Pushing Risky Firms on a String: Asymmetric Effects of Monetary Policy *

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Abstract

We show that financial frictions explain why monetary policy tightenings affect firms' borrowing and investment decisions more than monetary policy easings. We measure the severity of firms' financial frictions through their distance to default and show that proximity to default increases the responsiveness of firms' borrowing and investment decisions to contractionary monetary policy surprises but not to expansionary surprises. Moreover, a significant response of investment and borrowing to policy changes is only detected for firms with high risk of default and in response to contractionary shocks. These findings suggests that monetary policy acts like a string that can pull firms to curtail their investment but not push them to increase it. In aggregate, the transmission of monetary policy—and, in particular, of policy tightening—to the real economy depends on the severity of financial frictions for nonfinancial firms.

Keywords: Monetary policy, asymmetry, firm heterogeneity, investment, financial frictions

JEL Classification Codes: D22, D25, E22, E44, E52

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1 Introduction

Monetary policy tightening shocks tend to transmit more strongly into aggregate spending and employment than easing shocks, as shown in studies using aggregate time series data (Barnichon et al., 2017; Angrist et al., 2018; Debortoli et al., 2020; Jordà et al., 2020; Barnichon et al., 2022). At the same time, studies exploiting cross-sectional variation in firm-level data show that financial frictions significantly affect firms' response to monetary policy, although these studies do not distinguish between the effects of tightening and easing policy actions (Gertler and Gilchrist, 1994; Cloyne et al., 2018; Ottonello and Winberry, 2020). We contribute to this literature by showing that the differential effects of monetary policy tightening and easing on firm spending dynamics depend on the severity of firms' financial frictions, and that such frictions explain the asymmetric effects of monetary policy documented in the macro-econometric literature.

To test our hypothesis behind the asymmetric nature of the monetary policy transmission, we use firm-level data and exploit firms' heterogeneity with respect to the severity of their financial constraints to trace firms' differential response to accommodative and contractionary monetary policy shocks. We execute our analysis in a database covering the 1995-2021 period that combines quarterly Compustat data for U.S. firms with high-frequency monetary policy shocks around FOMC announcements from Miranda-Agrippino and Ricco (2021). We first show that the well-documented asymmetric effects of monetary policy on aggregate economic activity also occur in our sample: both investment and net corporate debt issuances respond more to interest rate increase surprises than to decreases.

Next, we show that financial constraints—proxied in our benchmark regressions by distance to default—increase the responsiveness of firm investment to contractionary shocks but do not affect the responsiveness to expansionary shocks. More specifically, we find that the capital stock of firms that are below the 25^{th} percentile of the distance to default distribution—i.e., the 25% riskiest firms that are closest to default—declines, on average, by about 5% three years after a one standard deviation *contractionary* monetary policy shock occurs. We find no significant response of the capital stock after the same contractionary shock in the less financially constrained group of firms, those above the 25^{th} percentile of distance to default. In response to *accommodative* monetary policy shocks, investment does not respond for either constrained or unconstrained firms. In sum, contractionary shocks "pull" financially constrained firms "with a string", while expansionary shocks resemble "pushing all firms with a string".

A similar pattern as the one found for investment is found for employment. As with investment, a statistically significant response of employment to policy changes is only detected for firms with high risk of default and in response to contractionary shocks. In all other cases, estimates are statistically insignificant at conventional levels. This result suggests that monetary policy, as for investment, is successful in reducing the workforce for risky firms, but is unable, on average, to increase employment with accommodative monetary policy.

For financial frictions to be an important driver of these differential responses of investment, it must be that firms' borrowing follows a similar pattern. To assess this, we explore the heterogeneous response of borrowing across firms with a differential degree of ex-ante default probabilities in response to tightening and loosening shocks. The results mirror those of investment: when monetary policy tightens unexpectedly, firms that are ex-ante already close to default strongly reduce their borrowing–suggesting they hit their borrowing constraint–,while the borrowing of safer firms does not respond to contractionary monetary policy. The magnitudes are similar than in the case of investment: total debt of the 25% most financially constrained firms declines, on average, by about 6% three years after a one standard deviation contractionary monetary policy shock. We again find that, in response to accommodative monetary policy shocks, borrowing does not respond for either constrained or unconstrained firms. Taken together, these results suggest that tighter monetary policy increases the severity of financial constraints for firms already facing constraints, preventing them from borrowing to finance their investment.

We address the presence of possible biases in our estimates in several ways. Our choice for our main proxy for financial constraints, firms' distance to default, is based on the measure proposed by Merton (1974) and Bharath and Shumway (2008). This measure is one of the only observable firm characteristics that has been shown to perform very well as a proxy of financial constraints. Farre-Mensa and Ljungqvist (2016) show that firms that are close to default behave as if they face difficulties increasing their leverage even when their incentives to lever up are strong. Moreover, it seems reasonable to assume that when monetary policy tightens, default risk increases for all firms, but especially for those firms already closer to default.[1] In addition, our results are robust to considering an alternative measure of financial constraints, net leverage, defined as total debt minus cash holdings over total assets. With regards to monetary policy shocks, our preferred measure is the one introduced by Miranda-Agrippino and Ricco (2021) that combines the use of high-frequency financial market surprises around key monetary policy announcements with a strategy to separately identify exogenous monetary policy shocks from shocks about new information from the Federal Reserve regarding the state of the economy. These monetary policy shocks can therefore be considered orthogonal to shocks to firms' investment opportunities. As a robustness check, we also confirm our results using the Jarociński and Karadi (2020) shocks, which are built using a different methodology to purge innovations to the information set about economic fundamentals. Finally, as further robustness of our analysis, we replicate and confirm the well-known results of Ottonello and Winberry (2020), who show that the investment of firms that are highly leveraged and closer to default react *less* to monetary policy shocks. We show that, under their exact specification and data sample, their result holds only for expansionary shocks and flips sign or is insignificant for contractionary shocks, consistent with our hypothesis and our earlier results.

Why do financial frictions drive this asymmetry? To address this question, we introduce and

[1] For instance, firms that are close to default may already ex-ante be more strongly incentivized to engage in risk-shifting behavior (Jensen and Meckling, 1976), which would be amplified by higher level of interest rates. Moreover, when firms proximity to default rises, it increases difficulties to raise equity on the equity markets, forcing them to tap private investment in public equity (Chaplinsky and Haushalter, 2010).

study a New Keynesian model with a standard capital structure optimization in the presence of financial frictions. In the model, default rates and borrowing costs are nonlinear with respect to changes in the monetary policy stance, responding strongly to contractionary monetary policy but only weakly to expansionary policy.[2] In turn, investment and hiring also respond in this nonlinear fashion.

Two main mechanisms are behind the asymmetry in the model. First, an increase in leverage induced by a monetary tightening induces an increase in defaults that is significantly higher than the size of the decrease in defaults that follows an equivalent decline in leverage (in absolute value) induced by a monetary easing. Second, because firms are able to adjust the stock of debt every period, but cannot commit to future leverage choices, in the presence of outstanding long-term debt shareholders will resist ex-post debt buybacks because repaying debt early, by reducing expected default costs, benefits existing debtholders at the shareholders' expense. This downward stickiness of outstanding debt results in much stronger effects on default rates, bond spreads, and investment following contractionary policy shocks than expansionary ones.[3]

The remainder of the paper is structured as follows. Section 2 reviews the literature. Section 3 explains the data we use. Section 4 describes the empirical strategy. Section 5 presents the empirical results. Section 6 introduces and analyzes the theoretical framework. Section 7 concludes.

2 Literature Review

A large empirical literature studies how firms' financial conditions affect their response to monetary policy. Monetary policy rates and credit spreads tend to comove (Gertler and Karadi, 2015; Gilchrist et al., 2015; Caldara and Herbst, 2019), and the comovement is significantly stronger for more financially distressed firms (Anderson and Cesa-Bianchi, 2020; Palazzo and Yamarthy, 2022). The sales, inventory, and debt of small financially distressed firms are more responsive to a monetary policy tightening (Gertler and Gilchrist, 1994; Caglio et al., 2021), perhaps because they have less flexibility to shift toward alternative forms of financing after banks contract their lending supply when monetary policy tightens (Becker and Ivashina, 2014).

The evidence on the role of heterogeneous firm financial conditions on the response of investment is mixed. Some studies show that more financially distressed public firms react less to (expansionary) monetary policy (Ottonello and Winberry, 2020), while others show this is not the case for small private firms (Caglio et al., 2021), for certain sample periods (Lakdawala and Moreland, 2021), and over longer horizons (Jeenas, 2019). Moreover, some authors argue that firm-level measures of financial distress are highly endogenous and capture other factors; for example, the effect of leverage on monetary policy sensitivity disappears when controlling for firm age and dividend-

[2]This hypothesis was advanced by (Stein, 2014)

[3]Additional nonlinear mechanisms might be at play. For example, higher interest rates introduce the possibility of credit rationing, a situation in which higher interest rates do not clear the credit market because, at such high rates, firms would default too often and there is excess demand for credit.

payer status (Cloyne et al., 2018). We contribute to this literature by reexamining this evidence separately for easing and tightening shocks and showing that this decomposition clarifies important controversies in this literature.

A smaller and more recent literature, shows in a macroeconomic time series context how monetary policy tightening shocks transmit more strongly into aggregate spending and employment than easing shocks (Barnichon et al., 2017; Angrist et al., 2018; Debortoli et al., 2020; Barnichon et al., 2022; Jordà et al., 2020).[4] Papers in this literature typically point to two mechanisms to explain this pattern of asymmetry: downward nominal rigidity in prices and wages (Debortoli et al., 2020) and financial factors (Stein, 2014). Some evidence has been provided on the first mechanism (Debortoli et al., 2020), which turns on the idea that when monetary policy tightens, nominal wages do not adjust downward, leading to large declines in output. Instead, when monetary policy loosens, prices and wages rise, mitigating the changes in output. We consider both mechanisms to be complementary. The focus of this paper is on the second mechanism, and we are the first to study such a mechanism formally.

The macro-financial literature using firm-level data often uses event-study methodologies around big contractionary credit shocks such as the global financial crisis to trace the impact of financial factors for the employment (Chodorow-Reich, 2014), investment (Almeida et al., 2011), and productivity (Duval et al., 2020). Manaresi and Pierri (2022) show that contractionary firm-level credit availability shocks have negative productivity consequences, but positive credit supply shocks have limited effects. We contribute to this literature by exploiting cross-sectional firm-level variation in financial conditions to assess the role of financial factors in explaining this pattern.

3 Data

Our sample consists of U.S. firms covered by Compustat at a quarterly frequency between 1990 and 2021, excluding utilities (Standard Industry Classification (SIC) codes 4900–4949) and financials (SIC codes 6000–6999). We remove observations with negative revenues, missing information on total assets or capital, or a value of total assets under $10 million in 2012 U.S. dollar value. We winsorize all variables at the 1% level to remove outliers. Firms in the sample are required to be active for at least five years after the monetary policy shock occurs, to cover the length of the horizon of the effects we study and ensure that effects are not driven by firm samples being different at short and long horizons. We refer to investment as the log difference in the capital stock, following Ottonello and Winberry (2020). Employment is not available at a quarterly frequency from Compustat. We use the annual Compustat data and linearly interpolate the employment data to study the effect of quarterly monetary policy shocks on employment.

One of our key firm-level variables is distance to default, which captures the likelihood of default over the near-term horizon. It is our baseline proxy for financial distress, as it is less likely

[4] Tenreyro and Thwaites (2016) shows that US monetary policy is less powerful in recessions.

to be affected by endogeneity concerns (Farre-Mensa and Ljungqvist, 2016). Distance to default is computed using Compustat and CRSP data following the Merton distance to default model, which takes as inputs the firm's equity valuations and leverage.

