Sophisticated Borrowing Constraints and Macroeconomic Dynamics*

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Abstract

Classic macro-finance models feature “hard" borrowing constraints, where creditors cut credit indiscriminately to maintain borrowing limits and financial acceleration ensues. We study “sophisticated" borrowing constraints featured in the debt contracts of U.S. nonfinancial firms. They use covenants to specify borrowing limits linked to operating earnings. Moreover, following covenant violation, creditors obtain control rights and improve firm performance by reducing agency problems, so earnings increase although capital decreases. We construct a quantitative model with these key features. At the micro level, our model matches the patterns of firms' earnings and capital before and after covenant violation. At the macro level, our model produces less financial acceleration, which is consistent with the resilience of U.S. nonfinancial corporations during recessions.

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1 Introduction

In classic macro-finance models, firms' debt contracts impose hard borrowing constraints (Kiyotaki and Moore, 1997), which require firms that reach these limits to cut borrowing and investment indiscriminately, resulting in sharp declines of output and earnings. At the macro level, the presence of such hard borrowing constraints leads to "financial acceleration": firms' adjustment further tightens borrowing constraints and precipitates larger economic contractions in response to aggregate shocks.

In this paper, we analyze "sophisticated" borrowing constraints that approximate key features of debt contracts among U.S. nonfinancial firms, and study the corresponding macroeconomic implications. These contracts have legally binding financial covenants that commonly set borrowing limits based on operating earnings. Unlike hard borrowing constraints, when financial covenants are violated, creditors do not indiscriminately enforce borrowing limits. Instead, creditors obtain control rights over firms' operations (Chava and Roberts, 2008; Roberts and Sufi, 2009; Nini, Smith, and Sufi, 2012). Importantly, they use the control rights to reduce managerial agency problems, and firm performance improves: earnings increase even though firms reduce capital expenditures.

We then develop a model of sophisticated borrowing constraints. The model features a contingent transfer of control rights, as in Aghion and Bolton (1992), which is triggered when firms hit contractual limits stipulated by financial covenants. This structure is consistent with the interpretation of covenant violation in previous work. Before covenant violation, managers have control rights and make decisions to maximize their value, but they are susceptible to agency problems and value some unproductive use of capital. After covenant violation, creditors gain control rights, make decisions to maximize their value, and alleviate managerial agency problems, as they do not value the unproductive use of capital.

We embed this framework of sophisticated borrowing constraints into an otherwise standard heterogeneous firms New Keynesian model, as in Ottonello and Winberry (2020). Heterogeneous production firms finance their production and investment expenditures through defaultable long-term debt or costly equity issuance. Their borrowing is subject to sophisticated borrowing constraints, defined in terms of the debt-to-earnings ratio, as documented by contractual evidence in Lian and Ma (2021). We contrast this framework with a minimally different model that instead features hard borrowing constraints, where managers always retain control rights and must strictly adhere to borrowing limits based on the debt-to-earnings ratio.

Our sophisticated borrowing constraint quantitatively matches the empirical patterns of firms' capital and earnings around covenant violation, using an extension of the covenant violation dataset in Nini, Smith, and Sufi (2012) shared with us by Greg Nini. Importantly, firms exhibit positive capital growth and declining earnings before covenant violation, but experience negative capital growth and

rising earnings afterwards. This empirical pattern is inconsistent with the standard hard borrowing constraint model, which predicts that capital growth and earnings growth should move in the same direction (driven by productivity shocks). Our sophisticated borrowing constraint model replicates this empirical pattern because constraint violation is driven by a combination of increasing agency frictions (which explain the positive capital growth before violation) and decreasing productivity (which explains the negative earnings growth before violation). Creditor control after the covenant violation curbs managerial agency frictions and removes unproductive use of capital, which explains the negative capital growth and rising earnings after violation. Our model also matches unconditional moments related to firms' borrowing, such as the fraction of firms newly violating a financial covenant each quarter, the total fraction of firms in the violation state, and the median firm-level leverage.

We then study the macroeconomic implications of sophisticated borrowing constraints, particularly the importance of financial acceleration in determining macroeconomic outcomes. By financial acceleration, we refer to the general equilibrium feedback mechanism in which (i) adverse economic outcomes tighten borrowing constraints, and (ii) the tightening of borrowing constraints further worsens economic outcomes. We find muted financial acceleration under sophisticated borrowing constraints, which contrasts with significant financial acceleration under hard borrowing constraints, for two reasons. First, on the extensive margin, constraint tightening causes some firms to violate sophisticated borrowing constraints, but the resulting transition to creditor control reduces managerial agency problems, improving rather than worsening economic outcomes. Second, on the intensive margin, firms that are not violating the sophisticated borrowing constraint also exhibit more muted responses. Because these firms can temporarily violate the constraint if needed, they do not precautionarily reduce borrowing and investment as aggressively as firms in the hard constraint model, which must cut back indiscriminately to avoid binding limits. Together, sophisticated borrowing constraints provide a form of stabilizer for nonfinancial firms during recessions and are consistent with their resilience during downturns (Gertler and Gilchrist, 2018; Jordà et al., 2022).

Related literature Our paper connects to three strands of literature. First, we contribute to the literature on the role of financial frictions in the macroeconomy. A core topic in this literature is financial acceleration: adverse economic outcomes exacerbate financial frictions, which in turn worsen economic outcomes (e.g., Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; Bernanke, Gertler, and Gilchrist, 1999). We show that with sophisticated borrowing constraints, which are central to the debt contracts among large U.S. nonfinancial firms, financial acceleration becomes muted.

Second, we amplify insights from theoretical and empirical research on debt contracting. A number of theories study creditor monitoring to address agency problems (Diamond, 1984; Jensen, 1986; Berlin and Loeys, 1988; Rajan and Winton, 1995; Hartman-Glaser, Mayer, and Milbradt, 2025), and

models of contingent control are particularly related to our focus on covenants (Smith and Warner, 1979; Aghion and Bolton, 1992; Dewatripont and Tirole, 1994; Berlin and Mester, 1999; Garleanu and Zwiebel, 2009). Moreover, empirical work of debt contracts has documented the importance of creditor control in practice, which follows violation of debt covenants (Chava and Roberts, 2008; Roberts and Sufi, 2009; Nini, Smith, and Sufi, 2012). In particular, the data show that firms' performance (e.g., earnings, profitability, and equity valuation) improves after covenant violation triggers creditor control, while they cut back on borrowing and capital expenditures. This observation has not been integrated into macroeconomic analysis. Our paper fills this gap and demonstrates its relevance for macroeconomic research. Bisetti, Li, and Yu (2024) also examine the macroeconomic implications of control transfers triggered by covenants, but their focus is on how creditor control reshapes the risk profile of investment projects, whereas we emphasize its role in alleviating agency frictions.

Third, our paper adds to the research agenda connecting macroeconomic models with firm-level data (e.g., Khan and Thomas, 2013; Ottonello and Winberry, 2020, 2024). Our focus is on incorporating realistic debt contracts including financial covenants (Lian and Ma, 2021; Chodorow-Reich and Falato, 2022; Ivashina, Laeven, and Moral-Benito, 2022; Fang and Zhou, 2023; Perez-Orive, Timmer, and van der Ghote, 2024; Caglio, Darst, and Kalemli-Ozcan, 2024; Greenwald, Krainer, and Paul, 2024, 2025; Adler, 2025). In doing so, we complement existing research that has examined this question through the lens of hard-constraint models (e.g., Greenwald, 2019; Drechsel, 2023). Our analysis shows that the sophistication of these contracts through the use of financial covenants, and the active role taken by lenders in case of violation, can dampen the effects of financial frictions on economic fluctuations. This result echoes the view that institutions shaping debt enforcement are central to macroeconomic fluctuations (e.g., Corbae and D'Erasmo, 2021; Jordà et al., 2022; Kornejew et al., 2024).

As mentioned above, our focus is nonfinancial firms. Debt contracts for financial institutions, such as deposits, commercial paper, asset-backed securities, repos, or bonds, generally do not enforce creditor control the same way (Ma and Scheinkman, 2019). One possibility is that payment default of financial institutions is messy (given their short-term liabilities), so creditors cannot credibly use payment acceleration as a threat to implement creditor control. Financial regulation also restricts the scope of creditor control. Many debt contracts for financial institutions (e.g., margin loans) enforce hard borrowing constraints tied to the market value of financial securities, and the accompanying financial acceleration has been well studied in the literature (Brunnermeier and Pedersen, 2009; Geanakoplos, 2010; Brunnermeier and Sannikov, 2014). Debt contracts for households cannot easily implement creditor control either, but they also do not continuously enforce compliance with borrowing limits after origination. In general, resolution of households' financial distress is challenging, which has contributed to persistent downturns (Mian, Rao, and Sufi, 2013). Relatedly, Alonso (2018)

shows that modeling household borrowing constraints as soft versus hard has significant implications for the macroeconomic impact of a credit crunch.

2 Enforcement of Corporate Borrowing Constraints in Practice

Corporate debt contracts in the US commonly impose restrictions on borrowers using financial covenants, which are legally binding requirements that restrict firms' financial ratios. The most widely used set of financial covenants restrict total debt (or debt payments) as a function of operating earnings in the form of EBITDA (earnings before interest, taxes, depreciation, and amortization) (Lian and Ma, 2021). Violation of financial covenants triggers "technical default," in which case creditors have legal power to accelerate payments. In practice, creditors rarely pursue acceleration, but use the power from this threat to impose creditor control and influence firms' decisions; during this period, the borrower firm receives a "waiver" until its financial performance becomes satisfactory again (Nini, Smith, and Sufi, 2012; Lian and Ma, 2021). Such a contingent transfer of control rights engineered by financial covenants helps approximate optimal contracts in models of incomplete contracts, such as Aghion and Bolton (1992) and Dewatripont and Tirole (1994). They show why it is beneficial for managers to have control rights in good times to preserve the upside, but for creditors to have control rights to protect the downside. Financial covenants are especially common in loans, which assess covenant compliance on a quarterly basis (Lian and Ma, 2021).[1] Financial covenants, as well as violations are highly prevalent: as Nini, Smith, and Sufi (2012) highlight, each quarter around 15% of all public nonfinancial firms are in violation of financial covenants (and over 40% have violated a financial covenant at least once over a decade between 1997 and 2008).

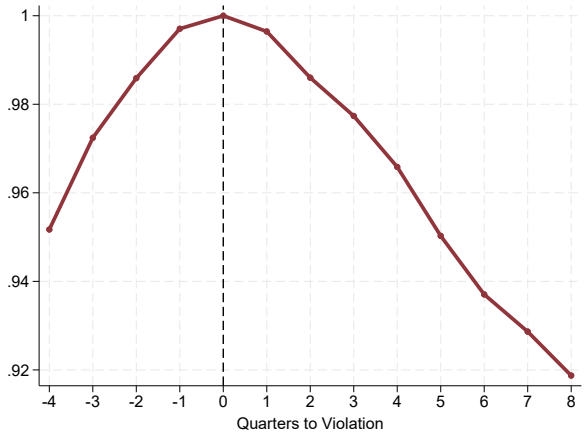
Several important papers collect data on covenant violation and analyze firm outcomes before and after covenant violation (Chava and Roberts, 2008; Roberts and Sufi, 2009; Nini, Smith, and Sufi, 2012). We highlight a striking pattern in Figure 1 following the event-time study approach of Nini, Smith, and Sufi (2012). We use data reporting financial covenant violations disclosed in firms' financial statements, kindly shared by Greg Nini, which extend the data in Nini, Smith, and Sufi (2012) to 2016. Panel (a) shows firms' capital in quarter $t+h$ relative to quarter t when they initially report a covenant violation (normalized by capital at the beginning of quarter t so that the differences over time come from the numerator rather than the denominator). Panel (b) shows firms' quarterly earnings in quarter $t+h$ relative to quarter t (normalized by capital at the beginning of quarter t).

The striking pattern in Figure 1 is that before covenant violation, firms have positive capital growth

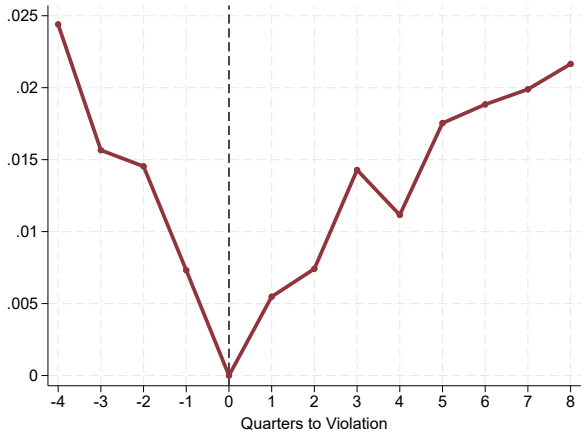
[1] Covenants in bonds are assessed whenever borrowers take significant actions (e.g., issuing new debt). Moreover, for large U.S. nonfinancial firms, monitoring-intensive syndicated loans typically become substantial when debt is high enough to be close to covenant violation.

