in the Appendix.

Figure 3: The baseline IRFs in the model



Notes: The impulse response function to different monetary policy shocks in the model. The black line shows the response of the aggregate variables to a pure monetary shock. The red line represents the aggregate response to a Fed information shock. All responses are in percentage deviation for the steady state. The impulse response function are obtained simulating a transition path back to the steady state after 100 periods using a backward-forward algorithm.

quarters in the model.[45] I plot the impulse responses to the two shocks in figure 3.

In the event that the monetary authority unexpectedly raises the nominal interest rate (i.e., pure monetary shock), a monetary shock leads to the contraction of output, consumption, and labor in the model. Because prices are sticky, they are slow to adjust, inflation and the price of the intermediate output falls, decreasing incentives to invest in new capital. Firms divest since the marginal benefit of capital decreases as the discounted return on future capital and the expected output decline. Furthermore, in response to a Taylor rule shock the cost of raising funds on the bond market increases, and firms that were hit by the shock experience a decline in their cash on hand. In turn, a decline in the amount of internal resources leads firms to raise more funds externally, i.e., via debt and equity issues. It follows that the distribution of firms over leverage shift towards the right hand-side.

A Fed information shock (red line) instead, leads the economy on a pattern similar to an expansionary demand shock and it operates mainly through the cost of borrowing. A Fed information shock increases investors' sentiment in the financial market thus, increasing the price of corporate bonds. Higher price of bonds increases the marginal benefit of debt and decrease in the marginal cost of capital. Differently from a pure monetary shock, labor and

[45] Ottonello and Winberry (2018) calibrates the persistence of the monetary shock to be 0.5.

output increase and prices slowly adjust upward, producing a period of inflation. As a result of higher inflation, the Fed reacts by increasing the nominal interest rate. Firms increase investment because the shock increases firms operating profits and lower the marginal cost of financing new capital at debt. Since firms in expectations increases the capacity to generate profits and dividends, stock market price increases along the transition path. Both shocks produce a response in the economy consistent with the aggregate impulse responses obtained in figure 10 in the Appendix.

4.3 Heterogeneous response of investment

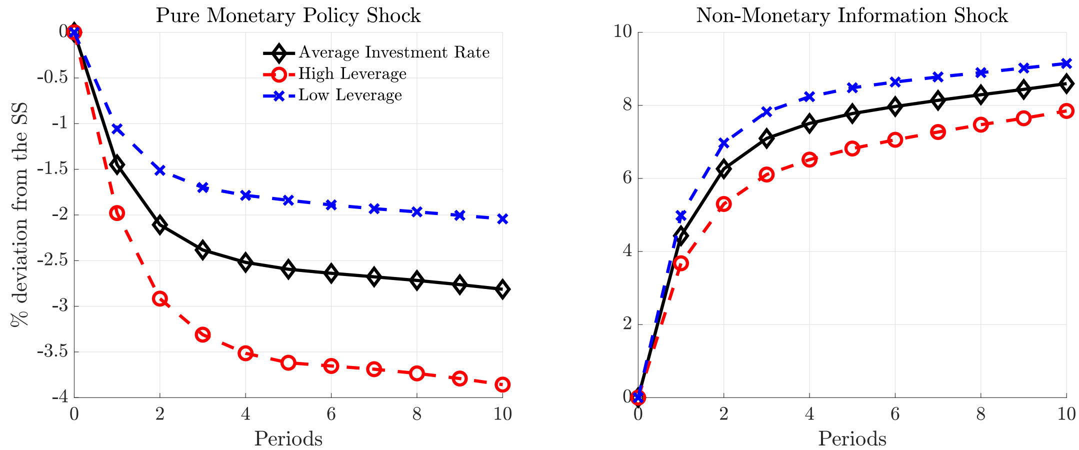
In this section, I show that the model also accounts for the heterogeneous responses to the two shocks at the firm level. To see this, I examine the response of investment at the firm level to the two shocks. I group the firm-level responses based on past leverage into two bins. I consider firms to be low leverage if their leverage is lower than 50 percent and high if their leverage exceeds 50 percent. In order to obtain an average estimate of the sensitivity of firms to the shock, I average the response of investment across firms within the same category (i.e., high or low leverage).[46] I plot the average responses to the two shocks in figure 4.

Figure 4 illustrates that firms with different leverage respond differently to the shocks in the model, consistent with the empirical findings documented in this paper. In particular, in response to a one standard deviation pure monetary policy shock (first graph), firm investment rate drops by around 0.8pp at impact (black line). Firms with different levels of leverage respond differently to the shock. Low leverage firms reduce their investment rates by almost 10 percent less than the average (blue dotted line). Viceversa, firms with high levels of leverage reduce investment rates by 20pp more than low leverage firms at the time of the impact (red dotted line). In response to a Fed information shock instead, firm investment rates increase by around 1.5 percent points at impact (black line). In the cross-sections, firms with low levels of leverage prior the shock increase their investment rates by 10 percent more than the average (blue dotted line), while firms with high levels of leverage increase their investment rates by 10 percent less than the average (red dotted). These results are consistent with previous results in the empirical part of the paper.

Pure monetary shock. The mechanism underlying the diverse investment responses observed in Figure 4 to a pure monetary shock exhibits similarities to the framework presented in Ottonello and Winberry (2018). When a Taylor rule shock occurs, resulting in an exogenous

[46] I only consider firms that constitute more than 1 per cent of the total number of firms in the stationary distribution.

Figure 4: Heterogeneous firm-level response in the model



Notes: The average cumulative impulse response function for investment rate across firms. The black line represents the average firm-level response of the investment rate respectively to a pure monetary shock (first graph) and Fed information shock (second graph). The blue line shows the average firm-level response of the investment rate for firms that have less than 50% of leverage (i.e., low leverage). The red line illustrates the average response of the investment rate at the firm level for firms with more than 50% leverage (i.e., high leverage). The averages are calculated by equally weighting firms that constitute more than 1 percent of the total firms.

rise in the nominal interest rate, the economy enters a recessionary phase. As the real interest rate increases, the stochastic discount factor decreases, leading to reduced marginal profits of capital and a decline in the marginal value of expanding capital investment. Consequently, firms exhibit a tendency to decrease their investment levels, irrespective of their leverage levels.

High leverage firms are more sensitive to the shock if its impact on their cash reserves is strong enough to counterbalance their higher marginal cost of capital. In a partial equilibrium context, highly leveraged or financially constrained firms are less adversely affected by a shock compared to low leverage firms, as they face a steeper marginal cost of capital curve and are more likely to rely on equity issuance. However, a pure monetary shock reduces operating profits for all firms due to a decline in labor and output, as well as higher borrowing costs. This prompts firms to increasingly depend on external financing for new investments. Low leverage firms, with ample cash reserves, are relatively unaffected by the decline in operating profits. In contrast, high leverage firms, already dependent on external financing, respond by increasing equity issuance, which further raises their marginal cost of capital and dampens investment by more.[47]

[47]This mechanism is analogous to the one observed in Ottonello and Winberry (2018)'s model with risky debt, where high leverage firms exhibit greater sensitivity to a policy hike if changes in the nominal interest

Figure 30 in Appendix F plots the responses for the key financial variables, cash on hand, equity and debt across firms with different levels of leverage after a pure monetary shock consistent with the explained mechanism.

Fed information shock. The mechanism behind the investment responses in Figure 4 to a Fed information shock is novel instead. A positive Fed information shock has two primary effects on firms' optimal decisions. Firstly, on average, firms increase their debt levels as rising bond prices enhance the attractiveness of debt, enabling them to issue more debt and raise additional funds. Secondly, firms engage in greater capital accumulation as the expected future profits rise, leading to an increase in the expected marginal benefit of capital. This anticipation of improved future economic conditions prompts firms to invest more in capital.

High leverage firms are less sensitive to a Fed information shock because they take less advantage from an improvement in their financial conditions. Firms with low leverage can increase their leverage position without increasing the likelihood of future equity issuance (i.e., if a firm expects to issue equity next period the marginal cost of debt is higher). Firms with high leverage do not find it desirable to increase their leverage positions instead. There are two reasons for this. First, raising debt will increase the likelihood that they will breach the debt ceiling tomorrow and incur in an additional cost. Second, adding an extra dollar of debt today will result in debt repayment tomorrow and therefore an increased likelihood of requiring external equity financing tomorrow, Strebulaev et al. (2012). It follows that in equilibrium, high-leverage firms find it optimal to reduce their leverage positions, whereas low-leverage firms increase them. Consequently, by expanding their leverage positions, low leverage firms experience a decrease in their marginal cost of capital, which encourages them to invest more.

Figure 30 in Appendix F plots the responses for the response of cash on hand, equity and debt across firms with different levels of leverage after a Fed information shock consistent with the explained mechanism.

5 Quantitative implications

This section studies aggregate implications and provide an explanation of the findings in the empirical part of this paper. Section 4.1 and 4.2 revisits the distributional effects of

rate substantially affect their default probabilities and debt prices. In a risk-free model, the heterogeneity mechanism is more general, as it only requires a shift towards more expensive external financing sources for firms.

monetary policy depending on the market sentiment. Section 4.3 explore the heterogeneous responses of bond prices to a Fed information shock and provide a set of counter-factual experiments.

5.1 State dependency of non-monetary communication

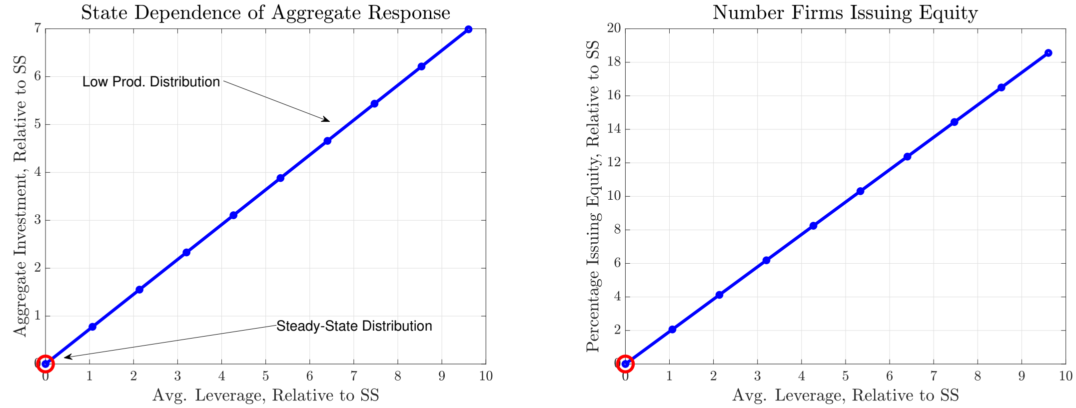
I study the response of aggregate investment to a monetary policy announcement in a recession and compare them in normal times. In order to quantify the state dependence of non-monetary communication, I fix firms' investment response across state space with respect to a Fed information shock as a function of firms' state variables and vary the initial distribution of firms. I vary the initial distribution of firms $\Gamma(z, K, B)$ by taking the weighted average of two reference distributions. The first reference distribution is the steady-state distribution $\Gamma_{\text{ss}}(z, K, B)$. The second reference distribution $\Gamma_{\text{bad}}(z, K, B)$ assumes that the conditional distribution of capital and debt for every level of productivity is equal to the distribution of capital and debt conditional on a low realization of productivity in steady state. I then compute the initial distribution as a weighted average of these two reference distributions, $\omega \cdot \Gamma_{\text{bad}} + (1 - \omega) \cdot \Gamma_{\text{ss}}$.[48]

Figure 5 shows the aggregate response of investment to a Fed information shock as function of the weight ω.Based on the calibration of the model, the effectiveness of a non-monetary policy announcement that increases the interest rate by 1 percentage point is enhanced by 0.8% in a recession for every 1% increase in the average leverage in the economy relative to the steady state level of leverage. Compared to the change in average leverage in the economy during the Great Financial Crisis, which was 4% higher, a Fed information shock is found to be 3% more effective.

The results stem from the interaction of two opposing forces. Firstly, a negative TFP recession shock amplifies the presence of financially constrained firms with low productivity, leading to a larger proportion of firms that are highly responsive to aggregate fluctuations, as depicted in Figure 5. Secondly, the shock increases the average leverage in the economy, thereby increasing the share of firms with lower sensitivity to non-monetary communication. The extent of these effects depends on the strength of the two channels and the dynamics of general equilibrium. Based on the calibration of my model, I find that the reduced sensitivity of high leverage firms to non-monetary communication is insufficient to counterbalance the larger number of firms that are highly responsive to aggregate fluctuations during a recession.

[48] Another approach is to simulate the separate transition paths of a Fed information shock and a negative aggregate TFP shock. By subtracting the impulse responses of the TFP shock alone from the joint transition path, we can isolate the specific effects of the policy shocks during a recession.

Figure 5: State dependency of non-monetary communication



Notes: Dependence of aggregate response of Fed information on initial distribution. I compute the change in aggregate capital for different initial distributions as described in the main text.