Our proxies for monetary policy shocks borrow from the work of Miranda-Agrippino and Ricco (2021) and Jarociński and Karadi (2020). These authors follow a well-established literature that uses high-frequency financial market surprises around key monetary policy announcements to identify unexpected variations in monetary policy. The innovative aspect of their approach is that they are able to separately identify exogenous monetary policy shocks from shocks about new information from the Federal Reserve regarding the state of the economy. These monetary policy shocks are therefore orthogonal to shocks to firms' investment opportunities. We compute the monetary surprise by adding up the monthly monetary policy shocks at the quarterly frequency. We separate the shocks series into accommodative and contractionary shocks, which take the value of the original shock if the shock is negative and positive, respectively, and value 0 otherwise.

For our baseline monetary policy shock, the Miranda-Agrippino and Ricco (2021) on the run 2-year wide surprises, we have 62 contractionary and 56 accommodative shocks. The average size of the contractionary (accommodative) shock is 5 (6) basis points with a standard deviation of 4 (5) and a maximum of 20 (29). We standardize the monetary policy shocks so that one unit is equal to a one standard deviation shock.

4 Empirical Strategy

We provide evidence on how exogenous changes in interest rates, identified with surprise changes in the monetary policy rate, have a different impact on the investment of firms with different financial conditions. We do so by estimating the path of the cumulative growth rate of the firm-level stock of real capital using the following Jordà (2005) local projection specification as our baseline estimation framework:

$$\begin{aligned}\Delta_h \log K_{i,t+h} = \gamma_{sq}^h + \sum_{g=1}^{n} \left(\rho_g^h + \lambda_g^{h+} \Delta r_t^+ + \lambda_g^{h-} \Delta r_t^-\right) I\left[D2D_{i,t-1} \in g\right] \\ + \alpha^h \mathbf{controls}_{i,t-1} + \epsilon_{i,t+h}, \qquad (1)\end{aligned}$$

where $\Delta_h \log K_{i,t+h}$ is the change in the log of the real stock of capital K between the end of quarter $t-1$ and the end of quarter $t+h$ and Δr_t is the monetary surprise in quarter t. We decompose Δr_t into tightening and easing shocks (Δr_t^+ and Δr_t^-), as described earlier. We classify firms every quarter into n groups of financial conditions indicated by g; in our baseline results, we choose two groups, capturing, respectively, the bottom quartile of the distribution of distance to default over the whole sample period and the top three quartiles. I is an indicator function that takes value 1 if firm i is in group g in the period preceding the monetary policy shock. Our coefficient of interest is λ_g^h, which gives us the interest rate sensitivity of investment for the different groups of firms. More precisely, λ_g^h measures the net cumulative response of investment between quarter t and quarter $t+h$ to a monetary policy shock in quarter t. In what follows, our results show the average response of investment of the firms in each group. These responses correspond, respectively, to $\lambda_{g=\text{low d2d}}^h$, and $\lambda_{g=\text{high d2d}}^h$. We study the response of investment up to a horizon of $h = 20$ quarters. Seasonal sector-quarter of year fixed effects are captured by γ_{sq}^h.The vector $\mathbf{controls}_{i,t}$ contains time-varying firm-level controls and aggregate controls. Throughout, we double cluster standard errors at the firm and time level to account for correlation within firm and time.[5]

To test our main hypothesis–financial frictions in nonfinancial firms explain an important part of the asymmetric effects of monetary policy on firm investment–, our empirical strategy is to rely on firm-level data and exploit the heterogeneous response of firms with different financial conditions to monetary policy. We first test if the well-documented asymmetric effects of monetary policy also occur in our sample. Next, we run specification (1) to estimate if financial distress–proxied by either low distance to default or high net leverage–increases the responsiveness of firm investment to contractionary shocks more so than it affects the responsiveness to expansionary shocks. To test if firm borrowing follows a similar behavior than investment, we replace the outcome variable in (1) with the change in the log of the real stock of debt.

To provide further insight into the mechanism at work, we assess if credit constraints play a more prominent role than debt overhang in accounting for the asymmetry. How to distinguish between a debt overhang channel and a borrowing constraints channel? A debt overhang channel operates when firms have a high expected default rate and high leverage. In such a situation, shareholders expect that the large debt claims will take up most of the recovery value of the firm in default and that default is likely, and thus have lower incentives to invest. A borrowing constraints channel operates when a firm has high financing needs but the contractionary monetary policy tightens its borrowing constraints or increases its external finance premium substantially so that the firm can borrow and invest less. One can conclude that if debt overhang is the main mechanism, then the effect of distance to default should be stronger for firms with high leverage.

5 Results

5.1 Baseline Results

We start by showing that monetary policy tightening shocks have stronger effects on investment in our sample, confirming the earlier results in the literature. Figure 1 displays the estimate of the average dynamic response of investment to a one standard deviation surprise increase in the interest rate across all firms in our sample using the monetary policy shocks obtained from Miranda-Agrippino and Ricco (2021). The left panel reports the effect of contractionary shocks and

[5]The statistical significance of our estimates does not change meaningfully if we cluster standard errors differently.

shows that they generate a strong and statistically significant drop in investment: a one standard-deviation surprise increase in interest rates is associated with a cumulative drop in investment of about 2.5 percent of the initial capital stock after 2 years. The right panel, instead, reports the effect of expansionary shocks and shows that they do not generate a response of investment that is statistically significantly different from 0.[6]

One potential explanation for the asymmetric effect of monetary policy on investment is that firms' borrowing is being restricted through tighter monetary policy, but not sufficiently stimulated by accommodative monetary policy. To test this hypothesis, we focus on firms that are close to default and study their response to monetary policy shocks. Firms whose default risk is high already before monetary policy is being tightened will be move even closer to default in response to higher interest rate. Instead, firms that are unlikely to default will even be able to borrow at higher interest rates and invest if investment projects will arise. In fact, Figure 2 shows a large degree of heterogeneity of their investment response in response to tighter monetary policy across firms that are close and far away from default. Firms which are close to default (top right panel) reduce their investment in response to a tighter monetary policy stance in a statistically significant way, while firms whose default probability is low are unresponsive to monetary policy tightening (top left panel). Economically, a one standard deviation tightening shock is associated with an around 5% lower capital stock after two years for firms that are close to default relative to a counterfactual in which monetary policy would not have tightened, while the effect on the capital stock of firms that are far away from default is statistically and economically negligibly.

Table 1 displays the results for the estimated equation focusing on the 2-year horizon. First, we document that contractionary monetary policy shocks have a stronger effect on investment than accommodative monetary policy shocks. Further decomposing this result into the investment response of firms that are close vs. further away from default, we can see that the effect of monetary policy is exclusively driven by contractionary shocks for firms that are close to default.

We now test whether the difference between these two responses is statistically significant. We estimate the following regression specification:

$$\begin{aligned}\Delta_9 LogK_{i,t+8} =& \beta_1 Shock_t + \beta_2 Shock_t * D2D_{i,t} + \beta_3 Shock_t * Contr_t \\ &+ \beta_4 D2D_{i,t} * Shock * Contr + \alpha \text{ controls} + \epsilon_{i,t}\end{aligned} \tag{2}$$

where $\Delta_9 LogK_{i,t+8} + \epsilon_{i,t}$ is the difference in the log capital stock between 2 years after the shock and the quarter before the shock.

Note that in this equation we are interested in the difference in the response between firms that are close to default and those that are far away, instead of the response of investment for both types of firms, separately. $Shock_t$ is the Miranda-Agrippino and Ricco (2021) monetary policy shock (we do not switch the sign here), reflecting positive values for contractionary shocks and negative

[6] In unreported results, we show that this evidence is robust to considering alternative monetary policy shocks such as Jarociński and Karadi (2020)

values for accommodative shocks. $D2D_{i,t}$ is a demeaned continuous measure of distance to default, where higher values reflect larger distance to default (safer firms), with a mean of zero. $Contr_t$ is a a dummy that takes value 1 if the shock is contractionary and 0 if it is accommodative. The vector controls includes variables such as the uninteracted regressors, double interactions including aggregated controls interacted with D2D, the triple interaction $D2D_{i,t} * Shock_t * Contr_t$, as well as firm fixed effects.[7]

The coefficient β_4 on $D2D_{i,t}*Shock_t*Contr_t$ is our main coefficient of interest. It tests whether, in response to contractionary monetary policy shocks, firms that are further away from default react less than those that are closer to default, relative to their response to accommodative shocks. In Table 5 we report that this is indeed the case.

The remaining coefficients are also of interest. First, given that our measure of $D2D$ is demeaned in this specification, the coefficient β_1 on $Shock$ can be interpreted as the effect of the monetary policy action if it is accommodative. The negative and significant estimate indicates that the effect is negative, meaning that monetary policy easing ($Shock < 0$) increases investment. The coefficient β_2 tests whether easing shocks are transmitted more strongly into higher investment for firms that are further away from default. The negative coefficient suggests this. A more accommodative shock ($Shock < 0$) for firms that are further away from default ($D2d > 0$) increases the response to the easing shock. This finding is consistent with Ottonello and Winberry (2020), who document that financially constrained firms respond less than financially unconstrained firms. The difference between $\beta_2 < 0$ and the Ottonello and Winberry (2020) result is that, in our context, we only find the stronger response of safer firms for accommodative shocks.

The estimate of β_3 tests the hypothesis of whether, for the average firm, contractionary shocks have stronger effects than accommodative shocks. The negative interaction coefficient indicates that this hypothesis cannot be rejected and is consistent with Figure 1.

Lastly, and as described above, the triple interaction is negative and statistically significant, indicating that, in response to contractionary shocks, firms that are riskier respond more, *relative* to their response to accommodative shocks. This negative coefficient, however, does not indicate whether firms that are closer to default respond more strongly than their safer counterparts. For this we need to test whether the sum of β_2 and β_4 is positive and statistically different from zero. The last row of Table 5 reports the p-value for a t-test for $\beta_4 + \beta_2 = 0$ and shows that the hypothesis that the sum is equal to zero can be rejected at the 5% level. Overall, this result shows that firms that are closer to default respond more to monetary policy contractions and less to monetary policy easings.

When making the cross-sectional comparison instead of focusing on the time series component, the inclusion of time fixed effects is possible. In the previous specification, we could not include time fixed effects because we estimated the effect of the monetary policy shock on investment separately.

[7]Note that we cluster standard errors in this regression only by firm and we do not double cluster errors by firm and time, as we are interested in the cross-sectional heterogeneity across firms and not in the effect of the shock itself.

This $sector * time$ fixed effect, that controls not only for time-specific characteristics, such as GDP growth, inflation, and aggregate uncertainty that could bias the result, but also controls for time-variant sector specific characteristics, such as the average investment in the sector in a given period, and only exploits the heterogeneity across firms with differential degrees of distance to default at a given point in time. Note that when including these fixed effects, $Shock_t$ and $Shock_t * Contr_t$ are collinear with the fixed effects so that the coefficients cannot be interpreted anymore in column (2)-(3).