Figure 1: Dynamics of Firm Outcomes around Covenant Violations

(a) Capital (k_{t+h}/k_t)



(b) Earnings ($(EBITDA_{t+h} - EBITDA_t)/k_t$)



Notes: Panel (a) shows firms' capital (property, plant, and equipment) in quarter $t+h$ relative to quarter t when they initially report a covenant violation (normalized by capital at the beginning of quarter t so that the differences over time come from the numerator rather than the denominator). Panel (b) shows firms' quarterly earnings in quarter $t+h$ relative to quarter t (normalized by capital at the beginning of quarter t). The line shows the median value for each quarter $t+h$. The sample includes US Compustat firms that have debt to EBITDA covenant in quarter t (according to DealScan data). Covenant violation data are kindly shared by Greg Nini and cover 1996 to 2016.

and declining earnings; after covenant violation, firms have negative capital growth and rising earnings. This pattern is consistent with the evidence from Nini, Smith, and Sufi (2012) Figure 4 (capital dynamics around covenant violation) and Figure 7 (earnings dynamics around covenant violation). In addition, Appendix Figure A.1 shows that after covenant violation, firms' equity value declines before covenant violation and rises after covenant violation, consistent with Nini, Smith, and Sufi (2012) Figures 8 and 9. Firms' debt contracts in practice use a variety of covenant specifications (e.g., interest coverage ratio covenants which require interest payments to be less than a fraction of operating earnings, debt-to-EBITDA covenants which require total debt to be less than a multiple of operating earnings, as well as other formulas). These figures focus on firms with debt-to-EBITDA financial covenants according to DealScan data and will be the sample for our model calibration where the covenant is written on debt-to-EBITDA as this is the most prevalent form. We verify that the core patterns in Figure 1 are robust when we consider all firms in Figure A.2, or all firms with earnings-based financial covenants (i.e., debt-to-EBITDA covenants plus interest coverage ratio covenants) in Figure A.3.

Finally, Table A.1 shows these patterns in regressions to check their robustness to controls. The outcome variables include the change in EBITDA in the next four quarters (normalized by beginning of quarter capital), and capital growth over the next four quarters. The regressions control for a number of firm characteristics (e.g., book leverage, EBITDA over capital, capital growth) in the previous

4 quarters as well as their squares and cubes following Nini, Smith, and Sufi (2012). The indicator variable “Violation" indicates the quarter of reporting an initial violation of financial covenants. The results show that future EBITDA is significantly higher and capital growth significantly lower following covenant violation, compared to the usual path of these variables.

Why would firms grow capital while their earnings decline prior to covenant violation? And why do earnings rise when they slim down capital after covenant violation? In fact, productivity shocks generally predict that capital growth and earnings growth should move in the same direction, rather than in the opposite direction. Standard models of financial acceleration with hard borrowing constraints also predict that when financial constraints bind, shocks should affect capital growth and earnings growth in the same direction. A natural interpretation is that substantial capital growth despite declining earnings prior to covenant violation represents excessive expansion due to managerial agency problems (Jensen, 1986). After covenant violation, creditors step in to cut down excessive expansion and improve operating efficiency (e.g., Chava and Roberts, 2008; Roberts and Sufi, 2009; Nini, Smith, and Sufi, 2012). The improved operating efficiency also helps explain the higher equity value observed after covenant violation, which is otherwise difficult to account for.[2]

Do creditors always have the right incentives to implement value-enhancing creditor control? In Figure A.5, we verify that the baseline patterns of capital and earnings dynamics around covenant violation hold in macro recessions (2001 to 2002 and 2007 to 2009) as well. Creditor control does improve earnings in macro recessions, even though some constrained lenders may cut credit supply suboptimally,[3] and our work focuses on the overall effect.

Why do shareholders not eliminate agency problems before the covenant violation? As Dewatripont and Tirole (1994) point out, if managers' contracts are incomplete, a contingent transfer of control rights—where managers cede control rights to creditors when firms perform poorly—is also in shareholders' interest, as it helps incentivize managers.

3 Model

We now develop a heterogeneous firm New Keynesian model featuring sophisticated borrowing constraints that capture key aspects of corporate borrowing constraint enforcement in Section 2, and study the macroeconomic implications. We describe the model in two steps. We begin by describing

[2]Furthermore, creditors are not taking short-termistic cost cutting at the expense of long-term value. In the data, we do not see changes in research and development (R&D) expenditures around covenant violation, as shown in Figure A.4, Panel A. This pattern contrasts with capital expenditures shown in Panel B. Creditors do not appear to cut R&D spending even as they reduce capital investment.

[3]In particular, Chodorow-Reich and Falato (2022) show that lenders with poor health cut credit supply following covenant violation following the Great Financial Crisis.

the core of our model, the "macro-finance block," and then proceed to describe the rest of the model.

3.1 The Macro-Finance Block

A unit mass of heterogeneous production firms produce and invest in capital, subject to sophisticated borrowing constraints. Time is discrete and infinite. There is no aggregate uncertainty. As further specified below, we study perfect foresight transition path in response to unexpected aggregate shocks realized at the beginning of period 0. Each firm $j \in [0,1]$ produces an undifferentiated good with relative price p_t (in terms of the final good, described below) using the production function $y_{jt} = z_{jt}\tilde{k}_{jt}^{\alpha}\ell_{jt}^{\nu}$, where z_{jt} is the firm's productivity, $\tilde{k}_{jt}$ is firm's capital input for production, ℓ_{jt} is the firm's labor input, and $\alpha+\nu<1$. The productivity follows a log-AR(1) process, $\log z_{jt+1} = \rho_z \log z_{jt} + \epsilon_{jt+1}$, where $\epsilon_{jt+1} \sim \mathcal{N}\left(0,\sigma_z^2\right)$ is independent over time. The production firm generates operating earnings

$$\pi_t\left(z_{jt},\tilde{k}_{jt}\right) \equiv \max_{\ell_{jt}} p_t z_{jt}\tilde{k}_{jt}^{\alpha}\ell_{jt}^{\nu} - w_t\ell_{jt} - f_c,$$

where w_t is the real wage and f_c is the average real fixed operating cost. Capital depreciates at rate δ, and firms can purchase new capital $k_{jt+1} - (1-\delta)k_{jt}$ in a competitive market with the relative price of capital $q_{k,t}$, subject to the adjustment costs

$$AC\left(k_{jt},k_{jt+1}\right) = \psi_{ac}\left(\frac{k_{jt+1}-(1-\delta)\,k_{jt}}{k_{jt}}\right)^2 k_{jt}.$$

Motivated by the empirical evidence in Section 2, we introduce managerial agency frictions. Specifically, managers derive utility $H\left(a_{jt-1},\tau_{jt}k_{jt}\right) = a_{jt-1}\left(\tau_{jt}k_{jt}\right)^{\alpha_H} - C_H\mathbb{I}\left(\tau_{jt}k_{jt}>0\right)$ by using a fraction $\tau_{jt}\in[0,1]$ of capital for unproductive use, with $\alpha_H\in(0,1)$, $C_H>0$, and the remaining capital used as input for production, $\tilde{k}_{jt} = \left(1-\tau_{jt}\right)k_{jt}$. a_{jt} captures the idiosyncratic shock to agency frictions, which we refer to as the "agency shock." It follows a log-AR(1) process $\log a_{jt} = \left(1-\rho_a\right)\log\left(\mu_a\right) + \rho_a\log a_{jt-1} + \epsilon_{jt}^a$, where $\epsilon_{jt}^a \sim \mathcal{N}\left(0,\sigma_a^2\right)$ is independent over time and independent of $\{\epsilon_{js}\}_{s=0}^{\infty}$. C_H captures the fixed cost of unproductive use of capital, which can be microfounded as the cost managers incur to avoid being caught diverting capital. The choice of $\tau_{jt}\in[0,1]$ is made at $t-1$, and the utility $H\left(a_{jt-1},\tau_{jt}k_{jt}\right)$ is also obtained at $t-1$, reflecting the time lag for managers to implement projects that yield personal benefits.[4] This explains why a_{jt-1} is relevant for the utility associated with unproductive use of period t capital. Creditors do not value the unproductive use of capital.

The production firm can finance its expenditures by both debt and equity. In terms of debt financing, the firm can borrow externally through a long-term, defaultable, real debt where the payment declines at a factor $\gamma\in[0,1]$. We use $b_{jt}\geq 0$ to denote the payment of long-term debt due at period t.

[4] If those decisions are instead made in the same period as production, then managers can easily lower τ_{jt} to boost earnings so that the sophisticated constraint $b_{jt+1}\leq\overline{b}_{jt+1}$ is satisfied based on (2), and they can always avoid violation.

The firm can issue new debt $b_{jt+1} - \gamma b_{jt}$ given the price schedule $q_{b,t}(\cdots)$, which captures the post-coupon-payment period-t price of debt that promises one unit of payment at $t+1$, γ at $t+2$, γ^2 at $t+3$, and so on. The price schedule is determined by creditors (financial intermediaries owned by the representative household) who competitively purchase and trade firms' debt, as further specified below.

The issuance of new debt is subject to the "sophisticated borrowing constraint," which governs the transition between two different states representing the allocation of control rights. In the normal state ($\omega_{jt} = n$), managers make decisions to maximize their value. In the violation state ($\omega_{jt} = v$), creditors make decisions to maximize their value. The transition from the normal state to the violation state is given by the sophisticated borrowing constraint, summarized by the mapping $\Gamma_b\left(b_{jt+1}, \overline{b}_{jt+1}\right) \mapsto \omega_{jt+1}$, where $\overline{b}_{jt+1}$ is threshold debt level that triggers covenant violation and the transition to violation state. If the firm is currently in the normal state $\omega_{jt} = n$, it stays in the normal state ($\omega_{jt+1} = n$) if the next period debt is below the threshold, $b_{jt+1} \leq \overline{b}_{jt+1}$ and transitions to the violation state ($\omega_{jt+1} = v$) if the next period debt is above the threshold $b_{jt+1} > \overline{b}_{jt+1}$:

$$\omega_{jt+1} = \Gamma_b\left(b_{jt+1}, \overline{b}_{jt+1}\right) = \begin{cases} n, & \text{if } b_{jt+1} \leq \overline{b}_{jt+1}, \\ v, & \text{if } b_{jt+1} > \overline{b}_{jt+1}. \end{cases} \tag{1}$$

Following the contractual evidence of Lian and Ma (2021) about the popularity of earnings-based covenants, we further specify the threshold debt level $\overline{b}_{jt+1}$ based on ratio of the face value of debt and earnings:

$$\tilde{q}_b^{\text{face}} \overline{b}_{jt+1} = \phi \pi_{t+1}\left(z_{jt+1}, \tilde{k}_{jt+1}\right), \tag{2}$$

where $\tilde{q}_b^{\text{face}} = \sum_{k=0}^{\infty} \beta^k \gamma^k = \frac{1}{1-\beta\gamma}$ is the face value of one unit of debt, β is the representative household's discount factor, and ϕ is the tightness of the constraint.[5][6] The contingent transfer of control rights engineered by sophisticated borrowing constraints helps approximate optimal contracts in models of incomplete contracts, such as Aghion and Bolton (1992) and Dewatripont and Tirole (1994). They show why it is beneficial for managers to have control rights in good times to preserve the upside, but for creditors to have control rights to protect the downside. One may also wonder why we do not model post-violations as a bargaining outcome between creditors and borrowers. This is because

[5] Following the practice of financial covenants, we assume that the threshold in (2) is specified based on the book value of debt, $\tilde{q}_b^{\text{face}}$, computed using a risk-free valuation of debt. Specifically, $\tilde{q}_b^{\text{face}}$ is the pre-coupon-payment risk-free face value of debt that promises one unit of payment in the current period, γ units of payment in the next period, and so on. Additionally, we let the face value $\tilde{q}_b^{\text{face}}$ be constant at its steady-state level. This is because financial covenants use book value of existing debt which does not vary with changes in interest rates. Moreover, if $\pi_{t+1}\left(z_{jt+1}, \tilde{k}_{jt+1}\right) < 0$, we simply set $\overline{b}_{jt+1} = 0$.

[6] Also, in practice, the threshold in (2) is typically specified in terms of operating earnings over the past twelve months. For tractability, we instead use current-period (quarterly) earnings to avoid an additional state variable for rolling earnings, which would make the model computationally intractable.

creditors have the legal power to accelerate payments. They rarely do so, as it is inefficient, but they use this power to impose creditor control and influence firms' decisions (Nini, Smith, and Sufi, 2012).

The firm can also issue equity. The literature has identified various frictions associated with equity issuance (e.g., Gomes, 2001; Hennessy and Whited, 2007; Guo et al., 2025), as well as with adjusting dividend payments (e.g., Jermann and Quadrini, 2012, and references therein). We capture these frictions with the cost function $AD\left(d_{jt}\right) = \left(1 + \psi_e \mathbb{I}\left(d_{jt} < 0\right)\right) \psi_d d_{jt}^2$, where d_{jt} denotes dividend payments to shareholders, and negative d_{jt} indicates equity issuance; $\psi_d > 0$ captures costs associated with adjusting dividends overall (motivated by the fact that around 90% of Compustat firms make zero dividend payments, we center this cost around zero); and $\psi_e > 0$ represents the additional cost of equity issuance. The firm pays corporate tax $T_{c,jt} = \tau_c \left[\pi_t\left(z_{jt}, \tilde{k}_{jt}\right) - \delta q_{k,t} k_{jt} - (1-\beta)\tilde{q}_b^{\text{face}} b_{jt}\right]$, where τ_c is corporate tax rate.[7]

From both normal & violation states $\omega_{jt} \in \{n, v\}$, firms could be liquidated for two possible reasons. First, firms liquidate with an exogenous exit probability $\chi_d \in (0,1)$. Second, when the total value of continuation (joint between shareholders and creditors, further specified below) is lower than that of liquidation, determined by $\xi q_{k,t} k_{jt}$, where $\xi \in [0,1]$ captures the liquidation value per dollar of capital.

