Credit Ratings and the Investment Channel of Monetary Policy

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Abstract

We document a novel channel of monetary policy transmission based on credit rating thresholds. Focusing on non-financial U.S. firms between 1990-2007, we find that firms near a rating downgrade are relatively more sensitive to monetary shocks than firms in the middle of the rating distribution. An unexpected 25 bp increase in the Fed Funds rate corresponds with approximately 2 pp lower debt growth and 1 pp lower investment for firms near a downgrade relative to middle-rated firms in the six quarters after the shock. Our results are robust to controlling for other channels of monetary policy and alternative measures of monetary shocks. To rationalize these findings, we introduce a two-period model where bankruptcy recovery rates differ across credit ratings.

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1 Introduction

Financial frictions play an important role in the transmission of monetary shocks to the real economy (Bernanke, Gertler and Gilchrist (1999)). Such frictions amplify the effect of unexpected changes in the policy interest rate on real economic activity, leading to heterogeneity in the firm-level response to monetary policy. That firms react differently to a given monetary shock based on financial characteristics is indeed well established in the existing literature. For example, Ottonello and Winberry (2020) find that firms with relatively higher leverage and lower distance to default are less responsive to monetary shocks.[1]

As the degree of financial frictions vary with the business cycle, one would expect the effect of monetary policy to similarly vary over time. Peersman and Smets (2005), among others, find that monetary policy is most effective during recessions, especially in industries that are more financially constrained. Another related type of well-documented asymmetry is that between an unexpected easing and tightening. Ravn, Sola et al. (2004), find that an unexpected easing has smaller effects on the real economy than an unexpected tightening. This asymmetry can be explained by downward wage or price rigidity (see Debortoli, Forni, Gambetti and Sala (2020)).

Financial frictions do not only affect firms' investment and capital structure decisions over the business cycle, but also in the long run. One particularly important financial friction is a firm's credit rating. Credit ratings play a critical role in the financial system by sorting firms on the degree of their credit risk. In addition, investors such as banks and pension funds rely on ratings to determine whether a firm's debt is eligible for purchase. Ratings

[1]The literature on the transmission mechanism of monetary policy given heterogeneous firm financial characteristics is vast. For other recent examples, see Cloyne, Ferreira, Froemel and Surico (2018), Jeenas (2019), Anderson and Cesa-Bianchi (2020), among others.

also signal information on firm quality. Given this role, there is an extensive literature documenting the impact of credit ratings on a wide range of firm outcomes, including asset prices (Hand, Holthausen and Leftwich (1992)), leverage (Kisgen (2006)), and investment (Harford and Uysal (2014)). However, less attention has been devoted to the role that credit ratings might play in magnifying or dampening exogenous shocks. In particular, the threat of a downgrade or potential for an upgrade might act as a constraint on a firm's ability to adjust to a given shock.

In this paper, we investigate whether credit ratings magnify the firm-level response to changes in the stance of monetary policy. More specifically, we look at whether the position of a firm within a credit-rating letter grade affects its reaction to exogenous monetary shocks. That credit ratings can act as a financial friction and affect the *unconditional* behavior of firms is well documented. For example, Kisgen (2006) finds that firms issue less debt relative to equity at upgrade and downgrade thresholds (firms rated "Plus" or "Minus", respectively) compared to firms in the middle of the rating distribution ("Mid" firms). Whether this feature of credit ratings as a financial constraint matters for monetary transmission remains an unexplored question. To briefly preview results, we find that firms with a Minus credit rating exhibit differentially higher sensitivity to monetary policy shocks than Mid firms. Plus firms are also relatively more responsive, but only during unexpected monetary tightening episodes. We document this differential responsiveness while controlling for firm-level credit risk, supporting our argument that credit-rating thresholds do in fact serve as a *friction* to the monetary transmission mechanism.

Our dataset includes a panel of 1,600 U.S. non-financial firms (44,380 firm-quarters) included in the Compustat North American Fundamentals quarterly database from 1990-

2007. We restrict our baseline analysis to firms with an S&P Long-term issuer credit rating between CCC- and AA+ in a given quarter.[2] In order to capture changes in the stance of monetary policy, we utilize high-frequency shocks to Fed Funds futures in short windows around FOMC announcements. We then merge monetary shocks aggregated at a quarterly frequency to firm-level financial characteristics from Compustat.

Our empirical methodology employs the projection method of Jordà (2005). In particular, we estimate regressions of growth rates of the log book value of debt and physical capital on lagged firm-level characteristics and macro variables. Our primary regressors of interest are interactions of dummy variables for Plus and Minus ratings with exogenous monetary policy shocks. In the baseline specification, we include an array of time-varying firm-level control variables that proxy for riskiness, such as size, leverage, liquidity, sales growth, and net working capital. We also control non-parametrically for time-invariant firm characteristics by including a firm fixed effect in all specifications. Finally, we control for changes in the aggregate state of the economy by including lags of GDP growth, the unemployment rate, and the inflation rate. All firm-level variables are also interacted with lagged GDP growth to account for any changes in the state of the economy that might differentially affect firms as a function of their characteristics.

We find that firms near a rating downgrade (Minus firms) exhibit greater responsiveness of debt growth and investment to monetary policy shocks than firms in the middle of the rating distribution (Mid firms that are neither Plus nor Minus). To be concrete, an unexpected 25 basis point (bp) increase in the Fed Funds rate corresponds with a 1.72 pp lower growth

[2] We also employ a "full" sample of firms that are either not rated, have a AAA rating, or are below CCC-. To give some context, in 2007Q4 our baseline sample accounted for approximately 19% of private non-residential fixed investment in the U.S. The full sample represented approximately 36%.

rate of debt and a 0.55 pp lower growth rate of physical capital stock for Minus relative to Mid firms in the subsequent four quarters. We find no corresponding differential sensitivity for Plus firms, suggesting that the threat of a downgrade matters more for firm behavior in this context (Kisgen (2009), Lemmon and Roberts (2010)).

To study the asymmetric effect of monetary policy and how it interacts with firm heterogeneity, we explore whether these initial results hold in response to unexpected monetary easing or tightening. We find that the debt growth of Minus firms is relatively more responsive following an accommodative shock (easing) compared to Mid firms. On the other hand, Plus firms' debt growth and investment is also more responsive, but only following unexpected tightening.

Identifying the effect of credit-rating thresholds on firm behavior is empirically challenging given that credit ratings are endogenous to other firm factors. For this reason, we first include industry-quarter dummy variables that control non-parametrically for shocks affecting all firms within a given industry and calendar quarter. Our coefficient estimates increase marginally with the inclusion of these variables, suggesting that sectoral shocks are not biasing our estimated sensitivities.

A second concern is that our estimates might reflect a differential responsiveness of firms based on their credit risk (Ottonello and Winberry (2020)). To address this issue, we include rating group-quarter dummy variables, where rating group is defined as a particular letter grade: AA, A, BBB, BB, B, CCC. Controlling for shocks affecting all firms within a particular credit-rating group in a given quarter and an array of firm-level financial characteristics, we thus argue that an individual firm's ranking within this letter is exogenous to other firm factors, at least in the short run. Due to discrete changes in the cost of credit from rating upgrades (AA+ to AAA) or downgrades (AA- to A+), we hypothesize that firms at credit-rating thresholds (AA-,AA+) should be more sensitive to changes in aggregate discount rates than firms in the middle of each letter distribution (AA). Empirically, we find that coefficient estimates are relatively stable to the inclusion of rating group-quarter dummy variables.

A final concern for identification is that the observed differential responsiveness of Minus firms might reflect other financial characteristics that are relevant for the transmission of monetary policy (size, liquidity, leverage, profitability). To rule out these alternative channels, we include interactions of all firm-level variables with our monetary shock measure and obtain results that are remarkably stable. Thus, we argue that, in response to exogenous changes in monetary policy, credit ratings affect firm behavior independent of other firm fundamentals. In this fully saturated specification, we find that an unexpected 25 basis point (bp) increase in the Fed Funds rate corresponds with a 2.20 pp lower growth rate of debt and a 0.79 pp lower growth rate of physical capital stock for Minus relative to Mid firms in the subsequent six quarters, with the observed effects levelling off after two years. We demonstrate that our baseline results are robust to alternative measures of debt (changes in leverage ratios, long-term debt issuance) and capital (capital expenditures/net property, plant, and equipment). Our results are also consistent with an alternative measure of monetary shocks and using the full sample of firms in estimation.

Consistent with Kisgen (2006), we interpret our findings as evidence that credit ratings should not be viewed as linear, bur rather that the letter itself carries additional weight. That is, the difference between two consecutive ratings of different letters (say between AA+ and AAA) is greater than that between two consecutive ratings within a letter (say between AA and AA+). Different reasons could explain this behavior. First, potential lenders such as banks are tightly regulated and their risk-taking, or decision to hold capital buffers against risks, is frequently monitored. If this assessment is based on the letter rating of debtors, firms will try to avoid a letter-changing downgrade in order to avoid losing potential lenders. Similarly, firms will try to obtain an upgrade in order to gain potential lenders and lower their borrowing costs. A similar argument can be made for institutional investors who are prevented from investing in firms below a certain threshold. If firms are more concerned about the letter itself than their position within a letter grade, it is reasonable to interpret Plus and Minus firms as being relatively more constrained than Mid firms.

In order to rationalize our results, we introduce a two-period theoretical framework that captures this behavior. In the model, firms are identical except for their credit rating. Firms must borrow to finance investment, but they do not know their future productivity. This generates default risk. We assume that the fraction of assets that creditors can recover in case of default depends on a firm's credit rating letter. Better-rated firms have higher recovery rates, since they are better managed and/or attract more experienced creditors. A firm's credit rating can be updated (by one notch at most) after it has made investment and borrowing decisions. The probability of a change in the credit rating is tied to the firm's probability of default. This gives different incentives to Plus and Minus firms. Following an expansionary monetary policy shock, all firms are more (less) likely to be upgraded (downgraded). This relaxes the financial constraint of Plus and Minus relatively more, leader to more magnified responses.

1.1 *Literature Review*

We contribute to two strands of the finance and economics literature. First, our paper contributes to the literature examining the role of credit ratings in corporate and market outcomes. There is an extensive empirical literature on the effects of credit ratings on bond and equity markets (Hand et al. (1992), Ederington, Yawitz and Roberts (1987), West (1973), and Ederington and Goh (1998)), capital structure choices (Faulkender and Petersen (2006), Kisgen (2006), Kisgen (2009)), and firm investment outcomes (Tang (2009), Harford and Uysal (2014), Almeida, Cunha, Ferreira and Restrepo (2017), Kisgen (2019), Alanis and Picard (2020)).

Much attention in the theoretical literature has addressed the incentives of credit rating agencies and the different contexts that can lead to rating inflation (Bolton, Freixas and Shapiro (2012), Josephson and Shapiro (Forthcoming)), and whether firm investment is affected by this inflation (Goldstein and Huang (2020)). Boot, Milbourn and Schmeits (2006) introduce a model emphasizing the importance of credit rating agencies as "credit watchers", updating their ratings in response to changes in firms' fundamentals. Interestingly, their model predicts that downgrades have greater effects on firms than upgrades. This is due to the fact that in their model, a downgrade happens when a firm has failed to respond appropriately to a "watch," revealing information to the market beyond the initial change in fundamentals.

Whether credit rating thresholds act as frictions and magnify shocks remains relatively less studied. Most of the work in this area focuses on the discrete changes in corporate decision-making resulting from the investment-grade threshold (Sufi (2009), Chernenko and

Sunderam (2012)). In the spirit of our paper, Lemmon and Roberts (2010) demonstrate that credit supply shocks result in differential declines in both borrowing and investment for non-investment grade firms. We contribute to this literature by focusing instead on the effect of being at a threshold (Plus or Minus) within a given rating group (letter).

Second, we contribute to the stream of literature examining whether there is a differential transmission of monetary policy shocks operating through firm financial frictions. The literature has identified the following firm characteristics to interact with financial frictions and result in a *lower* responsiveness of investment to monetary shocks: large size (Gertler and Gilchrist (1994)), old, dividend-paying (Cloyne et al. (2018)), low distance to default (Ottonello and Winberry (2020)), low liquidity (Jeenas (2019), and low share of bank loans in total credit (Ippolito, Ozdagli and Perez-Orive (2018), Crouzet (2021)).

In contrast, a number of studies employing high-frequency event studies find that financially constrained firms are *more* responsive to monetary policy shocks (Chava and Hsu (2020), Palazzo and Yamarthy (2021)). The effect of leverage on firms' responsiveness appears ambiguous. While Ottonello and Winberry (2020) finds that highly levered firms are less responsive to monetary surprises using a time period of 1990-2007, Anderson and Cesa-Bianchi (2020) find the opposite for the 1999-2017 period. For their part, Lakdawala and Moreland (2021) find that more leverage leads to less responsiveness in the pre-financial crisis period, but more responsiveness in the post-crisis period. We contribute to this literature by focusing on the role of the credit rating (within a letter), above and beyond other common measures of financial constraints.