5.2 Employment

In this subsection, we study the asymmetric effects of monetary policy through financial constraints on employment. Table 4 replicates Table 1 for employment instead of capital. The estimated specification is analogous to equation 1. Column (1) and (2) show that contractionary monetary policy is associated with a decline in employment and monetary policy accommodation is associated with an increase in employment, but both coefficients are statistically insignificant at conventional levels. However, the contractionary monetary policy shock coefficient is larger in magnitude than the accommodative monetary policy shock coefficient, consistent with the evidence that, in aggregate, the effect of tightening is stronger than that of easing. Column (3) decomposes the effect into safe and risky firms for accommodative and contractionary monetary policy shocks, respectively. Of the four coefficients, only the coefficient on contractionary monetary policy shock for risky firms is statistically significant, and the largest in value in absolute terms. This result suggests that monetary policy, as for investment, is successful in reducing the workforce for risky firms, but is unable to increase employment with accommodative monetary policy.

Table 5 tests formally whether the effect is different between contractionary and accommodative monetary policy shocks for firms that are closer to default. In the first column, we see again that accommodative monetary policy shocks are less effective in stimulating employment than contractionary monetary policy shocks are in curtailing employment, shown by $Shock \times Contr. < 0$. Across all columns and consistent with the previous results, this effect becomes even stronger when firms are closer to default (D2D is low).

Figure 3 show the dynamics of employment as a response of monetary policy shocks graphically. As for investment, employment seems unresponsive to accommodative monetary policy shocks, but contractionary monetary policy shocks significantly reduce employment growth for firms that are close to default.

5.3 Borrowing

When monetary policy is being loosened unexpectedly, one would expect firms to increase their borrowing due to the lower interest rates and increase their investment. However, the bottom panels of Figure 2 show that accommodative shocks do not seem to translate into higher investment for neither firms that are close to default nor those that are unlikely to default. These results suggests that a more accommodative monetary policy stance is unlikely to incentivize firms to borrow more to invest, regardless of their distance to default.

Figure 4 is consistent with this explanation. Firms with a high probability of default reduce their borrowing significantly in response to a surprise tightening of monetary policy. When the monetary policy stance becomes more contractionary, firms that are close to default face a tighter borrowing constraint and are, therefore, unable to keep borrowing. In terms of economic magnitudes, after two years, a one standard deviation tightening shock reduces the debt of firms that are close to default by around 5%, while the same shock reduces the debt of firms that are far away from default by around 2.5%, with the estimate for these firms also being much less precise statistically. Accommodative shocks should loosen the financial constraint that firms that are close to default are facing and enable them to borrow more. However, empirically, the bottom panels of Figure 4 do not show evidence that is consistent with a mechanism in which accommodative monetary policy loosens financial constraints and enables more borrowing.

To further evaluate the robustness of our results, we replace distance to default as our measure of financial constraints with net leverage, which is defined as debt minus cash over total assets. Firms that have higher net leverage are more likely to face borrowing constraints when monetary policy tightens and one would expect them to behave in a similar fashion as firms which are close to default. Figure 5 shows the result when we split firms into those whose net leverage is high (top 25%) and the rest. As expected, firms with high net leverage contract their investment in an economically and statistically significant way after a monetary policy tightening shock. Firms whose net leverage is on the lower side do not reduce investment in response to contractionary shocks. Table 6 displays the results of running regression (2) replacing the growth rate of capital with the growth rate of the debt stock 2 years ahead. The estimated response of the debt stock confirms the results of the impulse responses.

5.4 Debt Overhang vs. Financial Constraints

Lastly, we address the question whether a debt overhang or a financial constraints story is driving the differential result for high vs. low distance to default firms when monetary policy tightens. If debt overhang is the dominant driver of our results in Sections 5.1 and 5.3 that firms that are close to default are more responsive to tighter monetary policy, then one would expect this result to be stronger if those firms have relatively high leverage. If shareholders expect that firms' large debt claims will take up most of the recovery value of the firm in default and that default is likely, they have lower incentives to invest. In contrast, firms that are persistently credit constrained are likely to have less leverage and, if they are at the same time close to default, the contractionary shock will push them closer to the borrowing constraint, forcing them to invest less. Figure 6 is consistent with the latter explanation and speaks against a debt overhang story, as low leverage firms that are close to default are the most responsive, suggesting that they are ex-ante credit constrained and that contractionary monetary policy shocks push them further toward the borrowing constraint. However, these results should be interpreted carefully as differentiating debt overhang and borrowing constraints is notoriously difficult.

6 Theory

The purpose of this section is to propose a possible explanation for our main empirical finding, namely that financial frictions in firms explain why monetary tightening has clear effects on investment, employment, and borrowing while monetary accommodation generates much less pronounced responses. To that end, we build a standard New Keynesian business cycle model with three realistic features. First, firms borrow using long-term debt. Second, defaulting on that debt is costly. Third, debt financing enjoys a tax advantage over equity financing. In subsection 6.1 we describe the model and in subsection 6.2 we show that asymmetry arises naturally in this environment and explain why.

6.1 Model Description

We introduce a DSGE model with price rigidities and financial frictions. The economy features five types of agents: households, final goods producers, intermediate goods firms, capital producers, and a monetary authority. The modelling of households, final goods producers, capital producers, and the monetary authority are standard and discussed in Appendix A. Here, we discuss in some detail the modelling of intermediate goods firms, which are the agents at the center of our asymmetric mechanism.

Intermediate goods firms (”firms” for short) optimally choose dividend payouts, long-term nominal debt B_t, and real investment $g(i_t)k_t$ in a setting with idiosyncratic risk (captured by shock z_t), strategic default, and costly bankruptcy. We assume–as in Gomes et al. (2016)–that in every period a fraction λ of the stock of outstanding debt is paid back, while the remaining $(1-\lambda)$ remains outstanding. The firm is also required to pay a periodic nominal coupon c per unit of outstanding debt, which is tax deductible. The tax deductibility of interest increases the attractiveness of debt relative to equity. This benefit of debt, however, is compensated by the presence of financial distress and bankruptcy costs, which increase, in expectation, as the firm issues more debt. We, thus, capture the classic trade-off theory of capital structure. Firms produce intermediate goods using capital and labor, and are owned by households.

The firm's problem is homogeneous of degree one in capital and debt, so from now on we work with leverage ($\omega_t = b_t/k_t$, where $b_t = B_t/P_{t-1}$ is the stock of debt in real terms) as the only endogenous state variable. The equity value of a firm per unit of capital at the beginning of a period conditional on a decision by shareholders not to default is:

$$v(\omega_t) = \max_{\omega_{t+1}, i_t} p_t \left(\omega_{t+1} g(i_t) - (1-\lambda)\frac{\omega_t}{\mu_t} \right) - q_t^k i_t + \tau\delta \tag{3}$$

$$+ g(i_t) E_t \Big[SDF_{t,t+1} \int_{\underline{z}}^{z_{t+1}^*} \Big((1-\tau)(R_{t+1} - z_{t+1}) - ((1-\tau)c_{t+1} + \lambda)\frac{\omega_{t+1}}{\mu_{t+1}} + v(\omega_{t+1}) \Big) d\Phi(z_{t+1}) \Big]$$

subject to the Euler equation of bond holders:

$$\omega_{t+1} p_t = E_t SDF_{t,t+1} \Bigg[\Phi(z_{t+1}^*) \Bigg((c_{t+1} + \lambda)\frac{\omega_{t+1}}{\mu_{t+1}} \Bigg) + (1-\lambda)\frac{p_{t+1}\omega_{t+1}}{\mu_{t+1}} - (1-\tau)\int_{z_{t+1}^*}^{\overline{z}} z_{t+1} d\Phi(z_{t+1})$$

$$+ \big(1 - \Phi(z_{t+1}^*)\big) \Big((1-\tau)\xi R_{t+1} - \xi^k + v(\omega_{t+1}) \Big) \Bigg] \tag{4}$$

where $g(i_t) = 1 - \delta + i_t = \frac{k_{t+1}}{k_t}$ and z_{t+1}^* is the threshold for the idiosyncratic shock z_{t+1} above which shareholders find it optimal to default strategically. This threshold is given by:

$$z_t^* = R_t - \left(c_t + \frac{\lambda}{1-\tau} \right) \frac{\omega_t}{\mu_t} + \frac{v(\omega_t)}{1-\tau}. \tag{5}$$

Default occurs before period t production occurs. In default, incumbent shareholders lose their ownership of shares in the firm and bondholders take over and become the sole owners. As new owners, the bondholders are entitled to collect any claims to the firm assets, including current profits, the recovery value of capital, the outstanding debt liabilities, and the proceeds from the sale of the equity in the firm. The restructuring ends when bondholders sell the restructured firm to new equityholders. In the process, bond investors lose a fraction ξ^k of capital.

The first order conditions with respect to investment and leverage are, respectively:

$$q_t^k - p_t \omega_{t+1} \tag{6}$$

$$= E_t \left[SDF_{t,t+1} \int_{\underline{z}}^{z_{t+1}^*} \left((1-\tau)(R_{t+1} - z_{t+1}) - ((1-\tau)c_{t+1} + \lambda)\frac{\omega_{t+1}}{\mu_{t+1}} + v(\omega_{t+1}) \right) d\Phi(z_{t+1}) \right],$$

and

$$p_t g(i_t) + \frac{\partial p_t}{\partial \omega_{t+1}} \left(\omega_{t+1} g(i_t) - (1-\lambda)\frac{\omega_t}{\mu_t} \right) = -(1-\tau) g(i_t) E_t \left[SDF_{t,t+1} \Phi(z_{t+1}^*) \frac{\partial z_{t+1}^*}{\partial \omega_{t+1}} \right]. \tag{7}$$

Equation (6) equates the marginal cost of one additional unit of investment (LHS) to the marginal benefit (RHS), where one unit of investment costs q_t^k. Equation (7) equates the marginal proceeds of one additional unit of debt (LHS) to the marginal cost (RHS). One unit of debt can be sold for p_t and affects the price of debt. An increase in borrowing increases the default threshold ($\partial z_{t+1}^* / \partial \omega_{t+1} > 0$) making default more likely.

Note that firms optimal choices are not a function of the idiosyncratic shock z. The intuition is that equity issuance frictions affect aggregate dividends and not idiosyncratic dividends, which means that equity funds flow across firms to equalize the marginal product of capital and to optimize the debt-equity ratio.

6.2 Asymmetry in the Response to a Monetary Policy Shock

To be able to capture nonlinearities that can give rise to an asymmetric response to easing and tightening shocks, we solve the model by computing a third-order approximation to the solution of the model around its steady state. The model is calibrated following Gomes et al. (2016). We compute the impulse responses to contractionary and expansionary shocks in two economies: one with a low risk of default (annual default rate of 0.1%) and one with a high risk of default (annual default rate of 5.3%). Results are displayed in Figures 7 and 8.

Figure 7 shows clearly how, in an economy where firms have a high expected rate of default, a monetary tightening has a significantly stronger effects on spreads, defaults, borrowing, investment, and output, than a monetary accommodation. Figure 8, instead, shows clearly how, in an economy where firms have a low expected rate of default, a monetary tightening and a monetary accommodation have the same effects on financial variables and economic activity. In the rest of this section we provide an intuitive explanation for why this is the case.

Two main mechanisms operate to give monetary contractions an outsized role compared to accommodations. Both arise after monetary policy shocks affect outstanding leverage, by changing the real value of debt (for example, contractionary shocks lower inflation and increase the real burden of outstanding debt) and by affecting the value of assets. First, an increase in leverage induced by a monetary tightening induces an increase in defaults that is significantly higher than the size of the decrease in defaults that follows an equivalent decline in leverage (in absolute value) induced by a monetary easing. This follows from the nonlinearity in the function that maps leverage to expected default rates. As a result, spreads, investment, hiring, and borrowing are much more sensitive to monetary contractions.

