Monetary Policy Shocks, Financial Frictions, and Investment

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Abstract

This paper studies the level response of high and low credit quality firms to expansionary monetary shocks. By employing Jordà's (2005) panel local projection method, I find that following an expansionary shock high credit quality firms increase their fixed capital while the low credit quality firms reduce it. Firms' inventory and sales also respond to the shock similar to the investment across these two types of firms. In addition, their financing behavior is also different: after an expansionary shock hits, the high credit quality firms raise funds through equity while the low credit quality firms are unable to issue equity or debt. To explain these results, I build a simple model with two types of firms: financially constrained firms and unconstrained ones. The constrained firms face a trade-off in allocating their limited funds to wage payment and investment, while the unconstrained firms can finance their financial needs freely. The increase in wages following an expansionary shock forces constrained firms to cut their investment and, because of having less collateral, reduce their debt.

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1 Introduction

Investment is one of the most volatile components of GDP. Empirical studies have shown that investment is highly responsive to monetary policy shock (Christiano, Eichenbaum and Evans (2005)) and thus an important variable for monetary authorities to consider. Having a better understanding of firms' investment decisions and the heterogeneous effects of monetary shocks can provide valuable intuition for policymakers. In this paper, I study the role of financial frictions in the response of a firm's investment decision to monetary policy shock. Specifically, by employing the local projection method introduced by Jordà (2005), I estimate the level effect of expansionary shocks on the investment of high and low credit quality firms along a medium-term horizon.

The baseline empirical results are not consistent with what the financial accelerator literature would suggest. The financial accelerator literature shows that the financially constrained firms are the ones that benefit the most from expansionary shocks and are also hit the hardest by contractionary shocks. In contrast, Ottonello and Winberry (2018) finds that the firms with a larger distance to default, lower leverage, and higher credit rating are more responsive to the shocks. What their analysis does not show, however, is whether or not firms with a closer distance to default are going to expand after the expansionary shock hits. This paper, with the purpose of analyzing the role of financial frictions in the transmission of monetary shocks, focuses mostly on the level response of firms to the shock and not just their relative response.

In order to identify firms that are affected by financial frictions, I use the S&P's long-term issuer credit rating and group low credit quality firms as financially constrained and the high credit quality firms as unconstrained. I find that the high credit quality firms are the ones that expand after an expansionary monetary shock hits the economy. On the other hand, the low credit quality firms are the ones that contract. This pattern exists in various dimensions of firms' activities besides the investment, such as sales and inventory. The other difference between these two groups of firms is how their financing behavior through equity and debt gets affected by the shocks. The high credit quality firms can reduce their equity payout and raise funds, while the changes in the equity of low credit quality firms are not statistically different from zero. In addition to that, low credit quality firms reduce their debt, while the response of high credit quality ones is not significant.

In order to explain these results, I build a model with two types of firms: financially constrained firms and unconstrained ones. The financially constrained firms, similar to Jermann and Quadrini's (2012) model, face a working capital and a collateral constraint. The working capital constraint requires firms to finance their expenditures on investment, wage payment, and debt repayments at the beginning of each period and prior to the realization of their revenues. The collateral constraint limits the access of firms to external funds and makes them decide how to allocate the funds between wage payment and investment in capital goods. The collateral constraint means that the firm cannot raise funds more than the value of the collateral that can be liquidated in the event of default. In an expansion, where unconstrained firms can freely fund their wage payment and investment good purchases, the wages will rise as there is an increase in labor demand. In this situation, the constrained firms have to cut their investment if they want to maintain the previous level of employment and not decrease their labor force drastically in response to shock. As a result of the investment cut, financially constrained firms will have less amount of capital to use as collateral, and therefore have to reduce their amount of debt.

Based on this model, I show that the aggregate effect of the monetary shock depends on the share of financially constrained firms in the economy; The larger their share, the smaller the impact of the shock. Although this share is exogenous in the model, the comparative statics analysis can provide some hints on the state dependency of monetary policy. Assuming that more firms could face financial constraints during recessions, this simple model explains why monetary policy can be less effective during a recession.

The rest of the paper is organized as follows: Section 2 reviews the related literature. In section 3, I present the empirical evidence. In section 4, I discuss the model that explains the empirical results and in section 5 I conclude.

2 Literature Review

This paper is related to two major strands of the literature. The first one is the papers that employ the financial accelerator mechanism to show how small shocks can have a large and persistent effect on the economy. One of the most notable papers in this literature is Bernanke, Gertler and Gilchrist (1999). According to their explanation, firms face an external finance premium due to the existence of agency problems like asymmetric information. Since the external finance premium has an inverse relationship with the net worth of the firm, an expansionary shock can decrease the external finance premium by increasing the firm's net worth. Consequently, the interest rate that the firm has to pay for the external funds goes down more than the reduction of the nominal interest rate in the economy, creating large real effects. Cooley and Quadrini (2006) also use financial frictions as an amplification mechanism for monetary policy shocks. In another theoretical work, Kiyotaki and Moore (1997) construct a model in which firms face a collateral constraint, and a shock to technology and income distribution can have a possible long-lasting effect on the economy.

The empirical studies such as Gertler and Gilchrist (1994), Kashyap, Lamont and Stein (1994), and Oliner and Rudebusch (1996) support the idea of the financial accelerator mechanism. Gertler and Gilchrist (1994) studies the response of sales, inventories, and short-term debt of small and large firms following a tightening monetary policy. They find that small firms account for the larger share of manufacturing decline in a recession induced by a monetary shock. They observe that all three variables have a larger contraction for smaller firms. They argue that firm size is a reasonable measure of a firm's access to credit markets. Therefore, the credit-constrained firms will contract more following a contractionary shock.[1] In a similar study, Oliner and Rudebusch (1996) finds that investment is more sensitive to internal funds during monetary stringency for small firms but not for large firms. Kashyap, Lamont and Stein (1994) study the inventory investment of firms during the recession of 1981-1982, which is believed to be caused by a tightening monetary policy. They find that bank-dependent firms that do not have access to the bond market and also lack large liquid

[1] The idea that small firms are affected more by shocks only because of being financially constrained has been challenged in Crouzet and Mehrotra (2020).

asset reserves are the ones that cut their inventories more during the recession.[2]

The other strand of the literature studies the heterogeneous response of firms to monetary shock across different dimensions such as age, size, liquid asset reserves, debt, etc. One of the recent papers which is highly related to this paper is Ottonello and Winberry (2018). They study the heterogeneous response to the shock across three different proxies of default risk: Leverage, Distance to Default, and having credit rating above A from S&P's. They show that for all these three measures, low-risk firms turn out to be more responsive to the monetary shocks. In order to explain these results, they provide a heterogeneous New Keynesian model with financial frictions. In their setup, both high-risk and low-risk firms expand following an expansionary shock. However, the high-risk firms face an upward-sloping marginal cost curve for investment that dampens their response. As mentioned earlier, I focus on the level response of the low and high credit quality firms and empirically show low credit quality firms contract in a monetary expansion. For robustness check, I also group firms based on their distance to default and find that firms closer to default contract in an expansion caused by monetary policy.

The other similar and related paper to mine is Cloyne et al. (2019), in which they use firm age and dividend payout as a proxy to identify the firms that are financially constrained. They find that following a contractionary shock, younger firms, whether they pay dividends or not, contract more relative to the older firms. The older firms in their sample also contract. I, in contrast, use the S&P's credit rating as a proxy to identify the financially constrained firms. I group the high credit quality firms, firms with A- and higher ratings, as unconstrained and low credit quality firms, firms with BB+ rating or lower, as financially constrained. The financing behavior of these two groups of firms falls in line with the definitions of financial constraints elaborated in Farre-mensa and Ljungqvist (2016). In section B.5, I analyze the role of age in deriving the baseline results. I find that even after controlling for age, the baseline response of these two groups of firms is qualitatively preserved. For another robustness check, as mentioned earlier, I use the naive distance to default measure defined in Bharath and Shumway (2008) to include bank-dependent firms without access to the bond

[2]The firms that are not bank-dependent have access to the bond market besides having the option of borrowing from banks. Thus, they are not affected by financial frictions as much as bank-dependent firms.

market in my analysis. The constrained and unconstrained firms grouped by distance to default respond to shock in the same way as firms grouped by S&P's credit rating.

Other papers that study the heterogeneous effects of monetary shock are Crouzet and Mehrotra (2020), Jeenas (2018), and Ippolito, Ozdagli and Perez-Orive (2018). Crouzet and Mehrotra (2020) explore the role of firm size over the business cycle. In particular, they find large firms to be less responsive to monetary shocks relative to small firms. However, they argue that firm size is not a good proxy of financial constraints, and therefore, they propose a new explanation for the role of size in deriving the response of small and large firms. In section B.6, I make sure that firm size is not deriving the baseline results of this paper. Jeenas (2018) studies the role of liquid assets on a firm's balance sheet. He finds that firms with less liquid assets on hand are affected more by the shock and does not find explanatory power for leverage. Ippolito, Ozdagli and Perez-Orive (2018) study the floating rate debt channel and find that firms and especially the financially constrained ones that have more flexible rate debts are more sensitive to monetary shocks.

3 Empirical Evidence

3.1 Data Description

The firm-level data used in the empirical analysis comes from Compustat and CRSP. Compustat provides detailed quarterly balance sheet data for public firms, and CRSP provides daily stock price data needed for calculating the distance to default measure in section B.3. The rich set of variables from the firm's balance sheet allows us to control for factors that might affect the estimations.[3] The main variable of interest in this paper is capital investment. Instead of directly using lumpy measures of investment available in the Compustat, I follow the literature on using the change in the book value of a firm's tangible capital stock as its investment. Other variables that I study to evaluate the firm's performance are inventory, sale, total debt, and equity.

Since the goal of this paper is to study the role of financial frictions in the transmission

[3]However, the absence of non-public firms in the dataset is a downside of Compustat.

of monetary shock, I need to identify the firms that are facing frictions. Unlike most of the literature, I use S&P's long-term issuer credit rating to identify financially constrained firms. High credit quality firms, firms with A- rating or higher, which I also call *investment-grade* firms, are grouped as firms that are not affected by financial frictions. On the other hand, the low credit quality firms, firms with BB+ rating or lower, which I also call *junk-rated* firms, are grouped as financially constrained.[4] The behavior of firms grouped based on this criteria is consistent with the behavior of a financially constrained firm following a monetary shock: the investment-grade firms can raise funds through issuing new equity, while the junk-rated firms cannot.