The timing of events within each period t is as follows. At the beginning of each period, idiosyncratic shocks to existing firms' productivity and agency frictions occur, the allocation of control rights for existing is determined, and liquidation occurs for the two aforementioned reasons. New firms enter the economy, and the mass of entrants equals the mass of firms being liquidated. Each entrant starts in the normal state, and its initial borrowing, capital, fraction of capital in unproductive use, and technology and agency shocks are drawn from the distribution of $x = (b, k, \tau, z, a)$ of firms in the normal state in the previous period. Then, each existing and new firm (excluding liquidated ones) makes decisions as described below.

We now write the optimization problem in each state recursively. Once the allocation of control rights has been determined, the relevant state variables for each firm are (ω, x). We omit subscripts for current variables (e.g., b for b_{jt}) and use the superscript ' for future variables (e.g., b' for b_{jt+1}) for notational simplicity.

The manager's value. In the normal state ($\omega = n$) where the sophisticated borrowing constraint is not violated, the manager of each production firm holds control rights and makes decisions to maximize the manager's value. Specifically, they optimally choose next period's debt b', capital k', the fraction of capital for unproductive use τ', and the dividend payment d. The manager's value

[7] $(1-\beta)\tilde{q}_b^{\text{face}} b_{jt}$ captures steady-state interest payments on the debt, reflecting that only interest payments, not principal payments, are tax-deductible.

$V_{m,t}(n,x)$ can be written as the solution to their optimization problem:

$$V_{m,t}(n,x) = \max_{k',b'\geq 0,\tau'\in[0,1],d} d - AD(d) + H\left(a,\tau' k'\right) + \mathbb{E}\left[\Lambda_{t+1} V^0_{m,t+1}\left(\omega',x'\right)|z,a\right], \tag{3}$$

where Λ_{t+1} is the representative household's stochastic discount factor (SDF), further specified below, and is subject to the transition of firm states, $\omega' = \Gamma_b\left(b',\overline{b}'\right)$, and the flow budget constraint:

$$\underbrace{b}_{\text{debt payment}} + \underbrace{d}_{\text{dividends}} = \underbrace{\pi_t(z,(1-\tau)k)}_{\text{earnings}} + \underbrace{q_{b,t}\left(n,b',k',\tau',z,a\right)\left(b'-\gamma b\right)}_{\text{debt issuance}} - \underbrace{T_{c,t}(x)}_{\text{tax}} - \underbrace{\left[q_{k,t}\left(k'-(1-\delta)k\right)+AC\left(k,k'\right)\right]}_{\text{investment}}, \tag{4}$$

where $V^0_{m,t+1}\left(\omega',x'\right)$ captures the manager's value in the next period incorporating the possibility of liquidation, further specified below. We use $\left(k'_t(n,x),\ b'_t(n,x),\ \tau'_t(n,x),\ d_t(n,x)\right)$ to denote the optimally chosen managerial decisions in (3) at period t, and $\omega'_t(n,x)$ and $x'_t(n,x)$ to denote the corresponding (stochastic) laws of motion of the state variables.

The manager's value in the violation state is determined passively where $d_t(v,x)$, $\tau'_t(v,x)$, $k'_t(v,x)$, $\omega'_t(v,x)$, and $x'_t(v,x)$ are determined by the optimally chosen creditor decisions in (7) below:

$$V_{m,t}(v,x) = d_t(v,x) - AD(d_t(v,x)) + H\left(a,\tau'_t(v,x)\,k'_t(v,x)\right) + \mathbb{E}\left[\Lambda_{t+1} V^0_{m,t+1}\left(\omega'_t(v,x),x'_t(v,x)\right)|z,a\right]. \tag{5}$$

Production firms are owned by representative households, who receive the dividend payments. Their value, termed shareholder value, is given by the manager's value without the agency-friction $H(a,\tau k)$ term. Specifically, for $\omega = \{n,v\}$,

$$V_{s,t}(\omega,x) = d_t(\omega,x) - AD(d_t(\omega,x)) + \mathbb{E}\left[\Lambda_{t+1} V^0_{s,t+1}\left(\omega'_t(\omega,x),x'_t(\omega,x)\right)|z,a\right], \tag{6}$$

where $d_t(\omega,x)$, $\omega'_t(\omega,x)$, and $x'_t(\omega,x)$ are determined by the optimally chosen manager and creditor decisions in (3) and (7).

The creditor's value. In the violation state ($\omega = v$) where the sophisticated borrowing constraint is violated, the creditor obtains control rights and makes decisions to maximize the creditor's value. They do not derive value from unproductive use of capital and optimally choose next period capital k', the fraction of capital for unproductive use τ', the dividend payment d, and the fraction of (current) debt coupon payments to forgive ζ. The total value of debt to creditors who hold it at the beginning of t, $V_{c,t}(v,x)$, can then be written as the solution to their optimization problem:

$$V_{c,t}(v,x) = \max_{k',\tau'\in[0,1],d\geq 0,\zeta\in[0,1]} (1-\zeta)\,b + \mathbb{E}\left[\Lambda_{t+1} V^0_{c,t+1}\left(\omega',x'\right)|z,a\right] \tag{7}$$

and is subject to the transition of firm states (9) and the flow budget constraint:

$$\text{s.t.} \quad \underbrace{(1-\zeta)\,b}_{\text{debt payment (allowing forgiveness)}} + \underbrace{d}_{\text{dividend}} = \underbrace{\pi_t(z,(1-\tau)k)}_{\text{earnings}} - \underbrace{T_{c,t}(x)}_{\text{tax}} - \underbrace{\left[q_{k,t}\left(k'-(1-\delta)k\right)+AC\left(k,k'\right)\right]}_{\text{investment}}. \tag{8}$$

where $V^0_{c,t+1}(\omega', x')$ captures the creditor's value in the next period incorporating the possibility of liquidation, further specified below. We use $\left(k'_t(v,x),\ \tau'_t(v,x),\ d_t(v,x),\ \zeta_t(v,x)\right)$ to denote the optimally chosen creditor decisions in (7) at period t, and $\omega'_t(v,x)$ and $x'_t(v,x)$ to denote the corresponding (stochastic) laws of motion of the state variables.

The creditor's problem in (7) embeds three assumptions regarding creditor control in the violation state. First, we let debt naturally mature, $b' = \gamma b$. This is consistent with median debt issuance being zero during violation in the data.[8] Firms that are in violation cannot issue new debt given the covenant restrictions, and they typically do not have excess cash flows to repurchase additional debt either (if they had, they could have repurchased debt prior to violation to avoid it).

Second, we restrict $d \geq 0$, since equity issuance in violation is rare too with a median of zero.[9] For example, classic debt overhang problems would make equity issuance difficult in this case (Myers, 1977).

Third, we assume that the transition from the violation state back to the normal state is exogenous, governed by the transition probability λ. That is,

$$\omega_{jt+1} = \begin{cases} n, & \text{with probability } \lambda, \\ v, & \text{with probability } 1-\lambda. \end{cases} \tag{9}$$

The exogenous transition back to the normal state reflects that problems caused by managerial agency frictions (e.g., inefficient acquisitions, pet projects, bureaucracies) may take a nontrivial and unpredictable amount of time to mitigate. If transitioning back to the normal state is instead determined by whether the constraint $b_{jt+1} \leq \overline{b}_{jt+1}$ is satisfied, almost all violating firms will transition back immediately. This is because, as creditors do not value the unproductive use of capital, they significantly improve earnings by avoiding such use when they have control rights (set $\tau' = 0$) and the constraint $b_{jt+1} \leq \overline{b}_{jt+1}$ is satisfied immediately.

The creditor's value in the normal state is determined passively by the optimally chosen managerial decisions in (3). Specifically, the total value of debt to creditors who hold it at the beginning of t is given by:

$$V_{c,t}(n,x) = b + \frac{\gamma b}{b'_t(n,x)} \mathbb{E}\left[\Lambda_{t+1} V^0_{c,t+1}\left(\omega'_t(n,x), x'_t(n,x)\right) | z, a\right]. \tag{10}$$

Compared to (7), it captures that, in the normal state, there is no debt forgiveness but there is the possibility of debt dilution ($b' \neq \gamma b$). For the latter, because creditors can competitively trade firms' debt, all holders of debt at the beginning of $t+1$ have the same valuation; therefore, creditors who hold it at the beginning of t own a fraction $\frac{\gamma b}{b'_t(n,x)}$ of value at $t+1$.

[8] For firms in violation, the median quarterly net debt issuance relative to capital is -0.0025 and the mean is 0.0129.

[9] For firms in violation, the median quarterly net equity issuance relative to capital is 0 and the mean is 0.0268.

Liquidation. In the case of liquidation, one can recover a value of $\xi q_{k,t} k_{jt}$, where $\xi \in [0,1]$ captures the liquidation value per dollar of capital. The value of the creditor, manager, and shareholder in liquidation is then given by

$$V_{c,t}^{l}(x) = \min\left\{\xi q_{k,t} k, \tilde{q}_b^{\text{face}} b\right\} \quad \text{and} \quad V_{m,t}^{l}(x) = V_{s,t}^{l}(x) = \max\left\{\xi q_{k,t} k - \tilde{q}_b^{\text{face}} b, 0\right\}. \tag{11}$$

For $i \in \{m, c, s\}$ and $\omega \in \{n, v\}$, the value functions incorporating liquidation is then given by

$$V_{i,t}^{0}(\omega, x) = \chi_t^{l}(\omega, x)\, V_{i,t}^{l}(x) + \left(1 - \chi_t^{l}(\omega, x)\right) V_{i,t}(\omega, x), \tag{12}$$

where the probability of liquidation $\chi_t^{l}(\omega, x)$ is given by

$$\chi_t^{l}(\omega, x) = \begin{cases} \chi_d & V_{c,t}(\omega, x) + V_{s,t}(\omega, x) \geq V_{c,t}^{l}(x) + V_{s,t}^{l}(x) \\ 1 & V_{c,t}(\omega, x) + V_{s,t}(\omega, x) < V_{c,t}^{l}(x) + V_{s,t}^{l}(x) \end{cases}, \tag{13}$$

which incorporates two reasons for transition to liquidation: exogenous exit with probability $\chi_d \in (0,1)$ and cases where the total continuation value, jointly for shareholders and creditors, is lower than the liquidation value. The latter case mirrors the practice of the bankruptcy system in the US, where the supervising court decides on continuation or liquidation based on the total continuation value versus the liquidation value.

The price schedule. Because creditors competitively purchase and trade firms' debt at the firm-specific price schedule $q_{b,t}\left(\omega, b', k', \tau', z, a\right)$, the creditors' value and the price schedule are linked by, for $\omega \in \{n, v\}$,[10]

$$V_{c,t}(\omega, x) = (1 - \zeta_t(\omega, x))\, b + \gamma b q_{b,t}\left(\omega, b_t'(\omega, x), k_t'(\omega, x), \tau_t'(\omega, x), z, a\right). \tag{14}$$

The first term in (14) captures the debt payment at t. The second term captures the period-t value of debt that promises γb units of payment at $t+1$, where γ reflects debt maturing. Together with the creditor's value in (7) and (10), we obtain the usual recursive expression for the competitive price schedule:[11]

$$\begin{aligned} q_{b,t}\left(\omega, b', k', \tau', z, a\right) = {} & \mathbb{E}\left[\Lambda_{t+1}\left(1 - \chi_{t+1}^{l}\left(\omega', x'\right)\right)\left(\left(1 - \zeta_{t+1}\left(\omega', x'\right)\right) + \gamma q_{b,t+1}(\cdots)\right) | z, a\right] \\ & + \mathbb{E}\left[\Lambda_{t+1} \chi_{t+1}^{l}\left(\omega', x'\right) \min\left\{\xi q_{k,t+1} \frac{k'}{b'}, \tilde{q}_b^{\text{face}}\right\} | z, a\right], \end{aligned} \tag{15}$$

where $x' = \left(b', k', \tau', z', a'\right)$ and ω' are determined by (1) and (9). The first term captures the debt's value if the firm is not liquidated at $t+1$, and the second term captures the debt's value if the firm is liquidated at $t+1$.

[10] We define $\zeta_t(n, x) = 0$ (no debt forgiveness in the normal state) and $b_t'(v, x) = \gamma b$ (debt naturally matures in the violation state).

[11] In (15), the full argument list of $q_{b,t+1}$ is $\left(\omega', b_{t+1}'\left(\omega', x'\right), k_{t+1}'\left(\omega', x'\right), \tau_{t+1}'\left(\omega', x'\right), z', a'\right)$.

3.2 The Macro Block and Equilibrium

We follow Ottonello and Winberry (2020) to parsimoniously generate a New Keynesian Phillips curve that relates nominal variables to the real economy by introducing sticky-price retailers. There is a unit mass of retailers $i \in [0,1]$. Each retailer i produces a differentiated variety $\tilde{y}_{it}$ using the production firms' undifferentiated good as its input: $\tilde{y}_{it} = y_{it}$, where y_{it} is the amount of the undifferentiated good demanded by retailer i. Retailers set a nominal price for their variety $\tilde{p}_{it}$ but must pay a quadratic price adjustment cost $\frac{\varphi}{2}\left(\frac{\tilde{p}_{it}}{\tilde{p}_{it-1}} - 1\right)^2 Y_t$.