5.2 Revisiting the state dependency of pure monetary policy

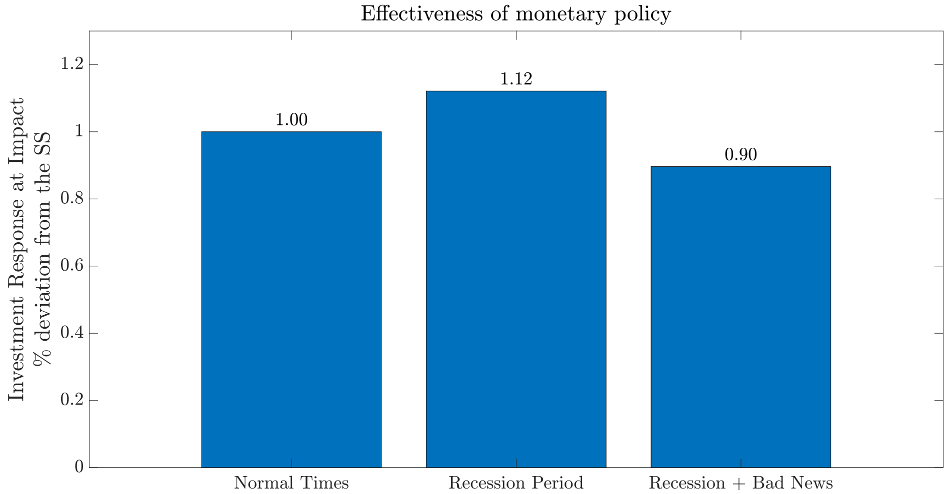
I use the model to revisit the distributional effects of pure monetary policy. Previous literature has focused on studying the effect of monetary policy in a recession compared to normal times without taking into account the potential confouding effect of a Fed information component (Koby and Wolf, 2020; Ottonello and Winberry, 2018). In practice however, as the Fed releases an easing statement, investors may misinterpret the information released triggering an negative shock.[49] Because this shock produces direct effects on the marginal cost of capital and distributional effects over time, the effectiveness of an expansionary Taylor rule shock in a recession may be dampened by a negative market response.

I estimate the response of aggregate investment to different types of (expansionary) monetary policy innovation in a recession and compare them in normal times. I consider two types of monetary policy surprises. One with a positive one standard deviation Taylor rule shock with no contamination and, a second surprised, mixed with a negative market response (half standard deviation). I simulate separately the transition path of the two monetary policy surprises jointly with a negative aggregate TFP shock. I calibrate the standard deviation and the persistence parameters of the TFP shock to lower output at impact by roughly 4% and to generate a recession for around eight quarters in the model.[50] I obtain the effect of an expansionary Taylor rule shock under recession by subtracting the impulse responses of the aggregate TFP shock from the joint transition path. I normalize the response of aggregate

[49]Figure 9 in Appendix A shows that this case is indeed widespread from 1990 to 2018.

[50]Similar to this paper, Koby and Wolf (2020) calibrates the standard deviation of the TFP shock to lower output at impact by 5%.

Figure 6: Revisiting state dependency of monetary policy



Notes: Response at impact of aggregate investment to an expansionary monetary policy shock under three different scenario. In the first column, the response of aggregate investment to a positive Taylor rule shock in normal times, which I normalize to 1. In the second column, the response of aggregate investment to an exogenous Taylor rule shock in a recession. In the last column, the response of investment to to an exogenous Taylor rule shock in a recession followed by a negative market reaction.

investment to the two shocks in normal times to 1 to ease the interpretation. I plot the results of this exercise in Figure 6.

Figure 6 shows two facts. First, given my calibration, a an expansionary Taylor rule shock that cuts the nominal rate by 10bp in a recession is 12% more effective in stimulating investment than in normal times. The result depends on the strength of real and financial frictions. A TFP-induced recession produces two effects on the economy that may affect the potency of a monetary policy shock. First, it increases the share of financially constrained firms (i.e., firms that issue equity increases) that, given the results in figure 4, are relatively more sensitive to interest rate changes. Second, it increases the relative cost of capital financing due to the presence of fixed adjustment costs which, in turn, discourages firms from investing in response to any expansionary policy shock during a recession. This mechanism is reminiscent of the one in Caballero and Engel (1999) and discussed in Koby and Wolf (2020).[51] Given my calibration, the distributional effects of leverage dominate the dampening effect of real frictions.

Second, Figure 6 shows that a negative market response to a FOMC statement may dampen the effectiveness of an expansionary monetary policy shock in a recession, and this

[51] In a downturn, firms are less sensitive to expansionary shocks because they are closer to their target capital and find it more expensive to adjust investment. As the fixed cost of investment does not change during a recession, the burden of paying the fixed cost is relatively higher in a recession than in normal times.

effect is not negligible. Based on my calibration, a negative miscomunication in an FOMC statement dampens the elasticity of investment to an interest rate cut by more than 20% compared to the equivalent non-market response case. The economic intuition is a negative market reaction increases the cost of capital at the margin for all firms in the economy. It follows that even though a recession increases the share of financially constrained firms in the economy, a steepening in the marginal cost of capital dampens the effectiveness of a monetary policy cut in a period of recession.

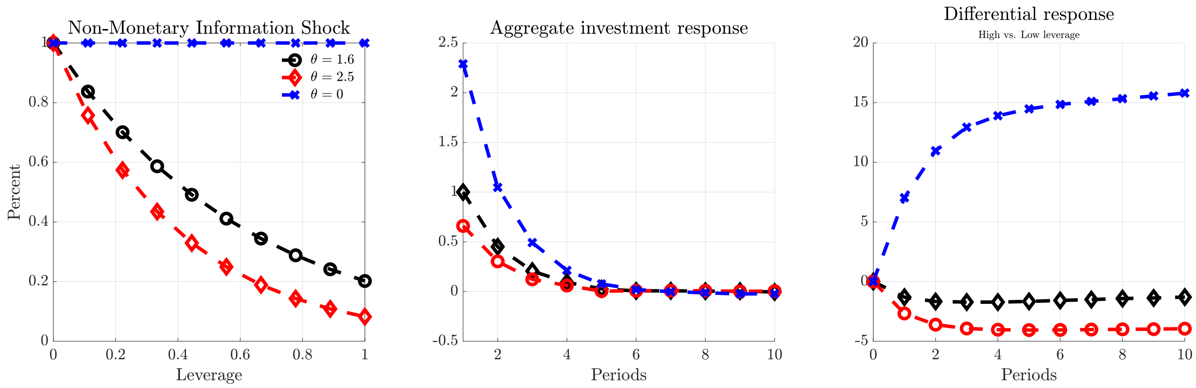
5.3 A counterfactual experiment

The heterogeneous responses of bond prices to a Fed information shock are crucial to explain the heterogeneity of firm-level investment observed in the data. With the price of debt being less sensitive to a Fed information shocks, high-leverage firms have less incentive to increase their debt positions and replace it with equity issuance. Nevertheless, high-leverage firms in the model have a larger propensity to invest, since they face a relatively steeper marginal costs of capital curve. This implies that if the price of debt for high leverage firms increased more in response to a Fed information shock, they would be able to save out of financial frictions, thus increasing their capital position by more. This source of heterogeneity is therefore, a dampener for Fed information shocks.

Figure 7 quantify the dampening effect of this channel in a the counter-factual experiment. I simulate the response of aggregate investment to the same shock using different parameters of θ_l. The parameter θ_l in the price of debt function controls the extent to which high leverage firms benefit less from a change in the market sentiment. I compare the results on aggregate and average investment of the benchmark model, $\theta_l = 1.5$, with two different values of $\theta_l = \{0, 2.5\}$. In the benchmark model $\theta_l = 1.5$, a shock to the risk premium affects the price of debt for high-leverage firms 4 time less than it does for a firm at 0 leverage. It follows that investment increases in the economy (i.e., I standardize the increase at 1pp at impact) and low-leverage firms contribute relatively more to the aggregate response.

If $\theta_l = 0$ (blue line), Fed information shocks increase debt prices equally across firms, regardless of the future leverage conditions. Now, firms with high-leverage have greater incentives to acquire more resources from the bond market to replace equity issuance. As high-leverage firms reduce their reliance on external equity issuance, they experience a decrease in their marginal cost of capital, thereby increasing their capital position. There are two effects that follow from this. First, high-leverage firms will be more sensitive to Fed information shocks and will increase their investments more than low-leverage firms (third column).

Figure 7: Counterfactual experiments to a Fed information shock



Notes: The results to a set of counter-factual experiments in the model for various values of θ_l. Black lines represents benchmark calibration, $\theta_l = 1.5$. Blue lines represents the model responses when $\theta_l = 0$. Red lines represents the model responses when $\theta_l = 2.5$. I report the heterogeneous effects of the shock along the leverage dimension in the first graph. The second graph illustrates the aggregate response to investment. All aggregate responses are re-scaled so that aggregate investment increases by one percentage point under the benchmark case. In the third graph, the average differential firm leverage response of the investment between high and low leverage firms. The averages are calculated by equally weighting firms that constitute more than 1 percent of the total firms.

Second, because high leverage firms increase investment by more, aggregate investment increases significantly more in response to the shock. According to my calibration, aggregate investment would increase more than twofold if $\theta_l = 0$, as compared to the benchmark case.

If $\theta_l = 2.5$ (red line) instead, Fed information shocks worsen the lower sensitivity of high leverage firms to price shocks. Firms with higher leverage find that issuing debt is even less beneficial compared to the benchmark case. Because of this, the differential investment response between high and low leverage decreases more, and aggregate investment increases by around 40 per cent less than in the benchmark scenario.

6 Conclusion

Monetary policy has experienced a notable evolution, shifting from the conventional Keynesian theory to a more contemporary framework. The new theory of monetary policy highlights the significance of beliefs and expectations in shaping economic outcomes. Through non-monetary communication strategies, central banks can impact firms' investment decisions by shaping investors' perceptions and confidence in the economic outlook. This emphasizes the role of psychological and informational factors in the transmission of monetary policy and underscores the importance of understanding how expectations and beliefs influence investment behavior.

In this paper, I study and quantify the role of financial frictions in the transmission of monetary policy on investment depending on the channel through which the policy is transmitted. While previous studies have examined the heterogeneous effect of monetary policy on firms' investment through the interest rates, this paper aims to provide a more comprehensive understanding of how financial frictions interact with monetary policy to shape investment decisions.

I show that financial frictions play a different role in the transmission of monetary policy depending on the channel. Using Compustat data, I show that in response to a pure monetary policy shock resulting in a 1% increase in average Q, a firm with 10 pp more leverage before the shock accumulate around 0.03% more capital stock after 2 years. Conversely, in response to a Fed information shock leading to the same increase in average Q, a firm with 10 pp higher leverage before the shock accumulates around 0.03% less capital after approximately the same period of time. Furthermore, I document that the transmission channel of Fed information to firms' capital investment is primary non-fundamental.

Finally, I develop a dynamic general equilibrium model with firm idiosyncratic productivity and financial frictions to rationalize the empirical findings and quantify the distributional effects of monetary policy announcements depending on the channel of monetary policy. I use the model to revisit the state dependency of monetary policy transmission. In my calibration, a negative market sentiment to an easing Taylor rule shock reduces the effectiveness of conventional monetary policy interventions in a period of recession by almost 20% compared to the no bad news case.

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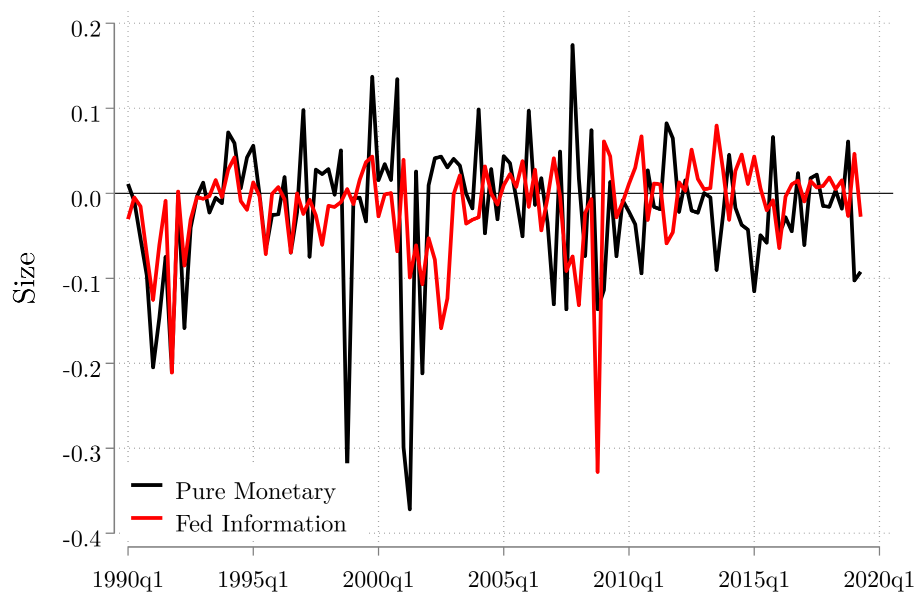
Appendix

A Construction of the dataset and cleaning

A.1 Decomposition of Fed announcement shocks from 1990-2018

Figure 8: Historical decomposition of the monetary policy shocks



Notes: The figure shows point estimates of the historical decomposition of Fed announcement components: the pure monetary policy shock (black line) and Fed information shocks (red line). Shocks are identified following Jarociński and Karadi (2020) approach. All the macro data series for the identification, and the time series of the shocks are available in their replication file. Since shocks are up to scale, I normalize both series of shocks to 1 standard deviation. The grey bar are the NBER recession periods from 1990 to 2019.