2 Empirical Analysis

2.1 *Monetary Policy Shocks*

Monetary policy shocks are extracted around FOMC meeting announcements from high-frequency changes in the current-month contract on Fed Funds futures (Cook and Hahn (1989), Gurkaynak, et. al. (2005)). The series of monetary shocks begins in January 1990 when the Fed Funds futures market began trading. We end the baseline sample at December 2007 in order to investigate the effects of conventional monetary policy, although we consider extended samples in the robustness section. Our precise measure follows Gorodnichenko and Weber (2016) and is defined as

$$\epsilon_j^M = w(j) \times (ffr_{j+\Delta_+} - ffr_{j-\Delta_-}), \tag{1}$$

where j denotes the time of a particular FOMC meeting, ffr_j is the implied Fed Funds rate from the expiring current-month contract at time j, Δ_+ and Δ_- denote the length of time (in minutes) for each FOMC meeting window, and $w(j)$ is a weight used to adjust for the fact that Fed Funds contracts make payments on the *average* value in a given month.[3] The particular time window chosen sets $\Delta_+ = 45$ minutes and $\Delta_- = 15$ minutes, which is standard convention in this literature. The series of announcement-day monetary shocks are aggregated to the calendar quarter level t and denoted in the remainder of the paper as ϵ_t^M. We follow Gorodnichenko and Weber (2016) and utilize the approach of "smoothing" the

[3]To be precise, $w(j) = \frac{N_j^M}{N_j^M - n_j^M}$ where n_j^M is the numerical day of the FOMC meeting in the month and N_j^M is the number of days in the month of the FOMC meeting.

shocks based on the number of days remaining in each quarter. An alternative approach would entail simply summing the shocks without weights ($\tilde{\epsilon}_t^M$). Results for this alternative measure are given in the robustness section. The first three rows of table 1 display summary statistics for the high-frequency (ϵ_j^M), quarterly smoothed (ϵ_t^M), and quarterly average ($\tilde{\epsilon}_t^M$) measures of monetary policy shocks. The series of shocks are identical to Ottonello and Winberry (2020), which aids in contrasting our results with theirs. The monetary shocks are scaled so that a positive realization corresponds with a decrease in interest rates.

2.2 *Firm-Level Data*

We use the Compustat North American quarterly database and keep all firms located in the United States. For comparability, our approach to screening firms into a final sample aligns with other papers in the literature (Crouzet (2021), Ottonello and Winberry (2020)). First, we remove firms in the following industries: financial services (SIC codes 6000-6799), utilities (4900-4999), and nonclassifiable establishments (9995-9997). Second, we drop firm-quarter observations with negative capital, assets, or sales, a major acquisition, extremely positive values of liquidity (cash and equivalents / total assets) or leverage (short- and long-term debt / total assets), and observations of investment rates for less than 20 quarters. These screenings are designed to reduce the reliance of our estimates on outliers and to provide a sufficiently long panel of firm-quarter observations. Lastly, we merge data from the Compustat S&P Credit Ratings file and keep the firm's long-term issuer credit rating at the end of the quarter before the monetary policy shock. For the baseline analysis, firm-quarters with an S&P long-term credit rating equal to AAA, CC, C, and D are excluded. Thus, only firm-quarters with credit ratings between the CCC- and AA+ are included in the final dataset. We define $Plus_{f,t-1}$ ($Minus_{f,t-1}$) to be a dummy variable equal to 1 if a firm has a credit rating in any rating category with a + (-) at the end of quarter $t-1$, and 0 otherwise. We also define $IG_{f,t-1}$ to be a dummy variable equal to 1 if a firm has a credit rating above the investment grade threshold of BBB- and 0 if not.

We first examine the effects of monetary policy shocks on changes in firm borrowing. We calculate the book value of debt, $d_{f,t}$, as the sum of Compustat variables debt in current liabilities (dlcq) and long-term debt (dlttq). The growth rate of debt from quarters t to $t+h$ then equals the log difference in each firm's real book value of debt over this period: $\Delta log(d_{f,t+h}) = log(d_{f,t+h}) - log(d_{f,t})$. We consider alternative measures of debt growth in the robustness section.

The primary real outcome of interest is firm investment in physical capital. We calculate the investment rate as the difference in the log of the real book value of firm tangible capital stock, $k_{f,t}$.[4] We follow the perpetual inventory approach and define the initial capital stock as each firm's first observation of gross property, plant, and equipment (Compustat variable ppegtq). We then iterate forward to calculate the cumulative capital stock using quarterly differences of net property, plant, and equipment (ppentq). The investment rate from quarters t to $t+h$ then equals the log difference in each firm's real book value of capital over this period: $\Delta log(k_{f,t+h}) = log(k_{f,t+h}) - log(k_{f,t})$. All outcome variables at each horizon h are Winsorized at the 1st and 99th percentiles.

In addition to the outcome variables of interest, we also utilize a number of firm financial

[4]All values are deflated using the Implicit Price Deflator for All Employed Persons in the Nonfarm Business Sector, which is taken from the St. Louis Fed's FRED database.

variables as controls in many specifications. These firm-level control variables include leverage, liquidity, size (log of the book value of real firm assets), one-year lagged sales growth, net working capital ((current assets - current liabilities) / total assets), and dummy variables for industry. The lower portion of table 1 presents summary statistics for the quarterly firm-level variables. The sample is fairly evenly split between firms with a plus, mid, or minus rating.

Table 1: Summary Statistics

	Number	Mean	SD	Min	p25	Med	p75	Max
ϵ_j^M	164	0.02	0.09	-0.15	-0.01	0.00	0.03	0.46
ϵ_t^M	71	0.04	0.11	-0.23	-0.01	0.01	0.08	0.48
$\tilde{\epsilon}_t^M$	72	0.04	0.12	-0.26	-0.01	0.01	0.06	0.48
$\Delta log(d_{f,t+4})$	43,389	-0.00	0.51	-3.01	-0.16	-0.02	0.15	2.03
$\Delta\tilde{d}_{f,t+4}$	44,258	0.02	0.15	-0.34	-0.04	-0.00	0.05	0.96
$\Delta log(k_{f,t+4})$	44,380	0.03	0.23	-0.95	-0.07	0.01	0.10	1.03
$Plus_{f,t-1}$	44,380	0.33	0.47	0.00	0.00	0.00	1.00	1.00
$Minus_{f,t-1}$	44,380	0.31	0.46	0.00	0.00	0.00	1.00	1.00
$IG_{f,t-1}$	44,380	0.48	0.50	0.00	0.00	0.00	1.00	1.00
$Size_{f,t-1}$	44,380	21.59	1.34	16.68	20.64	21.50	22.46	26.40
$Lev_{f,t-1}$	44,380	0.38	0.25	0.00	0.23	0.33	0.48	2.61
$Liq_{f,t-1}$	44,380	0.07	0.11	0.00	0.01	0.03	0.09	0.94
$\%\Delta Sales_{f,t-1}$	44,380	0.01	0.22	-5.75	-0.05	0.01	0.08	10.12
$NWC_{f,t-1}$	44,378	0.13	0.17	-1.87	0.02	0.12	0.24	0.91

This table reports summary statistics of monetary policy shocks and quarterly firm-level variables for the period of January 1990 to December 2007. Definitions of all variables are provided in the appendix.

A concern of our analysis is the firms at the Minus or Plus rating threshold might be different on dimensions other than credit rating that could reflect differences in riskiness or financial health. In table 2, we present results of differences in characteristics split by ratings. On average, Minus and Plus firms are smaller than Mid firms. In addition, Minus firms are less levered, more liquid, and exhibit higher investment rates than Mid and Plus firms. Given these observable differences, we are cautious to control for these other characteristics in a number of regression specifications to ensure that the credit rating channel we identify is not driven by alternative channels.

Table 2: Summary Statistics: Differences

	Mean			Minus-Mid		Minus-Plus		Mid-Plus	
	Minus	Mid	Plus	Diff	t-stat	Diff	t-stat	Diff	t-stat
$\Delta log(d_{f,t+4})$	-0.01	-0.00	-0.01	-0.00	-0.75	0.00	0.02	0.00	0.79
$\Delta\tilde{d}_{f,t+4}$	0.02	0.02	0.02	-0.00	-0.59	0.00	0.37	0.00	1.00
$\Delta log(k_{f,t+4})$	0.03	0.03	0.02	0.01	2.48	0.01	3.94	0.00	1.67
$Size_{f,t-1}$	21.58	21.73	21.47	-0.15	-9.90	0.11	7.04	0.26	16.81
$Lev_{f,t-1}$	0.37	0.37	0.41	0.00	0.99	-0.03	-11.41	-0.04	-12.63
$Liq_{f,t-1}$	0.08	0.07	0.07	0.01	4.26	0.01	8.12	0.00	4.03
$\%\Delta Sales_{f,t-1}$	0.01	0.01	0.01	0.00	0.34	-0.00	-0.15	-0.00	-0.50
$NWC_{f,t-1}$	0.38	0.37	0.36	0.02	7.28	0.02	9.01	0.00	2.05
Number	13975	15781	14622	.	.	.	.	.	.

This table reports means and t-statistics for differences of means for quarterly firm-level variables for the period of January 1990 to December 2007. Definitions of all variables are provided in the appendix.

2.3 *Baseline Regression Model*

In this section, we investigate how monetary policy shocks in a given quarter might affect firm outcomes over time as a function of firm-level heterogeneous characteristics. The baseline estimating equation follows the projection method of Jordà (2005) in which changes in outcomes of interest from quarters t to $t+h$, $\Delta y_{f,t+h}$, are modeled to depend on interactions of firm-level characteristics and monetary policy shocks:

$$\begin{aligned}\Delta_h y_{f,t+h} = \alpha_{f,h} + \zeta\epsilon_t^M + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h\epsilon_t^M)X_{f,t-1} \\ + \xi_1 Z_{t-1} + (\xi_2 W_{f,t-1} + \xi_3 X_{f,t-1})GDP_{t-1} + u_{f,t+h}\end{aligned} \tag{2}$$

where $\alpha_{f,h}$ is a firm fixed effect, ϵ_t^M is the monetary shock (positive corresponds with an unexpected decrease in the Fed Funds rate), $W_{f,t-1}$ is a vector containing the main firm-level credit rating variables of interest ($Plus_{f,t-1}$ and $Minus_{f,t-1}$), $X_{f,t-1}$ is a vector of firm-level control variables that proxy for firm financial positions and capital structure ($Size_{f,t-1}$,

$Lev_{f,t-1}$, $Liq_{f,t-1}$, $\%\Delta Sales_{f,t-1}$, $NWC_{f,t-1}$), Z_{t-1} is a vector of aggregate controls including four lags of GDP growth, the unemployment rate, and the inflation rate, and $u_{f,t+h}$ is a residual. All firm-level variables are also interacted with lagged GDP growth to account for any changes in the state of the economy that might differentially affect firms as a function of their characteristics. The inclusion of a firm fixed effect ($\alpha_{f,h}$) removes all time-invariant firm characteristics that might drive firm decisions.[5] Standard errors are double clustered by firm and calendar-quarter.

In this specification, the main coefficient estimates of interest are $\beta_{2,h}$, which capture changes in borrowing and investment outcomes for firms with a Plus or Minus rating relative to firms with a rating in the middle of a rating group. Based on the Credit Rating-Capital Structure theory, we hypothesize that credit-rating thresholds act as a friction to external finance. Thus, firms at a threshold should be more sensitive to changes in interest rates by virtue of their flexibility in issuing debt. Consider a hypothetical unexpected tightening in monetary policy for a firm with a B- rating. Due to discrete changes in the cost of debt from a downgrade to CCC+, this firm will likely be even *more* conservative in its desire to decrease leverage relative to a firm with a B rating. Thus, we would expect $\beta_{2,h} > 0$, and there to be a positive relation between the sensitivity of Plus or Minus firms to unexpected changes in monetary policy.

An advantage of the baseline model is that we can obtain estimates of the overall effect of changes to the stance of monetary policy on firm borrowing and investment. However, our choice of firm-level and aggregate variables might not adequately control for alternative

[5]Note that all regressions also include dummy variables for each credit rating, although given the lack of time variation in ratings, these coefficient estimates are not well identified.

drivers of firm borrowing and investment that might simultaneously correlate with the differential responsiveness of Plus or Minus firms to monetary policy shocks. In order to partially mitigate this issue, we estimate a second regression model with a richer array of dummy variables to control non-parametrically for these other potentially confounding factors. We include industry-quarter dummy variables to control for any shocks that might have affected all firms within a sector in a given quarter, $\alpha_{s,t+h}$. We also include rating group-quarter dummy variables, $\alpha_{g,t+h}$, to account for shocks that might affect firms with the same credit risk in a given quarter. Note that we define rating group to be one of the following broad credit rating categories: AA, A, BBB, BB, B, CCC. We estimate the following regression model:

$$\begin{aligned}\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h\epsilon_t^M)X_{f,t-1} \\ + (\xi_2 W_{f,t-1} + \xi_3 X_{f,t-1})GDP_{t-1} + u_{f,t+h}.\end{aligned} \tag{3}$$

As before, we are primarily interested in the estimates of $\beta_{2,h}$, which capture the differential responsiveness for Plus or Minus firms to exogenous changes in the stance of monetary policy relative to firms in the middle of the rating distribution in the *same* sector and *same* rating group in a given quarter. In addition, we can compare magnitudes with the baseline specification to determine how much those estimates might be biased from the exclusion of the sector-quarter and rating group-quarter dummy variables.