A representative, competitive final good producer purchases differentiated varieties from retailers and uses a CES production technology that incorporates retailers' varieties as inputs, with an elasticity of substitution γ_{CES}: $Y_t = \left(\int \tilde{y}_{it}^{\frac{\gamma_{CES}-1}{\gamma_{CES}}} di\right)^{\frac{\gamma_{CES}}{\gamma_{CES}-1}}$. Together, this gives rise to a New Keynesian Phillips curve (linearized for simplicity):

$$\log \Pi_t = \frac{\gamma_{CES} - 1}{\varphi} \times \log \frac{p_t}{p^*} + \beta \log \Pi_{t+1}, \tag{16}$$

where p_t is the relative price of output from financially constrained production firms, and $p^* = \frac{\gamma_{CES}-1}{\gamma_{CES}}$ is its steady-state value. The Phillips Curve links the macro block to the macro-finance block through the relative price p_t. When aggregate demand increases, sticky-price retailers expand production of their differentiated goods and raise demand for the heterogeneous firms' produced goods, y_{it}, which increases their relative price, p_t, and generates inflation through (16).

A representative, competitive capital goods producer produces new capital goods using the technology $\Phi\left(\frac{I_t}{K_t}\right) K_t$, where I_t is units of the final good used to produce capital, K_t is the aggregate start-of-period capital, and $\Phi(x) = \frac{\delta^{\frac{1}{\eta}}}{1-1/\eta}(x)^{1-1/\eta} - \frac{\delta}{\eta-1}$. Its optimality pins down the relative price of capital as $q_{k,t} = \left(\frac{I_t/K_t}{\delta}\right)^{1/\eta}$. The evolution of aggregate capital is then given by

$$K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right) K_t + K_t(1-\delta). \tag{17}$$

The monetary authority sets the nominal risk-free interest rate R_t^{nom} according to the Taylor rule

$$\log R_t^{\text{nom}} = \log \frac{1}{\beta} + \varphi_\pi \log \Pi_t + \epsilon_t^m, \tag{18}$$

where ϵ_t^m is the monetary policy shock and $\varphi_\pi > 1$ is the Taylor coefficient.

There is a representative household with preferences over consumption C_t and labor supply L_t with life-time expected utility

$$\mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \left(\log(C_t) - \Psi L_t\right)\right],$$

where β is the discount factor and Ψ parametrizes the disutility of labor. The household owns all firms in the economy, serving as a shareholder of both production firms and financial intermediaries that

lend to them. The stochastic discount factor and nominal interest rate are linked through the Euler equation for bonds, $\Lambda_{t+1} = \beta \frac{C_t}{C_{t+1}} = \frac{\Pi_{t+1}}{R_t^{\text{nom}}}$, where R_t^{nom} is the nominal risk-free interest rate, and Π_{t+1} is the inflation between period t and $t+1$.

The economy starts from a steady state with all ϵ_t^m equal to zero. An unexpected shock to monetary policy, $\{\epsilon_t^m\}_{t=0}^{\infty}$, is realized at the beginning of period 0, and we study the perfect-foresight transition back to the steady state.

An equilibrium is a set of value functions $\left\{V_{i,t}(\omega, x), V_{i,t}^0(\omega, x)\right\}_{\omega=n,v,i=m,c,s}$, decision rules $\left\{k_t'(\omega, x), \tau_t'(\omega, x), d_t(\omega, x), b_t'(n, x), \zeta_t(v, x)\right\}_{\omega=n,v}$, measure of firms $\mu_t(\omega, x)$, debt price schedule $\left\{q_{b,t}(\omega, b', k', \tau', z, a)\right\}_{\omega=n,v}$, probability of liquidation $\left\{\chi_t^l(\omega, x)\right\}_{\omega=n,v}$, and aggregate variables $\left\{C_t, Y_t, L_t, K_t, I_t, w_t, p_t, q_{k,t}, \Pi_t, R_t^{\text{nom}}, \Lambda_{t+1}\right\}$ such that (i) managers optimize in the normal state, creditors optimize in the violation state, and the probability of liquidation is given by (13), (ii) creditors price competitively, (iii) the household optimizes, (iv) the measure of firms is consistent with decision rules, (v) goods, labor, and capital markets clear, (vi) monetary policy follows (18).

3.3 The Hard Borrowing Constraint Model

We will contrast the above model with sophisticated borrowing constraints against a model with hard borrowing constraints. The key difference from the sophisticated borrowing constraint model specified above is that, consistent with the literature on hard borrowing constraint models (e.g., Khan and Thomas, 2013; Bianchi and Mendoza, 2018; Drechsel, 2023), agents always respect the hard borrowing constraint, so there is no violation state or liquidation. In the baseline hard borrowing-constraint problem, we also remove managerial agency frictions, as these are not part of standard hard borrowing-constraint models . Besides these two differences, the rest of the production firm's problem is exactly the same as above. The relevant firm state is $x = (b, k, z)$ and the firm's value V_t^{hard} can be written as the solution to the following optimization problem:

$$V_t^{\text{hard}}(x) = \max_{b' \geq 0, k', d} \; d - AD(d) + \mathbb{E}\left[\Lambda_{t+1} V_{t+1}^{\text{hard}}\left(x'\right) | z\right] \tag{19}$$

subject to the flow budget constraint

$$d = \pi_t(z, k) - b + q_{b,t}^{\text{hard}} \cdot \left(b' - \gamma b\right) - q_{k,t}\left(k' - (1-\delta)k\right) - AC\left(k, k'\right) - T_{c,t}(x) \tag{20}$$

and the hard borrowing constraint

$$\tilde{q}_b^{\text{face}} b' \leq \phi^{\text{hard}} \mathbb{E}\left[\pi_{t+1}\left(z', k'\right) | z\right]. \tag{21}$$

The enforcement of hard borrowing constraints differs from that of sophisticated borrowing constraint. When a firm hits hard borrowing constraints, it must cut credit indiscriminately to remain within borrowing limits.

We consider two additional extensions featuring different versions of hard borrowing-constraint models. First, we introduce a hard borrowing-constraint model with managerial agency frictions. Second, we consider a hard borrowing-constraint model where the borrowing constraint takes the form of an asset-based borrowing constraint.

$$\tilde{q}_b^{\text{face}} b' \leq \phi^{\text{hard}} q_{k,t+1} k'. \tag{22}$$

4 Dynamics of Firm Outcomes Around Covenant Violations: Model and Data

Calibration. We calibrate the model in two steps. First, we exogenously assign a subset of parameters. Second, we choose the remaining parameters to match moments in the data. Table 1 lists the parameters that are exogenously assigned. The model period is one quarter, so we set the discount factor to $\beta = 0.990$. We choose total returns to scale $\alpha+\nu = 0.850$, a commonly used value in the heterogeneous-firm literature, and set $\nu = 0.610$, close to the value documented in Karabarbounis and Neiman (2014). We set the quarterly depreciation rate to $\delta = 2.5\%$, also a commonly used value in the literature. We set ϕ, the capacity of earnings-based borrowing, to 14, following the contractual evidence in Lian and Ma (2021).[12] The liquidation value per dollar of capital is set to $\xi = 0.350$, based on Kermani and Ma (2023). We set the quarterly exogenous exit rate to $\chi_d = 0.5\%$ based on the exit rate of large firms with more than 500 employees in census Business Dynamics Statistics (BDS) database, and the corporate tax rate to $\tau_c = 0.3$ based on estimates of the effective corporate tax rate in recent decades in Dyreng et al. (2017). The elasticity of substitution across differentiated varieties is $\gamma_{CES} = 10$, and the slope of the New Keynesian Phillips curve, which determines φ, is $\kappa \equiv (\gamma_{CES} - 1)/\varphi = 0.1$, both taken from Ottonello and Winberry (2020). The elasticity of aggregate investment with respect to the relative price of capital goods is $\eta = 4$, also from Ottonello and Winberry (2020). We set the Taylor rule coefficient to $\varphi_\pi = 1.5$. Finally, the disutility of labor $\Psi = 0.8$ is chosen so that the steady-state real wage is normalized to one.

[12] Lian and Ma (2021) find that the capacity of earnings-based borrowing, measured as the debt-to-annual-earnings ratio, is approximately 3.5, which corresponds to a debt-to-quarterly-earnings of 14.

Table 1: Fixed Parameters

β	0.990	Discount Factor
α	0.240	Capital Share
ν	0.610	Labor Share
δ	0.025	Depreciation Rate
ξ	0.350	Recovery in Liq.
ϕ	14.000	Debt to Earnings Limit
χ_d	0.005	Exogenous Exit Prob.
τ_c	0.300	Corporate Tax
γ_{CES}	10.000	Elasticity of Substitution
κ	0.100	Philips Curve Slope
η	4.000	Elasticity of Investment
φ_π	1.500	Taylor Rule Coefficient
Ψ	0.800	Disutility of Labor

Notes: This table displays parameters exogenously fixed in the calibration. A model period is one quarter.

We then choose the parameters listed in Table 2 to match both unconditional empirical moments related to firms' financing in Table 3 and firm outcomes around covenant violations in Figure 1, evaluated in the steady state of the model in the absence of aggregate shocks. The first set of parameters, $(\rho_z, \sigma_z, \psi_{ac})$, governs technology, including the stochastic process for idiosyncratic productivity shocks and capital adjustment costs. The second set of parameters, $(\rho_a, \sigma_a, \mu_a, \alpha_H, C_H)$, governs the stochastic process for idiosyncratic agency shocks and the agency frictions embedded in managers' preferences. The third set of parameters governs firms' financing decisions and the sophisticated borrowing constraints, including the dynamics of debt through its maturity parameter γ, the probability of transitioning from the violation state back to the normal state λ, frictions to adjusting dividends and raising equity (ψ_d, ψ_e), and the fixed operating cost f_c.

Table 2: Fitted Parameters

ρ_z	0.876	Persistence of TFP Shocks
σ_z	0.099	SD of TFP Shocks
ψ_{ac}	0.115	Capital Adj Cost
ρ_a	0.704	Persistence of Agency Shocks
σ_a	0.225	SD of Agency Shocks
μ_a	0.066	Mean of Agency Shocks
α_H	0.426	Agency Curvature
C_H	0.055	Agency Fixed Cost
γ	0.977	Coupon Decay Rate
λ	0.107	Prob. of Transition to Normal from Violation
ψ_d	0.458	Dividend Adj Cost
ψ_e	0.619	Equity Issuance Cost
f_c	0.046	Fixed Operating Cost

Notes. This table displays parameters that are chosen to match moments in Table 3 and Figure 1.

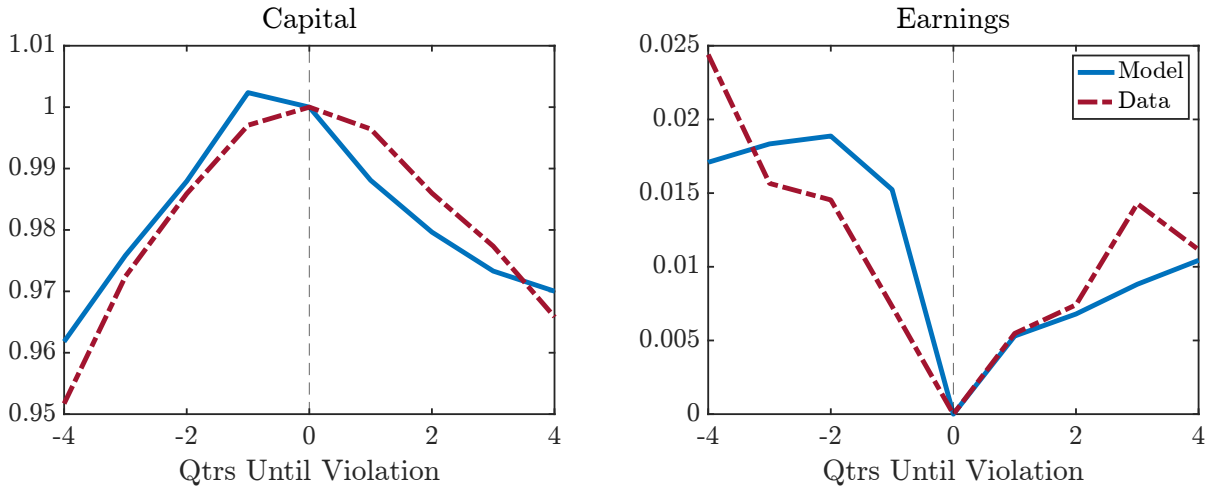
Table 3: Unconditional Targeted Moments and Model Fit

	Model	Data
Median Leverage	0.293	0.320
New Violation Rate	0.019	0.025
Frac. in Violation	0.146	0.150
Median Dividend to Capital	0.024	0.000
Median Equity Issuance to Capital	0.000	0.001

Notes. This table displays the empirical moments targeted in our calibration and the corresponding values generated by the steady state of the model. Leverage, dividend to capital ratio, and equity issuance to capital ratio correspond to $\tilde{q}_b^{\text{face}} b/k$, $\max\{d,0\}/k$, and $\max\{-d,0\}/k$ in the model, respectively. We use assets as a proxy for capital when calculating unconditional moments in this table.