As mentioned earlier, financial friction is not observed directly in the dataset, and thus, using proxies to identify the financial constraint is inevitable. Many different proxies are used in the literature for that purpose: firm size (e.g., Gertler and Gilchrist (1994)), age (e.g., Cloyne et al. (2019)), paying out dividend (e.g., Fazzari et al. (1988)), having a credit rating (e.g., Kashyap, Lamont and Stein (1994)), or a linear combination of size, age, or leverage (e.g., Kaplan-Zingales, Whited-Wu, and Hadlock-Pierce indices). Farre-mensa and Ljungqvist (2016), however, show that none of the mentioned proxies measure the financial constraints. They find that firms that are deemed to be financially constrained based on those measures can borrow following an exogenous change in their need for funds. They test two new proxies for financial constraints and find public firms with closer distance to default (DD) and privately owned firms to be financially constrained based on their definition. Although I use the S&P's credit rating to identify the financially constrained firms, we can show that the credit rating has a high correlation with the DD measure. In fact, I check the robustness of the baseline results by employing DD to identify the financial constraints in section B.3, finding that the baseline results stay the same qualitatively. Using DD also helps to resolve the issue of not including the bank-dependent firms without bond rating in the baseline regressions.

Table 1 provides summary statistics of firm characteristics across two groups of firms. The investment-grade firms are, on average, bigger and have lower leverage relative to junk-

[4]Throughout this paper, I use "investment-grade", "high credit quality" and "financially unconstrained" interchangeably. Same applies to "junk rated", "low credit quality" and "financially constrained".

Table 1: Investment-grade vs. Junk-rated firms

		Size	Lev.	Liq.	$\Delta log(k_{it})$	$\Delta log(invt_{it})$	$\Delta log(sale_{it})$
Mean	Investment-grade	\$16870.72	0.251	0.062	0.88%	0.74%	1.27%
	Junk-rated	\$2237.94	0.517	0.075	0.91%	0.79%	1.35%
Median	Investment-grade	\$7330.49	0.247	0.034	0.39%	0.77%	1.30%
	Junk-rated	\$971.05	0.470	0.034	-0.13%	0.57%	1.45%
St. dev.	Investment-grade	\$26994.00	0.118	0.075	4.44%	12.78%	14.15%
	Junk-rated	\$4889.54	0.295	0.097	7.53%	15.83%	21.02%

Notes: Blue represents the investment-grade firms and orange the junk-rated. Size is measured as book assets in millions of 2012 real dollars. The outliers for leverage (lev.) and liquid asset ratio (liq.) are dropped at 0.99 cutoff, and for the growth variables at 0.01 and 0.99 cutoffs.

rated firms while they have almost the same liquid asset on hand. Their average one-period growth in fixed capital, inventory, and sales are almost the same. In appendix A, I explain in detail how the sample is constructed.

Another variable crucial for conducting the analysis is the monetary shock. I use the monetary shocks series generated by Romer and Romer (2004) and extended by Coibion and Gorodnichenko (2012) to cover the period until 2008. Romer and Romer (2004) identify monetary policy shocks as changes to the intended Federal Funds rate that is not predictable by the economic information in the Federal Reserve's Greenbook forecasts. To transform the monthly series to quarterly, I simply sum over shocks within each quarter. In order to check the robustness of the results of the baseline model, I also use high frequency identified monetary shocks in appendix B.1.

3.2 Regression Model

The baseline empirical model to study the effect of monetary shock on high and low credit quality firms is as follows:

$$\Delta_h \log\left(y_{i,t+h}\right) = f_{i,h} + q_{t+h} + Trend + \Theta_h' W_{i,t-1} + \sum_{j=1}^{4} \Omega_{h,j}' Y_{t-j} \\ + \left(\beta_h + \gamma_h^- \varepsilon_t^- + \gamma_h^+ \varepsilon_t^+\right) \times \mathbb{1}_{i \notin \mathcal{I}_{t-1}} + \left(\tilde{\beta}_h + \tilde{\gamma}_h^- \varepsilon_t^- + \tilde{\gamma}_h^+ \varepsilon_t^+\right) \times \mathbb{1}_{i \in \mathcal{I}_{t-1}} + u_{i,h,t+h} \tag{1}$$

This local projection model estimates the cumulated effect of monetary shock on $y_{i,t}$ after h period. The dependent variable is the change in the logarithm of the variable of interest between period $t-1$ and $t+h$. On the right hand side, I control for firm-level fixed effect $f_{i,h}$, quarterly dummies q_{t+h} to take out seasonal effects, and a linear $Trend$. $W_{i,t}$ denotes a vector of firm-level variables that contains log(size), sales growth, Tobin's q, cash flow, capital share, leverage, and liquid asset ratio. I also control for lags of aggregate variables for four quarters included in Y_t. These variables are inflation, GDP growth, unemployment rate, and excess bond premium. $\mathcal{I}_t$ is the set of investment-grade firms at time t. $\mathbb{1}_{i \in \mathcal{I}_{t-1}}$ is an indicator that equals one when firm i is an investment-grade firm at time $t-1$ and equals zero otherwise. Firm-level and aggregate control variables are measured at least one period before the shock to ensure that those variables are exogenous to the shock.

The monetary policy shock is normalized so that one standard deviation expansionary shock (27 basis points change in federal fund rate (APR)) equals 1. I relax the assumption of symmetric effect for monetary shocks during expansion and contraction and control for positive and negative shocks. Some empirical findings suggest that the effects of monetary shock during tightening and easing periods are not symmetric. For example, Oliner and Rudebusch (1996) finds that internal funds do matter for small firms following a monetary tightening while there is no significant link between internal funds and investment during expansions. This asymmetric effect is also consistent with early theoretical works on credit channels of monetary policy (e.g., Gertler and Hubbard (1988), Bernanke and Gertler (1989)). Recent empirical and theoretical studies like Tenreyro and Thwaites (2016) and Vavra (2014) also argue that the real effect of monetary policy is smaller during the recession.

The parameters of interest are the coefficients of monetary shocks which estimate the average level effect of shock across two groups of firms. γ_h^+ and $\tilde{\gamma}_h^+$ compare the level response of investment-grade and junk-rated firms to an expansionary shock respectively. Likewise γ_h^- and $\tilde{\gamma}_h^-$ compare the level response of the two groups to contractionary shock. Figure

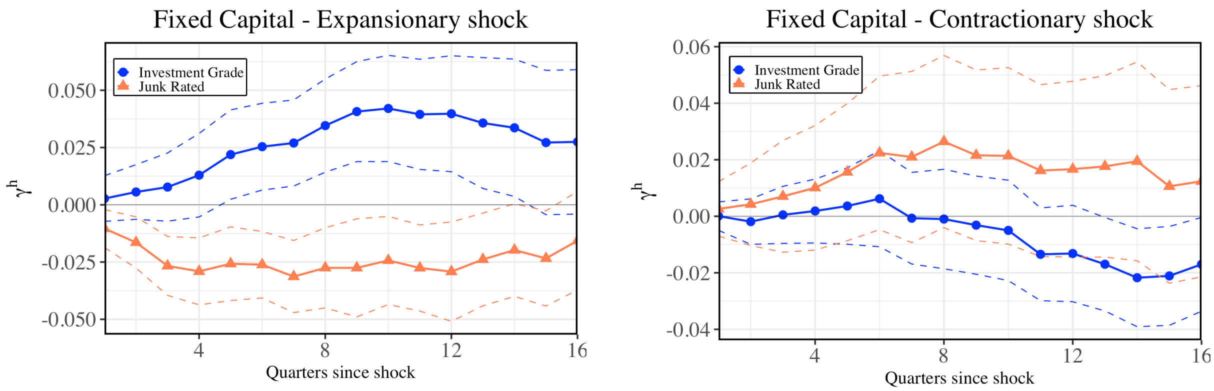

Figure 1: The level effect of one s.d. monetary shock on fixed capital

Notes: The point estimates and the 95% confidence interval for γ_h by estimating specification 1, with $y_{i,t+h} = k_{i,t+h}$. Standard deviations are two-way clustered across both firms and time dimensions.

1 shows the effect of monetary shocks on the investment of firms across the groups. The left panel shows the level effect of expansionary shock. Following a one standard deviation expansionary shock, the fixed capital of investment-grade firms expands by around 3.4 % at its maximum. In contrast, the fixed capital of junk-rated firms contracts by 2.7%. Although high and low credit firms respond to expansionary shock distinctly, the difference between the response of these two groups is not statistically significant following a contractionary shock. The right panel shows that the junk-rated firms tend to expand after a contractionary shock hits. However, the estimates are not statistically significant. Also, the investment-grade firms do not respond to shocks for almost ten quarters and then decrease their fixed capital. Based on the fact that the response of firms across two groups is not different during contractions, in the rest of the paper, I focus on expansionary monetary shocks.[5]

Inventory and sales are the two other variables used as dependent variables in the baseline regression specification 1 to examine how firms perform following an expansionary monetary shock. Figure 2 shows the impulse response functions. Investment-grade firms increase their inventory by almost 5% while the junk-rated ones reduce their inventory by 7.5 %. Investment-grade firms also increase their sale by 4 percent. In contrast, the sale of the

[5]The difference between expansions and contractions might simply be driven by not having enough observations for contractionary shocks during the period of analysis.

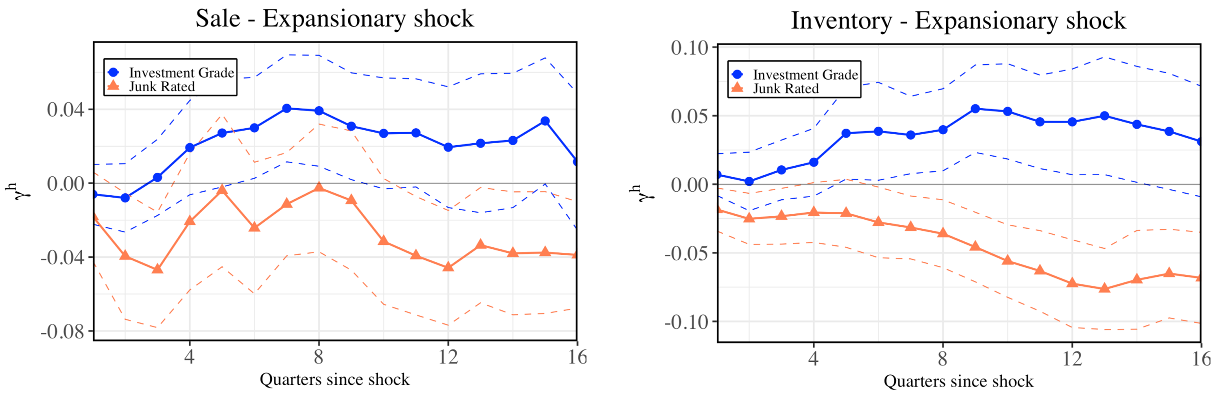

Figure 2: The level effect of one s.d. monetary shock on inventory and sale

*Notes:*The point estimates and the 95% confidence interval for γ_h by estimating specification 1, with $sale_{i,t+h}$ and $invt_{i,t+h}$ as $y_{i,t+h}$. Standard deviations are two-way clustered across both firms and time dimensions.

junk-rated firms goes down after the expansionary shock hits. However, the estimations are not statistically significant for all horizons.