A.2 Firm-level variables on Compustat

I construct the firm-level variables in the Compustat database as follows.

- **Capital Stock.** Capital stock is equal to the book value of capital. I use the perpetual inventory method to calculate the capital value for each firm i at a time t. I measure the initial value of firm i's capital stock as the earliest available entry of $ppegtq_{i,t}$, and then iteratively construct $k_{i,t}$ from $ppentq_{i,t}$ as:

$$k_{i,t+1} = k_{i,t} + ppentq_{i,t+1} - ppentq_{i,t}$$

- **Leverage.** Leverage is the ratio of debt in current liabilities $dlcq_{i,t}$ and long-term debt $dlttq_{i,t}$ on total assets, $atq_{i,t}$. I average leverage within the year.

- **Cash liquidity.** I calculate cash holdings as the ratio of cash and short-term investments $cheq_{i,t}$ on total assets $atq_{i,t}$. I average cash liquidity within the year.

- **Investment Rate.** Investment rate is the ratio of the variation of capital stock as calculated in (i) on the past value of capital $k_{i,t-1}$.

- **Rating.** Rating is the S&P domestic long term issuer credit rating $spcsrc_{i,t}$. I divide the sample in three groups based on 2-quarters lag ratings. I assign value 2 if *spcsrc* is between A+ and A-, value 1 if *spcsrc* is between B+ and B-, value 0 otherwise.

- **Dividends.** Dividends is the sum of common dividends $dvy_{i,t}$ and preferred dividends, $dvpq_{i,t}$.

- **Firm Size.** I construct a measure of size for each firm following Gertler and Gilchrist (1994). For each firm i, I calculate the moving average of the sales over the past ten years. For each quarter t, a firm i is a large firm (value 0) if it is above the 30th percentile of the distribution for average sales of that year or is a small firm (value 1) if it is below the threshold.

- **Total assets.** Total assets is the variable $atq_{i,t}$ in Compustat.

- **Sectoral dummies.** I construct a sectoral dummies following Ottonello and Winberry (2018): (i) agriculture, forestry and fishing: sic < 999; (ii) mining: sic $\in [1000, 1499]$; (iii) construction: sic $\in [1500, 1799]$; (iv) manufacturing: sic $\in [2000, 3999]$; (v) transportation, communications, electric, gas, and sanitary services: sic $\in [4000, 4999]$; (vi) wholesale trade: sic $\in [5000, 5199]$; (vii) retail trade: sic $\in [5200, 5999]$; (viii) services: sic $\in [7000, 8999]$.

- **Average Q.** The average Q is the sum of the market value of the firm *mkval* net of Common/Ordinary Equity *ceqq*, total assets atq and investment tax credit *txditcq*, divided by *atq*.

I deflate capital stock, sales, and total assets using the implied price index of gross value added in the U.S. non-farm business sector. To control for outliers in the regressors, I trim the variables, leverage, cash holdings, total assets at the 1% top-level and sales growth at the 1% top and bottom level as standard in the main reference literature. I transform all regressors in logarithm before the estimation.

A.3 Sample selections

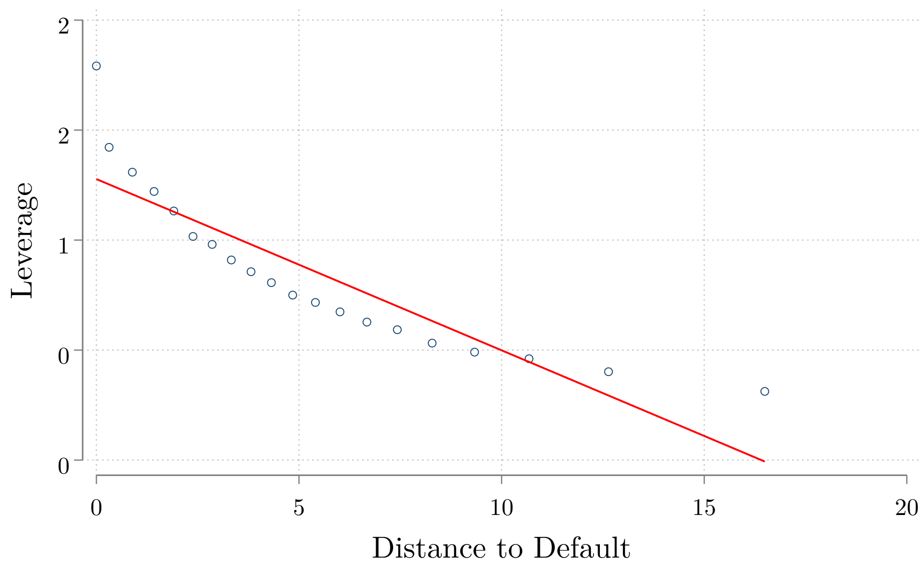
The sample period is 1990Q1 to 2018Q4. I perform the following cleaning steps:

- I keep only US-based firms, $fic_{i,t} =$"USA".
- To avoid firms with strange production functions, drop regulated utilities and financial companies, I drop all firm-quarters for which the 4-digit sic code is in the range [4900,5000) or [6000,7000).
- To get rid of years with extremely large values for acquisitions to avoid the influence of large mergers, I drop all firm-quarters for which the value of acquisitions $acq_{i,t}$ is greater than 5% of total assets $atq_{i,t}$.
- I drop all firm-quarters for which the measurement of Total Assets $atq_{i,t}$, Sales $saleq_{i,t}$, Property, Plant and Equipment (Net) $ppentq_{i,t}$, Cash and Short-Term Investments $cheq_{i,t}$, Debt in Current Liabilities $dlcq_{i,t}$, Total Long-Term Debt $dlttq_{i,t}$, Total Inventories $invtq_{i,t}$ are missing or negative.
- I drop all firm-quarters before a firm's first observation of Property, Plant, and Equipment (Gross) $ppegtq_{i,t}$.

After computing the yearly moving averages for leverage and liquid asset ratios but before estimating (1), I drop all firms observed between 1990Q1-2016Q4 for less than 40 quarters.

A.4 Firm leverage and distance to default in the data

Figure 9: Plot the relationship between firms' leverage and distance to default

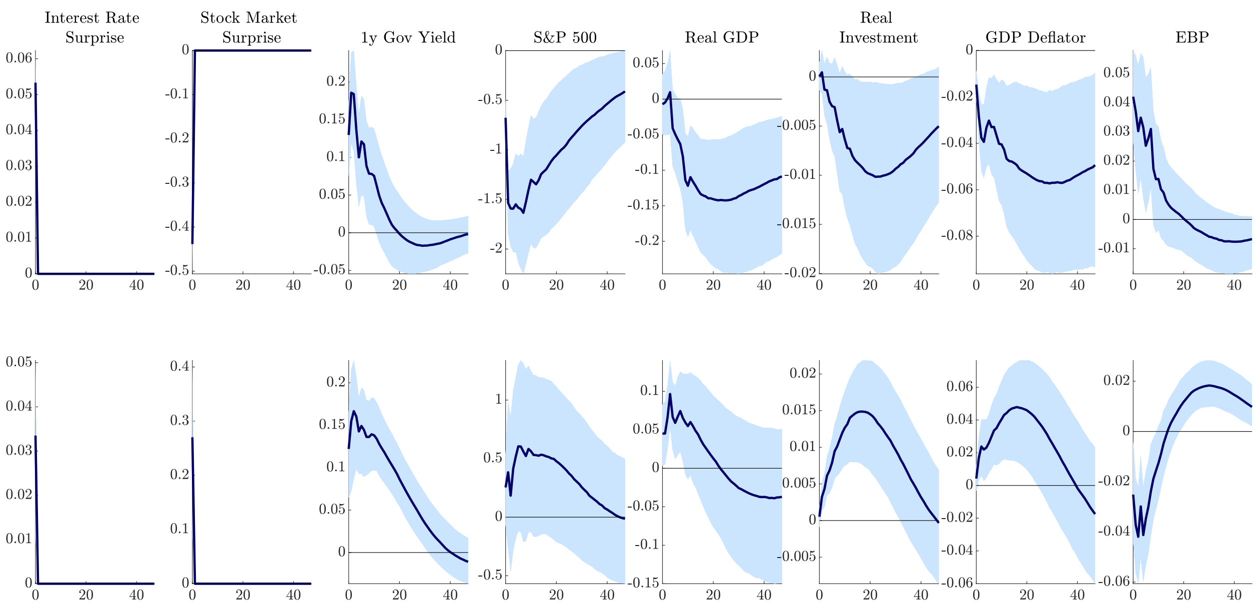


Notes: The figure illustrates the relationship between leverage and distance to default in the data. Leverage is calculated as the ratio of debt in current liabilities ($dlcq_{i,t}$) and long-term debt ($dlttq_{i,t}$) to shareholder equity (i.e., total assets minus liabilities), averaged within the year. The distance to default is estimated for each firm in Compustat, following the procedure outlined in Merton (1974). A value of distance to default above 3 indicates that a firm faces a low or zero probability of default, while a value lower than 3 may suggest a higher probability of default.

B Additional results and robustness

B.1 Aggregate response to identified shocks

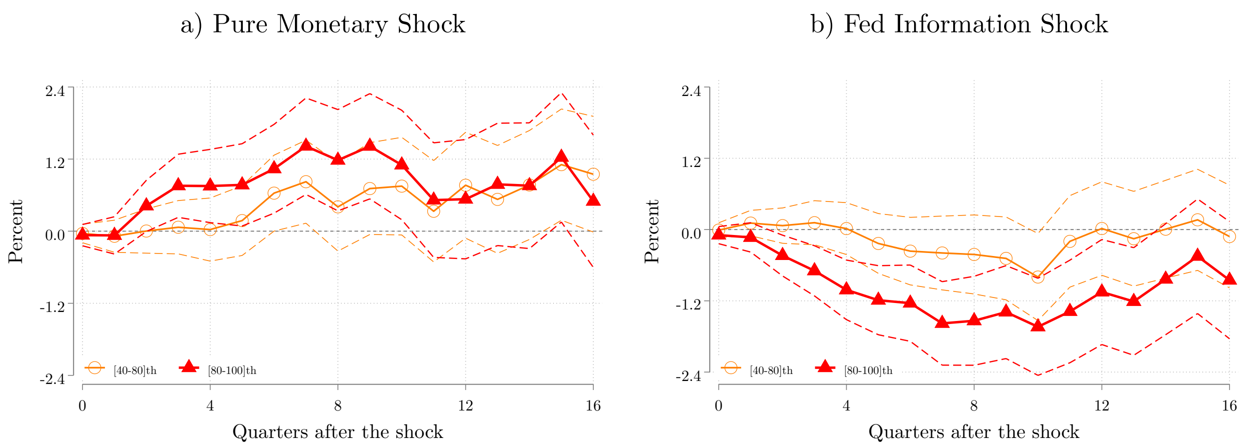
Figure 10: Aggregate IRFs to the identified shocks



Notes: The aggregate impulse responses to a contractionary one-standard deviation pure monetary policy shock (first row) and a non-pure monetary policy shock (second raw) identified using Jarociński and Karadi (2020) decomposition. I plot the median response along with the [14,86] percent confidence intervals. The results show that a pure monetary policy shock produces contractionary effects on the economy that are similar to a standard Taylor rule shock in a New-Keynesian framework. The variables real investment, real GDP, and prices unambiguously fall after the shock while the cost of borrowing rises. Instead, a non-pure monetary policy shock produces expansionary effects on the economy that are instead similar to a demand shock, the variables real investment, real GDP, and prices increase after the shock.