Lastly, for some specifications, the series of monetary policy shocks ϵ_t^M is included as an interaction with $X_{f,t-1}$. Interacting these other firm-level variables with the monetary policy shock reinforces the argument that we are identifying differential responsiveness of plus or

Minus firms *independent* of alternative channels of monetary policy transmission.

3 Results

In this section, we report baseline results for the sensitivities of firm borrowing and investment to monetary policy shocks for firms at credit-rating thresholds.

3.1 *Debt Growth*

We first estimate regressions in which the outcome of interest is the log difference in the real book value of debt, $\Delta log(d_{f,t+h})$. For reference, we report results for four-quarter horizon regressions in this and all subsequent tables in this section. First, we investigate the overall effect of unexpected changes in interest rates on borrowing by restricting $\beta_{2,h}$ in equation 2 to be zero. The result in column 1 of table 3 confirms that an unexpected decrease in interest rates stimulates borrowing, although the coefficient estimate is not statistically significant. The lack of significance is not surprising given that the sample is restricted to firms with a credit rating between CCC- and AA+. In robustness exercises, we estimate equations 2-3 for a wider sample of firms, including those without a credit rating, and find stronger effects, which is consistent with much of the existing literature on monetary transmission.

Next, we drop the restriction that $\beta_{2,h} = 0$, while continuing to restrict $\delta_h = 0$, and report coefficient estimates for the semielasticity of debt growth to monetary shocks for Plus and Minus firms relative to Mid firm. The results in columns 2-4 of table 3 suggest that firms at the Minus credit rating threshold are positively and significantly impacted by monetary policy shocks relative to Mid firms. To give some context, an unexpected one standard

Table 3: Sensitivity of debt growth to monetary policy shocks (1-year horizon)

	(1)	(2)	(3)	(4)	(5)
ϵ_t^M	0.52	-0.39			
	(0.62)	(0.85)			
$\epsilon_t^M \times Plus_{f,t-1}$		1.17	1.24	1.03	1.03
		(0.81)	(0.81)	(0.87)	(0.86)
$\epsilon_t^M \times Minus_{f,t-1}$		1.72**	2.00***	2.05***	2.20***
		(0.75)	(0.75)	(0.74)	(0.75)
Number of Observations	43,365	43,365	43,158	43,158	43,158
R^2	0.27	0.27	0.29	0.30	0.30
Firm Controls	yes	yes	yes	yes	yes
Aggregate Controls	yes	yes	no	no	no
Sector-Quarter Dummies	no	no	yes	yes	yes
Rating Group-Quarter Dummies	no	no	no	yes	yes
Other MP Channels	no	no	no	no	yes

Columns 1 and 2 show estimation results from the following regression at the four-quarter horizon ($h = 4$) $\Delta_h log(d_{f,t+h}) = \alpha_{f,h} + \zeta\epsilon_t^M + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h)X_{f,t-1} + \xi Z_{t-1} + u_{f,t+h}$ where $log(d_{f,t+h})$ is the log of real book value of debt, $\alpha_{f,h}$ is a firm fixed effect, ϵ_t^M is the monetary shock (positive corresponds with an unexpected decrease in the fed funds rate), $W_{f,t-1}$ is a vector containing dummy variables for having plus ($Plus_{f,t-1}$) or minus ($Minus_{f,t-1}$) credit ratings, $X_{f,t-1}$ is a vector of firm-level control variables containing the log of firm assets, leverage, liquidity, lagged sales growth, and net working capital, and the interaction of all firm-level variables with lagged GDP growth, and Z_{t-1} is a vector of aggregate controls including four lags of GDP growth, the unemployment rate, and the inflation rate. Columns 3-5 show results from $\Delta_h log(d_{f,t+h}) = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h)X_{f,t-1} + u_{f,t+h}$ where $\alpha_{s,t+h}$ is a sector-by-quarter dummy variable and $\alpha_{g,t+h}$ is a credit rating group-by-quarter dummy variable (columns 4 and 5 only). Standard errors given below coefficient estimates are double clustered at the firm and quarter levels. ***, **, and * denote significance at the 1, 5, and 10% levels.

deviation (25 bp) increase in the Fed Funds rate corresponds with at least a 1.72 percentage-point relative decrease in the cumulative growth rate of debt in the subsequent four quarters relative to firms in the middle of the rating distribution. The coefficient estimates for the Plus rating dummy variables, while also positive, are not statistically different from zero. Thus, most of the observed differential effect of monetary policy shocks on borrowing goes through firms with a Minus credit rating.

A few additional points are worth mentioning. First, comparing coefficient estimates from columns 2 to 3, we find that the inclusion of industry-quarter dummy variables leads to marginally larger sensitivities. Second, adding rating group-quarter dummy variables also only slightly increases coefficient estimates between columns 3 and 4. Thus, the sensitivity of debt growth to monetary policy shocks for Minus firms is not driven by differential exposures to industry conditions or credit risk. Lastly, we drop the restriction that $\delta_h = 0$ and allow for monetary policy shocks to affect firm borrowing via other firm-level characteristics: leverage, liquidity, sales growth, and net working capital. The coefficient estimates on the Minus dummy variable in column 5 are only modestly higher in this case. Thus, the stability of coefficient estimates from columns 2 to 5 offers strong support for the fact that the channel we have identified is not driven by differential transmission from these other channels.

3.2 *Investment*

In table 4, we report results in which the outcome of interest is the log difference in the real book value of capital, $\Delta log(k_{f,t+h})$. As is the case with the debt regressions, in column 1 we find a positive, but not significant, overall sensitivity of investment to monetary policy shocks among the set of rated firms in this paper. Turning to the estimates of $\beta_{2,h}$, in columns 2-5 we report positive semielasticities of investment to monetary policy shocks for firms at the Minus rating threshold. An unexpected 25 bp increase in the Fed Funds rate corresponds with a 0.55-0.79 percentage-point relative decline in the cumulative growth rate of capital in the subsequent four quarters relative to firms in the middle of the rating distribution.

3.3 *Dynamic Response*

In figure 1, we report results from estimation of equation 3 at horizons of 0-20 quarters ahead. The solid black lines present coefficient estimates and the dashed regions contain

Table 4: Sensitivity of investment to monetary policy shocks (1-year horizon)

	(1)	(2)	(3)	(4)	(5)
ϵ_t^M	0.07	-0.24			
	(0.22)	(0.25)			
$\epsilon_t^M \times Plus_{f,t-1}$		0.42	0.50	0.36	0.35
		(0.35)	(0.34)	(0.34)	(0.34)
$\epsilon_t^M \times Minus_{f,t-1}$		0.55	0.71**	0.75**	0.79**
		(0.33)	(0.34)	(0.35)	(0.34)
Number of Observations	44,332	44,332	44,120	44,120	44,120
R^2	0.37	0.37	0.39	0.40	0.40
Firm Controls	yes	yes	yes	yes	yes
Aggregate Controls	yes	yes	no	no	no
Sector-Quarter Dummies	no	no	yes	yes	yes
Rating Group-Quarter Dummies	no	no	no	yes	yes
Other MP Channels	no	no	no	no	yes

Columns 1 and 2 show estimation results from the following regression at the four-quarter horizon ($h = 4$) $\Delta_h log(k_{f,t+h}) = \alpha_{f,h} + \zeta\epsilon_t^M + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h)X_{f,t-1} + \xi Z_{t-1} + u_{f,t+h}$ where $log(k_{f,t+h})$ is the log of real book value of capital, $\alpha_{f,h}$ is a firm fixed effect, ϵ_t^M is the monetary shock (positive corresponds with an unexpected decrease in the fed funds rate), $W_{f,t-1}$ is a vector containing dummy variables for having plus ($Plus_{f,t-1}$) or minus ($Minus_{f,t-1}$) credit ratings, $X_{f,t-1}$ is a vector of firm-level control variables containing the log of firm assets, leverage, liquidity, lagged sales growth, and net working capital, and the interaction of all firm-level variables with lagged GDP growth, and Z_{t-1} is a vector of aggregate controls including four lags of GDP growth, the unemployment rate, and the inflation rate. Columns 3-5 show results from $\Delta_h log(k_{f,t+h}) = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h)X_{f,t-1} + u_{f,t+h}$ where $\alpha_{s,t+h}$ is a sector-by-quarter dummy variable and $\alpha_{g,t+h}$ is a credit rating group-by-quarter dummy variable (columns 4 and 5 only). Standard errors given below coefficient estimates are double clustered at the firm and quarter levels. ***, **, and * denote significance at the 1, 5, and 10% levels.

95% confidence intervals. As is evident from the left panels of the figure, Plus firms do not display any differential sensitivity of either debt growth or investment relative to Mid firms at any horizon. In contrast, as shown in the right panels, the observed positive sensitivities of debt growth and investment to monetary shocks for Minus firms increases one quarter after the shock and peaks after one year. To be precise, an unexpected 25 bp increase in the Fed Funds rate corresponds with a 2 pp relative decline in the cumulative growth rate of debt in the subsequent five quarters, and a 1 pp relative decrease in the cumulative growth rate of physical capital in the subsequent six quarters relative to Mid firms, before levelling off after a two-year horizon. The confidence interval estimates beyond this horizon widen as well.

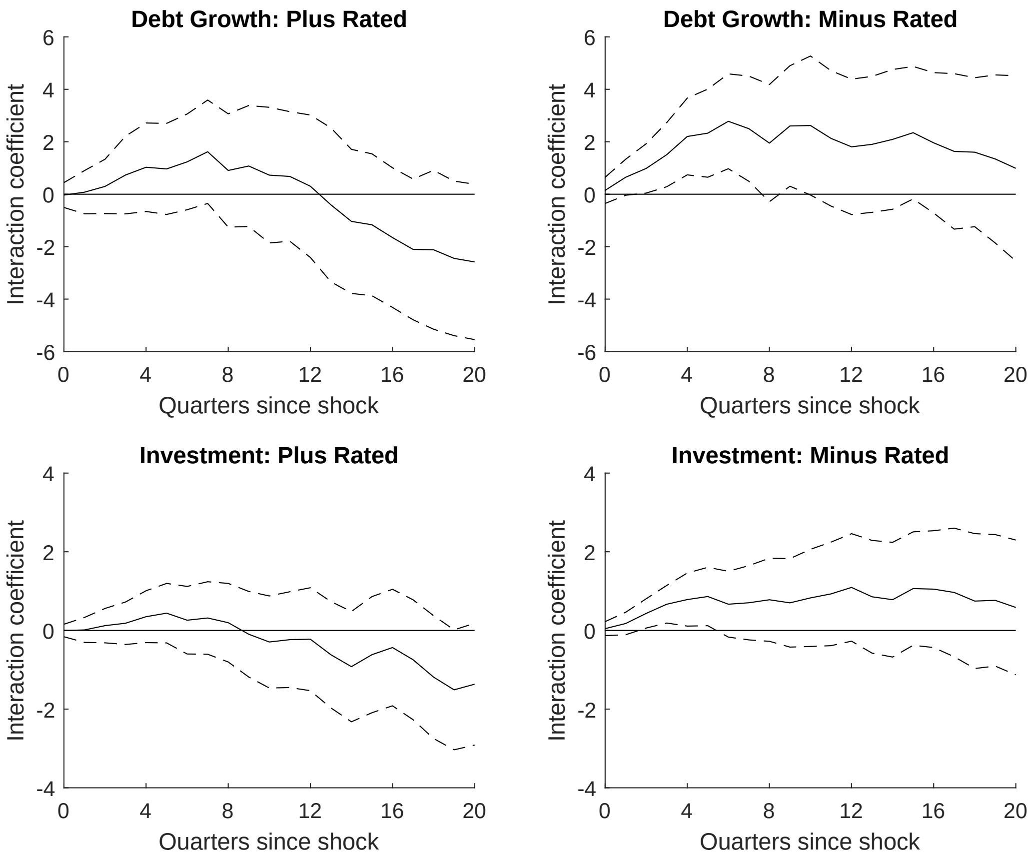


Figure 1: Debt growth and investment sensitivities to monetary policy shocks
This figure reports coefficient estimates of $\beta_{2,h}$ for Plus and Minus firms from the following regression: $\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h\epsilon_t^M)X_{f,t-1} + u_{f,t+h}$. The dependent variable for results in the upper panel is the change in the log book value of debt ($\Delta log(d_{f,t+h})$), while for the lower panel it is the change in the log physical capital stock ($\Delta log(k_{f,t+h})$). Estimates are shown for the period 1990Q1-2007Q4 for horizons 0-20 quarters after the initial monetary policy shocks.

All of these regressions include the specifications with the most controls: industry-quarter and rating group-quarter dummy variables and interactions of alternative firm-level characteristics and monetary shocks. While unreported, we also find results consistent with Jeenas (2019), namely that lower liquidity corresponds with a positive sensitivity to monetary shocks that increases with horizon. Our results offer compelling evidence in favor of the hypothesis that credit rating thresholds matter for the transmission of monetary policy to firm borrowing and investment. However, we emphasize that our results are complementary to other channels, in particular liquidity, that significantly matter for the conduct of monetary policy.

To summarize, we argue that the Minus rating threshold acts as a significant friction in amplifying unexpected changes in the stance of Fed policy. Our estimates further suggest that we have identified a unique channel of monetary transmission that is not driven by differential exposures of different sectors or firms with fundamentally different credit risks.