I also study the financing behavior of firms following an expansionary shock. I follow Fama and French (2005) in defining the equity of firms as total stockholder's equity minus retained earnings. The change in the equity then measures the net issuance of equity (issue minus repurchase of equity). Since this definition of equity does not include the dividend payout, I adjust the measure by subtracting the dividend paid during the period of interest from equity. I call this new measure adjusted equity that captures the net payments to the firm's owners. The dependent variable of regression model 1 will be $\frac{S_{t+h}-S_{t-1}-\sum_{i=0}^{h} div_{t+i}}{S_{t-1}}$ instead of $\Delta_h log(y_{i,t+h})$.

Figure 3 shows how firms' equity and debt financing get affected by shocks. As it is shown in the left panel, investment-grade firms are able to raise funds by decreasing their net equity issuance and dividend payments, while junk-rated firms are not. It is consistent with the fact that financially constrained firms would face more difficulty in raising external funds, and therefore, not as able as unconstrained firms in meeting their financial needs. The right panel shows how the total debt of firms changes following an expansionary shock. Investment-grade firms increase their total debt, even though the estimates are not statistically different from

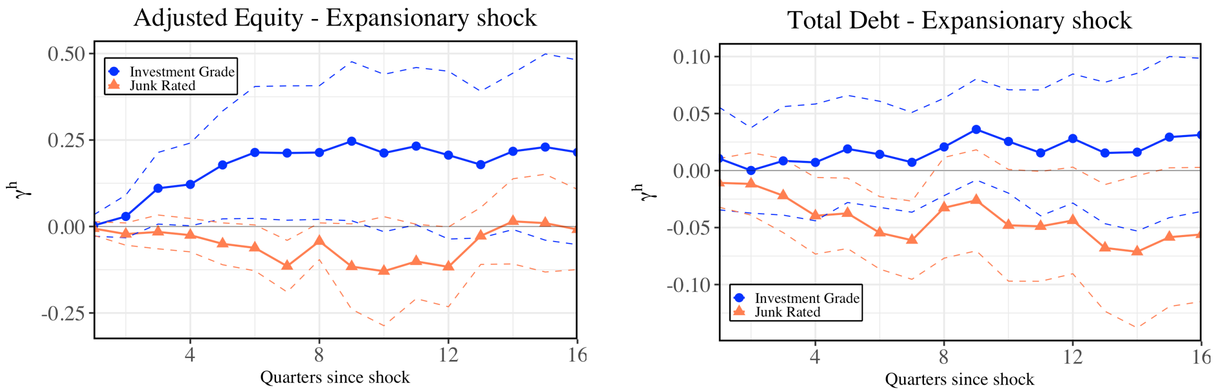

Figure 3: The level effect of one s.d. monetary shock on adjusted equity and total debt

Notes: The point estimates and the 95% confidence interval for γ_h by estimating specification 1, with $y_{i,t+h} = debt_{i,t+h}$. For adjusted equity, I use $\frac{S_{t+h}-S_{t-1}-\sum_{i=0}^{h} div_{t+i}}{S_{t-1}}$ as dependent variable in equation 1. Standard deviations are two-way clustered across both firms and time dimensions.

zero on any horizon.[6] On the other hand, the junk-rated firms reduce the amount of total debt they owe. To summarize, the high credit quality firms that are deemed to be financially unconstrained can raise funds through equity and debt, while the low credit quality firms which are believed to be constrained are not able to raise fund. These findings would help us in explaining the possible mechanism that is behind the empirical results.

4 Model

In this section, I provide a simple model to explain the empirical results. The model has two types of firms: Financially constrained firms and unconstrained ones. The constrained firms in the model are similar to the Jermann and Quadrini (2012). These firms face a working capital constraint and need to use debt and equity to finance it while simultaneously facing a collateral constraint. On the other hand, unconstrained firms can raise funds freely through equity consistent with the empirical findings. The difference in firms' access to external funds is able to generate the central empirical evidence showed in section 3: the investment-grade

[6]In appendix B.7, I show that the long-term debt of investment-grade firms increases, and it is statistically significant.

firms increase their fixed capital following an expansionary shock while the junk-rated firms reduce it.

4.1 Financially Constrained Firms

As mentioned earlier, I follow Jermann and Quadrini (2012) with some modifications to model constrained firms. There is a continuum of constrained firms in the $[0, \alpha_s]$ interval, with a production function $F(k_t^{jr}, n_t^{jr}) = y_t^{jr} = (k_t^{jr})^{\alpha}(n_t^{jr})^{1-\alpha}$. Where y_t^{jr} is the intermediate good produced by firm, k_t^{jr} is the level of fixed capital owned by firm at time t chosen at period $t-1$, and n_t^{jr} is the period t labor input chosen at period t. At the beginning of each period, and after the realization of shock, firms need to raise funds to finance their working capital. It is because the revenue of firms is realized at the end of the period. They use intraperiod loan l_t and intertemporal liabilities B_{t+1} for this purpose. The working capital constraint that firm faces is as follows:

$$\frac{B_{t+1}}{P_t R_t} + l_t = w_t n_t^{jr} + i_t^{jr} + \frac{B_t}{P_t} + \frac{\gamma_p}{2}(\frac{p_t^{jr}}{p_{t-1}^{jr}} - 1)^2 y_t \tag{2}$$

Where w_t is the real wage, n_t^{jr} is labor demand, i_t^{jr} is investment, and y_t is output. $\frac{\gamma_p}{2}(\frac{p_t^{jr}}{p_{t-1}^{jr}} - 1)^2 y_t$ is the Rotemberg's adjustment cost that firm has to pay if decides to change its price. $R_t = 1 + (1-\tau)r_t$ is the effective gross interest rate, where τ is the tax advantage and r_t is the nominal interest rate. Using the firm's budget constraint

$$i_t^{jr} + \frac{B_t}{P_t} + w_t n_t^{jr} + d_t^{jr} + \frac{\gamma_p}{2}(\frac{p_t^{jr}}{p_{,t-1}^{jr}} - 1)^2 y_t = \frac{p_t^{jr} y_t^{jr}}{P_t} + \frac{B_{t+1}}{P_t R_t} \tag{3}$$

We can verify that $l_t = \frac{p_t^{jr} y_t^{jr}}{P_t} - d_t^{jr}$, where d_t^{jr} is firms equity payout to its shareholders. When d_t^{jr} becomes negative, it means that the firm is raising fund from its shareholders to pay back its intraperiod loans. The firm's ability to borrow intra- and intertemporally is bounded by a collateral constraint. This constraint exists due to the possibility of default. The firm decides to default after the realization of its revenue but before the repayment of the intraperiod loan l_t. In the event of default, the lender would be able to recover some part of the debt by liquidating the firm's fixed capital. Assuming the liquidation value of fixed capital is ξk_{t+1}, the collateral constraint will be

$$\xi k_{t+1}^{jr} \geq l_t + \frac{B_{t+1}}{P_t(1+r_t)} \tag{4}$$

It means that firm's total debt $l_t + \frac{B_{t+1}}{P_t(1+r_t)}$ cannot be greater than the liquidated value of the collateral ξk_{t+1}^{jr}. Firm's objective is to maximize its expected lifetime equity payout $\mathbb{E}_t \sum_{j=0}^{\infty} m_{t+j} d_{t+j}$, where m_{t+j} is the stochastic discount factor.

Firms set their price in monopolistic competition and determine the demand for their product. They need to make sure that they employ enough input to meet the demands. In other words, they face a production constraint as follows:

$$(k_t^{jr})^{\alpha}(n_t^{jr})^{1-\alpha} \geq (\frac{p_t^{jr}}{P_t})^{-\theta} y_t \tag{5}$$

The right hand side comes from the maximization problem of final good producer which I explain in section 4.3. Firms accumulate capital according to

$$k_{t+1}^{jr} \leq (1-\delta)k_t^{jr} + \big(1 - \rho^{jr}(\frac{i_t^{jr}}{i_{t-1}^{jr}} - 1)^2\big) i_t^{jr} \tag{6}$$

$\rho_{jr}(\frac{i_t^{jr}}{i_{t-1}^{jr}} - 1)^2 i_t^{jr}$ is the adjustment cost of the investment which is common in New Keynesian models. Combining equation 4 and 2 gives us an equation that would help explain the mechanism:[7]

$$(\xi - 1)k_{t+1}^{jr} = w_t n_t^{jr} - (1-\delta)k_t^{jr} + \frac{B_{t+1}}{P_t}(\frac{1}{1+r_t} - \frac{1}{R_t}) + \frac{B_t}{P_t} + \frac{\gamma_p}{2}(\frac{p_t^{jr}}{p_{t-1}^{jr}} - 1)^2 y_t \tag{7}$$

Assume an expansionary shock hits the economy, and wages rise due to an increase in demand for labor. $(1-\delta)k_t^{jr}$ is predetermined, and therefore, does not change. Since $\xi < 1$, the only case that k_{t+1}^{jr} goes down following the shock is when the right-hand side goes up. It will happen if the firm chooses not to cut its labor. In addition, the inflation rate in the economy should not be too big so that the real value of the firm's debt $\frac{B_t}{P_t}$ does not diminish significantly. Section 4.7 shows that the calibrated model can generate these results.

[7]It is easy to show that equation 4 binds in a deterministic steady-state. Following an expansionary shock, the constraint becomes even tighter as firms try to raise funds to finance their working capital.