B.2 Heterogeneous effect of monetary policy by leverage group

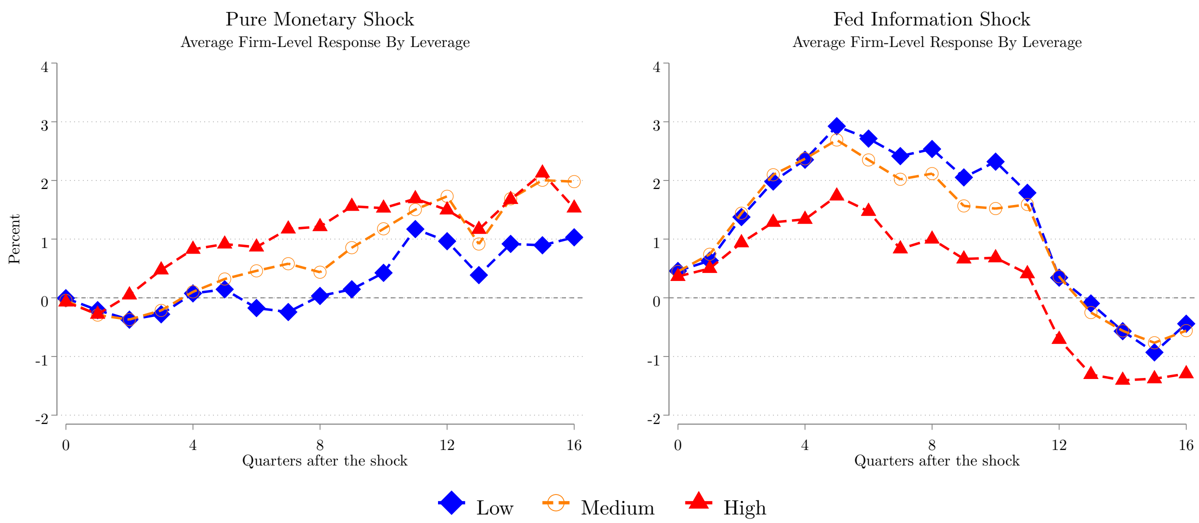
Figure 11: Heterogeneous response of investment by leverage group



$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{i,h} + \alpha_{t\times j,h} + \sum_{j=1}^{3}\left[\beta^{s}_{h,g}\cdot \Delta \mathrm{q}_t + \alpha^{s}_{h,g}\right]\mathbb{1}\left[i\in g_j\right] + \Gamma'_h W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms belonging to different leverage groups relative to a reference group. The orange line represents the average differential response of capital between a firm in the 40th to 80th percentile of the leverage distribution and a firm in the bottom 40%, while the red line represents the average differential response of capital between a firm above the 80th percentile of the leverage distribution and a firm in the bottom 40%. The point estimates and 90% confidence intervals for the $\beta_{h,g}$ coefficients for each leverage group are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructued following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

Figure 12: Average response to identified shocks by leverage group



Notes: The figures illustrate the average response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms that belong to different leverage groups. A firm is classified as low leverage if it falls within the 40th percentile of past year leverage, medium if it falls between the 40th and 80th percentile, and high if it is above the 80th percentile. The blue line is the average response of capital accumulation for a firm that is low leverage; the orange line is the average response of capital accumulation for a firm that is medium leverage; the red line is the average response of capital accumulation for a firm that is high leverage. The point estimates are calculated by summing the average response for low leverage firms with the differential responses for each leverage group, as obtained from Figure 11. Confidence intervals are not shown for clarity. Additional details on variable construction can be found in Appendix A.

B.3 Robustness to different specifications and sample

Figure 13: Heterogeneous response of investment in the sample 1990-2008

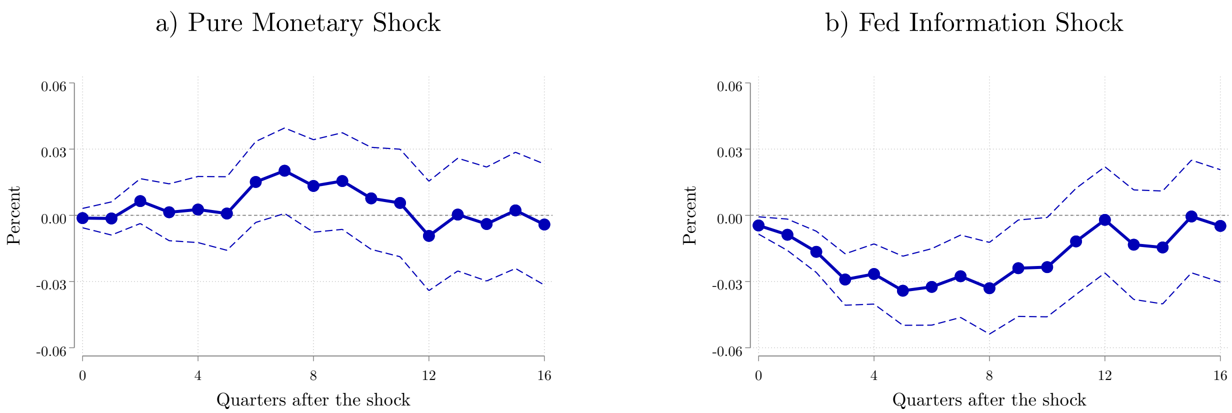
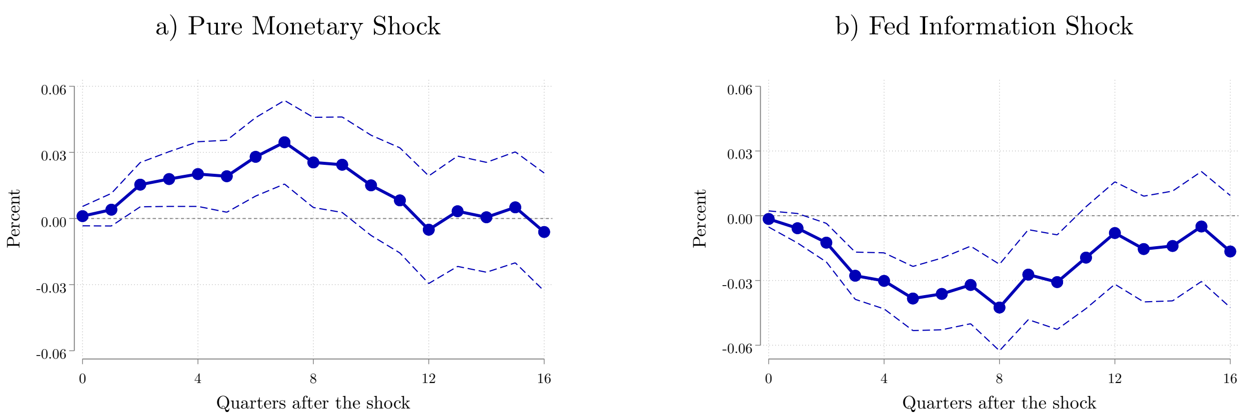
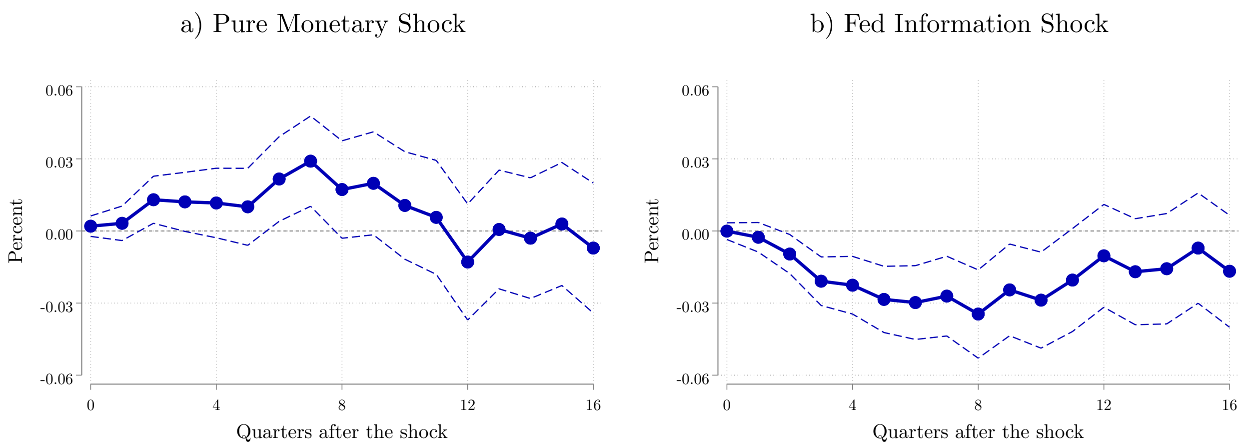


Figure 14: Heterogeneous response of investment in the sample 1994-2018



Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms with a 10 percentage point difference in past leverage. Figure 13 illustrates the estimates in the period 1990Q1-2008Q4, while Figure 14 illustrates the estimates considering the period 1994Q1-2018Q4. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation 1 using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructued following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

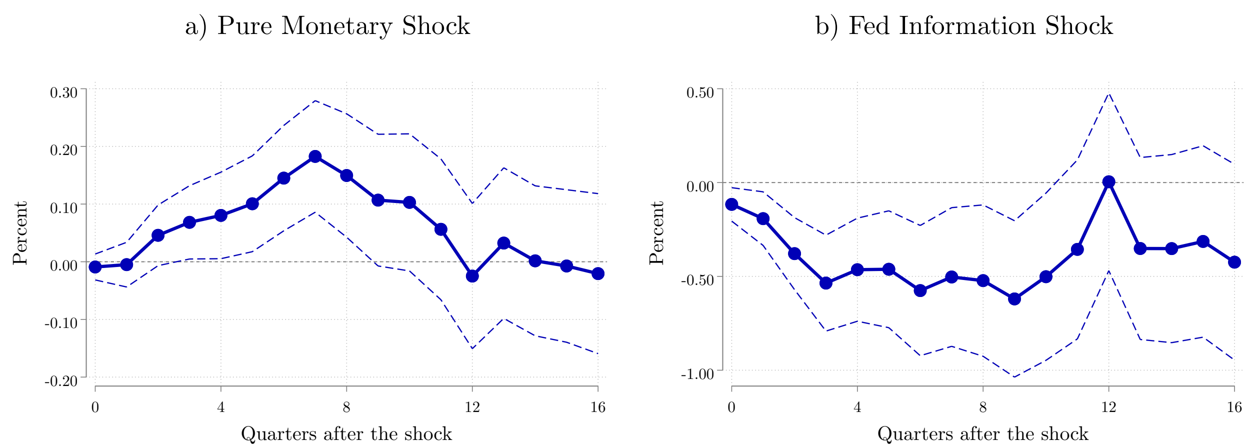
Figure 15: Heterogeneous response of investment without time fixed effects



$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{i,h} + \left(\beta_h \Delta q_t + \delta_h\right) \mathrm{lev}_{i,t-4} + \Gamma_h' W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms with a 10 percentage point difference in past leverage. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and without time-sector fixed effects. $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are used as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructued following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Sample is from 1990 to 2018. Additional details on variable construction can be found in Appendix A.

Figure 16: Heterogeneous response of investment using Poorman identification



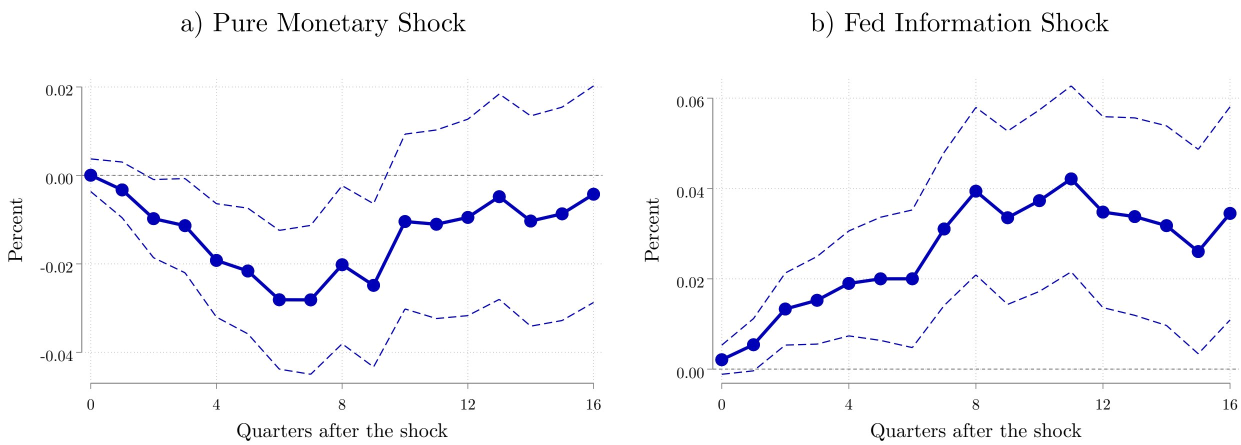
$$\Delta_h \log(k_{i,t+h}) = \alpha_{i,h} + \alpha_{t,j,h} + (\beta_h \Delta q_t + \delta_h)\,\text{lev}_{i,t-4} + \Gamma'_h W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms with a 10 percentage point difference in past leverage. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are the "Poorman identification" shocks from Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

C Relating to prior literature

C.1 Relating to Jeenas (2018a)