Second, because firms are able to adjust the stock of debt every period, but cannot commit to future leverage choices, in the presence of outstanding long-term debt shareholders will resist ex-post debt buybacks because repaying debt early, by reducing expected default costs, benefits existing debtholders at the shareholders' expense. Rational forward-looking creditors understand the incentives of shareholders and anticipate that an increase in borrowing today will, all else equal, result next period in higher debt, and price the debt accordingly. Importantly for our asymmetry result, this stickiness of leverage is much stronger downward than upward.

7 Conclusion

In this paper we have shown empirical support for the hypothesis that financial frictions in nonfinancial firms are important to explain why the magnitude of the response of investment to monetary policy tightening shocks is stronger than the response to easing shocks.

We built a standard New Keynesian business cycle model with long-term debt, costly default, and a tax advantage of debt to propose a possible explanation for these empirical findings. In the model, an increase in defaults is significantly larger for tightening than an decrease in defaults to easings due to a nonlinearity that maps leverage to expected default rates.

Our results carry an important policy implication, which is that the effectiveness of monetary policy depends on the aggregate distribution of financial conditions in nonfinancial firms. A contractionary monetary policy action might have stronger effects on investment in an environment of poor credit quality and tight financial conditions for nonfinancial firms. However, the effectiveness of expansionary monetary policy does not seem to depend as much on firm financial conditions.

In the current context, as since the beginning of 2022, more firms have moved closer to default, the results in the paper would imply that the potency of the recent interest rate increases by the Federal Reserve has increased.

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Figure 1: Local Projections: Average Response of Investment to Tightening and Easing Shocks. The charts display the estimate of the dynamic response of investment to a one standard deviation monetary policy tightening or easing shock, respectively. The left panel shows the effect of contractionary shocks while the right panel reports the effect of accommodative shocks. The dependent variable is the difference between the log of total capital in period *t+h* and in period *t-1*. The monetary surprise in quarter t,Δr_t, is calculated by adding up the monthly monetary policy shocks obtained from Miranda-Agrippino and Ricco (2021). Shaded areas represent the 99% confidence intervals of the estimates.

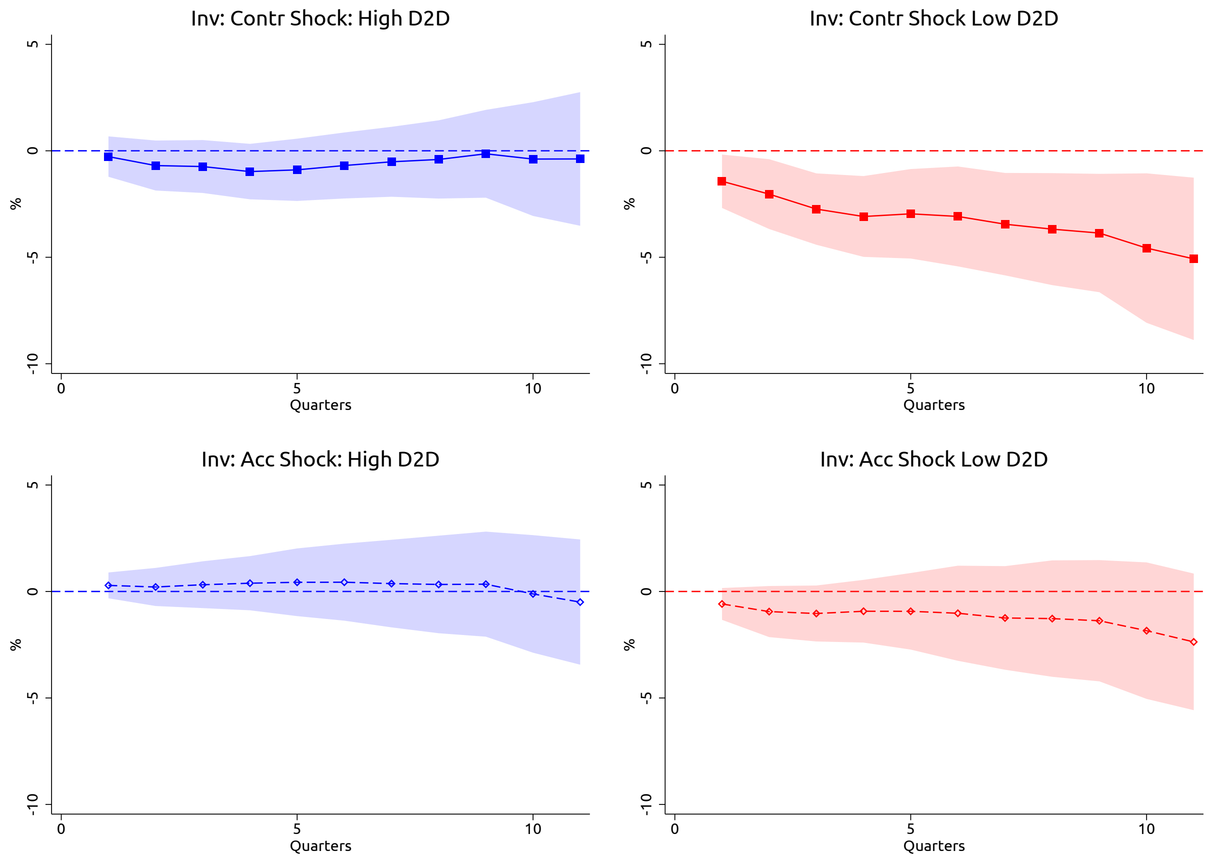


Figure 2: Local Projections: Response of Investment to Tightening and Easing Shocks by Distance to Default. The charts display the estimate of the dynamic response of investment to a one standard deviation monetary policy tightening or easing shock, respectively.The upper panels show the effect of contractionary shocks while the lower panels report the effect of accommodative shocks. The dependent variable is the difference between the log of total capital in period *t+h* and in period *t-1*. The monetary surprise in quarter t,Δr_t, is calculated by adding up the monthly monetary policy shocks obtained from Miranda-Agrippino and Ricco (2021). Shaded areas represent the 99% confidence intervals of the estimates.

Figure 3: Local Projections: Response of Employment to Tightening and Easing Shocks by Distance to Default. The charts display the estimate of the dynamic response of employment to a one standard deviation monetary policy tightening or easing shock, respectively.The upper panels show the effect of contractionary shocks while the lower panels report the effect of accommodative shocks. The dependent variable is the difference between the log of total capital in period $t{+}h$ and in period t-1. The monetary surprise in quarter t,Δr_t, is calculated by adding up the monthly monetary policy shocks obtained from Miranda-Agrippino and Ricco (2021). Shaded areas represent the 99% confidence intervals of the estimates.

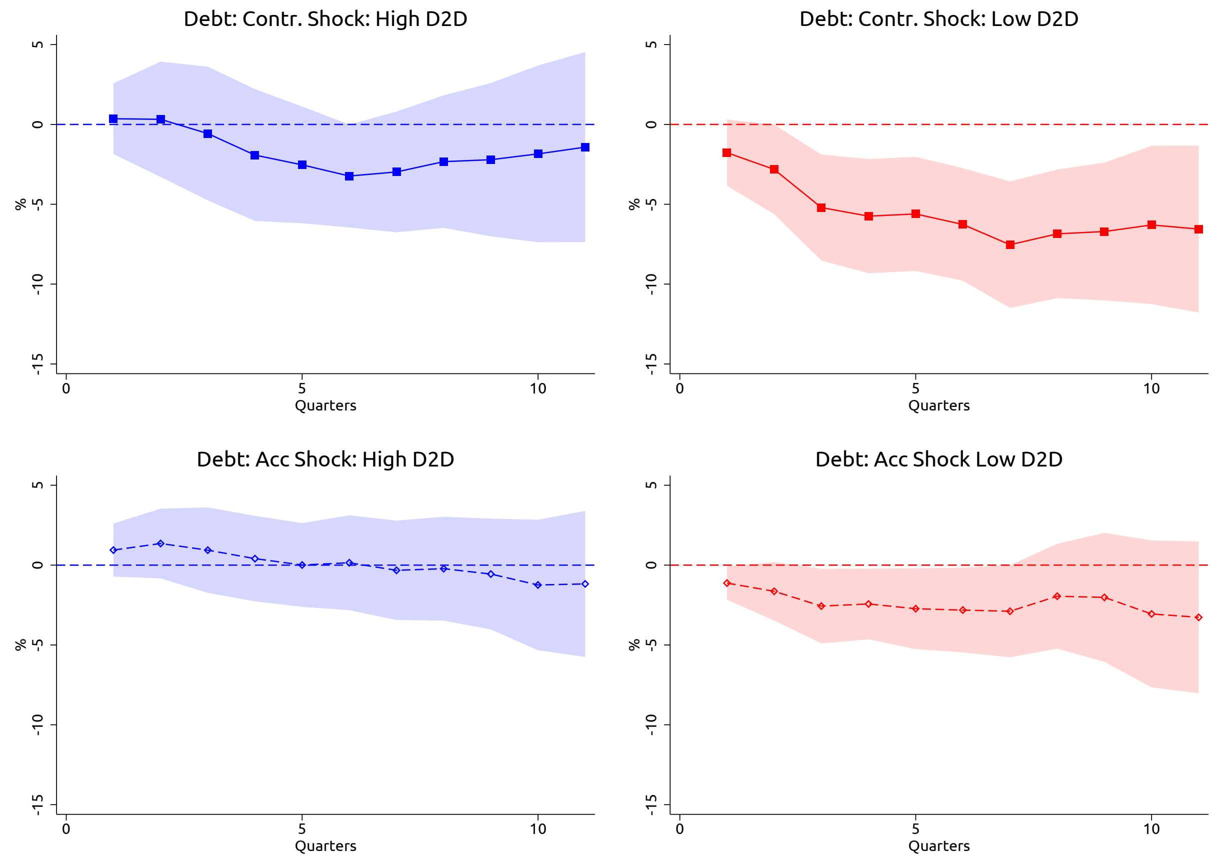


Figure 4: Local Projections: Response of Net Debt Issuance to Tightening and Easing Shocks by Distance to Default. The charts display the estimate of the dynamic response of investment to a one standard deviation monetary policy tightening or easing shock, respectively. The upper panels show the effect of contractionary shocks while the lower panels report the effect of accommodative shocks. The dependent variable is the difference between the log of total capital in period $t+h$ and in period *t-1*. The monetary surprise in quarter t,Δr_t, is calculated by adding up the monthly monetary policy shocks obtained from Miranda-Agrippino and Ricco (2021). Shaded areas represent the 99% confidence intervals of the estimates.