4.2 Unconstrained Firms

There is a continuum of firms in the $[\alpha_s, 1]$ interval that are not financially constrained. Unlike constrained firms, these firms do not face any working capital or collateral constraint. The assumption here is that firms can freely issue equity at any point of time to meet their financial needs. Similar to constrained firms, Unconstrained ones maximize their expected equity payout $\mathbb{E}_t \sum_{j=0}^{\infty} \beta^t m_{t+j} d_{t=j}^{ig}$ by choosing $d_t^{ig}, n_t^{ig}, p_t^{ig}, k_{t+1}^{ig}, i_t^{ig}$ subject to following constraints:

$$i_t^{ig} + w_t n_t^{ig} + d_t^{ig} + \frac{\gamma_p}{2}(\frac{p_t^{ig}}{p_{,t-1}^{ig}} - 1)^2 y_t = \frac{p_t^{ig} y_t^{ig}}{P_t} \tag{8}$$

$$(k_t^{ig})^{\alpha}(n_t^{ig})^{1-\alpha} \geq (\frac{p_t^{ig}}{P_t})^{-\theta} y_t \tag{9}$$

$$k_{t+1}^{ig} \leq (1-\delta)k_t^{ig} + \big(1 - \rho^{ig}(\frac{i_t^{ig}}{i_{t-1}^{ig}} - 1)^2\big) i_t^{ig} \tag{10}$$

4.3 Final Good Producers

The final good producer buys intermediate goods, aggregates them in a CES fashion, and sells the final good y_t to the households at a competitive price P_t. The maximization problem of the final good producer is as follows:

$$\max_{y_t^{ig}, y_t^{jr}, y_t} P_t y_t - \int_0^{\alpha_s} p_t^{jr} y_{i,t}^{jr} d_i - \int_{\alpha_s}^1 p_t^{ig} y_{i,t}^{ig} d_i \tag{11}$$

Subject to:

$$y_t = \left((\int_0^{\alpha_s} y_{i,t}^{jr} d_i)^{\frac{\theta-1}{\theta}} + (\int_{\alpha_s}^1 y_{i,t}^{ig} d_i)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{12}$$

The first order conditions with respect to y_t^{jr} and y_t^{ig} give rise to the demand functions for the constrained and unconstrained firms: $y_t^x = (\frac{p_t^x}{P_t})^{-\theta} y_t$.[8]. Substituting the demand function in equation 12 gives the aggregate price:

[8]Since firms in each categories behave the same, I have dropped the subscript i.

$$P_t = \left(\alpha_s^{\frac{\theta-1}{\theta}} (p_t^{jr})^{1-\theta} + (1-\alpha_s)^{\frac{\theta-1}{\theta}} (p_t^{ig})^{1-\theta} \right)^{\frac{1}{1-\theta}} \tag{13}$$

4.4 Households

The model is populated with a standard representative household. Households consume final good c_t and supply labor n_t to firms. They live forever and maximize their expected lifetime utility from consuming final goods and leisure $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \big(ln(c_t) + \psi\ ln(1-n_t)\big)$. Households are the shareholders of the firms. They also hold non-contingent bonds issued by constrained firms. Their budget constraint is as follows:

$$c_t + \sum_{x \in \{ig,jr\}} p_t^x s_t^x + \frac{B_{t+1}}{P_t(1+r_t)} \leq w_t n_t + \sum_{x \in \{ig,jr\}} s_{t-1}^x (p_t^x + d_t^x) + \frac{B_t}{P_t} + T_t \tag{14}$$

Where p_t^x is the price of the share s_t^x of the investment-grade and junk-rated firms, d_t^x is the equity payout paid by firms to the households, B_t is a one-period non-contingent nominal bond, r_t is the nominal interest rate, P_t is the price of the final good, w_t is the real wage paid to the worker, and T_t is the real transfer paid to the household in period t. First-order conditions with respect to s_t^x give

$$p_t^x = \beta \mathbb{E}_t \frac{c_t}{c_{t+1}} (d_{t+1}^x + p_{t+1}^x) \tag{15}$$

Using forward substitution, equation 15 results in $p_t^x = \mathbb{E}_t \sum_{j=1}^{\infty} \beta^j \frac{c_t}{c_{t+j}} d_{t+j}$. In general equilibrium and because firms are owned by the households, the stochastic discount factor would be given by $m_{t+j} = \beta^j \frac{c_t}{c_{t+j}}$.

4.5 Monetary Policy and General Equilibrium

In order to close the model, we need to specify the monetary policy. I assume that monetary authority responds gradually to inflation and an output gap by following a Taylor rule:

$$\frac{1+r_t}{1+\bar{r}} = \left(\frac{1+r_{t-1}}{1+\bar{r}} \right)^{\rho_r} \left((\frac{\pi_t}{\bar{\pi}})^{\nu_\pi} (\frac{y_t}{\bar{y}})^{\nu_y} \right)^{1-\rho_r} \exp(\epsilon_t^m) \tag{16}$$

Where $\pi_t = \frac{P_t}{P_{t-1}}$. Also $\bar{r}, \bar{\pi}$, and $\bar{y}$ are the steady state values for interest rate, inflation and output. ϵ_t^m is the i.i.d monetary shock with the normal distribution $\epsilon_t^m \sim \mathcal{N}(0, \sigma_m)$.

In the equilibrium, following market clearing condition also holds:

$$n_t = \alpha_s n_t^{jr} + (1 - \alpha_s) n_t^{ig} \tag{17}$$

$$y_t = c_t + \alpha_s i_t^{jr} + (1 - \alpha_s) i_t^{ig} + adj_t \tag{18}$$

Where adj_t is the sum of all adjustment costs in the model. In appendix C, I list all the first-order conditions needed for computing the equilibrium.

4.6 Parameterization

Steady-state targets: Following Jermann and Quadrini (2012), I set $\beta = 0.9825$ which implies an annual return of 7.32 % on holding shares. The utility parameter ψ is set to 1.2007 to have labor equal 0.3 in steady state. The Cobb-Douglas parameter α is set to 0.36, the depreciation rate δ is 0.025, and the tax wedge τ is 0.35. I set the elasticity of substitution over intermediate goods $\theta = 3.8$, as in Bernard et al. (2003), which implies a steady state markup of 35.7% . The share of junk-rated firms α_s is set to 0.26 using observation between $1990 - 2008$ from Compustat and solving $\frac{\alpha_s k^{JR}}{(1-\alpha_s)k^{IG}} = \frac{1}{T}\sum_t(\frac{\sum_i k_{i,t}^{JR}}{\sum_i k_{i,t}^{IG}})$, where t is time and i denotes a firm. The liquidation parameter is set to $\xi = 0.4552$ to target total debt to total asset ratio of junk-rated firms in Compustat.[9]

Non-steady-state targets: The parameters that do not have any steady-state equivalent are estimated by targeting the empirical impulse response functions (IRF) of fixed capital of both investment-grade and junk-rated firms. These parameters determine the adjustment cost for investment, price setting, and the monetary policy rule. To estimate $\boldsymbol{\gamma} \equiv [\rho^{ig}, \rho^{jr}, \gamma_p, \rho_r, \nu_\pi, \nu_y]$, I follow Christiano, Eichenbaum and Evans (2005) in minimizing the distance of model IRFs from the empirical IRFs. $\boldsymbol{\gamma}$ will be the solution of

$$\min_{\boldsymbol{\gamma}} [\hat{\boldsymbol{\Psi}} - \boldsymbol{\Psi}(\boldsymbol{\gamma})]' \boldsymbol{V}^{-1} [\hat{\boldsymbol{\Psi}} - \boldsymbol{\Psi}(\boldsymbol{\gamma})] \tag{19}$$

where $\boldsymbol{\Psi}(\boldsymbol{\gamma})$ denotes the mapping from $\boldsymbol{\gamma}$ to model IRF , $\hat{\boldsymbol{\Psi}}$ is the empirical IRF, and $\boldsymbol{V}$ is the diagonal matrix with variances of the empirical IRFs on its diagonals.

[9] Both total debt and total asset measures are net of liquid assets.

Table 2: Parametrization

Description	**parameter**	**Source**
Discount factor	$\beta = 0.9825$	JQ(2012)
Tax advantage	$\tau = 0.35$	JQ(2012)
Production technology	$\alpha = 0.36$	JQ(2012)
Depreciation rate	$\delta = 0.025$	JQ(2012)
Elasticity of substitution	$\theta = 3.8$	Bernard et al. (2003)
Utility parameter	$\psi = 1.2007$	
Liquidation parameter	$\xi = 0.4552$	
Share of JR firms	$\alpha_s = 0.26$	
Investment adjustment cost	$\rho^{ig} = 0.0026$	
Investment adjustment cost	$\rho^{jr} = 0.6531$	
Price adjustment cost	$\gamma_p = 300$	
Monetary policy	$\rho_r = 0.9964$	
Monetary policy	$\nu_\pi = 2.4994$	
Monetary policy	$\nu_y = 1.0$	

4.7 Impulse Response Functions

In this section, I provide the model IRFs to a one standard deviation expansionary monetary shock. The economy is in the steady-state and receives an unexpected shock to monetary policy $\epsilon_t^m = -0.0027$ (APR). The shock will be zero for the periods after, and IRFs show the perfect foresight transition path of the economy back to the steady-state. As it is shown in figure 4, the model IRF for junk-rated firms can perfectly fit the empirical IRFs. For the investment-grade firms, the IRFs are inside the 95% confidence interval for all periods except the first two.

Figure 5 presents the firm and aggregate level IRFs. Investment-grade firms raise funds through equity (by reducing their equity payout), hire more labor, and purchase more capital goods. Having increased the input required for production, they are capable of producing more and increasing their sale. On the other hand, Junk-rated firms do not raise any funds through equity. Their access to the debt market is also limited by collateral constraints. Therefore, they have to allocate their limited resources between two major parts of their expenditures: investment and wage payments. On impact, they cut their investment to prevent reducing their labor force and production drastically. Since their fixed capital di-

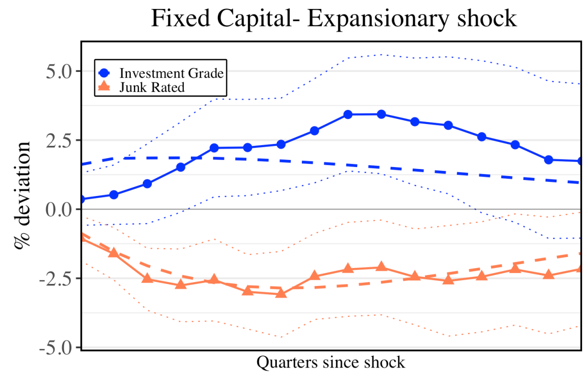

Figure 4: The model IRFs (dashed line) vs. the empirical IRFs following an expansionary shock

minishes due to a reduction of investment, they will have less collateral to offer to lenders and therefore have to cut their debt as well.