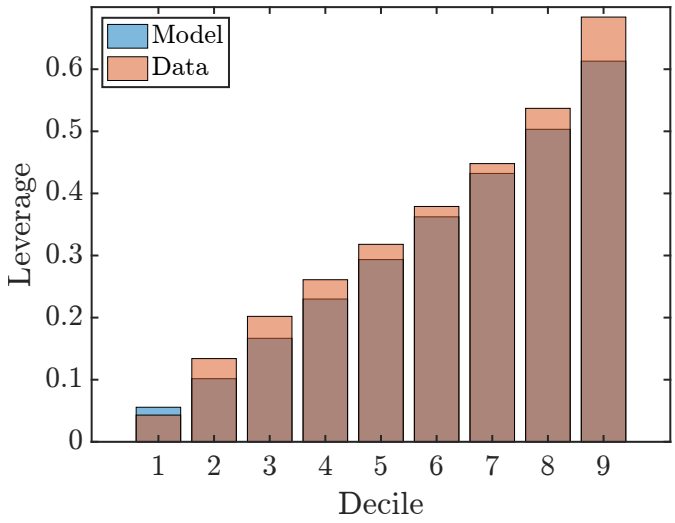
In terms of unconditional moments (Table 3), we target the median leverage (0.320), the fraction of firms newly violating a financial covenant each quarter (2.5%), the total fraction of firms in the violation state (15%), the median dividend payments to capital ratio (0.024), and the median equity issuance to capital ratio (0.001). Those are calculated based on Compustat firms that have debt/EBITDA covenants, using the same sample as Figure 1. For firm outcomes around covenant violations, we match the dynamics of median capital and earnings changes in Figure 1, normalized by capital in the first quarter of covenant violation t, corresponding to k_{jt+h}/k_{jt} and $\left(\pi_{jt+h}-\pi_{jt}\right)/k_{jt}$ in the model, for $h \in \{-4,-3,\cdots,4\}$.

Figure 2: Targeted Dynamics Around Covenant Violations and Model Fit



Notes: The blue solid line in the left panel shows the median firm's capital in period $t+h$ normalized by its capital at t when they initially violate the sophisticated borrowing constraint, i.e., k_{t+h}/k_t in the model. The blue solid line in the right panel shows the median firm's earnings in period $t+h$ relative to period t, normalized by capital at t, i.e., $(\pi_{t+h}-\pi_t)/k_t$ in the model. The lines are based all firms violating the sophisticated borrowing constraint in the steady state of the model. The red dashed lines in both panels correspond to their empirical counterparts, i.e., the median lines in Figure 1.

Figure 3: Distribution of Leverage: Model vs. Data



Notes: The red bar plots the deciles of firm leverage in the data, using a sample of US Compustat firms that have a debt-to-EBITDA covenant according to DealScan. The blue bar plots the deciles of firm leverage in the steady state of the model, defined as $\tilde{q}_b^{\text{face}} b/k$.

Despite being overidentified, in the sense that the model features 13 fitted parameters and 21 targeted moments (5 unconditional moments and 16 moments describing the dynamics of earnings and capital around covenant violations), the model matches the targeted moments reasonably well.

In particular, Figure 2 shows that the model closely tracks the dynamics of capital and earnings around covenant violations, although it implies a slightly less gradual decline in earnings before the violation. The calibrated parameters in Table 2 are broadly comparable to existing estimates in the literature. For example, the average duration of covenant violation $\frac{1}{\lambda} \approx 9$ quarters is close to their empirical counterparts for Compustat firms.

While all parameters are jointly chosen to match the full set of moments, the parameters governing idiosyncratic productivity and agency shocks, σ_z, ρ_z, σ_a, and ρ_a play a particularly important role in shaping capital and earnings dynamics around covenant violations. To see this more formally, Figure C.3 reports the local sensitivities of the targeted moments with respect to the model parameters, computed using the tools developed by Andrews, Gentzkow, and Shapiro (2017). These results show that, as further discussed below, increases in the volatility or persistence of productivity shocks raise the correlation between earnings and capital around covenant violations, while increases in the volatility or persistence of agency shocks reduce this correlation. Given these shocks, the magnitude of capital changes around covenant violation are particularly influenced by the parameters driving the attractiveness of diverting capital for unproductive use, (μ_a, α_H, C_H), the maturity of debt, γ, and the probability of transition to the normal state from violation, λ.

Turning to unconditional moments, Figure C.3 shows that greater persistence of productivity shocks, longer debt maturity, and higher frictions to adjusting dividends and raising equity increase median leverage, while higher volatility of productivity shocks, a greater attractiveness of diverting capital to unproductive uses, and higher fixed operating costs induce more precautionary behavior and are associated with lower leverage. The violation rate and the fraction of firms in violation increase with the volatility of productivity shocks, but decline with higher capital adjustment costs and a greater attractiveness of diverting capital to unproductive uses, both of which lead managers to behave more cautiously. Finally, the parameters governing frictions to adjusting dividends and raising equity are naturally related to the dividend-to-capital ratio and median equity issuance relative to capital, although Table C.3 shows that the latter is locally insensitive around our calibrated parameter values.

Validation. Figure 3 shows that our model generates a distribution of leverage, which is not targeted in the calibration, that is closely aligned with that observed in the data. In addition, Appendix Table C.1 shows that the firm size distribution implied by the model, illustrated by the lower and upper interquartile distances relative to the median of the capital distribution, is also aligned with its empirical counterpart.

Appendix Table C.1 further shows that the model is broadly consistent with several unconditional moments of investment and earnings that are not targeted in the calibration. First, it generates volatilities of investment rates ($\frac{k'-(1-\delta)k}{k}$) and earnings to capital that are in line with those observed in the

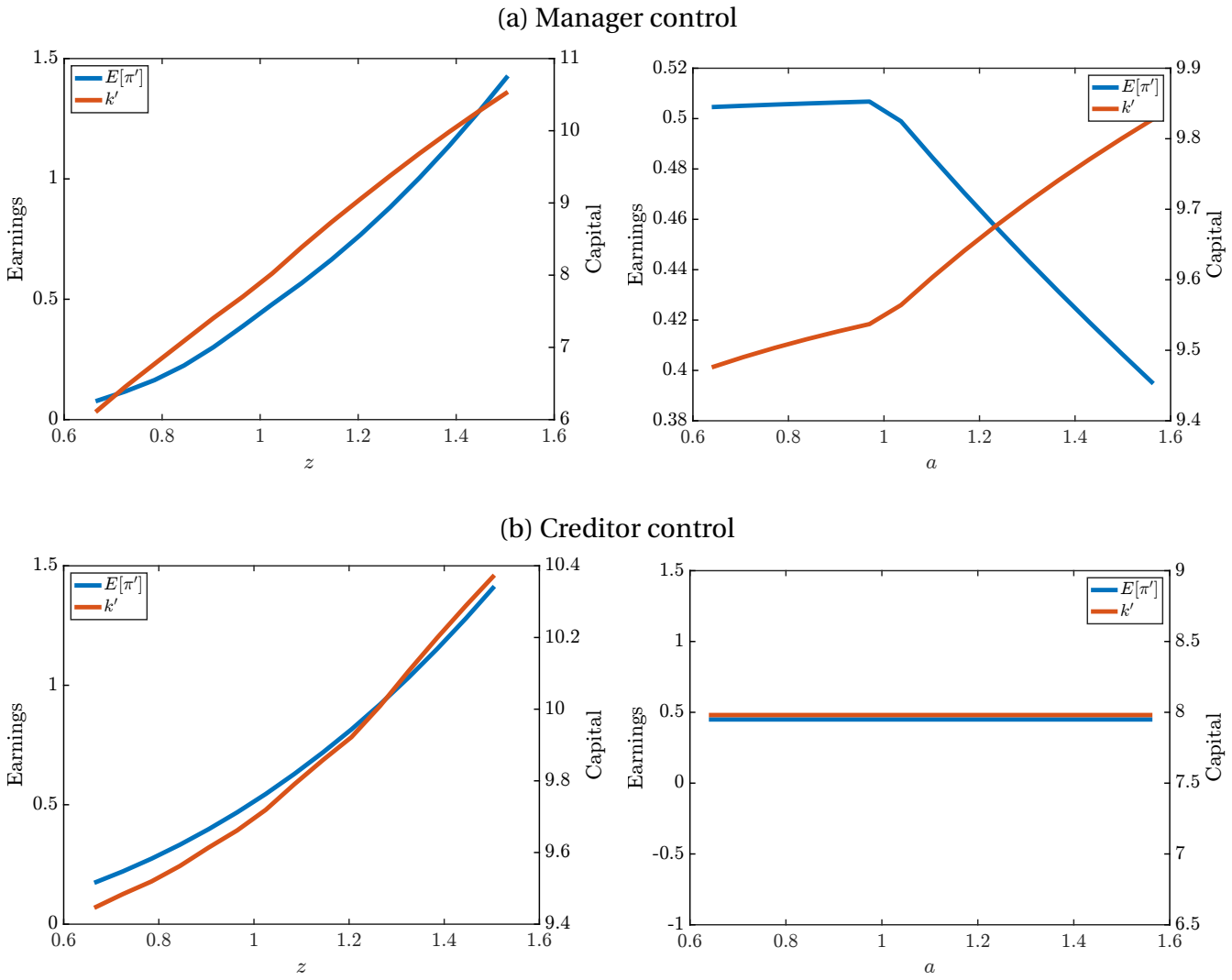
data. Second, it produces a positive comovement between these variables, albeit stronger than in the data, as well as a negative comovement between covenant violation rates and earnings to capital. Finally, the model predicts positive autocorrelation in both investment rates and earnings to capital, although the autocorrelation of earnings to capital is larger than in the data.

Policies under manager and creditor control. To better understand how our model matches the dynamics of capital and earnings before covenant violations (under manager control) and after violations (under creditor control), we now zoom in on policies under manager and creditor control.

We start with the normal state under manager control. Panel (a) of Figure 4 plots the manager's chosen next period capital $k'(n,x)$ in the steady state and the corresponding expected earnings $\mathbb{E}\left[\pi'|z,a\right]$ (determined by $k'(n,x)$ and the manager's chosen $\tau'(n,x)$) as functions of current productivity z and agency shock a.[13]

[13]We omit the subscript t when describing steady-state value functions and decision rules. For example, $k'(n,x)$ captures the manager's optimally chosen capital in the normal state in the steady state.

Figure 4: Capital and Earnings under Manager and Creditor Control



Notes: The red lines plot next period capital, k', as a function of current productivity z (left subfigures) and the agency shock a (right subfigures). The blue lines plot next period expected earnings, $\mathbb{E}\left[\pi' \mid z, a\right]$, as a function of current productivity z (left subfigures) and the agency shock a (right subfigures). Every non-moving state variable is fixed at the median of the ergodic distribution. The plots in panel (a) are based on the manager's problem in (3), evaluated in the steady state when the firm is in the normal state. The plots in panel (b) are based on the creditor's problem in (7), evaluated in the steady state when the firm is in the violation state.

The left subfigure shows that with higher productivity, z, the manager chooses higher capital, as the marginal product of capital will be persistently higher. Earnings will also be higher due to both the direct effect of productivity and the higher chosen capital. The right subfigure shows that with higher agency shocks, a, the manager also chooses higher capital, as the unproductive use of capital becomes more attractive. However, earnings decrease with a because the manager allocates a higher fraction of capital, τ', to unproductive use.

We now turn to the violation state under creditor control. We first comment on a few features of creditor's optimal policy in (7). First, the creditor optimally chooses not to allocate any capital to unproductive use, $\tau'(v,x) = 0$ because they do not derive any value from it. As further explained below, such an alleviation of managerial agency frictions is key for the model to match the recovery of earnings after covenant violations in Figure 1. Second, the creditor optimally chooses not to pay dividends, $d(v,x) = 0$.[14] This is because, from the flow budget in (8), creditors can use any funds that would have been paid as dividends—which do not increase creditor value—to increase next period capital, k', thereby increasing creditor value. Third, when the debt burden, b, is high relative to capital k and productivity z, creditors may choose debt forgiveness ($\zeta(v,x) > 0$, although this is rare in the ergodic distribution of our model.

Panel (b) of Figure 4 plots the creditor's chosen next period capital $k'(v,x)$ in the steady state and the corresponding expected earnings $\mathbb{E}\left[\pi'|z,a\right]$ (determined by $k'(v,x)$ and $\tau'(v,x)$) as functions of current productivity z and agency shock a. Compared to Panel (a), capital $k'(v,x)$ increases much less with z. This can be seen from the flow constraint (8) under creditor control when dividend payments are set to zero:

$$(1-\zeta(v,x))\, b = \pi\left(z,(1-\tau)\, k\right) - T_c\left(x\right) - q_k\left(k'(v,x) - (1-\delta)\, k\right) - AC\left(k, k'(v,x)\right). \tag{23}$$

Under creditor control, z only affects $k'(v,x)$ through the direct effect on current earnings $\pi\left(z,(1-\tau)\, k\right)$. This contrasts with the case under manager control, where $k'(n,x)$ also increases with z because it raises the marginal product of capital in the future. Earnings also increase somewhat less with z compared with manager control, but is more sensitive to z than capital.

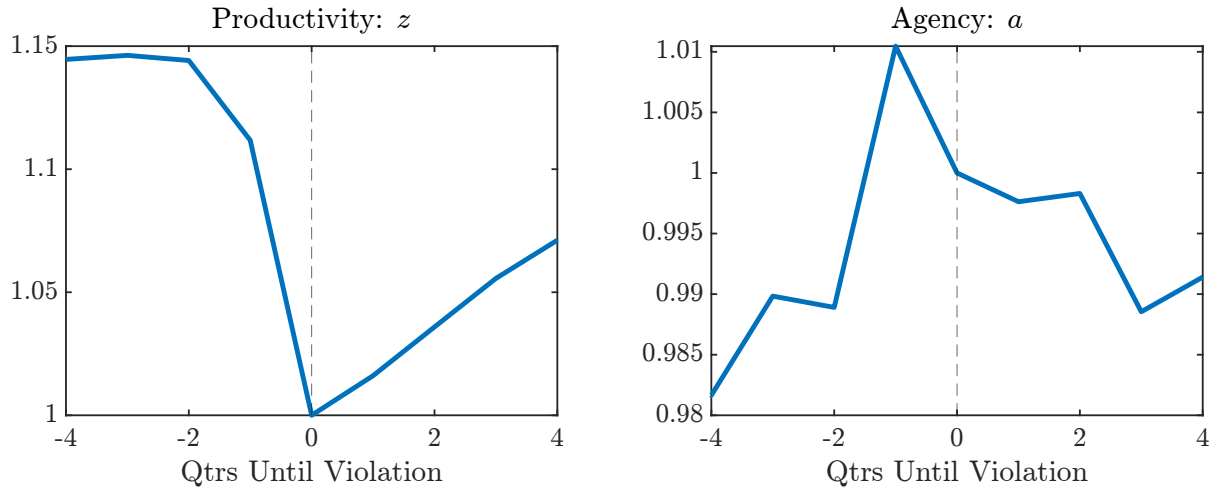
Moreover, Panel (b) Figure 4 shows that, under creditor control, next period capital and expected earnings are no longer sensitive to the agency shock, a. This is because creditors choose $\tau'(v,x) = 0$, making their expected earnings insensitive to the agency shock a, and from the flow constraint (23), $k'(v,x)$ does not depend on a either.