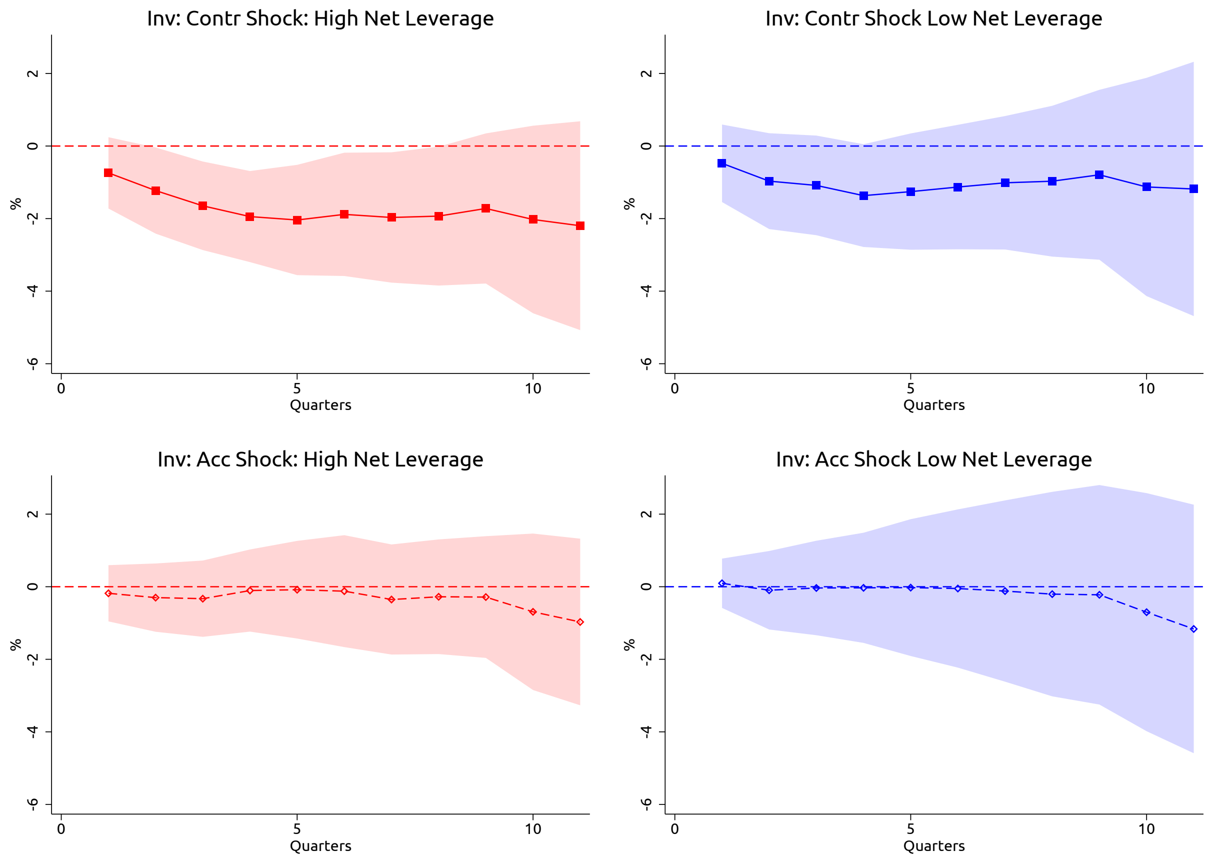


Figure 5: Local Projections: Response of Investment to Tightening and Easing Shocks by Net Leverage The charts display the estimate of the dynamic response of investment to a one standard deviation monetary policy tightening or easing shock, respectively. The upper panels show the effect of contractionary shocks while the lower panels report the effect of accommodative shocks. The dependent variable is the difference between the log of total capital in period $t+h$ and in period *t-1*. The monetary surprise in quarter t,Δr_t, is calculated by adding up the monthly monetary policy shocks obtained from Miranda-Agrippino and Ricco (2021). Shaded areas represent the 99% confidence intervals of the estimates.

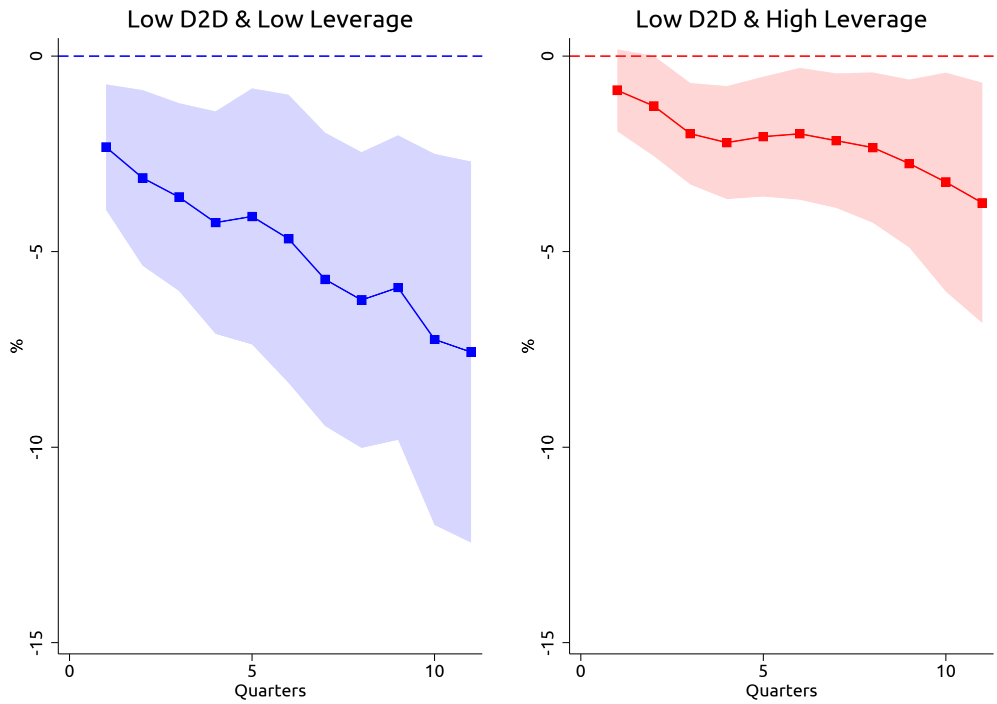


Figure 6: Local Projections: Response of Investment to Tightening Shocks of low Distance to Default Firms by Net Leverage The charts display the estimate of the dynamic response of investment to a one standard deviation surprise increase in the interest rate for firms which are close to default. The left panel shows the effect for low leverage (below median) firms and the right panel shows the effect for high leverage firms (above median). The dependent variable is the difference between the log of total capital in period *t+h* and in period *t-1*. The monetary surprise in quarter t,Δr_t, is calculated by adding up the monthly monetary policy shocks obtained from Miranda-Agrippino and Ricco (2021). Shaded areas represent the 99% confidence intervals of the estimates.

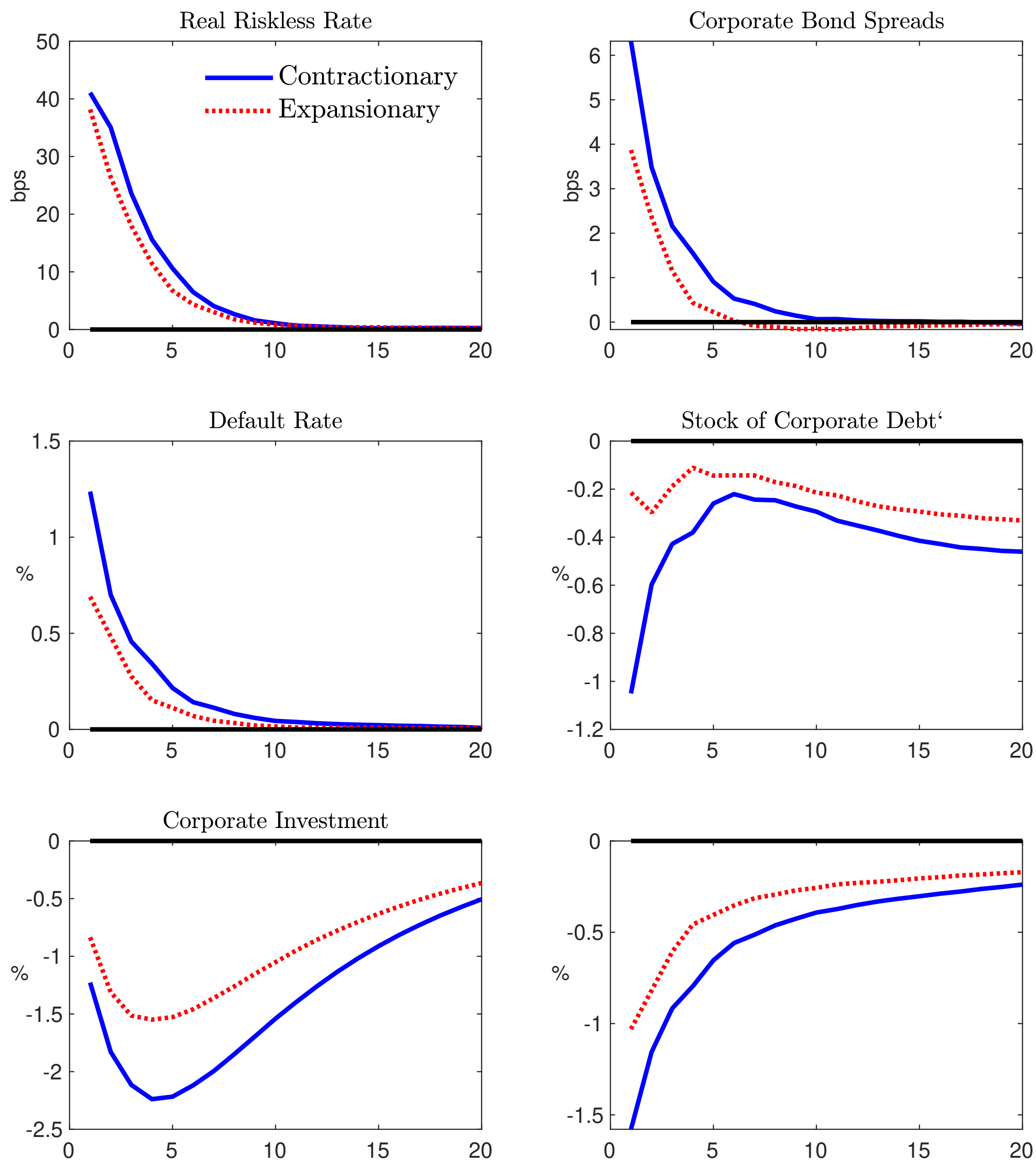


Figure 7: Impulse Responses of Key Variables to Contractionary and Expansionary Monetary Policy Shocks: Economy With a High Average Expected Default Rate The charts display the simulated responses of key variables to a one standard deviation surprise increase or decrease in the innovation to the error term of the Taylor rule guiding the short-term nominal riskfree interest rate.