4.8 Aggregate Implication of Financial Friction

Here I present a comparative statics analysis of the aggregate effects of financial friction. Keeping all other parameters the same, I change $\alpha_s = 0.26$ to $\alpha_s = 0.50$ and examine the aggregate impact of a monetary shock in the economy. As shown in figure 6, in an economy with a larger share of junk-rated firms, the effect of monetary shock will be smaller. In this case, the output increases by 4.3%, labor by 6.7%, and investment by 23.2% on impact. While in the case with a smaller share of junk-rated firms, the output increases by 6.2%, labor by 9.7%, and investment by 35.8%. The on-impact response of consumption to the shock is almost the same for both cases. However, in an economy with a smaller share of junk-rated firms, the transition back to the steady-state is slower. These results suggest a dampening role for financial frictions in the economy rather than an amplifying one.

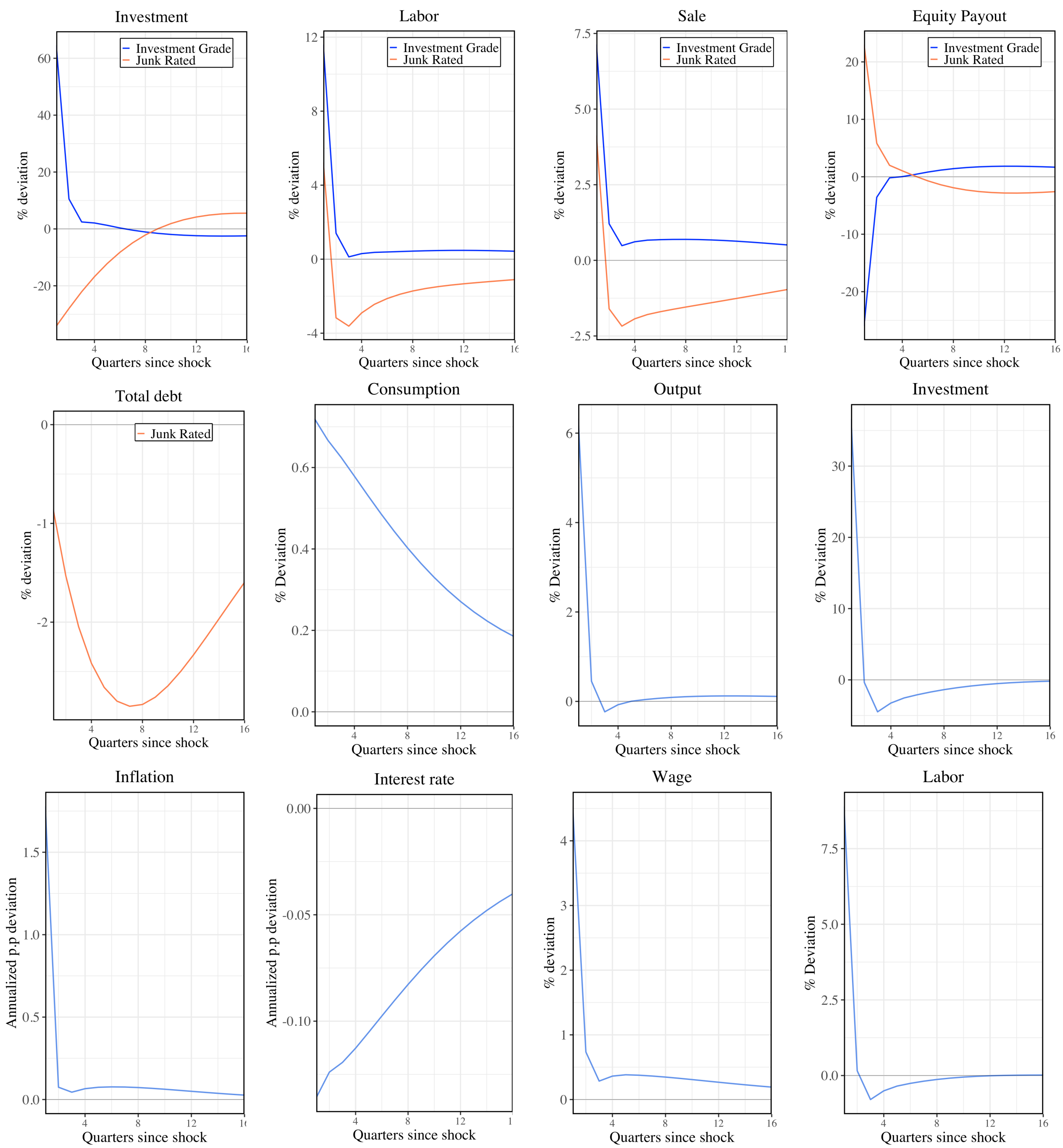

Figure 5: Model IRFs to expansionary monetary shock: firm level and aggregate variables

Notes: Figures without labels are the IRFs of aggregate variables.

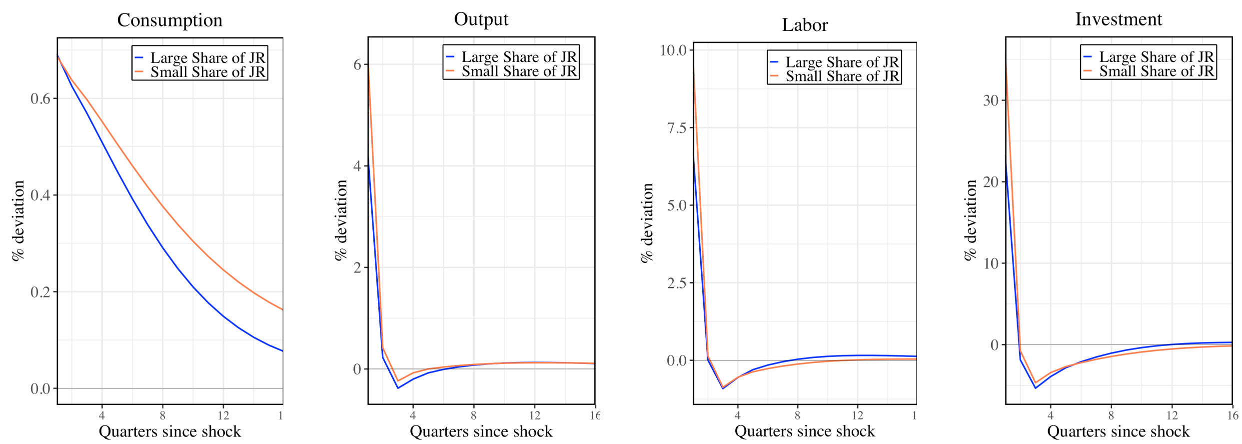

Figure 6: IRFs of aggregate variables to expansionary monetary shock: Large and small share of junk rated firms

Notes: Small share for junk-rated is when $\alpha_s = 0.26$ and large share is when $\alpha_s = 0.50$.

5 Conclusion

In this paper, I showed that low credit quality firms (junk-rated firms) reduce their investment following an expansionary shock while high credit quality firms (investment-grade firms) expand it. This pattern is also observed in the response of firms' inventory and sale to monetary shock. Consistent with the definitions of financial constraints, investment-grade firms can raise funds through equity by reducing their equity payout. In contrast, junk-rated firms cannot take advantage of the equity market. Moreover, they cut their total debt following the shock. To explain these empirical facts, I built a simple model with two types of firms: financially constrained and unconstrained. Constrained firms face working capital and collateral constraints. While their unconstrained counterparts are expanding following an expansionary shock, the constrained firms need to allocate their limited fund resources to wage payments. Since wages go up in an expansion, the constrained firms will have fewer resources and therefore are forced to cut their investment. These results suggest a dampening role for financial frictions rather than an amplifying one. Also, it emphasizes the fact that the junk-rated firms are not the ones that are benefiting from a surprise reduction of the policy rate.

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A Appendix: Sample Selection

A.1 Firm Level Data

Firm-level data comes from Compustat and CRSP. Following recent papers on the heterogeneous effect of monetary shocks on firms' investment like Jeenas (2018) and Ottonello and Winberry (2018), I focus on the period between 1990Q1 and 2007Q4. The observations during the financial crisis are omitted since I am interested in the effects of the conventional monetary policy. Excluding the data before 1990 also allows me to check the robustness of the results to high frequency identified monetary shocks that are available from 1990. The baseline result is broadly robust to including observations from 1985-1990. I exclude the following firms from my sample:

1. Firms that are incorporated outside US.
2. Firms in utilities (SIC codes 4900–4999), finance, insurance, and real estate (SIC codes 6000–6999), and public administration sector (SIC codes 9100–9999).
3. Observations with non-positive values for $ATQ_{i,t}$, $PPENTQ_{i,t}$, $PPEGTQ_{i,t}$, $SALEQ_{i,t}$, $INVTQ_{i,t}$, $PRCCQ_{i,t}$, and $CSHOQ_{i,t}$.
4. Observations with negative values for $DLCQ_{i,t}$, $DLTTQ_{i,t}$, and $CHEQ_{i,t}$.
5. Firms that have less than 40 observations in the sample, unless otherwise stated.

Also, When I run the regression model 1, I drop 1 percent of outlier observations at both tails of distribution for dependent variable $\Delta_h log(y_{i,t+h})$.

A.1.1 Dependent Variables:

1. *Fixed Capital:* I use the perpetual inventory method to construct the time series of fixed capital. This method is common in the literature and used in many papers such as Jeenas (2018), Ottonello and Winberry (2018), and Clementi and Palazzo (2019). The first observation for the fixed capital $k_{i,0}$ will be set as the earliest available value

for the $PPEGTQ_{i,t}$ (Property, Plant and Equipment (Gross)) in the dataset. Fixed capital for the following periods would be iteratively constructed from this equation:

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

where $k_{i,t}$ is the firm i's capital at the end of period t and $PPENTQ_{i,t}$ is the net value of Property, Plant and Equipment on firm's balance sheet. Before applying the perpetual inventory method, I deflate $PPENTQ_{i,t}$ and $PPEGTQ_{i,t}$ using the implied price index of gross value added in the U.S. non-farm business sector (BEA-NIPA Table 1.3.4 Line 3).