3.4 *Asymmetric Response to Monetary Shocks*

In this section, we investigate whether there is an asymmetric response to monetary policy shocks depending on whether the shock represents an overall easing or tightening of policy. We define a positive monetary shock for the case of a surprise decrease in interest rates (ϵ_t^{M+}) and a negative shock for an increase in rates (ϵ_t^{M-}). The coefficients of interest from this regression are $\beta_{2,h}$ and $\beta_{3,h}$, which we estimate separately for Plus and Minus firms.

$$\begin{aligned}\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^{M+} + \beta_{3,h}\epsilon_t^{M-})W_{f,t-1} \\ + (\gamma_h + \delta_{1,h}\epsilon_t^{M+} + \delta_{2,h}\epsilon_t^{M-})X_{f,t-1} + u_{f,t+h}\end{aligned} \tag{4}$$

Estimates from these regressions are shown in table 5 and figures 2 and 3. First, focusing on regressions in which 1-year debt growth is the outcome of interest, we find that the relatively larger sensitivity of Minus firms is driven primarily by unexpected *easing* in the stance of monetary policy. A surprise one-standard deviation (25 bp) decrease in the Fed Funds rate corresponds with a 2.54 pp larger increase in one-year debt growth for Minus firms relative to Mid firms.

Table 5: Sensitivity of debt and capital growth to positive/negative monetary policy shocks (1-year horizon)

	Dependent Variables (4-quarter growth rates):			
	Debt Growth		Capital Growth	
	(1)	(2)	(3)	(4)
$\epsilon_t^{M+} \times Plus_{f,t-1}$	0.16	0.20	-0.18	-0.17
	(0.95)	(0.95)	(0.33)	(0.33)
$\epsilon_t^{M+} \times Minus_{f,t-1}$	2.41***	2.54***	0.50	0.57
	(0.86)	(0.88)	(0.37)	(0.37)
$\epsilon_t^{M-} \times Plus_{f,t-1}$	4.15*	3.98*	2.27***	2.26***
	(2.23)	(2.22)	(0.68)	(0.69)
$\epsilon_t^{M-} \times Minus_{f,t-1}$	0.66	0.83	1.61*	1.55*
	(1.49)	(1.47)	(0.88)	(0.89)
Number of Observations	43,158	43,158	44,120	44,120
R^2	0.30	0.30	0.40	0.40
Firm Controls	yes	yes	yes	yes
Aggregate Controls	no	no	no	no
Sector-Quarter Dummies	yes	yes	yes	yes
Rating Group-Quarter Dummies	yes	yes	yes	yes
Other MP Channels	no	yes	no	yes

Regression results are shown from estimation of the following regression at the four-quarter horizon ($h = 4$) $\Delta_h log(y_{f,t+h}) = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^{M+} + \beta_{3,h}\epsilon_t^{M-})W_{f,t-1} + (\gamma_h + \delta_{1,h}\epsilon_t^{M+} + \delta_{1,h}\epsilon_t^{M-})X_{f,t-1} + u_{f,t+h}$. The dependent variable in columns 1 and 2 is $log(d_{f,t+h})$ (the log of real book value of debt), and in columns 3 and 4 it is $log(k_{f,t+h})$ (the log of real book value of capital). $\alpha_{s,t+h}$ is a sector-by-quarter dummy variable, $\alpha_{g,t+h}$ is a credit rating group-by-quarter dummy variable, $\alpha_{f,h}$ is a firm fixed effect, ϵ_t^{M+} is a positive realization of the monetary shock (positive corresponds with an unexpected decrease in the fed funds rate), ϵ_t^{M-} is a negative realization of the monetary shock (negative corresponds with an unexpected increase in the fed funds rate), $W_{f,t-1}$ is a vector containing dummy variables for having plus ($Plus_{f,t-1}$) or minus ($Minus_{f,t-1}$) credit ratings, $X_{f,t-1}$ is a vector of firm-level control variables containing the log of firm assets, leverage, liquidity, lagged sales growth, and net working capital, and the interaction of all firm-level variables with lagged GDP growth. Standard errors given below coefficient estimates are double clustered at the firm and quarter levels. ***, **, and * denote significance at the 1, 5, and 10% levels.

As demonstrated by figure 2 the observed higher sensitivity of Minus firms persists significantly for 2-3 years after the initial unexpected easing in policy. Interestingly, these higher elasticities for debt growth are more muted for investment. There is weak evidence of a relatively larger expansion in capital spending for Minus firms relative to Mid firms in the first year after an unexpected monetary easing. However, the magnitude and significance of these estimates is muted relative to debt growth. Thus, Minus firms respond to unexpected accommodative monetary policy shocks by primarily increasing debt growth relatively more

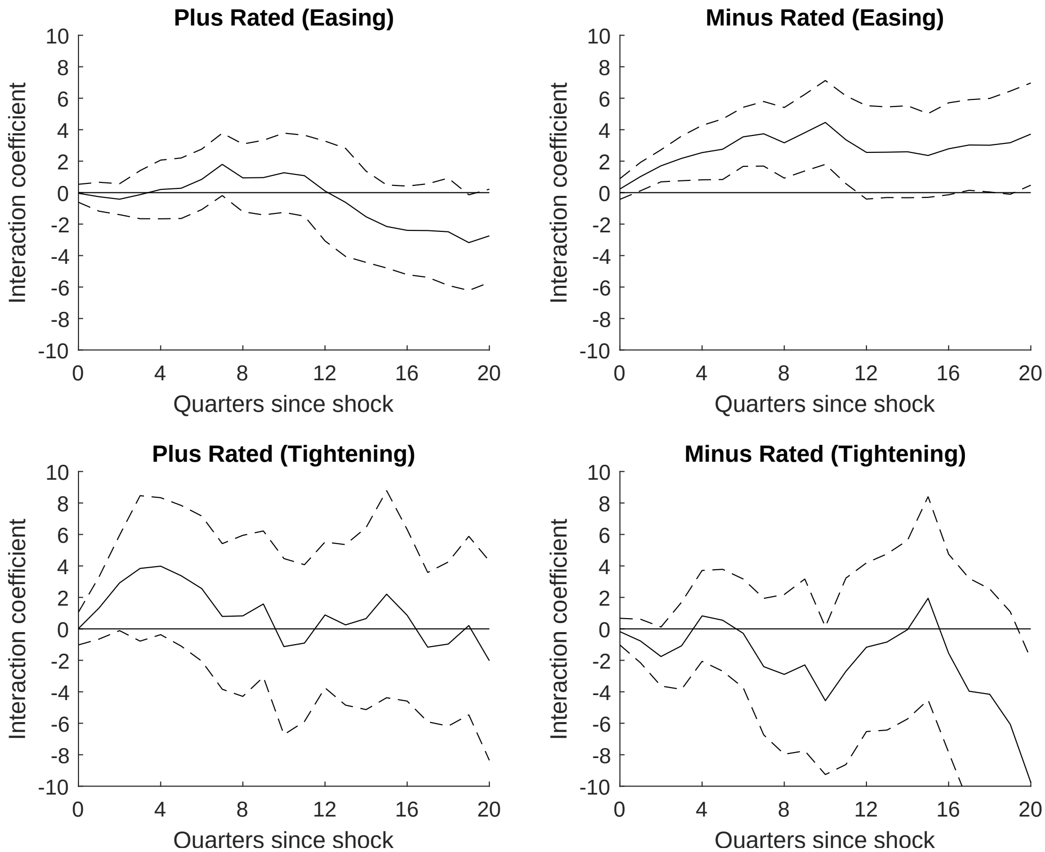


Figure 2: Debt growth sensitivities to positive/negative monetary policy shocks
This figure reports coefficient estimates of $\beta_{2,h}$ and $\beta_{3,h}$ for Plus and Minus firms from the following regression: $\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^{M+} + \beta_{3,h}\epsilon_t^{M-})W_{f,t-1} + (\gamma_h + \delta_{1,h}\epsilon_t^{M+} + \delta_{2,h}\epsilon_t^{M-})X_{f,t-1} + u_{f,t+h}$. The dependent variable for these results is the change in the log book value of debt ($\Delta log(d_{f,t+h})$), Estimates are shown for the period 1990Q1-2007Q4 for horizons 0-20 quarters after the initial monetary policy shocks.

than Mid firms.

In response to an unexpected monetary tightening, Plus firms decrease debt growth and investment by relatively more than Mid firms in the year following the shock. However, as demonstrated by figure 2, these are estimates are not precisely estimated beyond a one-year horizon. Minus firms exhibit similar behavior, although the estimates are similarly imprecise.

The results in this section confirm that there is a substantial asymmetry in the response of Plus and Minus firms to monetary shocks. In terms of the sensitivity of debt growth and investment, Minus firms are relatively more response than Mid firms to unexpected decreases

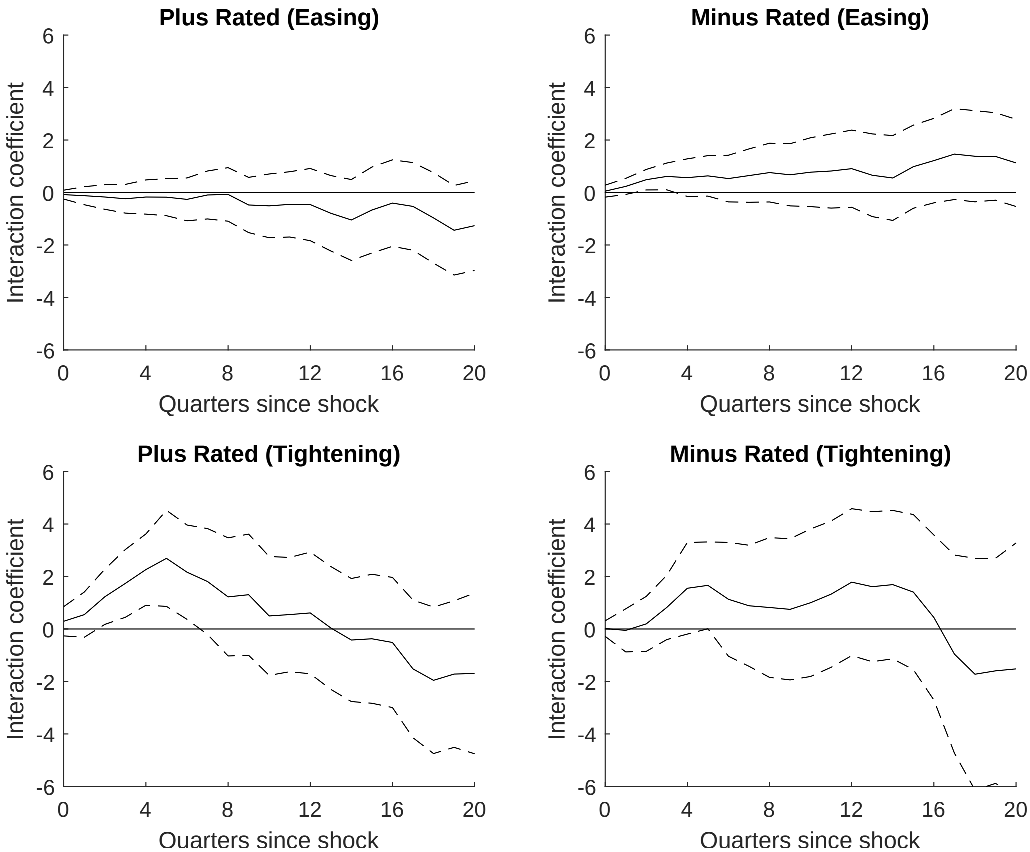


Figure 3: Investment sensitivities to positive/negative monetary policy shocks
This figure reports coefficient estimates of $\beta_{2,h}$ and $\beta_{3,h}$ for Plus and Minus firms from the following regression: $\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^{M+} + \beta_{3,h}\epsilon_t^{M-})W_{f,t-1} + (\gamma_h + \delta_{1,h}\epsilon_t^{M+} + \delta_{2,h}\epsilon_t^{M-})X_{f,t-1} + u_{f,t+h}$. The dependent variable for these results is the change in the log book value of capital ($\Delta log(k_{f,t+h})$), Estimates are shown for the period 1990Q1-2007Q4 for horizons 0-20 quarters after the initial monetary policy shocks.

in interest rates. In contrast, Plus firms are relatively more responsive than Mid firms to unexpected increases in interest rates. Although we employ a different methodology than Ravn et al. (2004) and focus on firm-level outcomes, we similarly find that an unexpected tightening has more magnified effects on investment than an easing.

4 *Robustness*

In section 3, we concluded that monetary policy shocks magnify the borrowing and investment response of firms with a Minus credit rating relative to firms in the middle of the rating distribution. In this section, we investigate the robustness of this result.

4.1 *Other Borrowing Measures*

Our first set of robustness checks considers alternative borrowing measures. We first utilize a measure of borrowing constructed from cash-flow statements that captures the addition to leverage due to changes in debt (Kisgen (2006)). We utilize Compustat data on variables for long-term debt issuance (dltisy), long-term debt reduction (dltry), changes in current debt (dlcchy), sale of common and preferred stock (sstky), and purchase of common and preferred stock (prstkcy). These variables are available at a quarterly frequency, but are released as year-to-date. Thus, we define quarterly variables to be the values of dltisy, dltry, dlcchy, sstky, and prstkcy in the first fiscal quarter of each year. Subsequent values for the remainder of the fiscal year are then calculated as the changes in the year-to-date values.