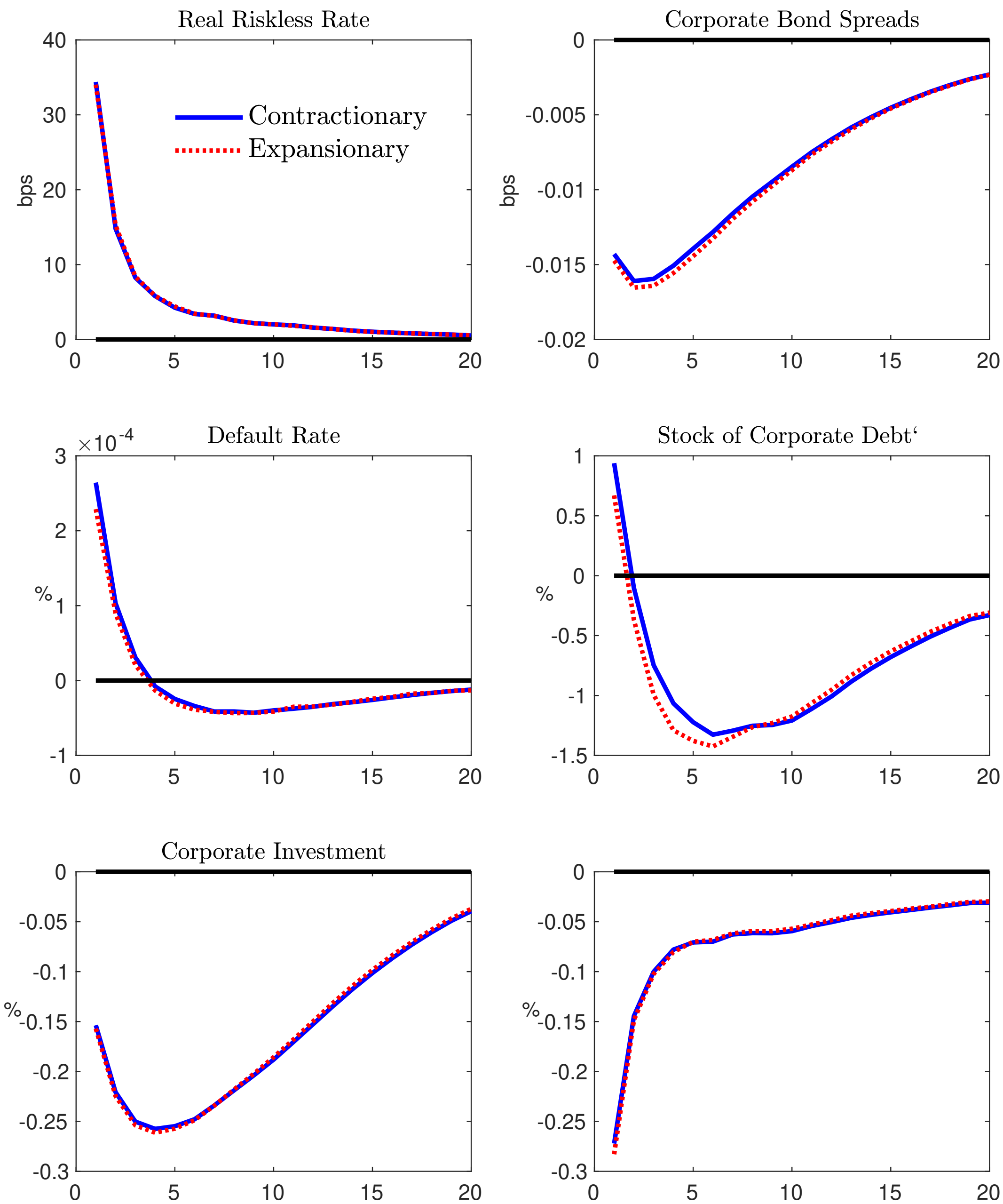


Figure 8: Impulse Responses of Key Variables to Contractionary and Expansionary Monetary Policy Shocks: Economy With a Low Average Expected Default Rate The charts display the simulated responses of key variables to a one standard deviation surprise increase or decrease in the innovation to the error term of the Taylor rule guiding the short-term nominal riskfree interest rate.

Table 1: Response to Tightening and Loosening Shocks of Low and High Distance to Default Firms

	$Log(Capital)_{t+8} - Log(Capital)_{t-1}$		
	(1)	(2)	(3)
Acc. Shock	0.337	0.255	
	(1.526)	(1.545)	
Contr. Shock	-2.445*	-2.835**	
	(1.388)	(1.425)	
Acc. Shock × High D2D			0.331
			(0.890)
Acc. Shock × Low D2D			-1.273
			(1.061)
Contr. Shock × High D2D			-0.405
			(0.713)
Contr. Shock × Low D2D			-3.679***
			(1.021)
R-squared	0.314	0.311	0.427
N	201,806	199,335	183,224
Firm FE	Y	Y	Y
Industry-Time FE	N	N	N
Industry-Quarter FE	N	Y	Y
Agg Controls	Y	Y	Y
Firm Controls	N	N	Y

This table displays the coefficient from the following estimated equation: $\Delta_9 LogK_{i,t+8} = +\beta_1 Acc.Shock_t * HighD2D + \beta_2 Acc.Shock_t * LowD2D_{i,t} + \beta_3 Contr.Shock_t * HighD2D_{i,t} + \beta_4 Contr.Shock_t * LowD2D_{i,t} \alpha$controls where $\Delta_9 LogK_{i,t+8} + \epsilon_{i,t}$ is the difference in the log capital stock between 2 years after the shock and the quarter before the shock. $Acc.Shock_t$ is the sign-flipped Miranda-Agrippino and Ricco (2021) shock if the shock is identified as a accommodative shock, taking only positive values. The larger the value, the more accommodative the shock. $Contr.Shock_t$ is the Miranda-Agrippino and Ricco (2021) shock if the shock is identified as a contractionary shock, taking only positive values. The larger the value, the more contractionary the shock. $HighD2D$ is a dummy that is one if the firm is above the 25^{th} percentile in the distance to default distribution (safe firms). $LowD2D$ is a dummy that is one if the firm is within the 25^{th} percentile of the distance to default distribution (risky firms). Standard errors are clustered at firm level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 2: Differential Response of Tightening Shocks for Firms further away from Default

	$Log(Capital)_{t+8} - Log(Capital)_{t-1}$		
	(1)	(2)	(3)
Shock	-1.218***		
	(0.154)		
Shock × D2D	-0.295***	-0.227***	-0.182***
	(0.038)	(0.041)	(0.041)
Shock × Contr.	-0.613*		
	(0.319)		
Shock × D2D × Contr.	0.447***	0.380***	0.321***
	(0.066)	(0.073)	(0.072)
R-squared	0.333	0.368	0.376
N	172,634	174,634	172,634
Firm FE	Y	Y	Y
Time FE	-	Y	-
Industry-Time FE	N	-	Y
Industry-Quarter FE	Y	-	-
Agg Controls Int.	N	N	Y
p: β [shock*d2d]+ β [shock*d2d*pos]=0	.0024	.0049	.0104

This table displays the coefficient from the following estimated equation: $\Delta_9 LogK_{i,t+8} = \beta_1 Shock_t + \beta_2 Shock_t * D2D_{i,t} + \beta_3 Shock_t * Contr_t + \beta_4 D2D_{i,t} * Shock * Contr + \alpha$ controls $+ \epsilon_{i,t}$ where $\Delta_9 LogK_{i,t+8} + \epsilon_{i,t}$ is the difference in the log capital stock between 2 years after the shock and the quarter before the shock. $D2D_{i,t} * Shock_t * Contr_t$ is the interaction between a continuous variable of distance to default (higher values capturing further away from default) $D2D_{i,t}$, the Miranda-Agrippino and Ricco (2021) monetary policy shock $Shock_t$, and a dummy that is one if the shock is contractionary and zero if it is accommodative ($Contr_t$). controls includes controls such as the individual terms and double interaction of $D2D_{i,t} * Shock_t * Contr_t$, aggregated controls interacted with D2D as well as firm fixed effects. The p-value displays the p-value for a t-test for $\beta_4 + \beta_2 = 0$. Standard errors are in parentheses. Standard errors are clustered at firm level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 3: Response to Tightening and Loosening Shocks of Low and High Distance to Default Firms

	$Log(Debt)_{t+8} - Log(Debt)_{t-1}$		
	(1)	(2)	(3)
Acc. Shock	0.345	0.011	
	(2.030)	(2.126)	
Contr. Shock	-4.289**	-5.433**	
	(2.119)	(2.171)	
Acc. Shock × High D2D			-0.224
			(1.263)
Acc. Shock × Low D2D			-1.946
			(1.273)
Contr. Shock × High D2D			-2.329
			(1.611)
Contr. Shock × Low D2D			-6.852***
			(1.563)
R-squared	0.200	0.200	0.332
N	149,179	147,671	140,676
Firm FE	Y	Y	Y
Industry-Time FE	N	N	N
Industry-Quarter FE	N	Y	Y
Agg Controls	Y	Y	Y
Firm Controls	N	N	Y

This table displays the coefficient from the following estimated equation: $\Delta_9 LogD_{i,t+8} = +\beta_1 Acc.Shock_t * HighD2D + \beta_2 Acc.Shock_t * LowD2D_{i,t} + \beta_3 Contr.Shock_t * HighD2D_{i,t} + \beta_4 Contr.Shock_t * LowD2D_{i,t}\alpha$controls where $\Delta_9 LogD_{i,t+8} + \epsilon_{i,t}$ is the difference in the log debt stock between 2 years after the shock and the quarter before the shock. $Acc.Shock_t$ is the sign-flipped Miranda-Agrippino and Ricco (2021) shock if the shock is identified as a accommodative shock, taking only positive values. The larger the value, the more accommodative the shock. $Contr.Shock_t$ is the Miranda-Agrippino and Ricco (2021) shock if the shock is identified as a contractionary shock, taking only positive values. The larger the value, the more contractionary the shock. $HighD2D$ is a dummy that is one if the firm is above the 25^{th} percentile in the distance to default distribution (safe firms). $LowD2D$ is a dummy that is one if the firm is within the 25^{th} percentile of the distance to default distribution (risky firms). Standard errors are clustered at firm level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 4: Employment Response to Tightening and Loosening Shocks of Low and High Distance to Default Firms

	$Log(Employment)_{t+8} - Log(Employment)_{t-1}$		
	(1)	(2)	(3)
Acc. Shock	0.426	0.333	
	(1.216)	(1.255)	
Contr. Shock	-0.835	-1.170	
	(1.412)	(1.433)	
Acc. Shock × High D2D			0.082
			(0.707)
Acc. Shock × Low D2D			-0.946
			(0.840)
Contr. Shock × High D2D			0.287
			(0.819)
Contr. Shock × Low D2D			-1.775*
			(0.933)
R-squared	0.365	0.363	0.456
N	196,628	194,342	180,497
Firm FE	Y	Y	Y
Industry-Time FE	N	N	N
Industry-Quarter FE	N	Y	Y
Agg Controls	Y	Y	Y
Firm Controls	N	N	Y

This table displays the coefficient from the following estimated equation: $\Delta_9 LogE_{i,t+8} = +\beta_1 Acc.Shock_t * HighD2D + \beta_2 Acc.Shock_t * LowD2D_{i,t} + \beta_3 Contr.Shock_t * HighD2D_{i,t} + \beta_4 Contr.Shock_t * LowD2D_{i,t} \alpha$controls where $\Delta_9 LogE_{i,t+8} + \epsilon_{i,t}$ is the difference in log employment between 2 years after the shock and the quarter before the shock. $Acc.Shock_t$ is the sign-flipped Miranda-Agrippino and Ricco (2021) shock if the shock is identified as a accommodative shock, taking only positive values. The larger the value, the more accommodative the shock. $Contr.Shock_t$ is the Miranda-Agrippino and Ricco (2021) shock if the shock is identified as a contractionary shock, taking only positive values. The larger the value, the more contractionary the shock. $HighD2D$ is a dummy that is one if the firm is above the 25^{th} percentile in the distance to default distribution (safe firms). $LowD2D$ is a dummy that is one if the firm is within the 25^{th} percentile of the distance to default distribution (risky firms). Standard errors are clustered at firm level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 5: Differential Employment Response of Tightening Shocks for Firms further away from Default

	$Log(Employment)_{t+8} - Log(Employment)_{t-1}$		
	(1)	(2)	(3)
Shock	-0.970***		
	(0.103)		
Shock × D2D	-0.227***	-0.155***	-0.063*
	(0.026)	(0.027)	(0.032)
Shock × Contr.	-1.198***		
	(0.238)		
Shock × D2D × Contr.	0.424***	0.319***	0.138***
	(0.046)	(0.050)	(0.052)
R-squared	0.358	0.399	0.438
N	171,089	173,051	146,967
Firm FE	Y	Y	Y
Time FE	-	Y	-
Industry-Time FE	N	-	Y
Industry-Quarter FE	Y	-	-
Agg Controls Int.	N	N	Y
p: β [shock*d2d]+ β [shock*d2d*pos]=0	0	0	.0507