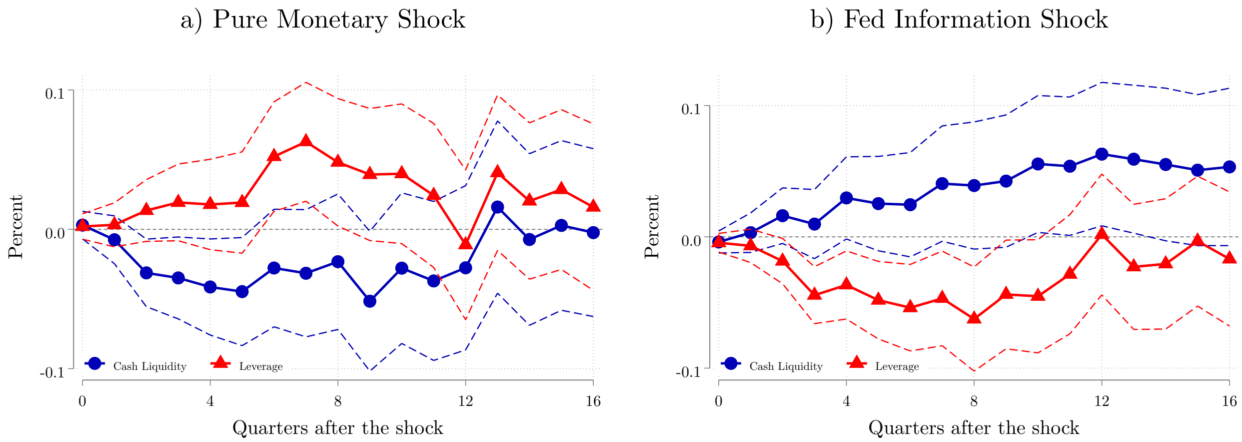
Figure 17: Heterogeneous response of investment using cash liquidity



$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{i,h} + \alpha_{t,j,h} + \left(\beta_h \Delta q_t + \delta_h\right) \mathrm{cash}_{i,t-4} + \Gamma_h' W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms with a 10 percentage point difference in cash liquidity (i.e., *cash* divided by *atq*). The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\mathrm{mps}}$ and $\varepsilon_t^{\mathrm{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\mathrm{mps}}$ and $\varepsilon_t^{\mathrm{info}}$ are constructed following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

Figure 18: Heterogeneous response of investment using cash liquidity and leverage

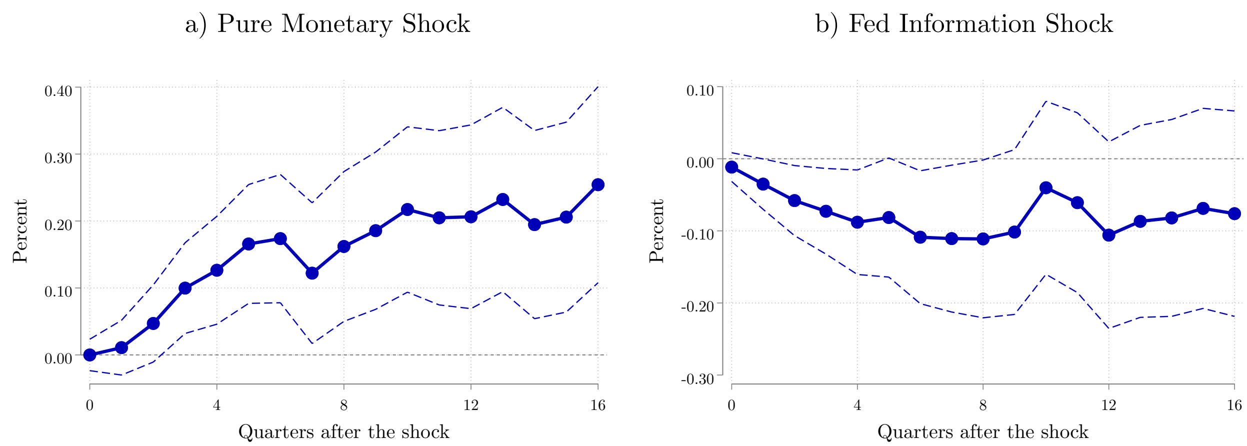


$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{i,h} + \alpha_{t,j,h} + \left(\beta_h \Delta q_t + \delta_h\right)\left[\text{cash}_{i,t-4} + \text{lev}_{i,t-4}\right] + \Gamma_h' W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms with a 10 percentage point difference in cash liquidity (i.e., *cash* divided by *atq*) and leverage. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructed following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

C.2 Relating to Gertler and Gilchrist (1994)

Figure 19: Heterogeneous response of investment using size

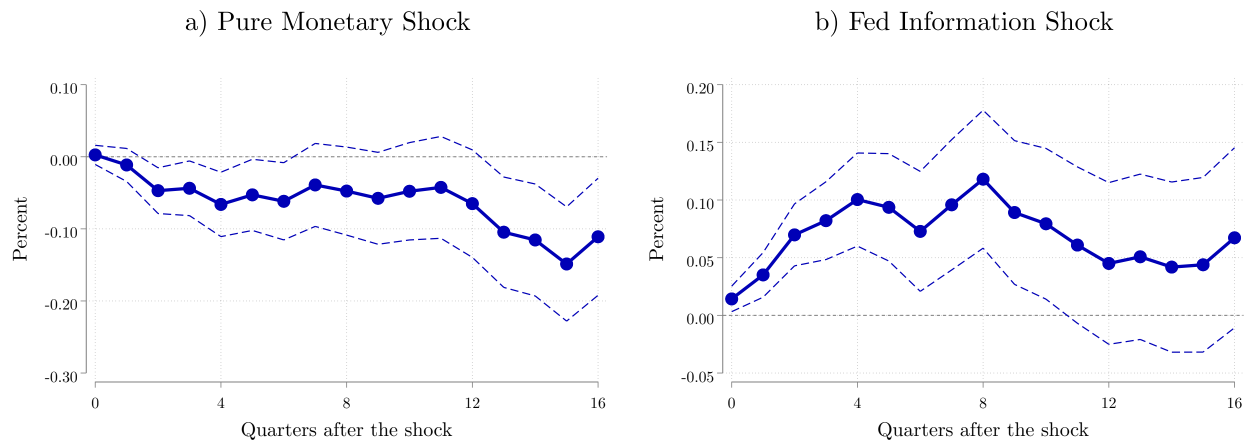


$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{i,h} + \alpha_{t,j,h} + \left(\beta_h \Delta q_t + \delta_h\right) \mathbb{1}_{\text{Small}_{i,t}} + \Gamma_h' W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among small and large firms. Firms' size is determined based on their sales growth, following the approach of Gertler and Gilchrist (1994). A positive value of β_h indicates that small firms are relatively more sensitive than large firms to a shock, while a negative value indicates the opposite. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructed following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

C.3 Relating to Cloyne et al. (2018)

Figure 20: Heterogeneous response of investment using age

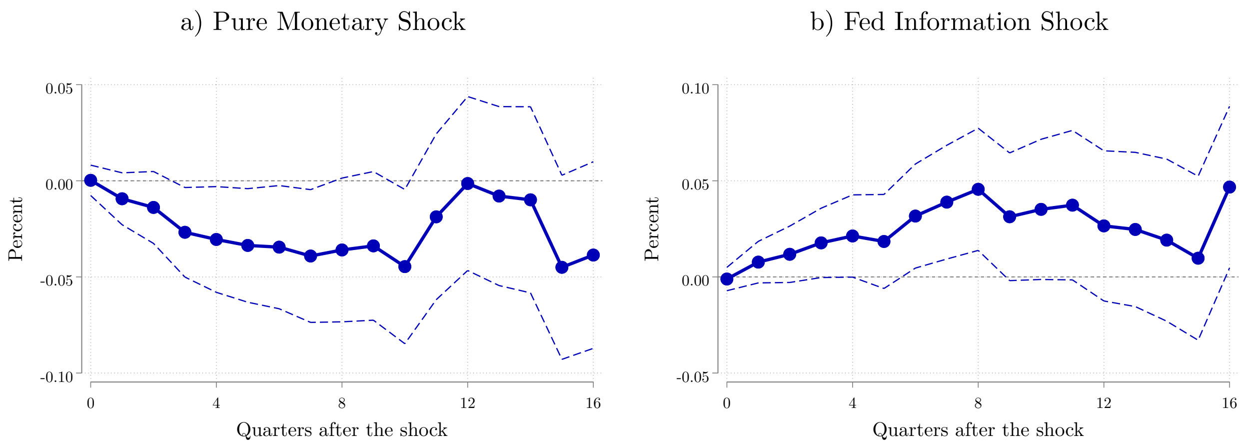


$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{i,h} + \alpha_{t,j,h} + \left(\beta_h \Delta q_t + \delta_h\right) \mathbb{1}_{\text{Young}_{i,t}} + \Gamma_h' W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among young and old firms. A firm is classified as "young" if it has been in existence for less than 25 years, while it is considered "old" if it has been in existence for more than 25 years. Firms' age in Compustat is constracted from the data available on Jay R. Ritter's website. A positive value of β_h indicates that young firms are relatively more sensitive than old firms to a shock, while a negative value indicates the opposite.The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructed following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

C.4 Relating to Ottonello and Winberry (2018)

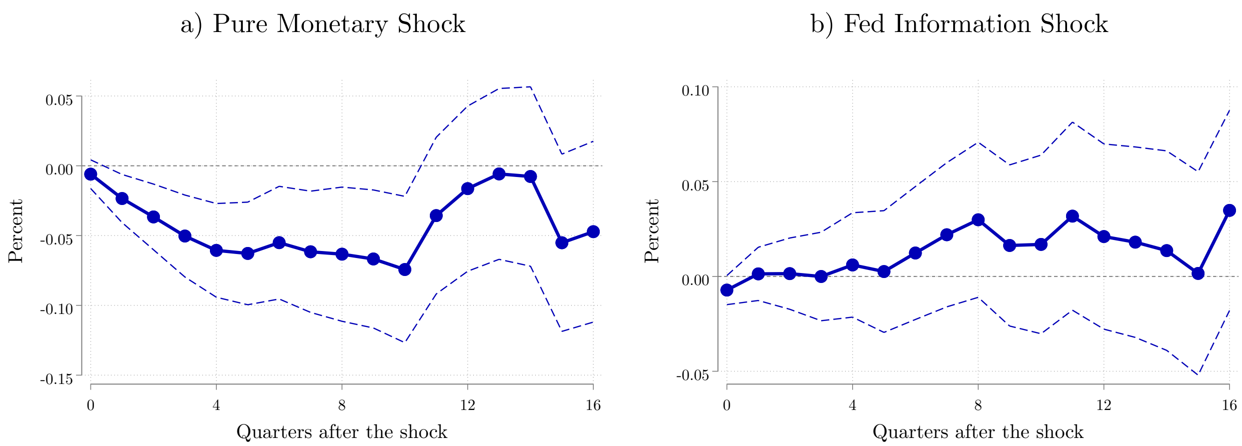
Figure 21: Heterogeneous response of investment using distance to default



$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{i,h} + \alpha_{t,j,h} + \left(\beta_h \Delta q_t + \delta_h\right) \mathrm{d2d}_{i,t-4} + \Gamma_h' W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms with a 10 percentage point difference in the distance to default. A positive value of β_h indicates that firms that are relatively more financially stable are more sensitive to a shock, while a negative value indicates the opposite. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructed following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

Figure 22: Heterogeneous response of investment using demeaned distance to default

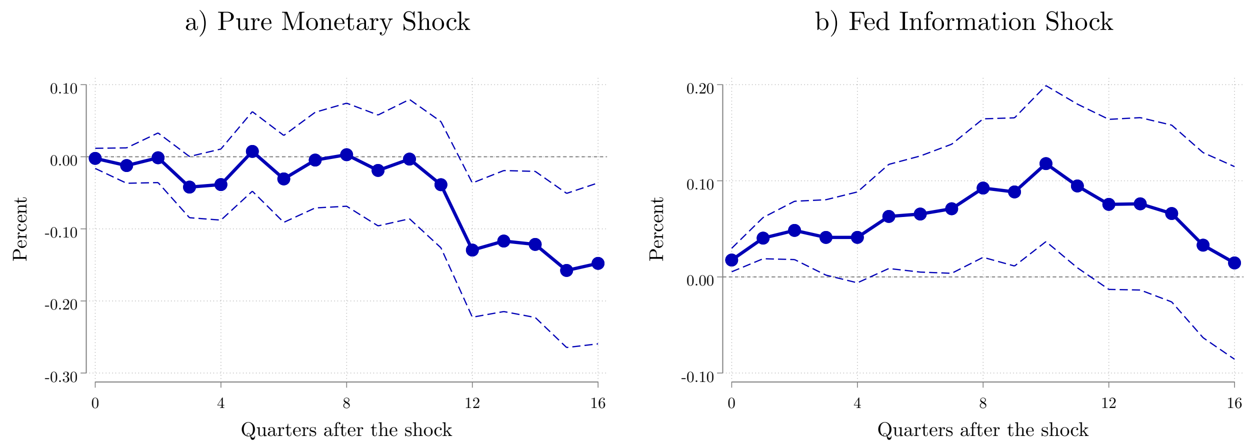


$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{i,h} + \alpha_{t,j,h} + \left(\beta_h \Delta q_t + \delta_h\right)\left[\mathrm{d2d}_{i,t-4} - \mathbb{E}_i \mathrm{d2d}_{i,t-4}\right] + \Gamma_h' W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) among firms with a 10 percentage point difference in the previously demeaned distance to default at the firm level. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructed following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