For expositional purposes, we define debt "issuance" in quarter t, $\tilde{d}_{f,t}$, to be long-term debt issuance minus long-term debt reduction plus changes in current debt from quarter t to $t+1$. We express our measure as cumulative debt issuance minus reduction from quarters t to t_h scaled by the real book value of assets in quarter $t-1$, $a_{f,t-1}$:

$$\Delta \tilde{d}_{f,t+h} = \frac{\sum_{j=0}^{h} \tilde{d}_{f,t+j}}{a_{f,t-1}} \tag{5}$$

We similarly define *net* debt issuance in quarter t, $\tilde{nd}_{f,t}$, to be long-term debt issuance minus long-term debt reduction plus changes in current debt minus equity issuance plus stock repurchases. This measure from quarters t to t_h equals:

$$\Delta\tilde{nd}_{f,t+h} = \frac{\sum_{j=0}^{h} \tilde{nd}_{f,t+j}}{a_{f,t-1}} \tag{6}$$

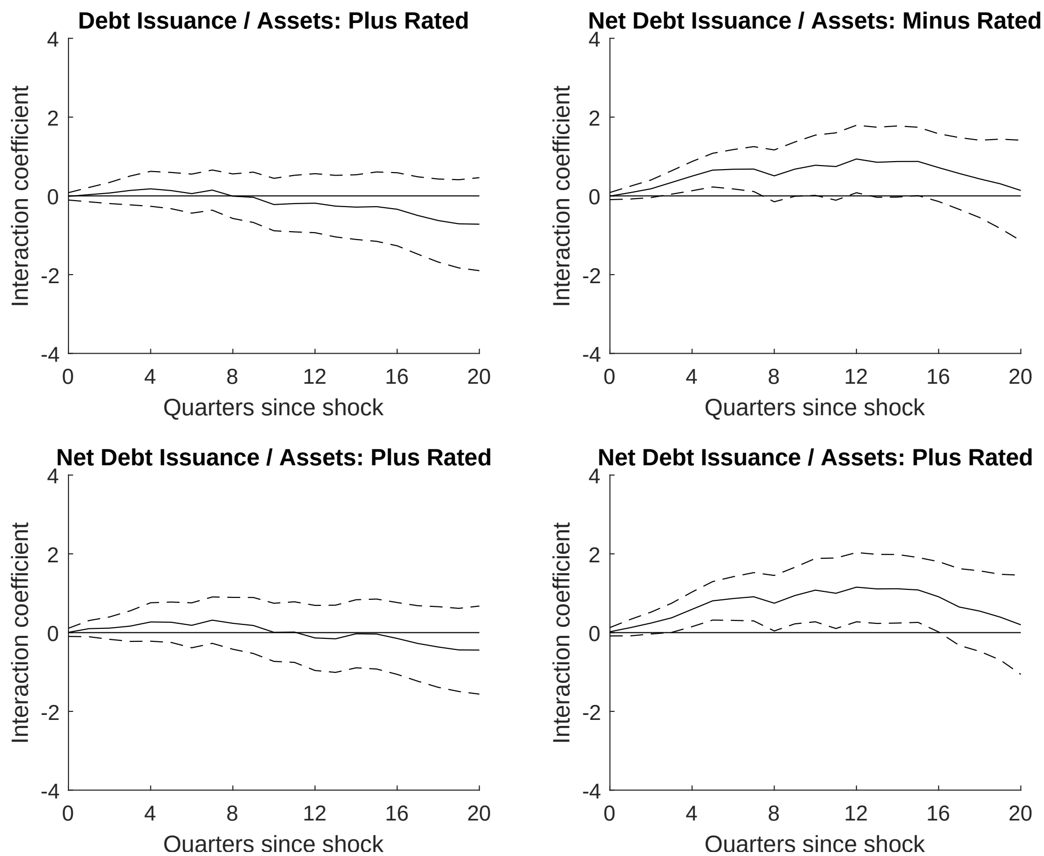


Figure 4: Debt issuance sensitivities to monetary policy shocks
This figure reports coefficient estimates of $\beta_{2,h}$ for Plus and Minus firms from the following regression: $\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h\epsilon_t^M)X_{f,t-1} + u_{f,t+h}$. The dependent variable for results in the upper panel is debt issuance / lagged assets ($\Delta\tilde{d}_{f,t+h}$), while for the lower panel it is net debt issuance / lagged assets ($\Delta\tilde{nd}_{f,t+h}$). Estimates are shown for the period 1990Q1-2007Q4 for horizons 0-20 quarters after the initial monetary policy shocks.

Results for these two measures are reported in figure 4. Results for both measures are broadly similar to those in figure 1. Namely, Minus firms are more responsive to monetary shocks than Mid firms, while Plus firms do not exhibit any differential sensitivities. Relative to our baseline results, we find a longer peak of three to four years for both measures, but relatively smaller magnitudes. These results suggest that, not only do Minus firms issue more debt relative to Mid firms following unexpectedly accommodative monetary policy shocks, but they also increase leverage in their capital structure.

To what extent is the observed larger sensitivities of debt growth and changes in leverage driven by long-term debt rather than due to short-term liquidity management? To address this question, we redefine both measures using only *long-term* debt, rather than total debt. The first measure captures changes in the real book value of long-term debt, $\Delta log(ltd_{f,t+h})$. The second measure is the change in long-term debt issuance scaled by lagged assets $\Delta \tilde{ltd}_{f,t+h}$.

In figure 5, we present results for these measures of changes in long-term debt. In both cases, the sensitivities increase immediately following an unexpectedly positive monetary shock for Minus firms relative to Mid firms. Comparing magnitudes with prior estimates suggests that the majority of the positive sensitivity of total debt is due to its long-term component.

4.2 *Other Investment Measures*

In our second robustness exercise, we consider an alternative measure of investment based on capital expenditures (Almeida, et. al. 2012). This measure has the advantage of also being constructed directly from firm cash-flow statements, although a disadvantage is

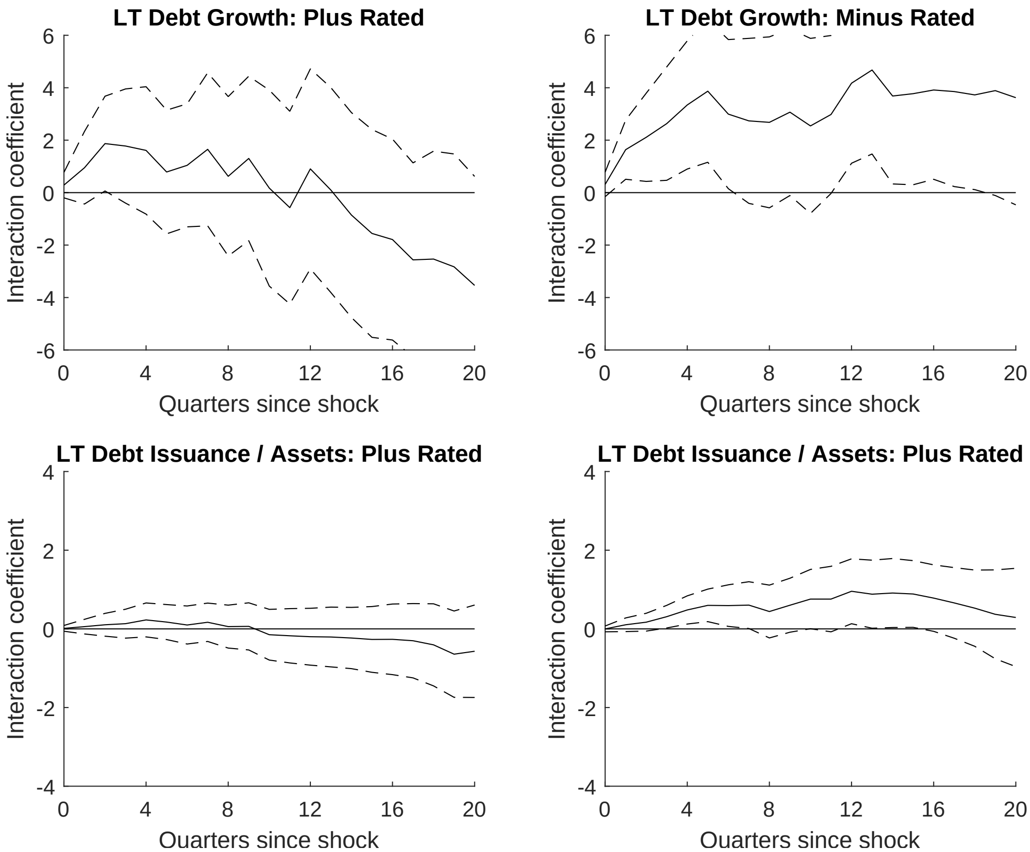


Figure 5: Long-term debt sensitivities to monetary policy shocks
This figure reports coefficient estimates of $\beta_{2,h}$ for Plus and Minus firms from the following regression: $\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h \epsilon_t^M)X_{f,t-1} + u_{f,t+h}$. The dependent variable for results in the upper panels is the change in the log of the book value of long-term debt ($\Delta log(ltd_{f,t+h})$), while for the lower panel it is long-term debt issuance / lagged assets ($\Delta \tilde{ltd}_{f,t+h}$). Estimates are shown for the period 1990Q1-2007Q4 for horizons 0-20 quarters after the initial monetary policy shocks.

that quarterly capital spending has a tendency to be lumpy. We utilize Compustat data on variables for capital expenditures (capxy) and net property, plant, and equipment (ppentq). As above, we convert capxy from a year-to-date measure to a quarterly frequency (capxq). We define capex investment from quarters t to t_h to be:

$$\Delta \tilde{i}_{f,t+h} = \frac{\sum_{j=0}^{h} capxq_{f,t+j}}{ppentq_{f,t-1}}. \tag{7}$$

Results for this alternative measure of investment are shown in figure 6. Similar to the baseline results, the investment sensitivity of Minus firms is positive and increasing until three years after an unexpectedly positive monetary shock.

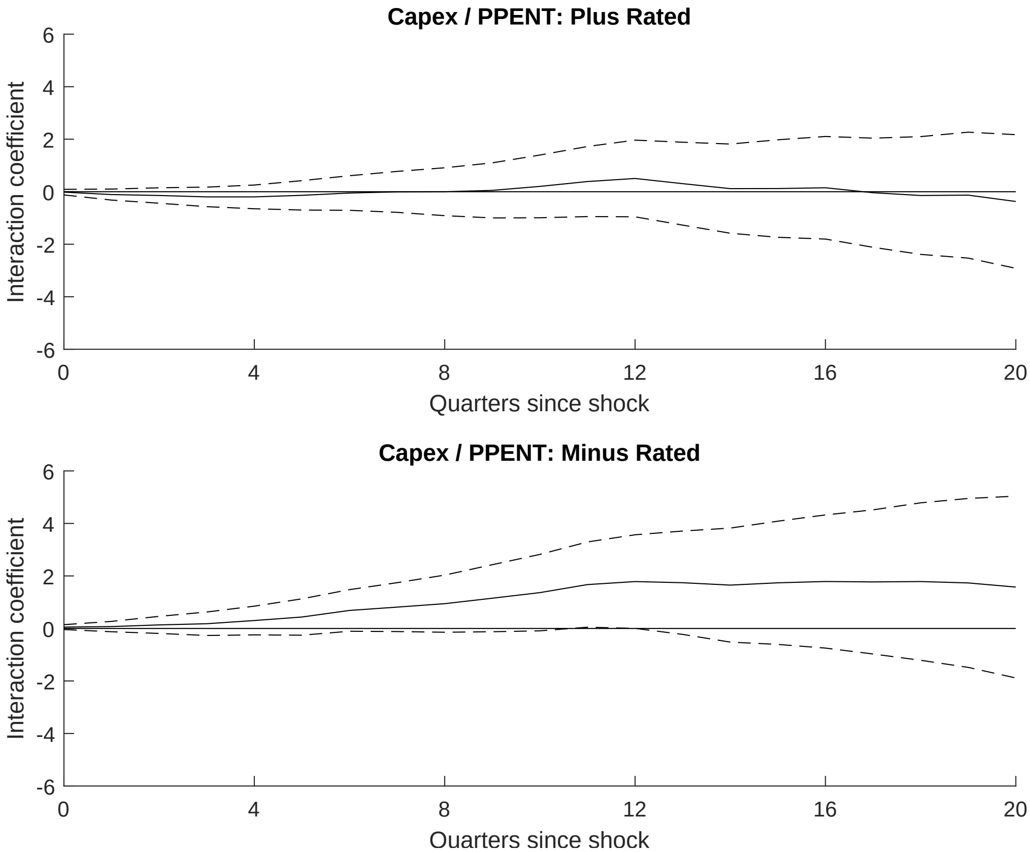


Figure 6: Capex investment sensitivities to monetary policy shocks
This figure reports coefficient estimates of $\beta_{2,h}$ for Plus and Minus firms from the following regression: $\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\epsilon_t^M)W_{f,t-1} + (\gamma_h + \delta_h \epsilon_t^M)X_{f,t-1} + u_{f,t+h}$. The dependent variable for these results is cumulative capital expenditure / lagged net PPE ($\tilde{i}_{f,t+h}$). Estimates are shown for the period 1990Q1-2007Q4 for horizons 0-20 quarters after the initial monetary policy shocks.