Dynamics around the violation of sophisticated borrowing constraints. We now explain how our model matches the dynamics of capital and earnings before and after covenant violations. Figure 5 shows that firms violating sophisticated borrowing constraints experience negative productivity shocks (decreases in z) and positive agency shocks (increases in a) before violations. After violations, z increases and a decreases. Moreover, after violations, unproductive capital use is reduced as creditor control alleviates managerial agency frictions.

The decline in earnings before violations in Figure 2 is explained by both negative productivity shocks and positive agency shocks before violations. From Panel (a) of Figure 4, both shocks lower

[14] We have verified that, in the violation state, creditors choose $\tau'(v,x) = 0$ and $d(v,x) = 0$ across the entire ergodic distribution of state variables in our model.

Figure 5: Firms' Idiosyncratic Shocks around Covenant Violations



Notes: The left panel plots the median firm's idiosyncratic productivity shocks z in period $t+h$ normalized by its productivity shocks at t, i.e., z_{t+h}/z_t in the model. The right panel plots the median firm's idiosyncratic agency shock a in period $t+h$ normalized by its agency shock at t when they initially violate the sophisticated borrowing constraint, i.e., a_{t+h}/a_t in the model. The lines are based on all firms violating the sophisticated borrowing constraint in the steady state of the model.

firms' earnings and contribute to violations of sophisticated borrowing constraints in (2). The increase in earnings after violations in Figure 2 is explained by i) creditor control after violations, which eliminates unproductive capital use ($\tau' = 0$), alleviates managerial agency frictions, and raises earnings, and ii) increases in z following violations.

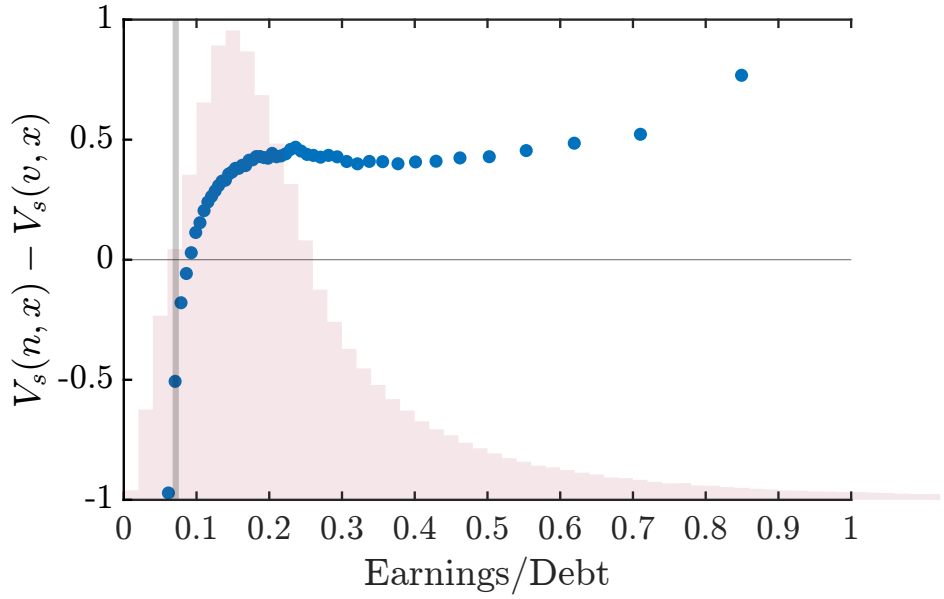
The increase in capital before covenant violations in Figure 2 is explained by positive agency shocks. Without agency shocks, capital would have otherwise decreased due to negative productivity shocks (according to Panel (a) of Figure 4). The decrease in capital after violations in Figure 2 is mostly explained by creditors divest capital after violations because their demand for capital declines when unproductive capital use is eliminated.

Without agency frictions, productivity shocks alone cannot jointly explain the dynamics of capital and earnings before and after covenant violations. The productivity process in Figure 5 would counterfactually lead to a decrease in capital before violations and an increase in capital after violations.

To further illustrate the importance of managerial agency frictions in explaining the dynamics of capital and earnings around covenant violations, we consider a variant of our model in which managerial agency frictions are shut down ($H(\cdots) = 0$).[15] We recalibrate this model using the same procedure as in our baseline model, matching both the unconditional empirical moments in Table 3 and the firm outcomes around covenant violations in Figure 1. Appendix Figure C.4 shows that such a model has difficulty explaining the dynamics of capital and earnings before and after covenant viola-

[15] Appendices Tables C.2 and C.3 report the calibrated parameters in this model and its fairly well fit to the unconditional moments.

Figure 6: Differences in Shareholder Value between Manager and Creditor Control



Notes: The figure plots the difference in the shareholder value function (defined in (6)) under manager control and creditor control, $V_s(n,\cdot) - V_s(v,\cdot)$, as a function of firms' earnings-to-debt ratios ($\pi/\tilde{q}_b^{\text{face}} b$ in the model). Each dot represents a percentile of the earnings-to-debt ratio in the ergodic distribution of the steady state of our model. The pink bar plot shows the probability density of the earnings-to-debt ratio in the ergodic distribution of our model. The grey line indicates the earnings-to-debt ratio corresponding to $1/\phi$.

tions despite directly targeting it.

Finally, despite not being targeted, our baseline model with agency frictions can also explain the empirical pattern in which firms' equity value declines before covenant violations (due to a combination of negative productivity shocks and positive agency shocks) and rises afterward (as creditor control alleviates managerial agency frictions and productivity recovers). Appendix Figure C.1 plots firms' cumulative equity returns based on the shareholder value, $V_s(\cdot)$ (defined in (6)), and shows that it aligns well with its empirical counterpart in Figure A.1.

Differences in value between manager and creditor control. After violations of sophisticated borrowing constraints, creditor control eliminates unproductive capital use, alleviates managerial agency frictions, and improves firms' earnings. One may wonder whether creditor control always improves the firm's performance. That is not the case. The creditor's capital policy in Panel (b) of Figure 4 helps explain why. Under creditor control, capital increases little with productivity: creditors do not raise capital in response to increases in the future marginal product of capital.

Figure 6 plots the difference in the shareholder value under manager control and creditor control, $V_s(n,\cdot) - V_s(v,\cdot)$ as a function of firms' earnings-to-debt ratios. Away from sophisticated borrowing constraints, when the earnings-to-debt ratio is high, shareholder value is higher under manager control. There, the benefits of managers' closer-to-optimal capital policy outweigh the costs of managerial agency

frictions arising from the unproductive use of capital. Close to or after violations of sophisticated borrowing constraints, when the earnings-to-debt ratio is low, shareholder value is higher under creditor control. In those states, shareholders prefer creditor control, as manager control leads to both agency frictions in terms of unproductive capital use and strong precautionary behavior, because managers want to avoid violating sophisticated borrowing constraints, since they can no longer derive utility from unproductive capital use. Such precautionary behavior can be seen in Figure 4, where capital is lower under manager control than under creditor control for low levels of productivity (when violations of sophisticated borrowing constraints become a concern). For most of the ergodic distribution of our model, shareholders would prefer managerial control to creditor control.

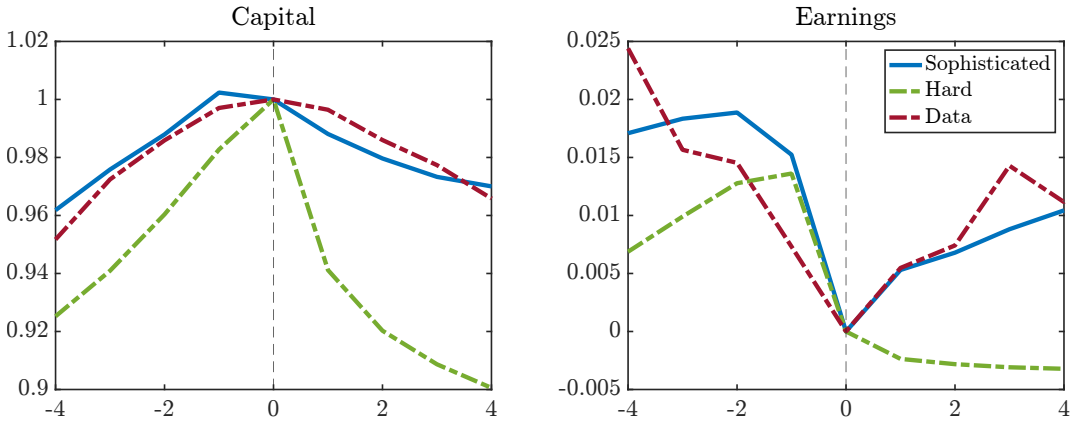
Appendix Figure C.5 also plots the difference in total shareholder and creditor values $V_s(n,\cdot) + V_c(n,\cdot) - (V_s(v,\cdot) + V_c(v,\cdot))$, under manager and creditor control. Similarly, total value is higher under manager control when the earnings-to-debt ratio is high, but higher under creditor control when the earnings-to-debt ratio is low. The pattern here is also consistent with the incomplete contract theory literature (e.g., Aghion and Bolton, 1992; Dewatripont and Tirole, 1994), which shows that it is preferable for the manager to have control rights when the firm is performing well, but for the creditor to have control rights when the firm is performing poorly.

Comparison with the hard-constraint model. Can the hard-constraint model described in Section 3.3 explain the dynamics of capital and earnings around covenant violations in Figure 1? We recalibrate this model using the same procedure as in our baseline model, matching both the unconditional empirical moments in Table 3 and the firm outcomes around covenant violations in Figure 1, where we interpret firms hitting the hard borrowing constraint (21) as "violations." Appendices Tables C.4 and C.5 and Figure 7 report the calibrated parameters in the hard-constraint model, its fit to the unconditional moments, and the dynamics of capital and earnings around covenant violations.

Despite directly targeting them, the hard-constraint model has difficulty matching both the unconditional moments and the firm outcomes around covenant violations. Despite having a high quarterly rate of hitting the hard borrowing constraint (10.0%, much higher than the 2.5% rate of covenant violations in the data), the hard borrowing constraint features only a small fraction of firms binding at the constraint (10.5%, compared with 15% of firms in the violation state in the sophisticated borrowing constraint model). This is because firms in the hard-constraint model do not want to remain at the binding constraint and have a strong precautionary motive to maintain some distance from it: exactly binding at the hard constraint is costly for firms, since temporarily violating it—as in the sophisticated constraint model—is not an option. The precautionary motive in the hard constraint model is even stronger than the manager's precautionary motive in the sophisticated constraint model, as further discussed below.

Moreover, firms' capital and earnings drop significantly after they hit the hard-borrowing con-

Figure 7: Targeted Dynamics Around Covenant Violations and Model Fit: Sophisticated vs Hard



Notes: The left panel plots the median firm's capital in period $t+h$ normalized by its capital at t, i.e., k_{t+h}/k_t in the model. The right panel plots the median firm's earnings in period $t+h$ relative to period t, normalized by capital at t, i.e., $(\pi_{t+h}-\pi_t)/k_t$ in the model. The blue lines are based all firms violating the sophisticated borrowing constraint in the steady state of our baseline model, where t captures when they initially violate the sophisticated borrowing constraint. The green lines are based on all firms hitting the hard borrowing constraint in the steady state of our hard-constraint model, where t denotes the initial period in which the hard constraint binds. The red lines correspond to their empirical counterparts, i.e., the median lines in Figure 1.

straint, much more so than in the sophisticated constraint model and in the data (Figure 7). This is because firms that hit the hard constraint are forced to sell capital to ensure that the hard constraint in (21) is satisfied and because they have a strong precautionary motive to maintain some distance from it. As further explained below, this is one of the key reasons why the sophisticated borrowing constraint model exhibits less financial acceleration in response to constraint tightening than the hard-constraint model.

In addition, we show that the previous conclusions about the hard-constraint model also apply to alternative versions of it: (i) the hard-constraint model with ϕ^{hard} recalibrated such that its median leverage matches that of the sophisticated-constraint model, while keeping all other parameters the same (Appendix Table C.6 and Appendix Figure C.6); (ii) the hard-constraint model with the asset-based borrowing constraint (22), calibrated using the same procedure (Appendix Tables C.7 and C.8, as well as Appendix Figure C.7); (iii) the hard-constraint model with agency frictions, calibrated using the same procedure (Appendix Tables C.9 and C.10, as well as Appendix Figure C.8).