This table displays the coefficient from the following estimated equation: $\Delta_9 LogE_{i,t+8} = \beta_1 Shock_t + \beta_2 Shock_t * D2D_{i,t} + \beta_3 Shock_t * Contr_t + \beta_4 D2D_{i,t} * Shock * Contr + \alpha$ controls$+ \epsilon_{i,t}$ where $\Delta_9 LogE_{i,t+8} + \epsilon_{i,t}$ is the difference in log employment between 2 years after the shock and the quarter before the shock. $D2D_{i,t} * Shock_t * Contr_t$ is the interaction between a continuous variable of distance to default (higher values capturing further away from default) $D2D_{i,t}$, the Miranda-Agrippino and Ricco (2021) monetary policy shock $Shock_t$, and a dummy that is one if the shock is contractionary and zero if it is accommodative ($Contr_t$). controls includes controls such as the individual terms and double interaction of $D2D_{i,t} * Shock_t * Contr_t$, aggregated controls interacted with D2D as well as firm fixed effects. The p-value displays the p-value for a t-test for $\beta_4 + \beta_2 = 0$. Standard errors are in parentheses. Standard errors are clustered at firm level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Table 6: Response to Tightening and Loosening Shocks of Low and High Distance to Default Firms

	$Log(Debt)_{t+8} - Log(Debt)_{t-1}$		
	(1)	(2)	(3)
Acc. Shock	0.345	0.011	
	(2.030)	(2.126)	
Contr. Shock	-4.289**	-5.433**	
	(2.119)	(2.171)	
Acc. Shock × High D2D			-0.224
			(1.263)
Acc. Shock × Low D2D			-1.946
			(1.273)
Contr. Shock × High D2D			-2.329
			(1.611)
Contr. Shock × Low D2D			-6.852***
			(1.563)
R-squared	0.200	0.200	0.332
N	149,179	147,671	140,676
Firm FE	Y	Y	Y
Industry-Time FE	N	N	N
Industry-Quarter FE	N	Y	Y
Agg Controls	Y	Y	Y
Firm Controls	N	N	Y

This table displays the coefficient from the following estimated equation: $\Delta_9 LogD_{i,t+8} = +\beta_1 Acc.Shock_t * HighD2D + \beta_2 Acc.Shock_t * LowD2D_{i,t} + \beta_3 Contr.Shock_t * HighD2D_{i,t} + \beta_4 Contr.Shock_t * LowD2D_{i,t}\alpha$controls where $\Delta_9 LogD_{i,t+8} + \epsilon_{i,t}$ is the difference in the log debt stock between 2 years after the shock and the quarter before the shock. $Acc.Shock_t$ is the sign-flipped Miranda-Agrippino and Ricco (2021) shock if the shock is identified as a accommodative shock, taking only positive values. The larger the value, the more accommodative the shock. $Contr.Shock_t$ is the Miranda-Agrippino and Ricco (2021) shock if the shock is identified as a contractionary shock, taking only positive values. The larger the value, the more contractionary the shock. $HighD2D$ is a dummy that is one if the firm is above the 25^{th} percentile in the distance to default distribution (safe firms). $LowD2D$ is a dummy that is one if the firm is within the 25^{th} percentile of the distance to default distribution (risky firms). Standard errors are clustered at firm level. The symbols *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

A Replication of Ottonello and Winberry (2020) and Decomposition into Expansionary and Contractionary Shocks

In a recent influential paper, Ottonello and Winberry (2020) claim that the investment of firms that are highly leveraged and closer to default reacts less to monetary policy shocks, a result that challenges conventional theoretical predictions and other evidence. In this appendix, we replicate their main result and show that, even sticking to their exact specification and data sample, this result holds only for expansionary shocks and not contractionary shocks.

We focus on their results using distance to default, as they are the ones that are strongest in their paper. Panel (a) in Figure B.1 replicates their main result (Panel (b) in Figure 1 in their paper), with the minor expositional difference that we do not flip the sign of the shocks, as they do. What they find, and we replicate, is that the investment of firms that have better financial conditions (i.e., are further away from default) is *more* responsive to an increase in the policy rate (drops more in response to the higher rates). When we break down the shocks series into negative (expansionary) and positive (contractionary) shocks, results show that this counterintuitive response is only present for expansionary shocks (see Panel (b)). The effect of distance to default is statistically insignificant in response to contractionary shocks and, if anything, the results flip sign after 6 quarters.

We repeat the same exercise using three other measures of monetary policy shocks. Figures B.2, B.3, and B.4 display the estimates obtained when using the shocks of Miranda-Agrippino and Ricco (2021), Jarociński and Karadi (2020), and Gürkaynak et al. (2005), respectively. In all three cases, the average effect of distance to default on the responsiveness to monetary policy is qualitatively similar to the result in Ottonello and Winberry (2020). Again, in all three cases, the result is driven entirely by the expansionary shocks. The effect of distance to default on the response to contractionary shocks is more intuitive: in all three cases, being close to default makes firm investment more responsive to monetary policy (or, in the case of Miranda-Agrippino and Ricco (2021) shocks, has no effects on transmission).

Taken together, the evidence shown here in the context of the exact specification, variable construction, and data sample as Ottonello and Winberry (2020) further supports the idea that financial factors are important to explain why contractionary shocks have stronger effects on aggregate spending than expansionary shocks.

B Full Model Description

We introduce a DSGE model with price rigidities and financial frictions. The economy features five types of agents: households, final goods producers, intermediate goods firms, capital producers, and a monetary authority. Intermediate goods firms are described in Section 6.1.

B.1 Households

There is a single representative household that owns all securities, and collects all income in the economy, including any rebate on corporate income tax revenues. The household's preferences over consumption C and hours worked N are as follows:

$$E\sum_{t=0}^{\infty}\beta^t e^{d_t}\left[(1-\theta)\frac{(c_t-hc_{t-1})^{1-\psi_{ies}}}{1-\psi_{ies}}+\theta\log(3-n_t)\right], \tag{8}$$

where the first term in the household utility function reflects utility from consumption, with habit parameter h and elasticity of intertemporal substitution ψ_{ies}, and the second term reflects disutility from supplying labor. The rate of intertemporal preference is $\beta \in (0,1)$ and d_t is an intertemporal preference shock with law of motion:

$$d_t = \rho_d d_{t-1} + \sigma_d \epsilon_{d,t}, \epsilon_{d,t} \sim \mathcal{N}(0,1). \tag{9}$$

It is assumed each member of the household works or invests independently in equities and debt and all household income (wages, return from bonds, return from equity of all producers, taxes/transfers) is then shared when making consumption and savings decisions.

Denote the period-t marginal utility of consumption, adjusted for habits, as Λ_t:

$$\Lambda_t = (1-\theta)(c_t-hc_{t-1})^{-\psi_{ies}} - (1-\theta)h\beta^t e^{d_t}(c_{t+1}-hc_t)^{-\psi_{ies}}. \tag{10}$$

We assume that there is some degree of real wage rigidity, given by w_{rig}. Labor supply is given by:

$$w_t = w_{rig}w_{t-1} + \frac{(1-w_{rig})\frac{\theta}{\Lambda_t}}{3-n_t}. \tag{11}$$

B.2 Retailers

The final good, used for consumption and investment, is a constant elasticity of substitution (CES) aggregate of the retailers' output, denoted Y_{rt}:

$$Y_t = \left[\int_0^1 (Y_{rt})^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{12}$$

where ϵ is linked to the elasticity of substitution across the different varieties of goods sold by retailers. It follows that each retailer faces the demand curve:

$$Y_{rt} = Y_t \left[\frac{P_{rt}}{P_t} \right]^{-\epsilon}, \tag{13}$$

and that the price index associated with the optimal bundle of the retailer varieties is

$$P_t = \left[\int_0^1 P_{rt}^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}. \tag{14}$$

There is a continuum of retailers, indexed by $r \in [0,1]$. Retailers buy goods from the intermediate producers at real (or deflated) price/cost P_{mt}, package them, and sell them to households at nominal price P_{rt}. Each retailer acts as a monopolist.

Following Calvo (1983) and Christiano, Eichenbaum, and Evans (2005), it's assumed retailers can change the price optimally in period t with probability $1-\psi$. A retailer chooses P_t^* to solve:

$$\max_{P_t^*} E_t \sum_{i=0}^{\infty} \psi^i M_{t,t+i} \left[\frac{P_t^*}{P_{t+i}} - P_{m,t+i} \right] Y_{r,t+i} \tag{15}$$

which implies the optimal price P_t^* will be identical across the retailers setting prices at time t.

The F.O.C. for the choice of P_t^* is

$$P_t^* = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{i=0}^{\infty} \psi^i M_{t,t+i} \frac{Y_{t+i}}{P_{t+i}^{-\epsilon}} P_{m,t+i}}{E_t \sum_{i=0}^{\infty} \psi^i M_{t,t+i} \frac{Y_{t+i}}{P_{t+i}^{1-\epsilon}}}. \tag{16}$$

The optimal price-setting behavior implies the following law of motion for the aggregate price level:

$$P_t = [(1-\psi)(P_t^*)^{1-\epsilon} + \psi[P_{t-1}^{1-\epsilon}]]^{\frac{1}{1-\epsilon}} \tag{17}$$

The Phillips Curve that arises from this problem is

$$\frac{u_t}{f_t} = \left(\frac{1 - \psi \mu_t^{\epsilon-1}}{1-\psi} \right)^{\frac{1}{1-\epsilon}}, \tag{18}$$

where

$$u_t = \frac{\epsilon}{\epsilon - 1} Y_t P_{m,t} + E_t \left[\psi M_{t,t+1} \mu_{t+1}^{\epsilon} u_{t+1} \right],$$

and

$$f_t = Y_t + \psi M_{t,t+1} \mu_{t+1}^{\epsilon-1} f_{t+1}.$$

B.3 Capital Producers

At the beginning of each period, capital producers buy the aggregate stock of old depreciated capital $(1-\delta)k_{t-1}$ from the population of entrepreneurs. The capital producers buy an amount i_t^{cp} of final goods, combine them with the old capital stock, and build new capital stock, k_t. Their profit maximization problem is:

$$\max_{i_t^{cp}} E_t \sum_{s=0}^{\infty} \beta^s SDF_{t,t+s} \left\{ q_{t+s}^k \left(k_{t+s} - (1-\delta)k_{t+s-1}\right) - i_{t+s}^{cp} \right\}, \tag{19}$$

subject to the physical capital accumulation technology:

$$k_t = \left[1 - S\left(\frac{i_t^{cp}}{i_{t-1}^{cp}}\right)\right] i_t^{cp} + (1-\delta)k_{t-1}, \tag{20}$$

where δ is the depreciation rate and the function S captures the presence of adjustment costs in the accumulation of capital. The steady-state properties of the function S are standard: $S(1) = 0$, $S^{'}(1) = 0$ and $S^{''}(1) > 0$, and characterize adjustment costs that are zero in the steady state, while positive and convex at any other $\frac{i_t^{cp}}{i_{t-1}^{cp}}$.