2. *Debt, Inventory, and Sale:* Total debt is the sum of short and long term debt ($DLCQ_{i,t}+DLTTQ_{i,t}$). The inventory is $INVTQ_{i,t}$ in Compustat and sale is $SALEQ_{i,t}$.

3. *Equity:* I follow Fama and French (2005) in defining Equity as Total Parent Stockholders' Equity ($SEQQ_{i,t}$) minus Retained Earnings ($REQ_{i,t}$). Since this definition of equity does not include the dividend payout, I adjust the measure by subtracting the amount of dividend paid ($CSHOQ_{i,t} \times DVPSXQ_{i,t}$) during the period of interest from equity. I call this new measure adjusted equity. Thus, the dependent variable in the baseline model 1 would be $\frac{S_{t+h}-S_{t-1}-\sum_{i=0}^{h} div_{t+i}}{S_{t-1}}$ instead of $\Delta_h log(y_{i,t+h})$. If an observation for the dividend is not available between two periods with available values for dividends, I interpolate the dividend value for that period linearly to avoid losing too many observations. Since this dependent variable is noisier than previous dependent variables because of being a ratio rather than a log difference, I exclude observations at 2.5% of both tails of the distribution.

A.1.2 Control Variables:

In the baseline regressions, I include following firm-level variables as controls:

1. *Size*: measured as firm's total assets ($ATQ_{i,t}$).

2. *Sales growth*: log difference of deflated value of sale ($SALEQ_{i,t}$) between period t and $t-4$.

3. *Cash flow ratio*: measured as the sum of Income Before Extraordinary Items ($IBQ_{i,t}$) and Total Depreciation and Amortization ($DPQ_{i,t}$) divided by firm's size $\left(\frac{IBQ_{i,t}+DPQ_{i,t}}{ATQ_{i,t}}\right)$.

4. *Leverage:* measured as sum of Debt in Current Liabilities ($DLCQ_{i,t}$) and Long-Term Debt ($DLTTQ_{i,t}$) divided by firm's size $\left(\frac{DLCQ_{i,t}+DLTTQ_{i,t}}{ATQ_{i,t}}\right)$. Outliers are dropped at 99% cutoff for each quarter.

5. *Liquid asset ratio:* measured as the ratio of Cash and Short-Term Investments ($CHEQ_{i,t}$) to firm's size $\left(\frac{CHEQ_{i,t}}{ATQ_{i,t}}\right)$. Outliers are dropped at 99% cutoff for each quarter.

6. *Capital share*: measured as the ratio of firm's fixed capital to its size.

7. *Tobin's q*: measured as the ratio of market to book value of assets. I follow Ottonello and Winberry (2018) and define the market value of asset as the book value ($ATQ_{i,t}$), plus the market value of common stock ($PRCCQ_{i,t} \times CSHOQ_{i,t}$), minus the book value of common stock ($CEQQ_{i,t}$), plus deferred taxes and investment tax credit ($TXDITCQ_{i,t}$) $\left(\frac{ATQ_{i,t}+PRCCQ_{i,t}CSHOQ_{i,t}-CEQQ_{i,t}+TXDITCQ_{i,t}}{ATQ_{i,t}}\right)$. The observations will be winsorized at 1% of each tail of the distribution.

A.2 S&P's Long-Term Issuer Credit Rating

These ratings are available at a monthly frequency. I define *Junk-Rated* firm as a firm with a rating equal to BB+ or lower for at least a month in a given quarter. The *Investment-Grade* firm, on the other hand, will be defined as a firm with an A- or above rating condition on not having BB+ or lower rating in the same quarter. I exclude firms with only BBB rating in a quarter from my sample, which are also known as investment-grade firms. It helps to have two sets of firms which are significantly different in terms of their credit ratings. The Baseline result is robust to also including BBB firms as investment-grades in the sample.

According to S&P's manuals, Prior to September 1, 1998, the rating is an "assessment of the creditworthiness of an obligor with respect to a senior or subordinated debt obligation". While After September 1, 1998, it is an "opinion of an issuer's overall creditworthiness" and not a specific type of debt. This issue might make the ratings not perfectly comparable before and after that time. However, in my analysis, I am interested in a set of rating categories (i.e., Junk Rated vs. Investment-Grade) and not a specific rating, and thus, this issue might be alleviated. In addition, excluding the firms with BBB ratings from the grouping procedures lowers the chance of misclassifying firms due to this change in definition.

A.3 Distance to Default

For a robustness check, I also group firms based on their Distance to Default (DD). To construct this variable, I use the formula in Bharath and Shumway (2008):

$$DtD = \frac{\log\left(\frac{E+D}{D}\right) + \left(r - 0.5\sigma_A^2\right)T}{\sigma_A\sqrt{T}}$$

E: Market capitalization

D: short-term debt + 0.5 $\times$ long-term debt

r: Trailing one year stock return

σ_A: Asset volatility

T: maturity = 1

In order to compute r and σ_A of the formula, I use the daily stock return data ($RET_{i,t}$) from CRSP. Based on the DD indicator, firms with zero debt will be at an infinite distance from defaulting. While having zero debt can also be a sign of financial constraint. I drop observations with zero debt from the sample to avoid this problem. I compute the median of DD among the observations within each period and categorize the firms with DD measure above the median as the investment-grade firms. The firms below the median will be grouped as junk-rated.

B Appendix: Robustness Checks

In this section, I discuss the robustness checks addressing some issues related to the baseline empirical regression and its results.

B.1 Other Types of Monetary Shocks

As a robustness check, I run the regression model 1 for fixed capital with three other shock series: the monetary shock in Gorodnichenko and Weber (2016) identified as a surprise in current federal funds futures rate, the shocks to the future path of monetary policy in Gürkaynak, Sack and Swanson (2005), and the shock series in Miranda-Agrippino and Ricco (2017) that controls for the information channel of monetary policy using Greenbook forecast revisions. Figure 7 shows that the results are broadly similar to the baseline estimations. Junk-rated firms contract following an expansionary shock, while the investment-grades expand. However, the confidence intervals are wider for Miranda-Agrippino and Ricco (2017) and Gorodnichenko and Weber (2016) series. Also, the response of investment-grade firms is more gradual.

B.2 Manufacturing vs. Non-Manufacturing Firms

Another concern regarding the IRFs is the possible compositional effect of sectors in each group of firms. Table 3 shows that manufacturing firms make up the largest portion of firms in both groups. Howes (2020) shows that manufacturing and non-manufacturing firms respond to shocks differently. He finds that a contractionary monetary shock causes firms in the manufacturing sector to expand while the non-manufacturing firms contract. I run the regression model 1 for two samples: a sample that includes only manufacturing firms and the one with only non-manufacturing firms. Figure 8 shows that baseline results are broadly robust.

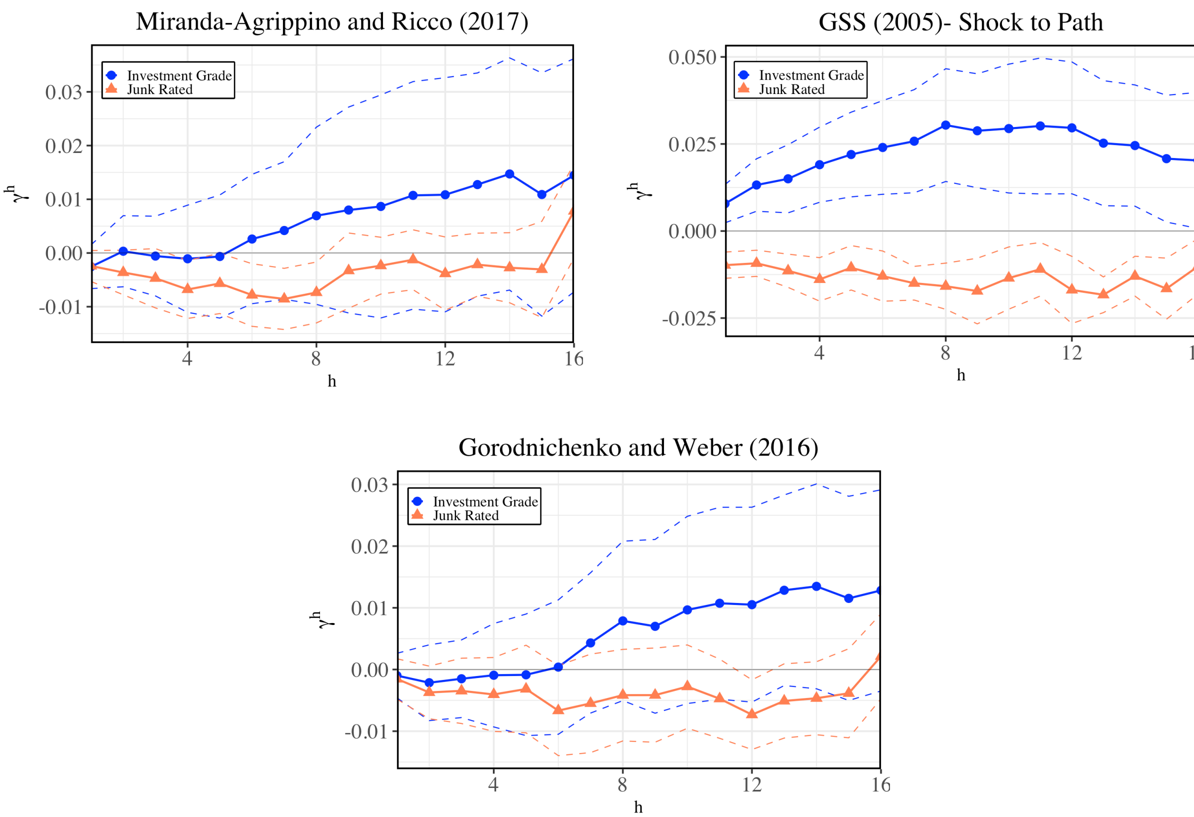


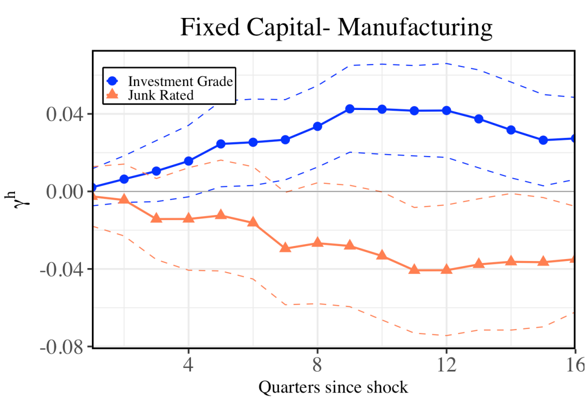
Figure 7: The level effect of different types of monetary shock on fixed capital

Notes: The point estimates and the 95% confidence interval for γ_h by estimating specification 1, with $k_{i,t+h}$ as $y_{i,t+h}$. Standard deviations are two-way clustered across both firms and time dimensions. The minimum number of observations for firms is decreased from 40 to 30 for Miranda-Agrippino and Ricco's (2017) shock series.