C.5 Relating to Whited (1992)

Figure 23: Heterogeneous response of investment using S&P credit rating



$$\Delta_h \log\left(k_{i,t+h}\right) = \alpha_{t,j,h} + \left(\beta_h \Delta q_t + \delta_h\right) \mathbb{1}_{\text{Good Rating}_{i,t-1}} + \Gamma_h' W_{i,t-1} + u_{i,t+h}$$

Notes: The figures illustrate the average heterogeneous response of capital accumulation to a pure monetary shock (panel a) and a Fed information shock (panel b) between firms with high credit score and low credit score. A positive value of β_h indicates that firms with a credit score $>$ B+ are relatively more sensitive than firms with a lowe credit score, while a negative value indicates the opposite. The point estimates and 90% confidence intervals for the β_h coefficients are reported, obtained by estimating equation hereabove using 2SLS and employing $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ as instruments for Δq_t. The confidence intervals are constructed based on two-way clustered standard errors at the firm and quarter levels. The instruments $\varepsilon_t^{\text{mps}}$ and $\varepsilon_t^{\text{info}}$ are constructed following the identification approach of Jarociński and Karadi (2020). The variable Δq_t represents the quarterly percentage change in the average Q calculated across firms for each quarter in Compustat. Additional details on variable construction can be found in Appendix A.

D Additional tests for the Fed information channel

Table 3: Robustness of the Q-test to different measure of sentiment

	No Sentiment	With Sentiment 1	With Sentiment 2
	(1)	(2)	(3)
Fed Information Shock	1.431***	1.103	1.021**
	(0.486)	(0.676)	(0.435)
Pure Monetary Shock	-1.353***	-1.784***	-1.300***
	(0.481)	(0.641)	(0.406)
Fixed Effects	Firm	Firm	Firm
Controls	Size, Trend	Size, Trend	Size, Trend
Period	1990-2018	1990-2018	1990-2018
Observation	339268	173557	324807

Notes: The table reports panel OLS estimates of the coefficients of a regression of the change in the Tobin's Q on the monetary policy shocks. Average Tobin's Q is the ratio of total assets, the market value of equity from CRSP, minus the book value of equity and deferred taxes to total assets. Pure and Fed information shocks are identified using Jarociński and Karadi (2020) approach. Variations in investor sentiment are proxy by the change in volatility index (VIX). The dataset runs from 1990-Q1 to 2018-Q4. Standard errors, clustered two-way at the firm and quarter level, are reported in parentheses. $* = 10\%$ level, $** = 5\%$ level, and $*** = 1\%$ level. See Appendix A for additional information on variables construction.

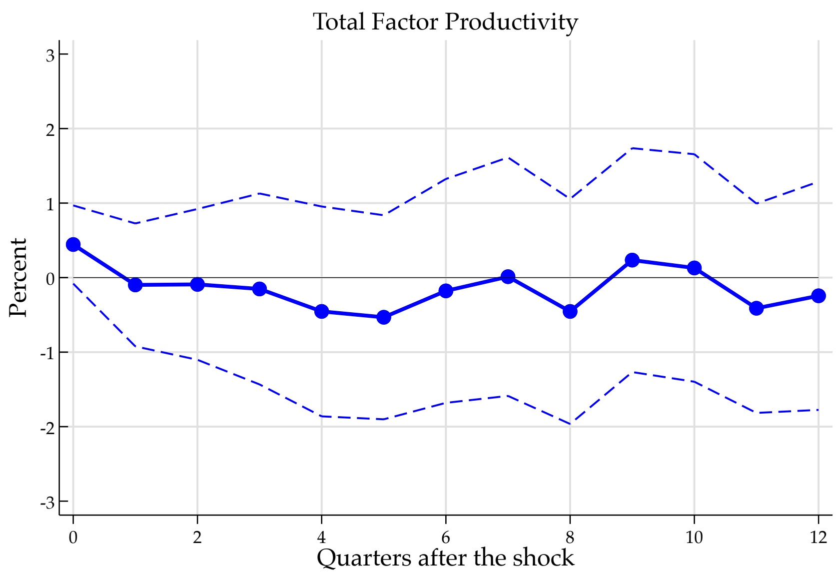
Table 4: Robustness of the Q-test to different specification

	No Sentiment	With Sentiment 1	With Sentiment 2
	(1)	(2)	(3)
Fed Information Shock	1.431***	1.103	1.021**
	(0.486)	(0.676)	(0.435)
Pure Monetary Shock	-1.353***	-1.784***	-1.300***
	(0.481)	(0.641)	(0.406)
Fixed Effects	Firm	Firm	Firm
Controls	Size, Trend	Size, Trend	Size, Trend
Period	1990-2018	1990-2018	1990-2018
Observation	339268	173557	324807

Notes: The table reports panel OLS estimates of the coefficients of a regression of the change in the Tobin's Q on the monetary policy shocks. Average Tobin's Q is the ratio of total assets, the market value of equity from CRSP, minus the book value of equity and deferred taxes to total assets. Pure and Fed information shocks are identified using Jarociński and Karadi (2020) approach. Variations in investor sentiment are proxy by the change in volatility index (VIX). The dataset runs from 1990-Q1 to 2018-Q4. Standard errors, clustered two-way at the firm and quarter level, are reported in parentheses. $* = 10\%$ level, $** = 5\%$ level, and $*** = 1\%$ level. See Appendix A for additional information on variables construction.

D.1 Other robustness checks

Figure 24: Response of aggregate TFP to a Fed information shock



Note: Plot the response of aggregate TFP to a non-pure monetary policy shock estimated using standard Local Projection. I use the Basu et al. (2006) utilization-adjusted series of TFP as a measure of aggregate productivity. I control for 4 lags of GDP growth, inflation, interest rate and excess bond premium in the regression. The results do not change if aggregate controls are removed. The impulse response is computed at quarterly frequency. I report the 90% confidence intervals.

E Model Details

E.1 Agents problem

Intermediate good producers. Denote $\{\varepsilon, \mathrm{S}\} = \{\varepsilon, \mathrm{K}, \mathrm{B}\}$ the state of a firm j in the economy. The intermediate good producers solve the following problem:

$$V(\varepsilon, S) = \max_{K', B'} \left\{ \mathcal{D}(\varepsilon, S, S') - (a_0 + \frac{a_1}{2}\mathcal{D}^2)\mathbb{1}_{\mathcal{D}<0} + \Lambda_{t,t+1} \sum_{\varepsilon'} \pi\left(\varepsilon'|\varepsilon\right) V'\left(\varepsilon', S'|\varepsilon\right) \right\} \quad (18)$$

subject to:

$$\mathcal{D}(\varepsilon, S, S') = \Pi(\varepsilon, S) - c_0 \left(\frac{I}{K}\right)^2 K + c_1 \mathbb{1}_{I \neq 0} - K' + (1-\delta)K + \mathcal{Q}B' \quad (19)$$

$$\Pi(\varepsilon, S) = (1-\tau)(p_t^w Z_t \varepsilon K^\alpha \mathrm{N}^{*\nu} - w_t N^* - \eta) - B + \tau\left(\delta K + i_t B\right) \quad (20)$$

$$N^*\left(\varepsilon, K\right) = \arg\max_{N \geq 0} \left\{ p_t^w Z_t \varepsilon K^\alpha N^\nu - w_t N \right\} \quad (21)$$

$$\mathcal{H}(\varepsilon, S, S') = (a_0 + a_1 \mathcal{D}^2)\mathbb{1}_{\mathcal{D}<0} \quad (22)$$

$$I = \mathrm{K}' - (1-\delta)K \quad (23)$$

$$B' \leq \theta_k K' \quad (\lambda') \quad (24)$$

where λ is the multiplier associated to the non-binding constrain. The optimality condition for capital can be obtained by taking the FOCs w.r.t to K' and combining with the envelope condition.

The FOC with respect to K' is:

$$-\frac{\partial \mathcal{D}}{\partial K'}\left(1 - a_1 \mathcal{D} \mathbb{1}_{\mathcal{D}<0}\right) = \Lambda_{t,t+1} \mathbb{E} V_{K'}\left(\varepsilon', S'\right) + \theta_k \lambda' \quad (25)$$

The envelope condition allows to characterize intertemporal payoffs for the capital choice:

$$V_k(\varepsilon, S) = \frac{\partial \mathcal{D}}{\partial K}\left(1 - a_1 \mathcal{D} \mathbb{1}_{\mathcal{D}<0}\right) \quad (26)$$

Taking the derivatives and combining equations (25) and (26), we have that:

$$\begin{aligned}\left(1-\varepsilon_t^{\text{risk}} e^{-\theta_l \frac{B'}{K'}} + c_0 \frac{I}{K}\right)(1 - a_1 \mathcal{D} \mathbb{1}_{\mathcal{D}<0}) = \\ \Lambda_{t,t+1}\mathbb{E}\left[\Pi_k(\varepsilon', S') + (1-\delta)\left(1 + c_0 \frac{I'}{K'}\right) + \frac{c_0}{2}\left(\frac{I'}{K'}\right)^2\right](1 - a_1 \mathcal{D}' \mathbb{1}_{\mathcal{D}'<0}) + \theta_k \lambda' \end{aligned} \tag{27}$$

which is equal to equation (**??**) in the paper.

Final good producers. Final good producers buy from retailers goods $\tilde{Y}_{i,t}$ at price $p_{i,t}$ and aggregate using a CES aggregator:

$$Y_t = \left[\int \tilde{Y}_{i,t}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

The demand of retail goods $\tilde{Y}_{i,t}$ is obtained solving:

$$\max_{\{\tilde{Y}_{i,t}\}} \quad P_t Y_t - \int p_{i,t} \tilde{Y}_{i,t} \qquad \text{s.t.} \quad Y_t = \left[\int \tilde{Y}_{i,t}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

Taking the FOCs w.r.t to $\tilde{Y}_{i,t}$ we get the demand of the good $\tilde{Y}_{i,t}$.

$$\tilde{Y}_{i,t} = \left(\frac{p_{i,t}}{P_t}\right)^{-\theta} Y_t$$

and substituting in the constraint, we get the aggregate price P_t.

$$P_t = \left(\int p_{i,t}^{1-\theta}\right)^{\frac{1}{1-\theta}}$$

Because final good producers are perfectly competitive, zero profits condition holds.

Retailers Retailers transform homogeneous good products $Y_{i,t}$ using a linear technology $\tilde{Y}_{i,t} = Y_{i,t}$. Retailers sell the heterogeneous good $\tilde{Y}_{i,t}$ to a final good producer at a price $p_{i,t}$ to be determined in a monopolistic competitive market, i.e., they take the demand of goods as given. It follows that retailers solve the following problem:

$$\max_{\{p_{i,t}\}} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t,t+1}\left(p_{i,t}\tilde{Y}_{i,t} - p_t^w Y_{j,t} - \frac{\phi_p}{2}\left(\frac{p_{i,t}}{p_{i,t-1}} - 1\right)^2 Y_t\right) \qquad \text{s.t.} \quad \tilde{Y}_{i,t} = \left(\frac{p_{i,t}}{P_t}\right)^{-\theta} Y_t$$

The FOCs for the problem gives:

$$p_{i,t}\frac{d\tilde{y}_{i,t}}{dp_{i,t}}+\tilde{Y}_{i,t}-p_t^w\frac{d\tilde{Y}_{i,t}}{dp_{i,t}}-\phi\left(\frac{p_{i,t}}{p_{i,t-1}}-1\right)\frac{Y_t}{p_{i,t-1}}+\mathbb{E}\Lambda_{t,t+1}\phi\left(\frac{p_{t+1}}{p_{i,t}}-1\right)\frac{Y_{t+1}}{p_{i,t}}\left(\frac{p_{i,t+1}}{p_{i,t}}\right)=0$$

Because all firms are symmetric and from pricing equation, it follows that:

$$\left(P_t-p_t^w\right)\frac{d\tilde{Y}_{i,t}}{dp_{i,t}}+Y_t-\phi\pi\frac{Y_t}{P_{t-1}}+\mathbb{E}\Lambda_{t,t+1}\phi\left(1+\pi_{t+1}\right)\pi_t\frac{Y_{t+1}}{P_t}=0$$

Finally, re-organizing the terms the New-Keynesian Phillips curve is:

$$\pi_t(1+\pi_t)=\frac{1}{\phi_p}\left[\theta p_t^w-(\theta-1)\right]+\mathbb{E}\Lambda_{t,t+1}(1+\pi_{t+1})\pi_{t+1}\frac{Y_{t+1}}{Y_t}$$

Assume that the final good price is the numeraire, $P_t=1$ and rewrite the NKPK in log-linearized form:

$$\log\Pi_t=\frac{\theta-1}{\phi_p}\log\frac{p_t^w}{p}+\beta\mathbb{E}_t\log\Pi_{t+1}$$

Because retailers operate in a monopolistic environment, their profits are distributed to the household. I omit the household problem since it is described in the paper.