4.3 *Other Monetary Shocks*

In the next robustness check, we utilize the measure of monetary shocks constructed from the simple (unweighted) sum of high-frequency shocks within a quarter, $\tilde{\epsilon}_t^M$. Table

7 displays results of the sensitivities of Plus and Minus firms for the baseline outcomes of debt growth, $\Delta_h log(d_{f,t+h})$, and investment, $\Delta_h log(k_{f,t+h})$. As is evident from the figure, the sensitivities are robust to this alternative measure of monetary shocks.

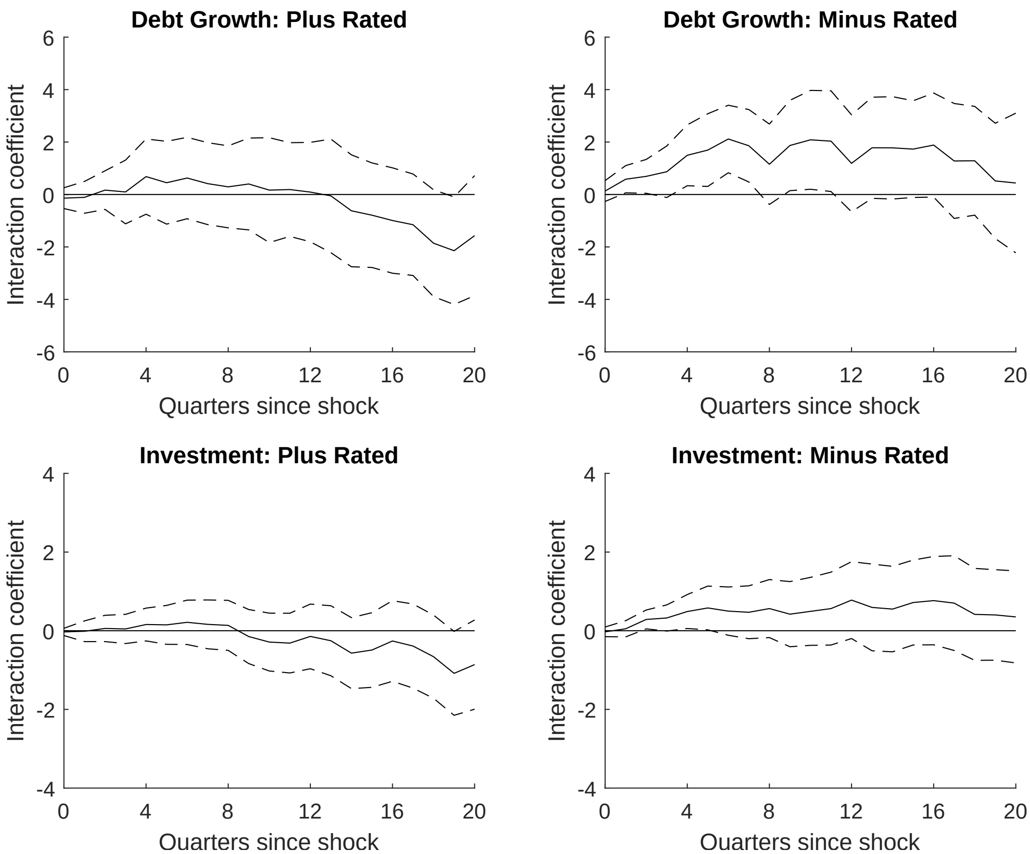


Figure 7: Debt growth and investment sensitivities to monetary policy shocks
This figure reports coefficient estimates of $\beta_{2,h}$ for Plus and Minus firms from the following regression: $\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\tilde{\epsilon}_t^M)W_{f,t-1} + (\gamma_h + \delta_h \tilde{\epsilon}_t^M)X_{f,t-1} + u_{f,t+h}$. Relative to the baseline case, we use the simple (unweighted) sum of monetary shocks in a quarter. The dependent variable for results in the upper panel is the change in the log book value of debt ($\Delta log(d_{f,t+h})$), while for the lower panel it is the change in the log physical capital stock ($\Delta log(k_{f,t+h})$). Estimates are shown for the period 1990Q1-2007Q4 for horizons 0-20 quarters after the initial monetary policy shocks.

4.4 *Full Sample*

In this robustness check, we estimate the baseline regressions using the full set of firms in the sample, regardless of whether they are rated. The major difference for this specification relative to the baseline one is that we also control non-parametrically for all shocks affecting unrated firms within a quarter. Including this larger set of firms does not qualitatively change the baseline results.

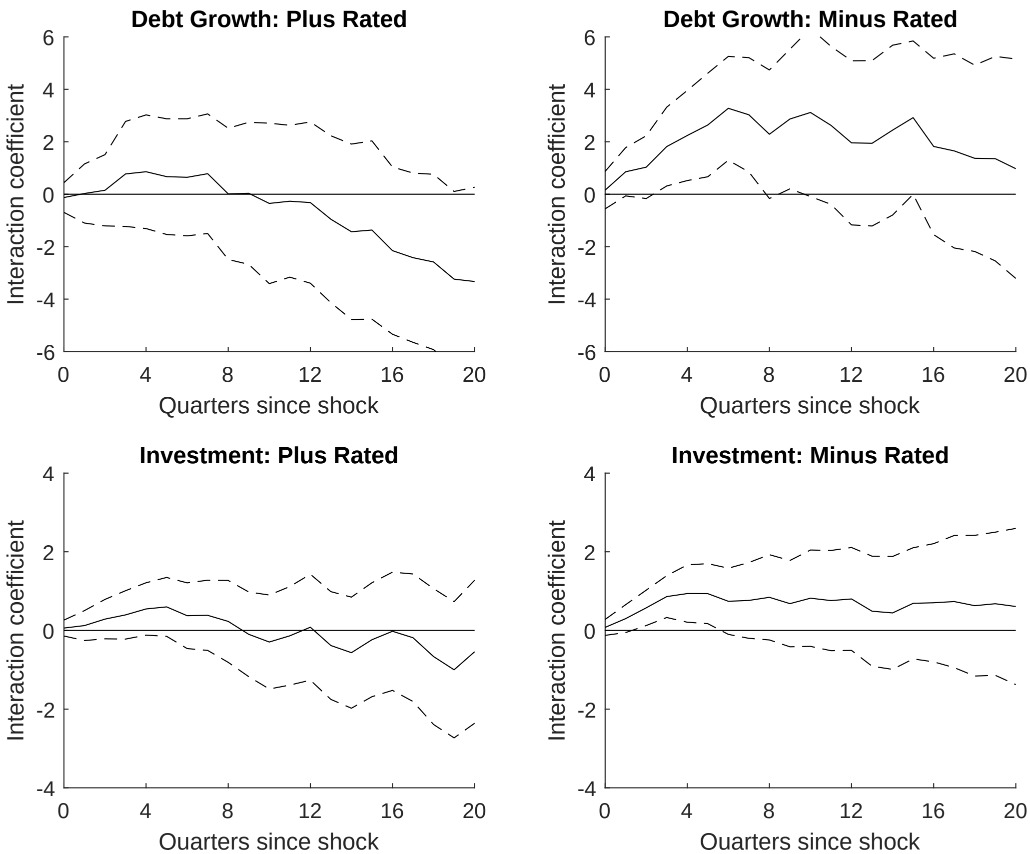


Figure 8: Debt growth and investment sensitivities to monetary policy shocks
This figure reports coefficient estimates of $\beta_{2,h}$ for Plus and Minus firms from the following regression: $\Delta_h y_{f,t+h} = \alpha_{f,h} + \alpha_{s,t+h} + \alpha_{g,t+h} + (\beta_{1,h} + \beta_{2,h}\tilde{\epsilon}_t^M)W_{f,t-1} + (\gamma_h + \delta_h\tilde{\epsilon}_t^M)X_{f,t-1} + u_{f,t+h}$. Relative to the baseline case, we do not exclude unrated firms and firms with either an AAA rating or rating below CC+. The dependent variable for results in the upper panel is the change in the log book value of debt ($\Delta log(d_{f,t+h})$), while for the lower panel it is the change in the log physical capital stock ($\Delta log(k_{f,t+h})$). Estimates are shown for the period 1990Q1-2007Q4 for horizons 0-20 quarters after the initial monetary policy shocks.

5 Two-period model

In this section we introduce a theoretical model to rationalize the empirical results. The model has two periods, t and $t+1$, and contains four different types of firms: A, $A-$, $B+$, and B. Firms with different ratings are identical except for one characteristic: the fraction of assets that can be recovered by creditors in case of default. This fraction is higher for A and $A-$ firms than for $B+$ and B firms. This assumption leads to different incentives across firm types and creates a mechanism able to explain why firms rated "plus" or "minus" react relatively more strongly to monetary policy shocks than mid-rated firms.

5.1 Technology

A firm's technology (and revenue) is given by

$$y_t = A_t(z_t k_t)^\alpha l_t^\nu \tag{8}$$

where A_t is aggregate technology and z_t is a firm-specific capital quality shock. We assume decreasing returns to scale: $\alpha + \nu < 1$. We abstract from aggregate technology and labor decisions: $A_t = l_t = 1$ for all t. The firm's operating profit is given by its revenue net of labor cost and fixed cost ξ^F:

$$y_t - w_t l_t - \xi^F = (1-\nu)A_t(z_t k_t)^\alpha l_t^\nu - \xi^F, \tag{9}$$

where the wage w_t is equal to the marginal product of labor. The capital quality shock z_t is log-normally distributed, with probability density function $\phi(\cdot)$ and cumulative density function $\Phi(\cdot)$. The underlying normal distribution has mean 0 and standard deviation σ_K. This shock affects the capital stock as a whole, so that it also affects the remaining, undepreciated capital $(1-\delta)z_t k_t$. After producing in period t, the firm has the possibility to sell existing capital for $q_t(1-\delta)z_t k_t$ and purchase new capital for $q_t k_{t+1}$. For simplicity, we assume that the relative price of capital $q_t = 1$ for all t.

5.2 Borrowing

To finance the purchase of new capital, the firm uses cash flow from operations and new debt b_{t+1}. At time t, the firm borrows $Q_t b_{t+1}$. Unless it defaults, it must repay $(1+(1-\tau)c_{t+1})b_{t+1}$ at time $t+1$, where c_{t+1} is the tax-deductible coupon rate, Q_t is the value of each dollar of debt to the creditor, and τ is the tax rate. The firm's cash flow at period t is therefore given by

$$(1-\tau)(1-\nu)A_t(z_t k_t)^\alpha l_t^\nu - \xi^F - (1-(1-\tau)c_t)b_t + q_t(1-(1-\tau)\delta)z_t k_t - q_t k_{t+1} + Q_t b_{t+1}. \quad (10)$$

5.3 Debt and investment decisions

The firm chooses k_{t+1} and b_{t+1} in order to maximize dividends (net cash flow) over t and $t+1$. Under limited liability, the firm's cash flow cannot be negative in a given period. Hence, k_{t+1} and b_{t+1} satisfy

$$d_t = (1-\tau)(1-\nu)A_t(z_t k_t)^\alpha l_t^\nu - \xi^F - (1-(1-\tau)c_t)b_t + q_t(1-(1-\tau)\delta)z_t k_t - q_t k_{t+1} + Q_t b_{t+1} \geq 0 \quad (11)$$

and

$$d_{t+1} = \max\left\{0, (1-\tau)(1-\nu)A_{t+1}(z_{t+1}k_{t+1})^{\alpha}l_{t+1}^{\nu} - \xi^F \right.$$
$$\left. -(1+(1-\tau)c_{t+1})b_{t+1} + q_{t+1}(1-(1-\tau)\delta)z_{t+1}k_{t+1}\right\}. \tag{12}$$

Since the second term in the maximum value operator is strictly increasing in z_{t+1} (for given b_{t+1} and k_{t+1}), there is a z^*_{t+1} such that this term is exactly equal to zero. If $z_{t+1} < z^*_{t+1}$, the firm's cash flow is insufficient to repay the debt and the firm defaults. If $z_{t+1} \geq z^*_{t+1}$, the firm is able to repay and keeps operating. z^*_{t+1} satisfies

$$(1-\tau)(1-\nu)A_{t+1}(z^*_{t+1}k_{t+1})^{\alpha}l_{t+1}^{\nu} + q_{t+1}(1-(1-\tau)\delta)z^*_{t+1}k_{t+1} = \xi^F + (1+(1-\tau)c_{t+1})b_{t+1} \tag{13}$$

From the perspective of period t, the firm's value is given by

$$\begin{aligned}
v_t = {} & (1-\tau)(1-\nu)A_t(z_tk_t)^{\alpha}l_t^{\nu} - \xi^F - (1+(1-\tau)c_t)b_t + q_t(1-(1-\tau)\delta)z_tk_t \\
& - q_tk_{t+1} + Q_tb_{t+1} \\
& + \beta(1-\tau)(1-\nu)A_{t+1}k_{t+1}^{\alpha}l_{t+1}^{\nu}\int_{z^*_{t+1}}^{+\infty} z_{t+1}^{\alpha}d\Phi(z_{t+1}) \\
& + \beta q_{t+1}(1-(1-\tau)\delta)k_{t+1}\int_{z^*_{t+1}}^{+\infty} z_{t+1}d\Phi(z_{t+1}) \\
& - \beta[1-\Phi(z^*_{t+1})][\xi^F + (1+(1-\tau)c_{t+1})b_{t+1}]
\end{aligned} \tag{14}$$

where β is the discount factor, where $\int_{z^*_{t+1}}^{+\infty} z_{t+1}d\Phi(z_{t+1})$ and $\int_{z^*_{t+1}}^{+\infty} z_{t+1}^{\alpha}d\Phi(z_{t+1})$ are the expected values of z_{t+1} and z_{t+1}^{α} over the range where the firm does not defaults, and where $\Phi(z^*_{t+1})$ is the probability of default. The firm chooses k_{t+1} and b_{t+1} to maximize this value

v_t while satisfying $d_t \geq 0$.