The first order condition of the capital producers' problem is:

$$q_t^k = \frac{1 - E_t SDF_{t,t+1} q_{t+1}^k S'\left(\frac{i_{t+1}^{cp}}{i_t^{cp}}\right)\left(\frac{i_{t+1}^{cp}}{i_t^{cp}}\right)^2}{1 - S\left(\frac{i_t^{cp}}{i_{t-1}^{cp}}\right) - S'\left(\frac{i_t^{cp}}{i_{t-1}^{cp}}\right)\frac{i_t^{cp}}{i_{t-1}^{cp}}} \tag{21}$$

A functional form for S that satisfies the properties above is:

$$S = \frac{1}{2}\theta_i \left(\frac{i_t^{cp}}{i_{t-1}^{cp}} - 1\right)^2 \tag{22}$$

$$S' = \theta_i \left(\frac{i_t^{cp}}{i_{t-1}^{cp}} - 1\right) \tag{23}$$

$$S'' = \theta_i \tag{24}$$

The per-period profits of capital producers are paid as dividends D_t^k to households, where:

$$D_t^k = q_t^k \left(k_t - (1-\delta)k_{t-1}\right) - i_t^{cp}. \tag{25}$$

B.4 Monetary Authority

The monetary authority uses the Taylor rule

$$\ln r_t = v_0 + \rho_r \ln r_{t-1} + (1-\rho_r)\left[v_\mu \ln \mu_t + v_y \ln\left(\frac{Y_t}{Y_{t-1}}\right)\right] + \zeta_t, \tag{26}$$

where r_t is the nominal (gross) one-period interest rate, which obeys the Euler equation

$$r_t = \frac{1}{E_t M_{t,t+1}/\mu_{t+1}}, \tag{27}$$

and ζ_t is an exogenous monetary policy shock with the following law of motion:

$$\zeta_t = \rho_\zeta \zeta_{t-1} + \sigma_\zeta \epsilon_{\zeta,t}, \epsilon_{\zeta,t} \sim \mathcal{N}(0,1) \tag{28}$$

B.5 Competitive Equilibrium and Aggregation

The final good in the economy is produced by aggregating the retailers' output with constant elasticity of substitution:

$$Y_t = \left[\int_0^1 (Y_{rt})^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \tag{29}$$

The retailer acts as a monopolist in producing their final good with the goods from the intermediate producers, which yields the following demand curve for their final product:

$$Y_{rt} = Y_t \left[\frac{P_{rt}}{P_t} \right]^{-\epsilon}, \tag{30}$$

where

$$Y_t = C_t + I_t + \xi_{kres} \xi_k (1 - \Phi(z^*)) \tag{31}$$

Labor market clearing results from equating labor demand, given by:

$$w_t = \left(\frac{\theta}{1-\theta} \right) \left(\frac{C_t}{3 - N_T} \right), \tag{32}$$

and labor supply, implied by intermediate producers' choice of labor:

$$w_t = (1-\alpha) \mathrm{A}_t \left(\frac{k_t}{n_t} \right)^{\alpha} P_{m,t}, \tag{33}$$

where $P_{m,t}$ is the price of the intermediate good to the retailer and

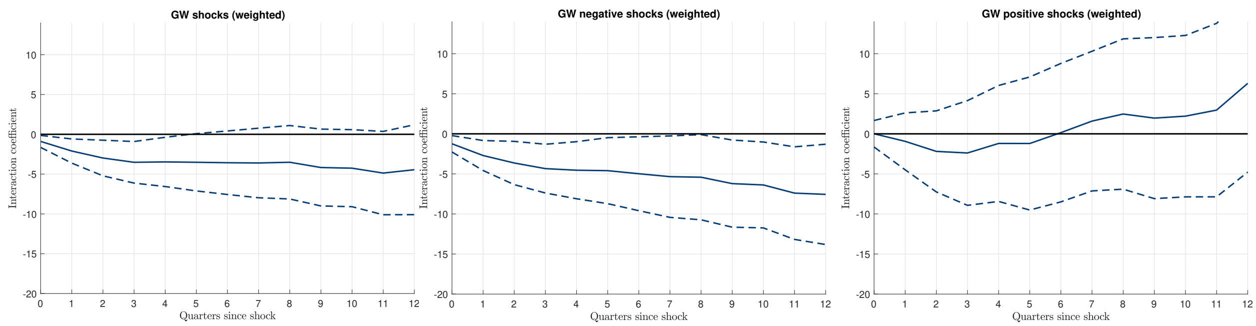
$$N_t = n_t. \tag{34}$$

Similarly for the rental rate of capital:

$$r_t = \alpha \mathrm{A}_t \left(\frac{k_t}{n_t} \right)^{1-\alpha} P_{m,t} \tag{35}$$

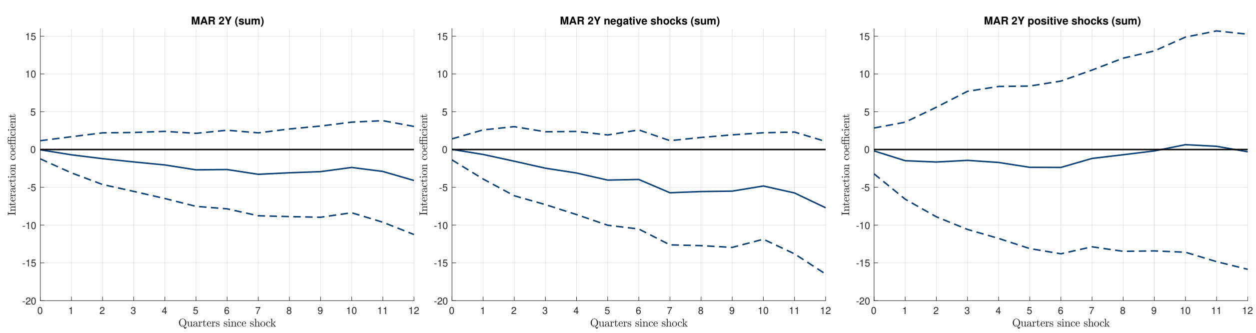
The law of motion for capital is given by:

$$k_t = (1 - \delta)k_{t-1} + i_t \tag{36}$$



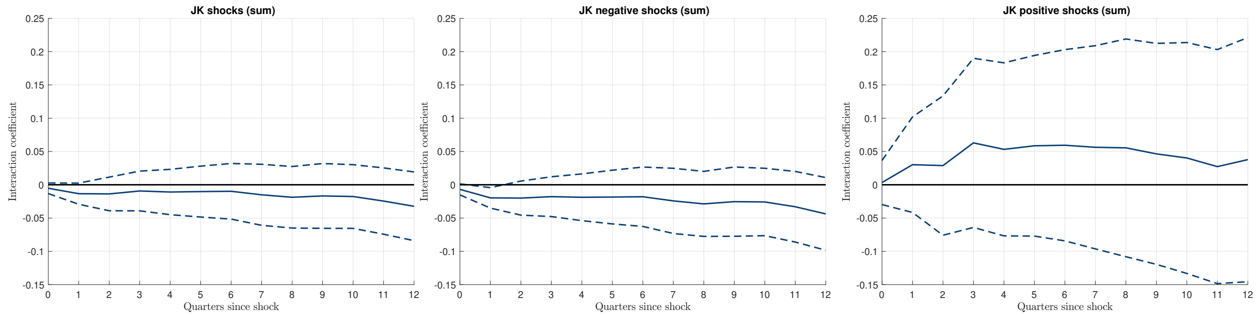
(a) All Shocks **(b) Expansionary Shocks** **(c) Contractionary Shocks**

Figure B.1: (Ottonello and Winberry, 2020) Replication – Distance to Default and the Response of Investment to a Monetary Policy Surprise The charts display the estimate of the effect of distance to default on the response of investment to a 1% surprise increase in the policy rate. Panel (a) replicates Figure 1-Panel (b) in Ottonello and Winberry (2020), with the only difference that the sign of the shock has been flipped for consistency with our other figures. Panels (b) and (c) display the estimates of the same regression but only for expansionary and contractionary shocks, respectively. The dependent variable is the difference between the log of total capital in period *t+h* and in period *t-1*. The monetary surprise in quarter $t, \Delta r_t$, is calculated by adding up the monthly monetary policy shocks obtained from Gorodnichenko and Weber (2016). Shaded areas represent the 90% confidence intervals of the estimates.



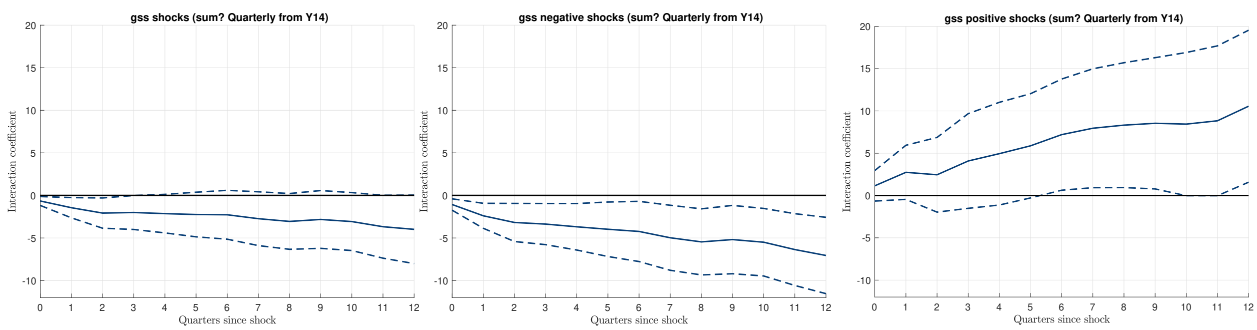
(a) All Shocks **(b) Expansionary Shocks** **(c) Contractionary Shocks**

Figure B.2: Ottonello and Winberry (2020) Replication – Distance to Default and the Response of Investment to a Miranda-Agrippino and Ricco (2021) Monetary Policy Surprise The charts display the estimate of the effect of distance to default on the response of investment to a 1% surprise increase in the policy rate. Panel (a) replicates Figure 1-Panel (b) in Ottonello and Winberry (2020), with the only difference that the sign of the shock has been flipped for consistency with our other figures and the monetary policy shock is different. Panels (b) and (c) display the estimates of the same regression but only for expansionary and contractionary shocks, respectively. The dependent variable is the difference between the log of total capital in period *t+h* and in period *t-1*. The monetary surprise in quarter $t, \Delta r_t$, is calculated by adding up the monthly monetary policy shocks obtained from Miranda-Agrippino and Ricco (2021). Shaded areas represent the 90% confidence intervals of the estimates.



(a) All Shocks (b) Expansionary Shocks (c) Contractionary Shocks

Figure B.3: Ottonello and Winberry (2020) Replication – Distance to Default and the Response of Investment to a Jarociński and Karadi (2020) Monetary Policy Surprise The charts display the estimate of the effect of distance to default on the response of investment to a 1% surprise increase in the policy rate. Panel (a) replicates Figure 1-Panel (b) in Ottonello and Winberry (2020), with the only difference that the sign of the shock has been flipped for consistency with our other figures and the monetary policy shock is different. Panels (b) and (c) display the estimates of the same regression but only for expansionary and contractionary shocks, respectively. The dependent variable is the difference between the log of total capital in period *t+h* and in period *t-1*. The monetary surprise in quarter t,Δr_t, is calculated by adding up the monthly monetary policy shocks obtained from Jarociński and Karadi (2020). Shaded areas represent the 90% confidence intervals of the estimates.



(a) All Shocks (b) Expansionary Shocks (c) Contractionary Shocks

Figure B.4: Ottonello and Winberry (2020) Replication – Distance to Default and the Response of Investment to a Gürkaynak et al. (2005) Monetary Policy Surprise The charts display the estimate of the effect of distance to default on the response of investment to a 1% surprise increase in the policy rate. Panel (a) replicates Figure 1-Panel (b) in Ottonello and Winberry (2020), with the only difference that the sign of the shock has been flipped for consistency with our other figures and the monetary policy shock is different. Panels (b) and (c) display the estimates of the same regression but only for expansionary and contractionary shocks, respectively. The dependent variable is the difference between the log of total capital in period *t+h* and in period *t-1*. The monetary surprise in quarter t,Δr_t, is calculated by adding up the monthly monetary policy shocks obtained from Gürkaynak et al. (2005). Shaded areas represent the 90% confidence intervals of the estimates.