E.2 Equilibrium

A recursive competitive equilibrium of the model is as follows:

Definition 1. A recursive competitive equilibrium of the model is as a set of the firms' value and policy functions $V(\varepsilon,K,B)$, $K^{*\prime}(\varepsilon,K,B)$, $B^{*\prime}(\varepsilon,K,B)$,$N^*(\varepsilon,K,B)$, a consumption and labor function C_t, N_t, a distribution of firms $\Gamma(\varepsilon,K,B)$ and, a set of prices w_t, i_t, p_t^w such that:

i) (Firms optimization) Firms choose $K^{*\prime}(\varepsilon,K,B)$, $B^{*\prime}(\varepsilon,K,B)$ and $N^*(\varepsilon,K,B)$ to maximize the future stream of dividends given their constraints;

ii) (Household optimization) Given the equilibrium prices, households choose consumption and labor paths that are consistent with the equations the Euler Equation and Frish labor supply;

iii) (Retailers and final good producers) Retailers set the price $pi,_t$ for the intermediate goods taking the demand of the final good producers as given. Retailers and final good producer' solutions aggregate to produce the NKP Curve.

iv) (Central bank and government) Central bank set the nominal interest rate i_t following a Taylor rule. Government collect taxes from the firms and redistribute lump-sum to the households;

iv) (Law of motion for the firms' distribution) The law of motion for the firm distribution Γ is generated by the stochastic process for idiosyncratic productivity and the firm policy function $K^{*\prime}(\varepsilon, K, B)$, $B^{*\prime}(\varepsilon, K, B)$:

$$\Gamma' = Q\Gamma$$

where Q is the transition matrix from the states (ε, K, B) to (ε', K', B'):

$$Q((\varepsilon, K, B), \mathcal{E} \times \mathcal{K} \times \mathcal{B}) = \mathbb{1}\left\{K^*(\varepsilon, K, B) \in \mathcal{K}, B^*(\varepsilon, K, B) \in \mathcal{B}\right\} \pi\left(\varepsilon' | \varepsilon\right)$$

vi) (Law of motion for aggregate state) The law of motion for the aggregate states follow the stochastic processes for the aggregate shocks;

vii) (Markets clearing) From the budget constraint, substituting dividends from wholesale producers and retailers. Aggregate prices w_t and p_t^w are consistent with market clearing conditions:

$$Y_t = C_t + I_t + \int \mathcal{G} dj - \int \mathcal{H} dj + \frac{\phi}{2}\pi_t^2 Y_t$$

I solve for the stationary equilibrium of the model and, study the response of the model along the perfect foresight transition path to an anticipated change in the future aggregate technology and unexpected change in the nominal interest rate. I rely on computational methods to study the solution of this problem.

E.3 Computational methods

This section provides details on the computational methods that I use to find the solution to the model in this paper. I solve the model using value function iteration, both in the steady-state and along the perfect-foresight transition path. To calculate the response of the economy to an unexpected aggregate shock, I use a standard backward-forward shooting method following Boppart et al. (2018) algorithm. Finally, to calculate the distribution of firms over the idiosyncratic state-space, I use the non-stochastic simulation approach following Young (2010).

Firm's optimal solution. To find an approximation of the solution in the steady-state, I discretize the state for $(\varepsilon, K, \frac{B}{K})$. I convert the continuous exogenous process for ε into the discretized Markov chain using Tauchen (1986). I fix the number of grid points for ε, $N_\varepsilon = 5$. Instead, the grid for K and $\frac{B}{K}$ is made up of a set of (13 x 8) in an interval $(0, K^{\max}]$ and $[-\theta_k, \theta_k]$ non-equally spaced points so to have more points in the lower part of the capital and higher part of leverage. Once I have set up the grids, I use value function iteration to find a solution.

1. Guess an initial value for the wage w_0^*;
2. Given the value for wage w_0^*, solve the firms' problem using value function iteration:
   i) Approximate the $\mathbb{E}V(\varepsilon, K', \frac{B'}{K'})$ with an higher-order polynomials and guess an initial vector of coefficient c_0;
   ii) Given the expected value function, find the optimal combination $(K', \frac{B'}{K'})$ such that it solve the Bellman equation for each element in the grid $(\varepsilon, K, \frac{B}{K})$;
   iii) Given the solution, calculate the new expected value function;
   iv) Update the coefficient of the expected value function using Newton method and find c_1;
   v) Iterate until $||c_1 - c_0||$ is arbitrary small;
3. Given a solution for K', B' and a coefficient vector c, calculate the distribution Γ of firms over $(\varepsilon, K, \frac{B}{K})$ in the stationary equilibrium using Young (2010). Before computing the ergodic distribution, I interpolate the solution over a finer grids over the states.
4. Using the cross-sectional distribution of firms calculate a new equilibrium value for wage w_1^*. Iterate until $|w_1^* - w_0^*|$ is small enough.

A solution to this problem deliver the policy function for K', B' and a vector of coefficient c^* over the space grid (ε, K, B).

Perfect-Foresight transitional dynamics. I compute the dynamics of the economy to an unexpected aggregate shock using a standard backward-forward algorithm. The algorithm is in 4-steps:

1. Guess a path for aggregate consumption $\left(C_t^{OLD}\right)_{t=1}^{T}$ and calculate the path for aggregate prices w_t, i_t, p_t^w and inflation π_t consistent with the model equations.

2. Backward: Start from time T, calculate backward the policy functions for $K^{*\prime}_{t,t+1}$ and $B^{*\prime}_{t,t+1}$ for all time t.

3. Forward: Given the policy functions obtained, iterate forward to calculate the distribution of firms $\Gamma_t = \Gamma_t(\varepsilon, K, B)$ over time using Young's method.

4. Use the results in (2) to calculate a new equilibrium path for aggregate consumption $(C_t)_{t=1}^{T}$. Iterate (1-4) until $|C_t - C_t^{OLD}|$ is small enough.

One problem with the backward-forward shooting method is that updating the path for "too quickly" may result in the overall procedure to diverge. I compute the new update path for consumption as a convex combination of the previous guess and the newly calculated path, with λ small:

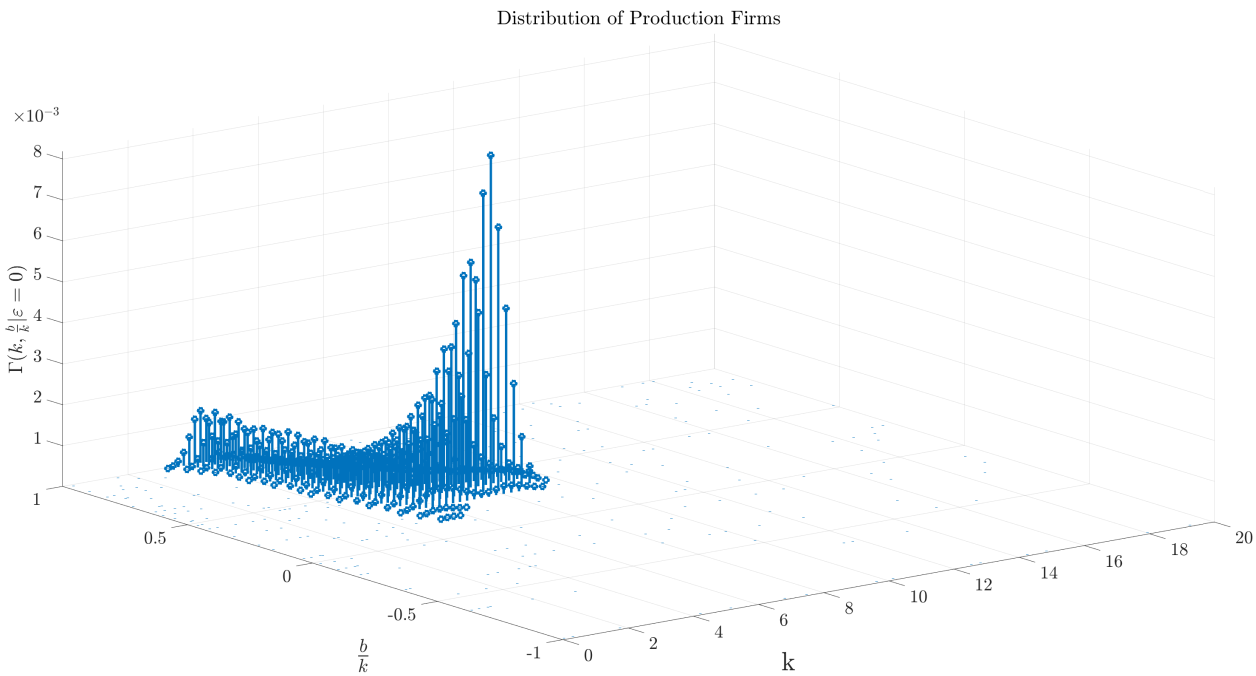
$$\left(C_t^{NEW}\right)_{t=1}^{T} = \lambda \left(C_t\right)_{t=1}^{T} + (1-\lambda)\left(C_t^{OLD}\right)_{t=1}^{T}$$

A solution to the algorithm delivers the impulse response function of the aggregate variable and the distribution of firms in response to an unexpected aggregate shock over time.

F Model results

F.1 Ergodic distribution of the model

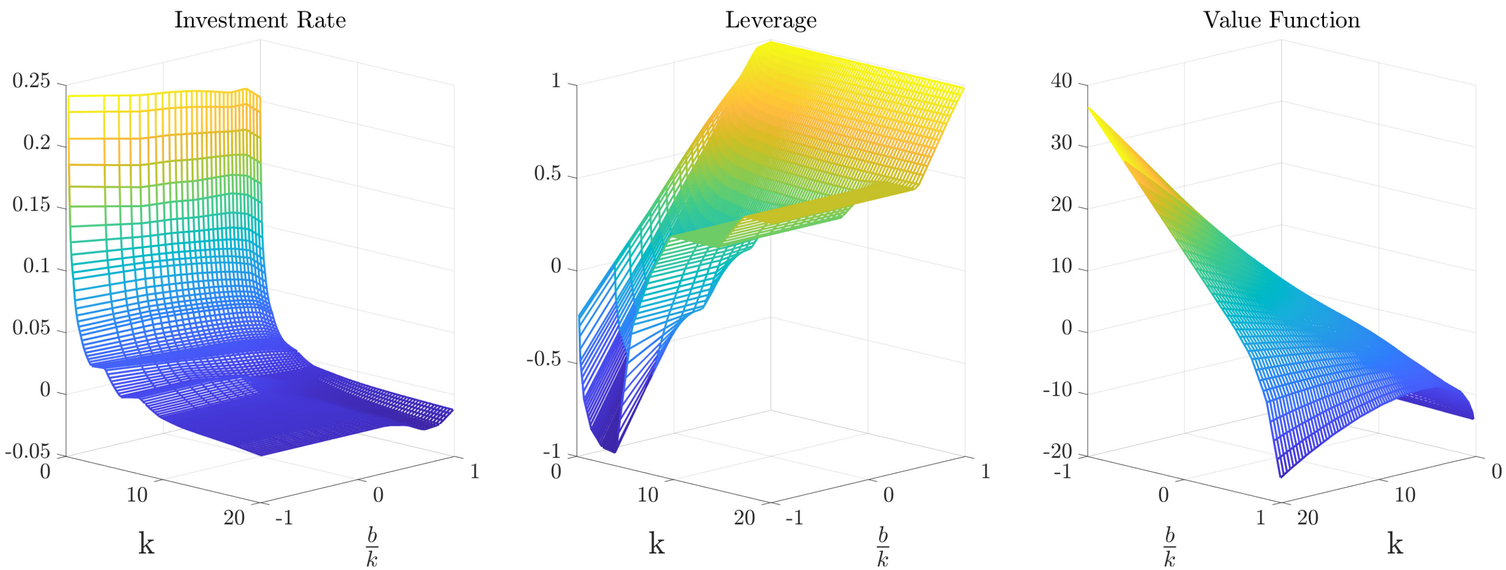
Figure 25: Ergodic distribution of the firms in the steady state.



Note: The ergodic distribution of the investment firms in the stationary equilibrium as a function of capital (x-axis) and leverage (y-axis). I approximate the ergodic distribution with Young (2010) method.