5.4 Creditors

Lending is perfectly competitive and creditors value the firm's debt $(Q_t b_{t+1})$ based on what they expect to receive at $t+1$ as repayment. If the firm's cash flow at $t+1$ is not sufficient to repay the debt $(z_{t+1} < z^*_{t+1})$, the firm defaults and creditors take control of the firm. They then continue to operate the firm normally, but have to pay a restructuring cost equivalent to a fraction $1 - \xi^K_{t+1}$ of the firm's assets (stock of capital).

$$
\begin{aligned}
Q_t b_{t+1} = {} & \beta[1 - \Phi(z^*_{t+1})](1 + c_{t+1}) b_{t+1} \\
& + \beta(1-\tau)(1-\nu) A_{t+1} k^\alpha_{t+1} l^\nu_{t+1} \int_0^{z^*_{t+1}} z^\alpha_{t+1} d\Phi(z_{t+1}) \\
& + \beta \xi^{Ke}_{t+1} q_{t+1} (1 - (1-\tau)\delta) k_{t+1} \int_0^{z^*_{t+1}} z_{t+1} d\Phi(z_{t+1}) \\
& - \beta \Phi(z^*_{t+1}) \xi^F
\end{aligned} \tag{15}
$$

where ξ^{Ke}_{t+1} is the fraction of assets (capital) that creditors *expect* to be able to recover in case of default.

5.5 Credit ratings and restructuring recovery rates

Restructuring recovery rates are specific to a firm's letter credit rating, with $\xi^{KA} > \xi^{KB}$: creditors are able to recover more assets from A-rated firms than from B-rated firms. This can reflect better management practices in higher-rated firms, or larger, more experienced creditors such as institutional investors investing in better rated firms' debt.

A firm's credit rating can be updated at the end of period t: after its k_{t+1} and b_{t+1} decisions have been made, but before z_{t+1} has been revealed. A firm's probability of being downgraded or upgraded is tied to its probability of default ($\Phi(z^*_{t+1})$). The probability of downgrade is given by $\tilde{p}_d\Phi(z^*_{t+1})$. The probability of upgrade is given by $\tilde{p}_u[1-\Phi(z^*_{t+1})]$. For A and B firms, a change in credit rating is inconsequential. The firm-type specific expected restructuring recovery rates are therefore given by

$$\xi^{Ke}_{t+1} = \begin{cases} \xi^{KA} & \text{For } A \text{ firms} \\ \tilde{p}_d\Phi(z^*_{t+1})\xi^{KB} + [1-\tilde{p}_d\Phi(z^*_{t+1})]\xi^{KA} & \text{For } A- \text{ firms} \\ \tilde{p}_u[1-\Phi(z^*_{t+1})]\xi^{KA} + [1-\tilde{p}_u[1-\Phi(z^*_{t+1})]]\xi^{KB} & \text{For } B+ \text{ firms} \\ \xi^{KB} & \text{For } B \text{ firms} \end{cases} \tag{16}$$

5.6 Timing

The timing of the firm is as follows:

Period t

1. z_t is realized
2. Firm produces using k_t
3. Firm decides how much to borrow (b_{t+1}) and how much capital to acquire (k_{t+1})
4. Firm borrows and acquires capital
5. Credit rating is updated

Period $t+1$

1. z_{t+1} is realized

2. Firm produces using k_{t+1}

3. Firm repays (if cash flow is sufficient) or defaults (if cash flow is not sufficient)

5.7 Monetary policy shocks

The monetary policy shock enters the model in two different ways. First, it affects the discount factor β. An expansionary shock increases the discount factor, making firms care more about the future. As a result, investment in k_{t+1} is relatively more valuable and, given a binding budget constraint, also provides more incentives to borrow. Because the coupon rate c_{t+1} is calibrated to equal $(1/\beta)-1$, this leads to a decrease in the coupon rate. Second, the shock also affects the parameters $\tilde{p}_d$ and $\tilde{p}_u$ regulating the probability of downgrade and upgrade. An expansionary shock results in a lower $\tilde{p}_d$ and a higher $\tilde{p}_u$. The rationale is that an expansionary monetary policy shock will result in increased demand in the overall economy, providing firms with more profitable opportunities. Since credit ratings depend not only on firms' balance sheets but also on profitable prospects, a positive demand shock increases ratings overall.

5.8 Firm's optimization problem

The firm maximizes its value v_t (equation (14)) where z^*_{t+1} is defined by equation (13), where ξ^{Ke}_{t+1} is defined by equation (16) and subject to constraints (11) and (15). Since the constraints always bind, the problem can be set up as a Lagrangian where $Q_t b_{t+1}$ has been directly substituted in the problem:

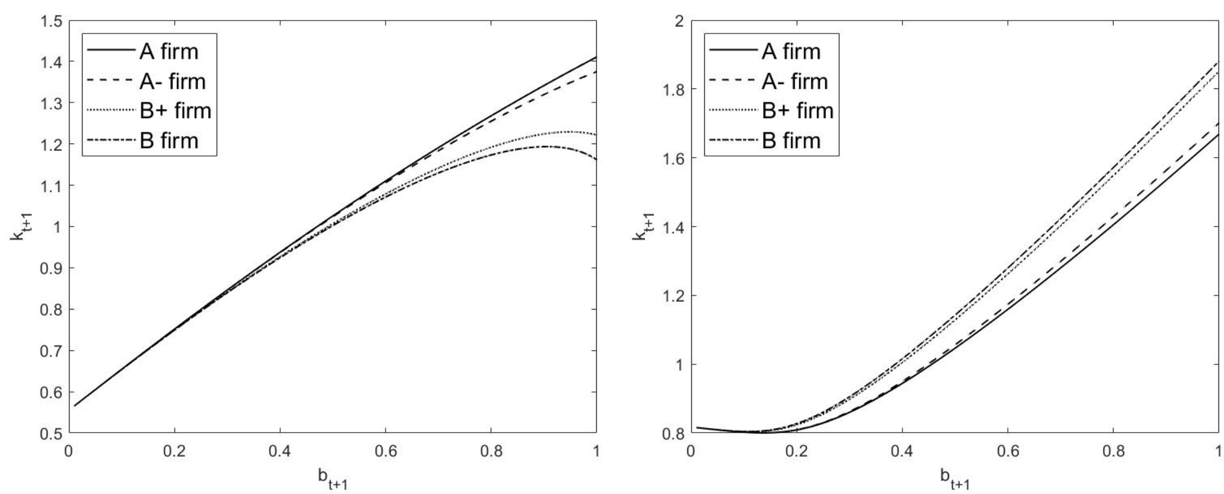
$$
\begin{aligned}
\mathcal{L} = &(1-\tau)(1-\nu)A_t(z_tk_t)^\alpha l_t^\nu - \xi^F - (1+(1-\tau)c_t)b_t + q_t(1-(1-\tau)\delta)z_tk_t \\
&- q_tk_{t+1} + \beta[1-\Phi(z_{t+1}^*)]\tau c_{t+1}b_{t+1} \\
&+ \beta(1-\tau)(1-\nu)A_{t+1}k_{t+1}^\alpha l_{t+1}^\nu \int_0^\infty z_{t+1}^\alpha d\Phi(z_{t+1}) - \beta\xi^F \\
&+ \beta q_{t+1}(1-(1-\tau)\delta)k_{t+1}\left[\xi_{t+1}^{Ke}\int_0^{z_{t+1}^*} z_{t+1}d\Phi(z_{t+1}) + \int_{z_{t+1}^*}^{+\infty} z_{t+1}d\Phi(z_{t+1})\right] \\
&+ \lambda_{t+1}\Big\{(1-\tau)(1-\nu)A_t(z_tk_t)^\alpha l_t^\nu - \xi^F - (1+(1-\tau)c_t)b_t + q_t(1-(1-\tau)\delta)z_tk_t \\
&+ \beta[1-\Phi(z_{t+1}^*)](1+c_{t+1})b_{t+1} + \beta(1-\tau)(1-\nu)A_{t+1}k_{t+1}^\alpha l_{t+1}^\nu \int_0^{z_{t+1}^*} z_{t+1}^\alpha d\Phi(z_{t+1}) \\
&+ \beta\xi_{t+1}^{Ke}q_{t+1}(1-(1-\tau)\delta)k_{t+1}\int_0^{z_{t+1}^*} z_{t+1}d\Phi(z_{t+1}) - \beta\Phi(z_{t+1}^*)\xi^F - q_tk_{t+1}\Big\} \qquad (17)
\end{aligned}
$$

Formulating the problem this way emphasizes the two financial frictions (departure from X). First, debt is beneficial to the firm because of the tax-deductibility of the coupon payment. Second, since $\xi_{t+1}^{Ke} < 1$, undepreciated capital is more valuable to the firm than to the creditor. Without these two frictions, the problem would boil down to maximizing the firm's expected cash flow of operation at $t+1$ over the non-default range of z_{t+1}:

$$
\begin{aligned}
&\beta(1-\nu)A_{t+1}k_{t+1}^\alpha l_{t+1}^\nu \int_{z_{t+1}^*}^{+\infty} z_{t+1}^\alpha d\Phi(z_{t+1}) + \beta q_{t+1}(1-\delta)k_{t+1}\int_{z_{t+1}^*}^{+\infty} z_{t+1}d\Phi(z_{t+1}) \\
&- \beta[1-\Phi(z_{t+1}^*)][\xi^F + (1+c_{t+1})b_{t+1}] \qquad (18)
\end{aligned}
$$

5.9 Model predictions and analysis

The firm's problem can be intuitively analyzed as a problem of value-maximization under a budget constraint. The budget constraint has a positive slope, since more borrowing (higher b_{t+1}) allows more investment (higher k_{t+1}). Ignoring the budget constraint, the firm's value is increasing in k_{t+1} and decreasing in b_{t+1}. Hence, the isovalue curves also have positive slopes. The firm aims to achieve the (b_{t+1}, k_{t+1}) combination with the lowest possible b_{t+1} and the highest possible k_{t+1} while remaining below or on the budget constraint. Firms of different types have budget constraints with different slopes. Since we assume $\xi^{KA} > \xi^{KB}$, the financial constraint is looser for A and A- firms than for B and B+ firms, everything else equal (that is, the value of their debt Q_t is higher, everything else equal). As a result, A firms have steeper constraints: a given increase in b_{t+1} allows them a larger increase in k_{t+1} (see Figure 9a). A- and B+ firms are in between, having a positive probability of falling in either category of restructuring recovery rates at $t + 1$.



(a) Budget constraints

(b) Isovalue curves

Figure 9: Constraints and isovalue curves for different firm types

Firms of different types also have different isovalue curves. The debt of higher-rated firms is more valuable to creditors, which increases the firm's cash flow for a given value of debt. The isovalue curves on Figure 9b all represent the same value $v_t = \bar{v}$. For higher-rated firms, a given level of debt is associated with a lower value of capital to reach the same $\bar{v}$. Lower-rated firms require higher k_{t+1} to reach the same value, making it less likely to satisfy the budget constraint. Put differently, a given combination of (b_{t+1}, k_{t+1}) yields lower value to lower-rated firms.

Following an expansionary monetary policy shock, all firms' budget constraint is loosened (becomes steeper). At the same time, the firms' debt is more valuable due to the lower probability of default and downgrade. Hence, a lower level of k_{t+1} is required to reach the same $\bar{v}$ (for a given b_{t+1}). This allows firms to reach a higher value while satisfying the budget constraint. Figure 10 shows the budget constraint and tangent isovalue curves (with and without the monetary policy shock) at the optimum point for each type of firm. $A-$ $(B+)$ firms react more strongly to the shock than A (B) firms. Because the effect of the change in probability of upgrade and downgrade affects only plus and minus firms, they have additional incentives to increase debt and investment. As a result, they are more affected by the shock. For the given calibration (see Appendix), the increases in k_{t+1}, b_{t+1}, and leverage for each type of firm are detailed in Table 6.