Table 3: Share of each sector in the sample condition on firm's type

	Investment Grade	Junk Rated
Agriculture	0.002	0.0038
Mining	0.038	0.066
Construction	0.0046	0.011
Manufacturing	0.583	0.461
Transportation	0.20	0.130
Wholesale	0.0333	0.041
Services	0.0333	0.041
Retail	0.077	0.121
Total	1	1

Notes: Total No. of observations is 50198



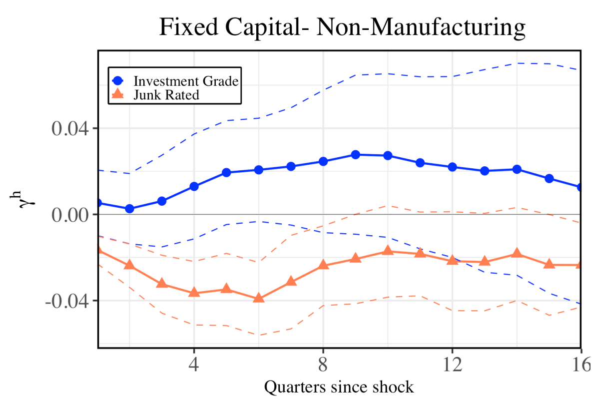


Figure 8: The level effect of one s.d. monetary shock on fixed capital for manufacturing and non-manufacturing firms

Notes: The point estimates and the 95% confidence interval for γ_h by estimating specification 1, with $k_{i,t+h}$ as $y_{i,t+h}$. Standard deviations are two-way clustered across both firms and time dimensions.

B.3 Grouping based on Distance to Default

n order to include firms without bond rating in the sample, I use the distance to default measure defined in A.3. The baseline results are robust to this way of identifying constrained firms as it is displayed in figure 9.

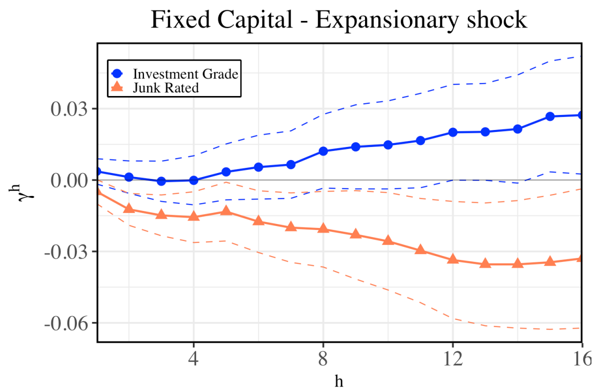


Figure 9: The level effect of one s.d. monetary shock on fixed capital

Notes: Grouping is based on distance to default. The point estimates and the 95% confidence interval for γ_h by estimating specification 1, with $k_{i,t+h}$ as $y_{i,t+h}$. Standard deviations are two-way clustered across both firms and time dimensions. Total no. of observations is 69300.

B.4 Heterogeneous Response to Shock

One concern regarding the baseline model 1 is the role of other firm-level characteristics in deriving the results. For example, junk-rated firms are, on average, smaller than investment-grade ones. Therefore, the observed difference in impulse responses is coming from the firm's size. One way to address this issue is by adding the interaction of firm-level controls and the shock to the regression as follows:[10]

$$\begin{aligned}\Delta_h \log\left(k_{i,t+h}\right) = f_{i,h} + q_{t+h} + Trend + \Theta_h' W_{i,t-1} + \sum_{j=1}^{4} \Omega_{h,j}' Y_{t-j} \\ + \Omega_h' W_{i,t-1}\varepsilon_t^m + \left(\beta_h + \gamma_h \varepsilon_t^m\right) \times \mathbb{1}_{i\in\mathcal{I}_{t-1}} + u_{i,h,t+h}\end{aligned} \tag{20}$$

[10] All variables of this specification are the same as the variables in model 1.

In this specification, the coefficient of the interaction term between monetary shock and investment-grade dummy γ_h captures the heterogeneous effect of the shock and not the level effect. A positive and statistically significant γ_h, shown in figure 10, means that the investment-grade firms increase their investment following an expansionary shock relative to junk-rated firms. In other words, even after controlling for all the firm-level interactions, the financial condition of the firms will still have explanatory power.

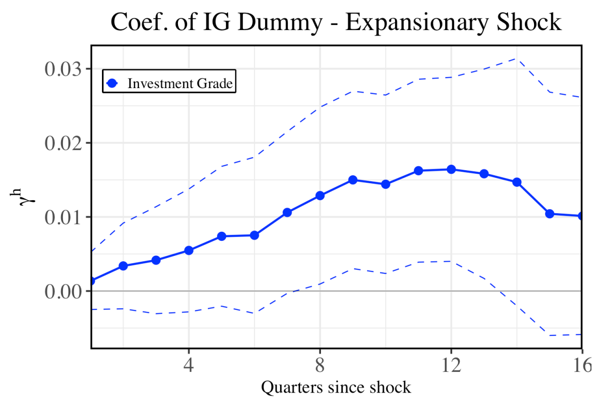


Figure 10: The relative effect of one s.d. monetary shock on fixed capital

Notes: The point estimates and the 95% confidence interval for γ_h by estimating specification 20, with $k_{i,t+h}$ as $y_{i,t+h}$. Standard deviations are two-way clustered across both firms and time dimensions.

B.5 Effect of Age

This section examines the role of age in the response of junk-rated and investment-grade firms. As mentioned earlier, Cloyne et al. (2019) use the firm's age as a proxy for financial constraints. Here I show that even after controlling for the firm's age the level response of investment-grade and junk-rated firms is broadly similar to the baseline results of model 1. I use the firm's age available on Jay R. Ritter's website and follow Cloyne et al. (2019) in defining young firms as firms that are 15 years old or younger. The rest of the firms in the sample are grouped as old. The new regression model is

$$\Delta_h \log\left(k_{i,t+h}\right) = f_{i,h} + q_{t+h} + Trend + \Theta_h' W_{i,t-1} + \sum_{j=1}^{4} \Omega_{h,j}' Y_{t-j}$$
$$+ \sum_{j \in \mathbb{J}} \left(\beta_h^j + \gamma_{j,h}^{+} \varepsilon_t^{+} + \gamma_{j,h}^{-} \varepsilon_t^{-}\right) \times \mathbb{1}_{i \in \mathcal{I}_{t-1}^{j}} + \left(\beta_h^a + \gamma_{a,h}^{+} \varepsilon_t^{+} + \gamma_{a,h}^{-} \varepsilon_t^{-}\right) \times \mathbb{1}_{i \in \mathcal{I}_{t-1}^{a}} + u_{i,h,t+h} \tag{21}$$

where $\mathbb{1}_{i \in \mathcal{I}_{t-1}^{a}}$ equals 1 if the firm i is a member of age group a in period $t-1$. Also $\mathbb{J} = \{\text{junk-rated}, \text{investment-grade}\}$.[11] We can easily calculate the level effect of shocks for young and old firms by adding up appropriate coefficients. Figure 11 displays the IRFs of investment-grade and junk-rated firms, condition on being young or old. The baseline results are broadly preserved. However, the confidence intervals are wider for young investment-grade firms, probably because of having fewer observations for this subgroup.

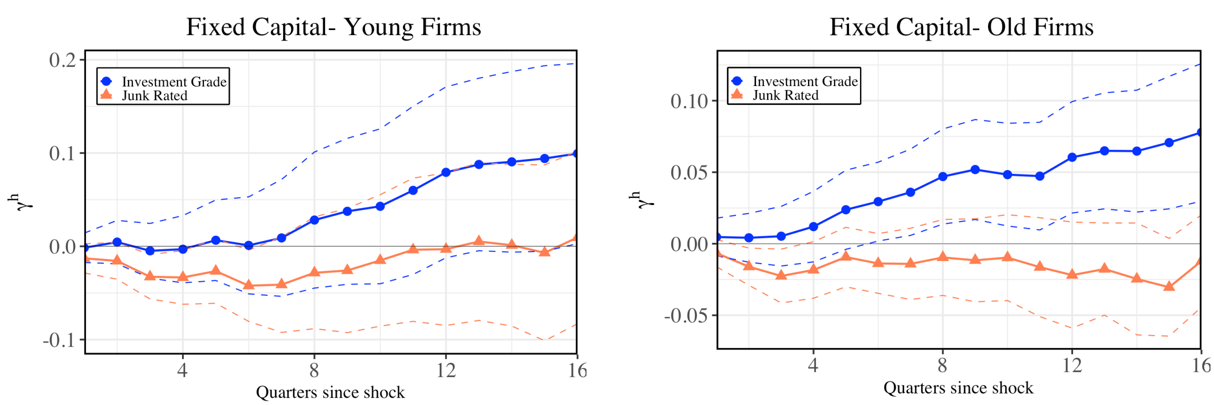


Figure 11: The level effect of one s.d. expansionary monetary shock on fixed capital for young and old firms

Notes: The point estimates and the 95% confidence interval for γ_h^{+} by estimating specification 21. Standard deviations are two-way clustered across both firms and time dimensions. The minimum number of observations for firms is decreased from 40 to 30.