5 Macro Implications of Sophisticated Borrowing Constraints

We now study the macroeconomic implications of sophisticated borrowing constraints, particularly the importance of financial acceleration in determining macroeconomic outcomes. We do so by contrasting these implications with those under hard borrowing constraints. By financial acceleration (e.g., Kiyotaki and Moore, 1997 and Bernanke, Gertler, and Gilchrist, 1999), we refer to the general

equilibrium feedback mechanism in which (i) adverse economic outcomes tighten borrowing constraints, and (ii) the tightening of borrowing constraints further worsens economic outcomes.[16]

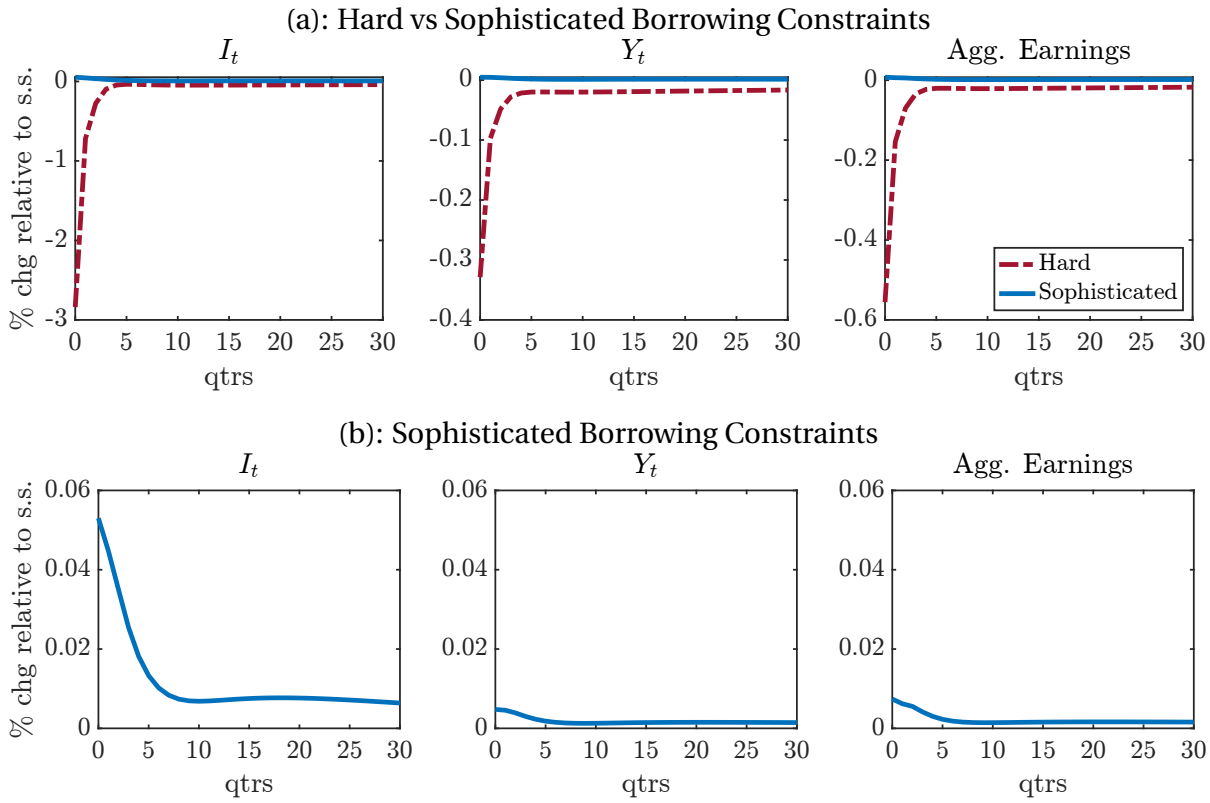
Constraint tightening shock. To gauge the importance of financial acceleration, a useful exercise is to study the macroeconomic impact of shocks to the tightness of the constraint ϕ, as examined in Khan and Thomas (2013). This directly informs the second step of the financial acceleration feedback (how tightening borrowing constraints further worsens economic outcomes) and is thus useful for understanding the role of financial acceleration in shaping the macroeconomic impact of other aggregate shocks (e.g., monetary policy shocks), which we will analyze later.

Specifically, we allow the tightness of borrowing constraints, ϕ_t, to be time varying. We then study the responses of key aggregate variables to an unexpected tightening of borrowing constraints at period 0, with an initial size of 1% of the steady-state borrowing capacity and with a persistence of 0.5.[17] We compute the perfect foresight transition path of the economy as it converges back to steady state. We compare the sophisticated-constraint model and the hard-constraint model based on their respective calibrations discussed in the previous Section.

[16] Similarly, the mechanism also applies to positive economic outcomes, which relax borrowing constraints.

[17] Specifically, in the sophisticated-constraint model, we consider a tightening with initial magnitude $\Delta\phi_0 = -1\% \times \phi$, and in the hard-constraint model, a tightening with initial magnitude $\Delta\phi_0^{\text{hard}} = -1\% \times \phi^{\text{hard}}$.

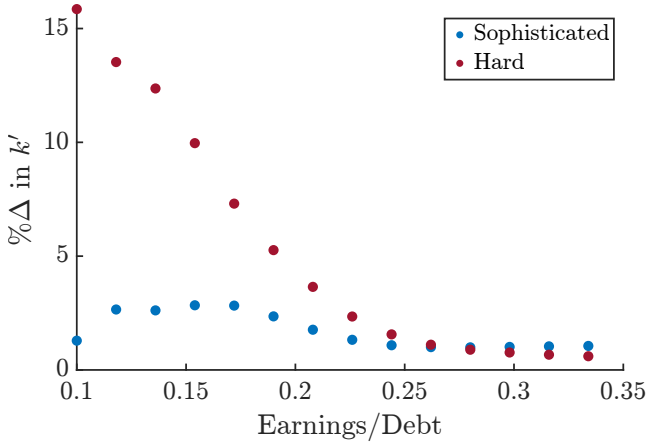
Figure 8: Macro Impacts of the Constraint Tightening Shock



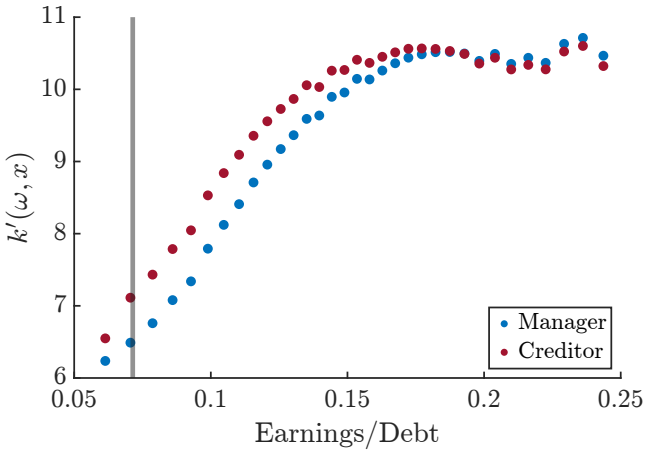
Notes: Panel A plots the responses of aggregate investment, output, and earnings to a tightening of sophisticated borrowing constraints with initial magnitude $\Delta\phi_0 = -1\% \times \phi$ in the sophisticated-constraint model (solid blue lines), and the counterpart responses to a tightening of hard borrowing constraints with initial magnitude $\Delta\phi_0^{\text{hard}} = -1\% \times \phi^{\text{hard}}$ in the hard-constraint model (dashed red lines). The constraint tightening shock has a persistence of 0.5. Panel B zooms in on the responses in the sophisticated borrowing constraints model. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure 9: Unpacking the Macro Impacts of the Constraint Tightening Shock

(a) Capital Decline from Constraint Tightening



(b) Capital Policy around the Sophisticated Constraint



Notes: Panel A plots the percentage decline in next-period capital k' when constraint tightness changes from ϕ to $0.9 \times \phi$ (and from ϕ^{hard} to $0.9 \times \phi^{\text{hard}}$ in the hard-constraint model) as a function of firms' earnings-to-debt ratios in the steady states of the sophisticated-constraint model (blue dots) and the hard-constraint model (red dots). Panel B plots next-period capital k' as a function of firms' earnings-to-debt ratios ($\pi / \tilde{q}_b^{\text{face}} b$ in the model) under creditor control (red dots) and manager control (blue dots) around the sophisticated borrowing constraints (the grey line indicates the earnings-to-debt ratio corresponding to $1/\phi$) in the steady state of our model.

Figure 8 plots the responses of aggregate investment I_t, output Y_t, and earnings $\int \pi_{jt} dj$ to the constraint tightening shock under both hard and sophisticated borrowing constraints. Under hard borrowing constraints, we observe a large decline in aggregate investment, output, and earnings. To better understand the large decline in investment, red dots in panel a) of Figure 9 show how much a firm's capital decreases when its constraint tightness ϕ^{hard} is lowered. It plots the decline as a function of a firm's earnings to debt ratio and shows that the decline is more pronounced when the firm is close to the hard constraint. In the extreme, firms with a binding hard constraint must adjust debt one-for-one with the tightening shock, resulting in a severe decline in capital (as the firms need to sell capital to pay down the debt to satisfy the hard constraint). Even firms whose borrowing constraints are not binding but are close to the constraint also adjust their capital due to a precautionary motive to avoid hitting the constraint in the future. The decline in aggregate investment then depresses aggregate demand and lowers aggregate output and earnings. The decline in earnings further tightens the hard borrowing constraints, thereby leading to financial acceleration that further worsens economic outcomes.

Under sophisticated borrowing constraints, we instead observe a small increase in aggregate investment, output, and earnings in response to the constraint tightening shock, which is more clearly illustrated in Panel B of Figure 8 with a scale tailored to the responses in the sophisticated-constraint

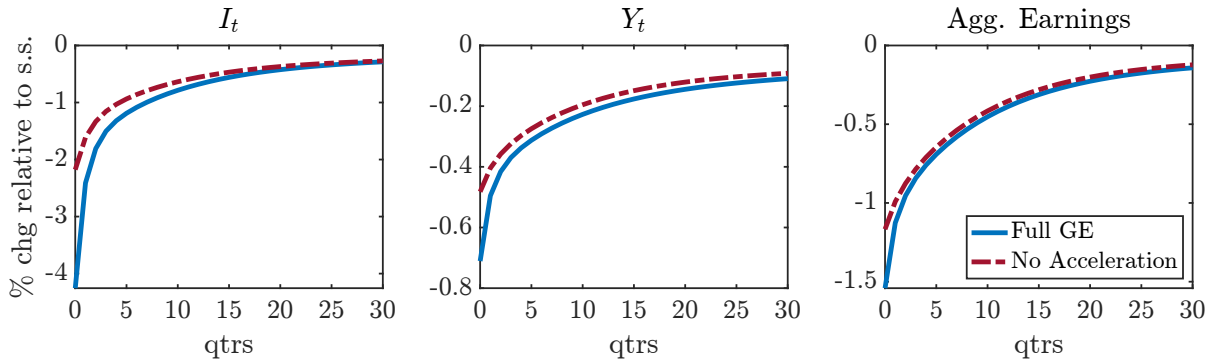
model. To better understand the mild increase in investment, we note that at the micro-level, the tightening of the sophisticated borrowing constraint affects firms' investment through two channels. First, there is an intensive-margin decrease in investment for firms for which the shock does not cause a transition between normal and violation states. To illustrate, blue dots in Figure 9 show how much a firm's capital decreases when the tightness of the sophisticated borrowing constraint ϕ is lowered and it stays in the normal state. Similar to firms that are close to but not exactly binding at hard constraints, these firms still lower their capital for precautionary reasons (i.e., managers respond precautionarily to avoid violating the sophisticated constraint), although the magnitude of such a precautionary response is much smaller.

Second, and dominating the intensive-margin decrease in investment, the constraint tightening shock increases investment by an extensive margin as the shock transitions some firms from normal to violation states. For example, in period 0, the extensive margin is driven by firms that satisfy the sophisticated constraint in the steady state ($\tilde{q}_b^{\text{face}} b_0 \leq \phi\pi\left(z_0, (1-\tau_0)\, k_0\right)$; recall that ϕ and $\pi(\cdots)$ without subscripts capture their respective steady-state counterparts), but that violate the constraint due to the shock ($\tilde{q}_b^{\text{face}} b_0 > \phi_0\pi_0\left(z_0, (1-\tau_0)\, k_0\right)$). The transfer of control rights leads to a change in investment approximately given by $k'(v,x) - k'(n,x)$. Panel (b) of Figure 9 compares $k'(v,x)$ and $k'(n,x)$ in a neighborhood around the sophisticated borrowing constraint, and we can see that the creditor chooses a higher level of capital $k'(v,x)$ than the manager $k'(n,x)$, primarily because the manager precautionarily adjusts capital to avoid losing control and the utility associated with unproductive use of capital. This implies that the extensive margin leads to an increase in investment in response to the constraint tightening shock. As illustrated in Appendix Figure C.12, which provides a full decomposition of the impulse response into extensive and intensive margins, the extensive margin mildly dominates the intensive margin and leads to the overall positive aggregate responses. Appendix B.2 formally defines the extensive and intensive margin decomposition.

The response of aggregate output and earnings under sophisticated borrowing constraints follows similar mechanisms to those of investment, with an additional channel on the extensive margin: creditor control after violation alleviates managerial agency frictions (by setting τ' to zero) and improves firms' production and earnings for a given level of capital. This translates into a lower average share of capital diverted for managers' personal benefit, as depicted in Appendix Figure C.9. Together, the positive extensive-margin responses break the second step of the financial acceleration feedback: tightening borrowing constraints no longer worsens economic outcomes.