Firm type	A	$A-$	$B+$	B
% increase in b_{t+1}	23.35	25.33	23.86	19.19
% increase in k_{t+1}	8.68	9.13	6.93	5.28
Increase in leverage (% pts)	5.5	5.8	5.0	3.9

Table 6: Responses to monetary policy shock (easing)

The change in incentives can be analyzed in more details by looking at the slope of the

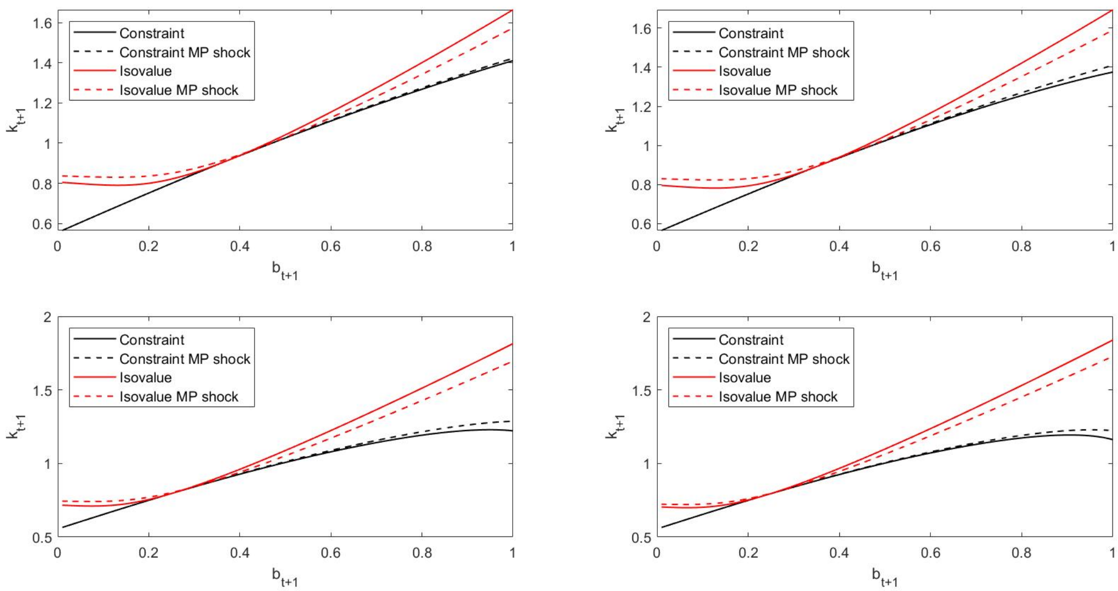


Figure 10: Optimal choices for four types of firms (with and without MP shock)

isovalue curves:

$$\frac{dk_{t+1}}{db_{t+1}} = -\frac{\text{marginal value of } b_{t+1}}{\text{marginal value of } k_{t+1}}$$

The marginal value of b_{t+1} can be expressed as

$$\begin{aligned} &\underbrace{\beta[1-\Phi(z^*_{t+1})]\tau c_{t+1}}_{\text{mv1}} + \underbrace{\beta q_{t+1}(1-(1-\tau)\delta)k_{t+1}\int_0^{z^*_{t+1}} z_{t+1} d\Phi(z_{t+1}) \frac{\partial \xi^{Ke}_{t+1}}{\partial b_{t+1}}}_{\text{mv2}} \\ &- \underbrace{\beta\phi(z^*_{t+1})\frac{\partial z^*_{t+1}}{\partial b_{t+1}}\left[\tau c_{t+1} b_{t+1} + (1-\xi^{Ke}_{t+1})q_{t+1}(1-(1-\tau)\delta)k_{t+1}z^*_{t+1}\right]}_{\text{mv3}} \end{aligned} \tag{19}$$

Figure 11 plots the three elements of the marginal value of additional debt with and without an easing monetary policy shock for each type of firms.The first term is positive and reflects the tax-deductibility of the coupon payment. For high levels of debt (given k_{t+1}), the probability of default is very high and this term goes to zero. This element is lower during easing, since the coupon rate c_{t+1} is lower. It affects all firm types similarly. The second term is zero for A and B firms, and negative for $A-$ and $B+$ firms (since $\frac{\partial \xi^{Ke}_{t+1}}{\partial b_{t+1}} \leq 0$). It reflects the decrease (increase) in the probability of being upgraded (downgraded) for an additional dollar of debt. During easing, A- firms benefit the most. They are less likely to be downgraded, so that additional debt is less costly. The third element is also negative and reflects the higher probability of default that comes with higher debt. Since the recovery rate friction $(1 - \xi^{Ke}_{t+1})$ is decreased during easing, this element decreases most for plus and minus firms during easing. Overall, during easing, the marginal value of debt increases the most for plus and minus firms.

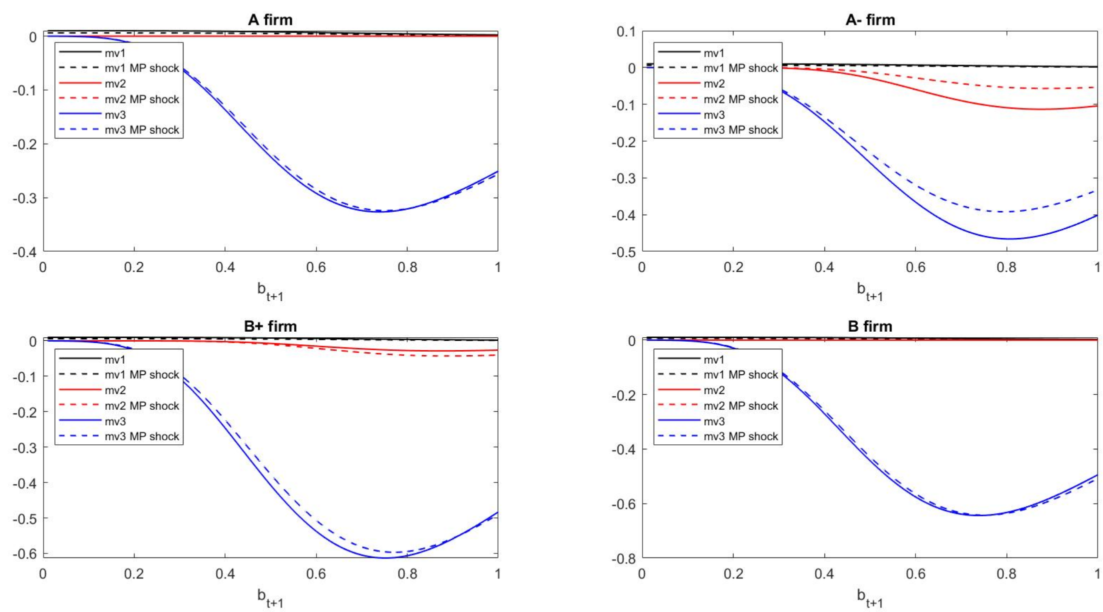


Figure 11: Marginal value of b_{t+1}

The marginal value of k_{t+1} can be expressed as

$$
\begin{aligned}
&-\underbrace{q_t}_{\text{mv1}}+\underbrace{\beta(1-\tau)(1-\nu)\alpha A_{t+1}k_{t+1}^{\alpha-1}l_{t+1}^{\nu}\int_0^{+\infty}z_{t+1}^{\alpha}d\Phi(z_{t+1})}_{\text{mv2}}\\
&+\underbrace{\beta q_{t+1}(1-(1-\tau)\delta)\left[\left(\xi_{t+1}^{Ke}+k_{t+1}\frac{\partial\xi_{t+1}^{Ke}}{\partial k_{t+1}}\right)\int_0^{z_{t+1}^*}d\Phi(z_{t+1})+\int_{z_{t+1}^*}^{+\infty}z_{t+1}d\Phi(z_{t+1})\right]}_{\text{mv3}}\\
&-\underbrace{\beta\phi(z_{t+1}^*)[\tau c_{t+1}b_{t+1}+(1-\xi_{t+1}^{Ke})q_{t+1}(1-(1-\tau)\delta)z_{t+1}^*k_{t+1}]\frac{\partial z_{t+1}^*}{\partial k_{t+1}}}_{\text{mv4}}
\end{aligned}
\tag{20}
$$

Figure 12 contains the four different elements of the marginal value of k_{t+1}. The first element represents the cost of acquiring new capital q_t this is constant and unaffected by the shock or firm type. The second element is the increase in production at $t+1$. Because of diminishing marginal product of capital ($\alpha < 1$) this is decreasing in k_{t+1} and identical across firm types and monetary policy choices. The third element captures the increase in undepreciated capital at the end of $t+1$ that results from additional k_{t+1}. If $\xi_{t+1}^{K} = 1$, the undepreciated capital is either the firm's or the creditors' (if default) assets, and would be independent of firm type and monetary policy. However, because of the friction caused by partial restructuring recovery rates, the capital is worth less for creditors. During monetary policy easing, downgrading (upgrading) is less (more) likely, the capital becomes more valuable for plus and minus firms. The fourth element reflects the effect of k_{t+1} on the probability of default. It is positive but non-monotonic since it follows the shape of the log-normal probability density function $\phi(z_{t+1}^*)$. Default matters only via the frictions: the tax-deductibility of the coupon, and partial restructuring recovery rates. During easing, the coupon rate c_{t+1} decreases, so that tax deductibility is less valuable. $A-$ and $B+$ firms are additionally affected because of the smaller friction of restructuring recovery rates: ξ_{t+1}^{Ke} increases for these two types of firms only. Overall, whether plus and minus firms' marginal value of capital is more or less affected than mid firms depends on whether the third or fourth element dominates. To have the third element dominates, the effect of monetary policy shock on credit rating change probability (that is, on $\tilde{p}_d$ and $\tilde{p}_u$) must be sufficiently large.

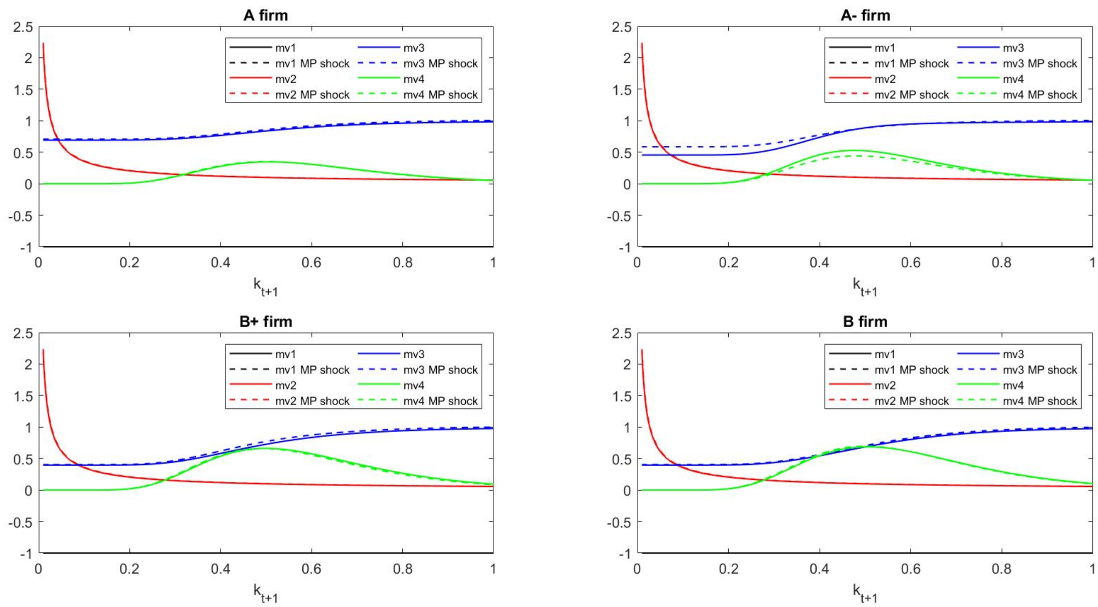


Figure 12: Marginal value of k_{t+1}

6 Conclusion

We identify a new and unexplored channel through which credit ratings affect firm outcomes. To the best of our knowledge, this is the first paper to look at the effects of monetary policy on firm debt issuance and investment by exploring the heterogeneity in credit risk exposure exclusively due to the risk of being upgraded or downgraded. We show that monetary policy shocks can alter the responsiveness of firms facing this friction independently of other financial frictions identified by the literature. While certain papers have used credit ratings as a proxy for default risk, or focused on the differential responsiveness for high-rated (for example, above A) firms, ours is the first to emphasize that the threat of a letter change makes firms more sensitive to unexpected changes in interest rates, regardless of the level of credit risk.

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7 Appendix - Calibration

The calibration of the model is summarized in Table A.1. The income share of capital α is calibrated to 0.21 and that of labor, ν, to 0.64. The depreciation rate δ is set for a quarterly economy to 0.025. The fixed cost ξ^F is set to 0.4. The discount factor β is set to 0.95, on the lower side to have sufficient room to have it increased or decreased during monetary policy shocks. The tax rate τ is set to 20% and the coupon rate to $(1/\beta) - 1$. The restructuring recovery rates ξ^A and ξ^B are set to 0.7 and 0.4, respectively. The standard deviation σ_K of the normal distribution of $\log z_t$ is set to 0.35. the credit rating change parameters $\tilde{p}_d$ and $\tilde{p}_u$ are set to 0.8 and 0.2, respectively. The remaining variables variables q_t, q_{t+1}, l_t, l_{t+1}, A_t, A_{t+1}, z_t, k_t are all set to 1. b_t is set to 0.3.

α	ν	δ	ξ^F	β	τ	c_t	ξ^A	ξ^B	σ_K	$\tilde{p}_d$	$\tilde{p}_u$
0.21	0.64	0.025	0.4	0.95	0.20	$(1/\beta) - 1$	0.7	0.4	0.35	0.8	0.2

Table A.1: Calibration