F.2 Policy function in the stationary equilibrium

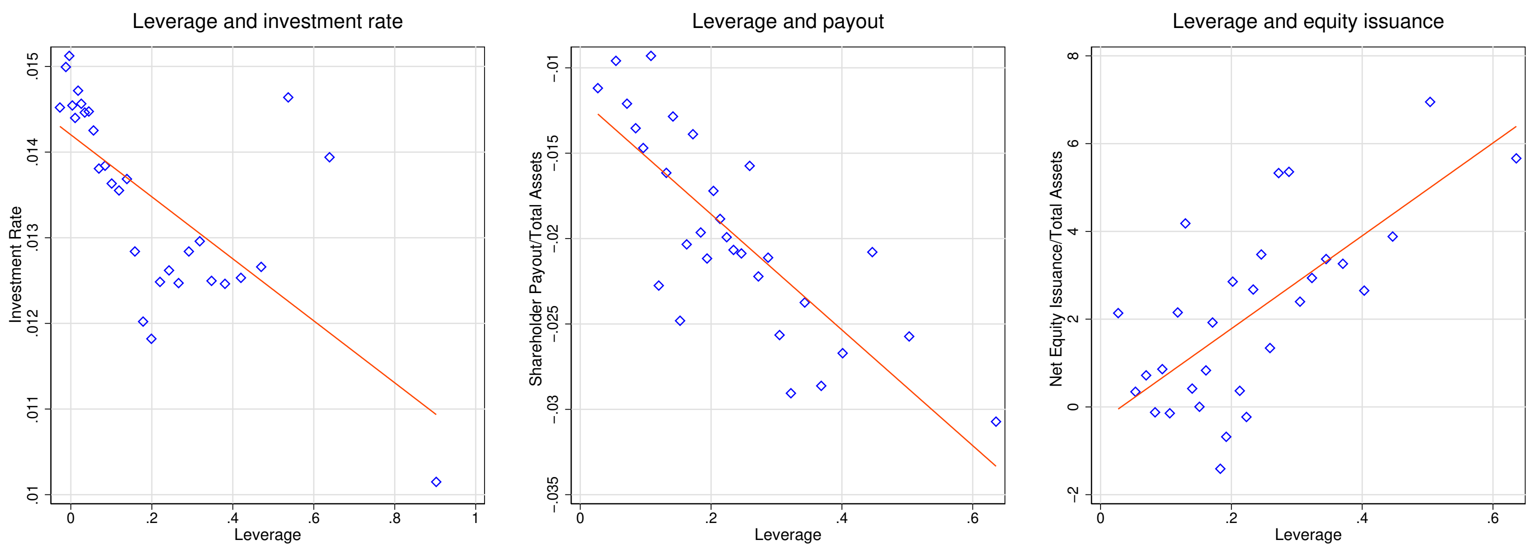
Figure 26: Policy functions in the steady state.



Note: Plot the optimal value and policy functions for investment rate and leverage in the stationary equilibrium over the state state grid $(k, \frac{b}{k})$. I fix the idiosyncratic productivity at the steady state level.

F.3 Cross-section correlation between leverage and other financial variables

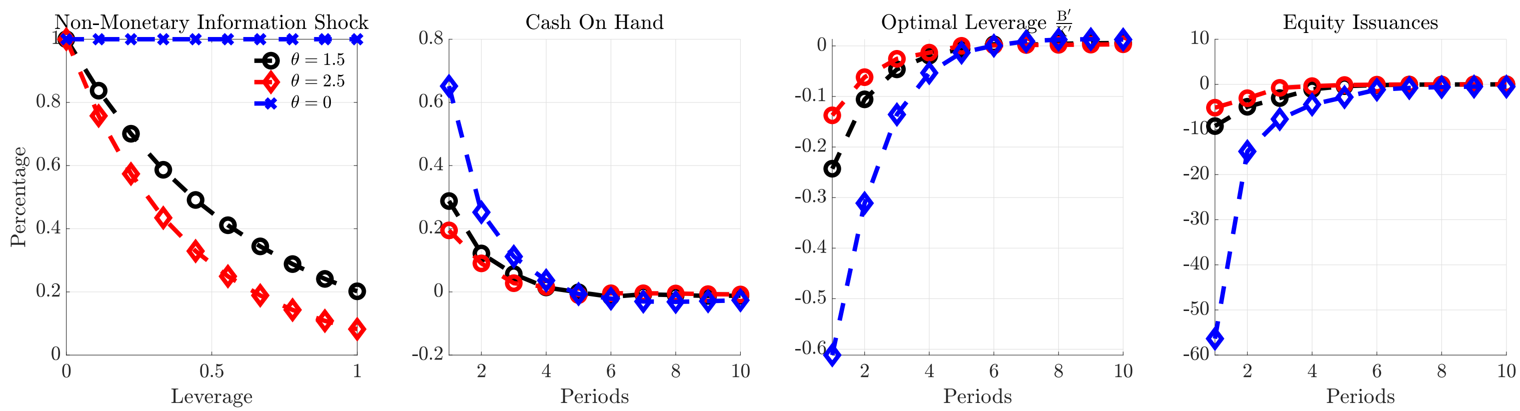
Figure 27: Leverage and other financial variables across US firms 1990-2016



Note: I plot the cross-sectional correlation between firms' leverage, investment rate, dividends payout, and equity issuance across Compustat firms from 1990 to 2016. To mimic steady state correlation, I compute firm averages over time on the entire time sample. Before plotting, I also trim the tails at 1.5% of the firm averages to avoid outliers.

F.4 Financial variable response to a non-monetary shock under different scenarios

Figure 28: Financial variable response for high leverage firms to a $\varepsilon_t^{\text{risk}}$ shock



Note: The average impulse response function for the price of debt, debt and equity issuance for high leverage firms in response to a non-pure monetary policy shock and different value of θ_l. Black lines represents benchmark calibration, $\theta_l = 1.5$. Blue lines represents the model responses when $\theta_l = 0$. Red lines represents the model responses when $\theta_l = 2.5$. High leverage firms are defined as firms that have more than 50% of leverage in the stationary distribution prior the shock hits. The averages are calculated by equally weighting firms that constitute more than 1 percent of the total firms.

F.5 Financial variables response to different monetary shocks

Figure 29: Financial variables response to a $\varepsilon_t^{\text{mps}}$ shock

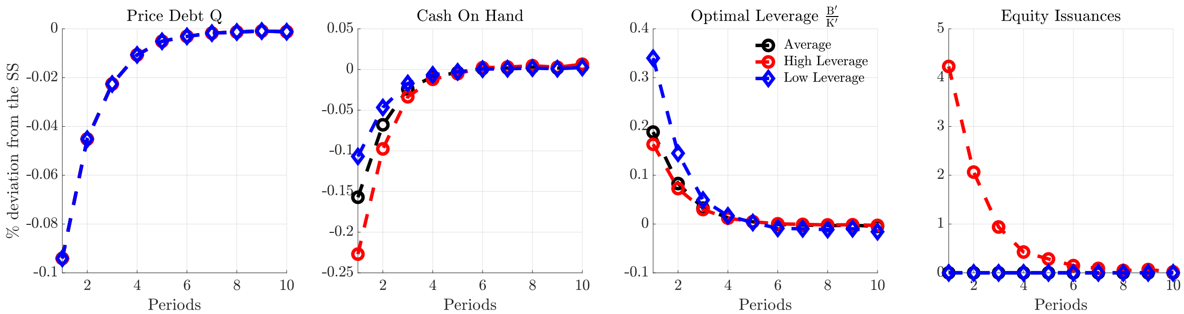
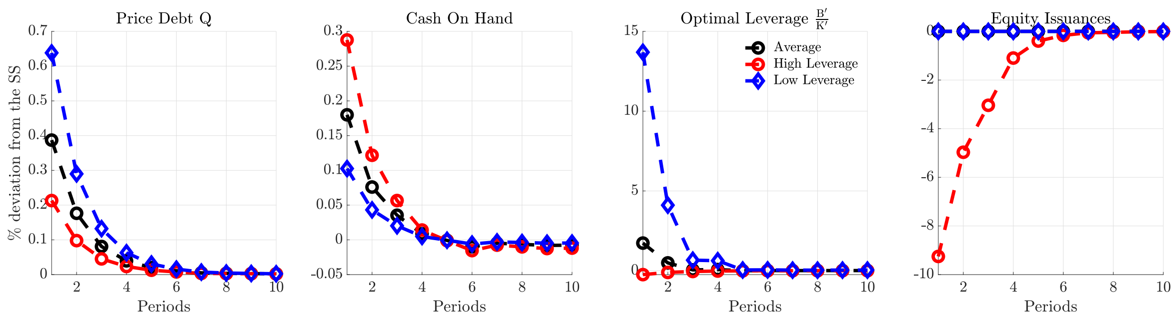


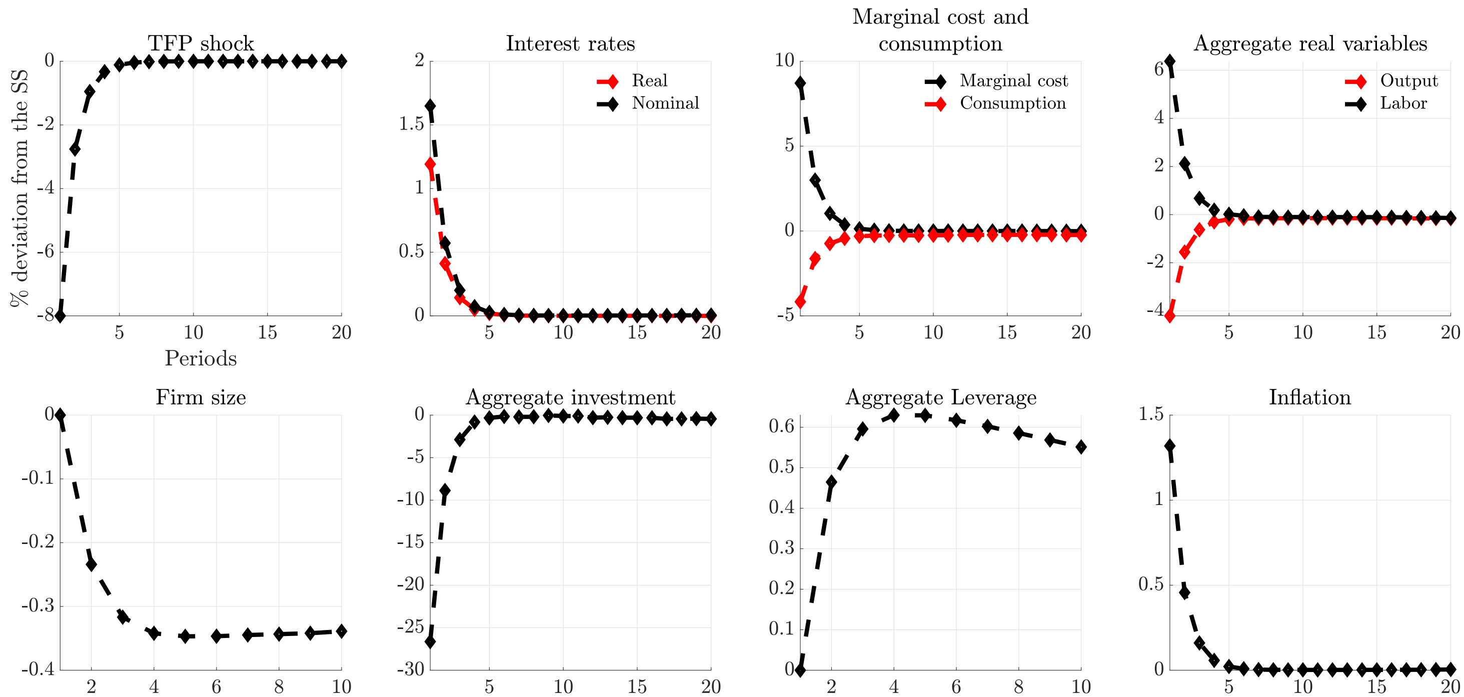
Figure 30: Financial variables response to a $\varepsilon_t^{\text{risk}}$ shock



Notes: The average impulse response function for the price of debt, debt and equity issuance across firms in response to a pure monetary policy shock (first column) and a Fed information shock (second column). The blue line shows the average firm-level responses of the main variables for firms that prior the shock have less than 50% of leverage (i.e., low leverage). The red line illustrates the average response for the same variables for firms with more than 50% leverage (i.e., high leverage). The averages are calculated by equally weighting firms that constitute more than 1 percent of the total firms.

F.6 Aggregate response to a productivity shock

Figure 31: IRFs to an aggregate productivity shock



Note: Plot the impulse response function of the model to a one standard deviation productivity shock in the model. The standard deviation is calibrated to generate a drop in output by 4 percent at impact whereas, the persistence of the shock is calibrated to induce a recession for eight quarters. Responses are presented as deviations with respect to the stationary equilibrium.