B.6 Effect of Size

Similar to the exercise in previous section, we can make sure that firm's size is not deriving the results by including dummies for size. This time the dummies for size are constructed

[11] All other variables of this specification are the same as the variables in model 1.

by calculating the lower, middle, and upper tercile of firm's size. We can run the following regression

$$
\begin{aligned}
\Delta_h \log\left(k_{i,t+h}\right) = f_{i,h} + q_{t+h} + Trend + \Theta_h' W_{i,t-1} + \sum_{j=1}^{4} \Omega_{h,j}' Y_{t-j} \\
+ \sum_{j \in \mathbb{J}} \left(\beta_h^j + \gamma_h^j \varepsilon_t^m\right) \times \mathbb{1}_{i \in \mathcal{I}_{t-1}^j} + \sum_{l \in \mathbb{L}} \left(\beta_h^l + \gamma_h^l \varepsilon_t^m\right) \times \mathbb{1}_{i \in \mathcal{I}_{t-1}^l} + u_{i,h,t+h}
\end{aligned}
\tag{22}
$$

where $\mathbb{J}$ ={Junk rated, Investment grade} and $\mathbb{L}$ ={small, medium, large}. Figure 12 displays the results.

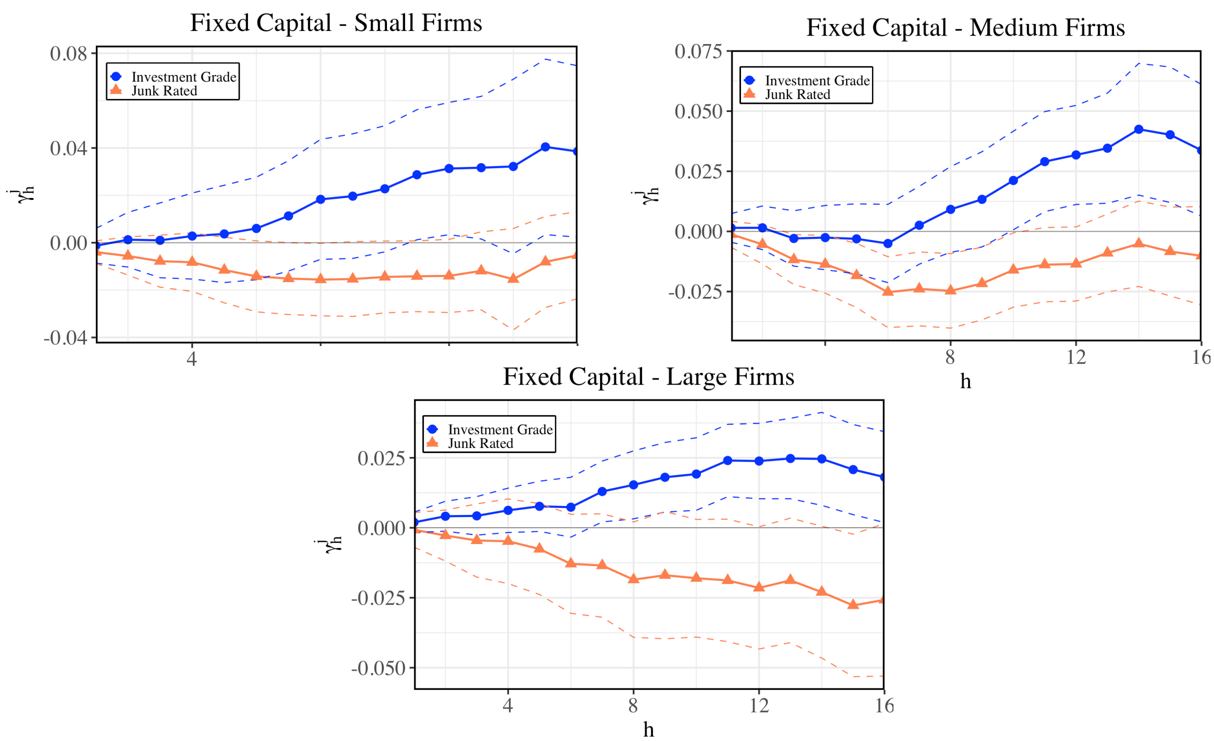


Figure 12: The level effect of one s.d. monetary shock on fixed capital for different firm size groups

Notes: The point estimates and the 95% confidence interval for γ_h by estimating specification 22. Standard deviations are two-way clustered across both firms and time dimensions. The minimum number of observations for firms is decreased from 40 to 30.

B.7 IRFs of Long-Term Debt

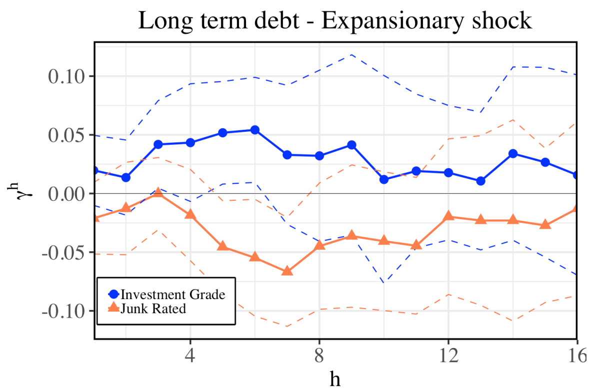


Figure 13: The level effect of one s.d. monetary shock on long-term debt

Notes: The point estimates and the 95% confidence interval for γ_h by estimating specification 1, with $DLTTQ_{i,t+h}$ as $y_{i,t+h}$. Standard deviations are two-way clustered across both firms and time dimensions.

C First-Order Conditions

C.1 Households:

$$\frac{\psi c_t}{1-n_t} = w_t \tag{C.1}$$

$$1 = \beta(1+r_t)\mathbb{E}_t \frac{c_t}{c_{t+1}} \frac{P_t}{P_{t+1}} \tag{C.2}$$

$$p_t^x = \mathbb{E}_t \frac{c_t}{c_{t+1}} (p_{t+1}^x + d_{t+1}^x) \tag{C.3}$$

C.2 Constrained Firms:

$\mu_t^{jr}, \gamma_t^{jr}, \phi_t^{jr}, \psi_t^{jr}, \lambda_t^{jr}$ are respectively the Lagrangian multipliers for equations 3, 4, 5, 6, and 2.

$$\begin{aligned}(1-\theta)\frac{\mu_t^{jr}+\lambda_t^{jr}}{P_t} + \theta\phi_t \frac{1}{p_t^{jr}} = (\mu_t^{jr}+\lambda_t^{jr})\gamma_p(\frac{p_t^{jr}}{p_{t-1}^{jr}}-1)\frac{1}{p_{t-1}^{jr}}(\frac{p_t^{jr}}{P_t})^{\theta} + \\ \mathbb{E}_t(\mu_{t+1}^{jr}+\lambda_{t+1}^{jr})\gamma_p(\frac{p_{t+1}^{jr}}{p_t^{jr}}-1)\frac{y_{t+1}}{y_t}(\frac{p_t^{jr}}{P_t})^{\theta}\frac{-p_{t+1}^{jr}}{(p_t^{jr})^2}\end{aligned} \tag{C.4}$$

$$(\mu_t^{jr}+\lambda_t^{jr})w_t = \phi_t^{jr} F_n(k_t^{jr}, n_t^{jr}) \tag{C.5}$$

$$\mu_t^{jr}+\lambda_t^{jr} = \psi_t^{jr}\big(1-\rho^{jr}-3\rho^{jr}(\frac{i_t^{jr}}{i_{t-1}^{jr}})^2 + 4\rho^{jr}\frac{i_t^{jr}}{i_{t-1}^{jr}}\big) + 2\rho^{jr}\mathbb{E}_t\phi_{t+1}^{jr}(\frac{i_{t+1}^{jr}}{i_t^{jr}})(\frac{i_{t+1}^{jr}}{i_t^{jr}}-1) \tag{C.6}$$

$$\frac{\mu_t^{jr}+\lambda_t^{jr}}{R_t} = \mathbb{E}_t \frac{\mu_{t+1}^{jr}+\lambda_{t+1}^{jr}}{\pi_{t+1}} + \frac{\gamma_t^{jr}}{1+r_t} \tag{C.7}$$

$$\xi\gamma_t^{jr} + \mathbb{E}_t(\phi_{t+1}^{jr}F_k\big(k_{t+1}^{jr}, n_{t+1}^{jr}) + (1-\delta)\psi_{t+1}^{jr}\big) = \psi_t^{jr} \tag{C.8}$$

$$\gamma_t^{jr} = \lambda_t^{jr} \tag{C.9}$$

$$\frac{\mu_{t+1}^{jr}}{\mu_t^{jr}} = \beta\frac{c_t}{c_{t+1}} \tag{C.10}$$

C.3 Unconstrained Firms:

$\mu_t^{ig}, \phi_t^{ig}, \psi_t^{ig}$ are respectively the Lagrangian multipliers for equations 8, 9, and 10.

$$\begin{aligned}(1-\theta)\frac{\mu_t^{ig}}{P_t} + \theta\phi_t^{ig}\frac{1}{p_t^{ig}} = \mu_t^{ig}\gamma_p(\frac{p_t^{jrig}}{p_{t-1}^{ig}}-1)\frac{1}{p_{t-1}^{ig}}(\frac{p_t^{ig}}{P_t})^{\theta} + \\ \mathbb{E}_t(\mu_{t+1}^{ig}+\lambda_{t+1}^{ig})\gamma_p(\frac{p_{t+1}^{ig}}{p_t^{ig}}-1)\frac{y_{t+1}}{y_t}(\frac{p_t^{ig}}{P_t})^{\theta}\frac{-p_{t+1}^{ig}}{(p_t^{ig})^2}\end{aligned} \tag{C.11}$$

$$\mu_t^{ig} w_t = \phi_t^{ig} F_n(k_t^{ig}, n_t^{ig}) \tag{C.12}$$

$$\mu_t^{ig} = \psi_t \big(1 - \rho^{ig} - 3\rho^{ig}(\frac{i_t^{ig}}{i_{t-1}^{ig}})^2 + 4\rho^{ig}\frac{i_t^{ig}}{i_{t-1}^{ig}}\big) + 2\rho^{ig}\mathbb{E}_t\phi_{t+1}(\frac{i_{t+1}^{ig}}{i_t^{ig}})(\frac{i_{t+1}^{ig}}{i_t^{ig}} - 1) \tag{C.13}$$

$$\frac{\mu_{t+1}^{ig}}{\mu_t^{ig}} = \beta\frac{c_t}{c_{t+1}} \tag{C.14}$$

$$\mathbb{E}_t(\phi_{t+1}^{ig} F_k\big(k_{t+1}^{ig}, n_{t+1}^{ig}) + (1-\delta)\psi_{t+1}^{ig}\big) = \psi_t^{ig} \tag{C.15}$$