Monetary policy shock. We now turn to the macroeconomic impact of a monetary policy shock. To gauge the importance of financial acceleration in determining the aggregate responses to the monetary policy shock and to connect it to the previously studied responses to the constraint tightening

Figure 10: Macro Impacts of the Monetary Policy Shock: Hard Borrowing Constraints



Notes: The figure plots the responses of aggregate investment, output, and earnings to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under hard borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

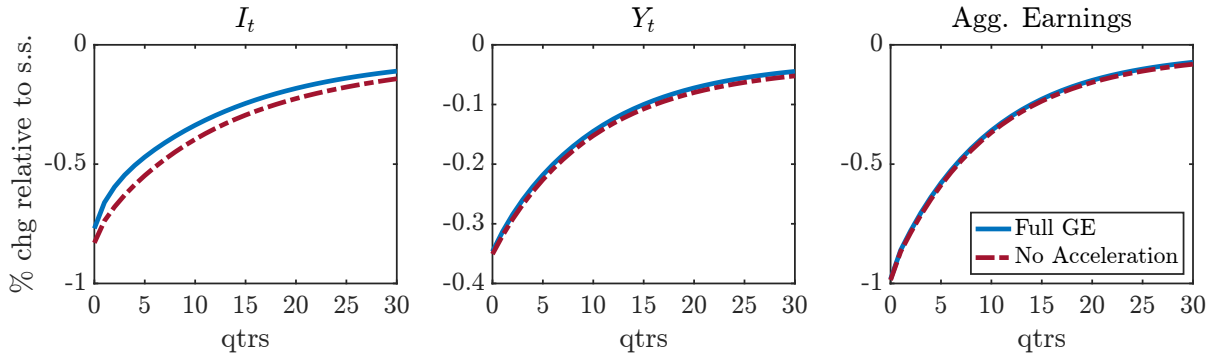
shock, we will compare the benchmark aggregate responses, incorporating the full general equilibrium feedback of financial acceleration, to counterfactual aggregate responses where the feedback is shut down. In this counterfactual, borrowing constraints are governed by the steady-state earnings function $\pi(\cdots)$ instead of the actual earnings function $\pi_t(\cdots)$. For example, in the sophisticated-constraint model, the evolution of firm states will be governed by the counterpart of (2):

$$\tilde{q}_b^{\text{face}} b_{jt+1} \leq \phi \pi \left(z_{jt+1}, \left(1 - \tau_{jt+1}\right) k_{jt+1} \right). \tag{24}$$

The counterfactual shuts down financial acceleration by shutting down the general equilibrium loop, whereby adverse economic outcomes (which lead to lower relative prices of production firms' goods, p_t) tighten borrowing constraints through a lower earnings function, $\pi_t(\cdots)$, and further worsen economic outcomes. Hence, the differences between the aggregate responses that incorporate general equilibrium feedback and the counterfactual responses can be viewed as the contribution of financial acceleration. These differences are also closely linked to the responses to shocks to the constraint tightening shock studied above.

Specifically, we study the aggregate investment, output, and earnings responses to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.90. The persistence is designed to roughly capture the fact that the magnitude of nominal interest rate changes after a monetary policy shock halves over a one-year horizon, as observed in Caravello, McKay, and Wolf (2024). We compute the perfect foresight transition path of the economy as it converges back to steady state.

Figure 11: Macro Impacts of the Monetary Policy Shock: Sophisticated Borrowing Constraints



Notes: The figure plots the responses of aggregate investment, output, and earnings to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under sophisticated borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure 10 plots both the full GE responses of aggregate investment, output, and earnings incorporating financial acceleration, and the counterfactual responses shutting down financial acceleration, for the hard-constraint model. The counterfactual responses are significantly dampened compared to the full GE responses, indicating that a nontrivial degree of financial acceleration worsens aggregate outcomes. The hard-constraint model produces considerable acceleration because: i. the monetary policy shock depresses aggregate demand, and lowers relative prices of goods produced by financially constrained firms p_t and their earnings—see Appendix Figure C.10—, further tightening the constraint; and ii. a tightening of the constraint has a significant macroeconomic impact, as emphasized previously.

Figure 11 plots the aggregate responses to monetary policy shocks in the sophisticated-constraint model. Overall, the responses of aggregate variables are less negative than those in the hard-constraint model and broadly aligned with those in New Keynesian models with heterogeneous firms and default risk (Ottonello and Winberry, 2020). The figure further shows that the full general equilibrium responses are similar to, and slightly less negative than, the counterfactual responses that shut down financial acceleration. As in the hard-constraint model, the monetary policy shock lowers relative prices p_t and earnings—see Appendix Figure C.11—tightening and triggering violations of the sophisticated borrowing constraints. However, unlike in the hard-constraint model, a tightening of the sophisticated constraint does not have a contractionary macro impact for the reasons discussed above.[18] Together, we find muted financial acceleration under sophisticated borrowing constraints,

[18] In Appendix Figure C.13, we also decompose the responses to monetary policy shocks in the sophisticated-constraint model into the extensive and intensive margins. Similar to the response to the constraint-tightening shock, the extensive margin—which captures the part of the responses arising because the shock transitions some firms into violation states—is positive, as creditor control avoids precautionary motives of managers, alleviates agency frictions, and improves firm

in contrast to the significant financial acceleration under hard borrowing constraints.

Robustness. The main lesson that financial acceleration is more significant under hard borrowing constraints than under sophisticated-constraint models is robust to different variants and alternative calibrations of these models. In Appendix Figures C.14–C.15, we show that this is indeed the case when we compare the aggregate responses of our sophisticated-constraint model with the responses of the hard-constraint model with asset-based lending described in Section 3.3. In Appendix Figures C.16–C.17, we show that the same lesson applies when we compare with the responses of a variant of the hard-constraint model where we recalibrate ϕ^{hard} such that its median leverage matches that of the sophisticated-constraint model, while keeping all other parameters the same. In Appendix Figures C.18–C.19, we show that the same lesson also applies when we compare with the responses of a variant of the hard-constraint model with agency frictions, recalibrated using the same procedure as in our baseline model.

Suggestive Empirical Evidence. In Appendix Figure A.6, we provide suggestive evidence that firms with above median share of debt against cash flows (using debt classifications from Lian and Ma (2021))—and therefore primarily subject to sophisticated borrowing constraints from financial covenants—are less sensitive to monetary policy shocks (Bauer and Swanson, 2023). Conversely, firms that rely more on borrowing against physical assets—and are therefore closer to the hard-constraint models we studied—are more sensitive to monetary policy shocks. In Appendix Figure A.7, we also show that nonresidential investment by firms is less sensitive compared to residential investment by households. Although sophisticated borrowing constraints are important among nonfinancial firms, they do not apply to households where implementing analogous creditor control is not possible. Correspondingly, the household sector can be much more sensitive to shocks.

6 Conclusion

Classic macro-finance models feature “hard" borrowing constraints tied to the liquidation value of physical assets, where creditors cut credit indiscriminately to maintain borrowing limits and financial acceleration ensues. In this paper, we study “sophisticated" borrowing constraints in the debt contracts of U.S. nonfinancial firms. They use covenants to specify borrowing limits linked to operating earnings. Moreover, following covenant violation, creditors obtain control rights and improve firm performance by reducing agency problems, so earnings increase although borrowing and investment decrease. We construct a quantitative model with these key features. At the micro level, our

outcomes. The intensive margin is negative, capturing how changes in the interest rate directly affect firms' policies.

model matches the patterns of firms" borrowing and investment in the data, in normal times and after covenant violation. At the macro level, our model produces less financial acceleration, consistent with the resilience of U.S. nonfinancial corporations during recessions.

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Appendices for:
Sophisticated Borrowing Constraints and Macroeconomic Dynamics

This Appendix contains further material for the article "Sophisticated Borrowing Constraints and Macroeconomic Dynamics". Any references to equations, figures, tables, assumptions, propositions, lemmas, or sections that are not preceded by "A."—"C." refer to the main article.

A Additional Empirical Results

Table A.1: Firm Outcomes after Financial Covenant Violation

	Change in EBITDA/capital		Capital growth	
	(1)	(2)	(3)	(4)
New covenant violation	0.034***	0.052***	-0.039***	-0.025**
	(0.011)	(0.012)	(0.011)	(0.011)
Beginning of period log capital	-0.006***	-0.078***	-0.001	-0.194***
	(0.001)	(0.008)	(0.001)	(0.017)
Beginning of period book leverage	0.004	-0.134**	-0.268***	-0.268***
	(0.061)	(0.053)	(0.077)	(0.072)
L.EBITDA/capital	-0.007	-0.097**	0.074***	0.086***
	(0.030)	(0.041)	(0.010)	(0.015)
L.Capital growth	-2.749*	-1.678	-9.519***	-4.971**
	(1.638)	(1.178)	(1.661)	(2.084)
Firm FE	No	Yes	No	Yes
Higher-order covenant controls	Yes	Yes	Yes	Yes
Lagged covenant controls	Yes	Yes	Yes	Yes
Observations	46713	46594	49057	48939
R-squared	0.039	0.260	0.140	0.394

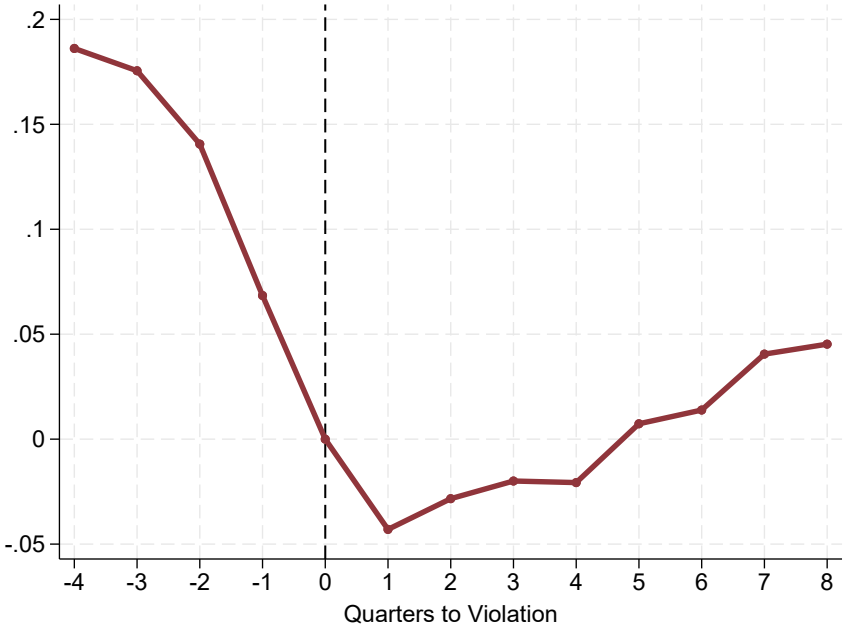
Notes: This table presents regressions at the firm-quarter level:

$$\Delta Y_{i,t\to t+4} = \alpha_t + \beta \text{Viol}_{i,t} + \sigma \log k_t + \sum_{k=1}^{4} \gamma_k z_{i,t-k} + \varepsilon_{i,t}.$$

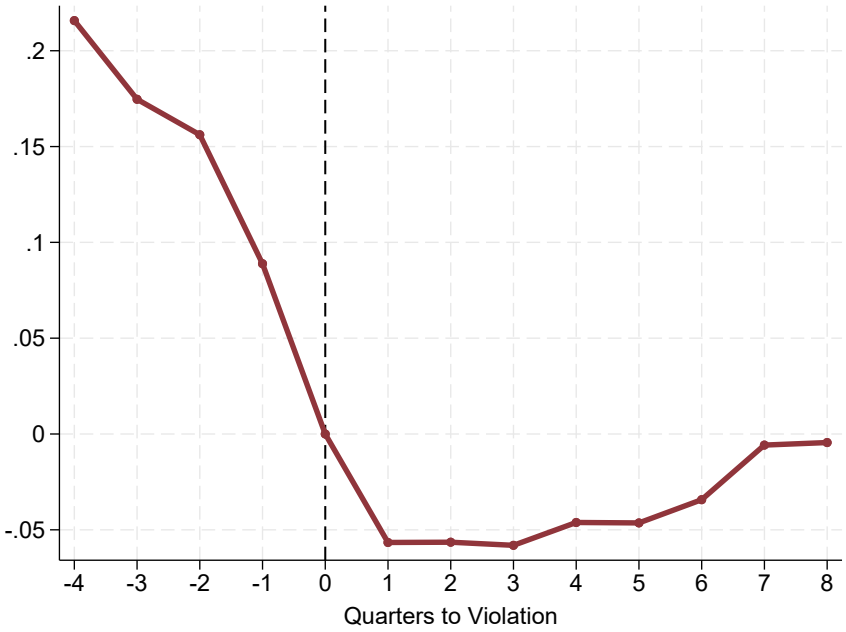
The dependent variable is $(\text{EBITDA}_{i,t+4} - \text{EBITDA}_{i,t})/k_{i,t}$ in columns (1) and (2), and $k_{i,t+4}/k_{i,t}$ in columns (3) and (4). The key dependent variable is an indicator variable, $\text{Viol}_{i,t}$, which takes value one if firm i reports an initial financial covenant violation in quarter t. Control variables $z_{i,t-k}$ for k from one to four include book leverage (debt/assets), EBITDA (normalized by beginning-of-period capital), and capital growth during quarter $t-k$, as well as their squares and cubes following Nini, Smith, and Sufi (2012). We include quarter fixed effects in columns (1) and (3), and additional firm fixed effects in columns (2) and (4). We double cluster standard errors by firm and quarter. Asterisks denote significance levels (*** 1%, ** 5%, * 10%). Sample years are 2002 to 2016.

Figure A.1: Cumulative Stock Returns around Covenant Violations

Panel A. Cumulative Stock Returns



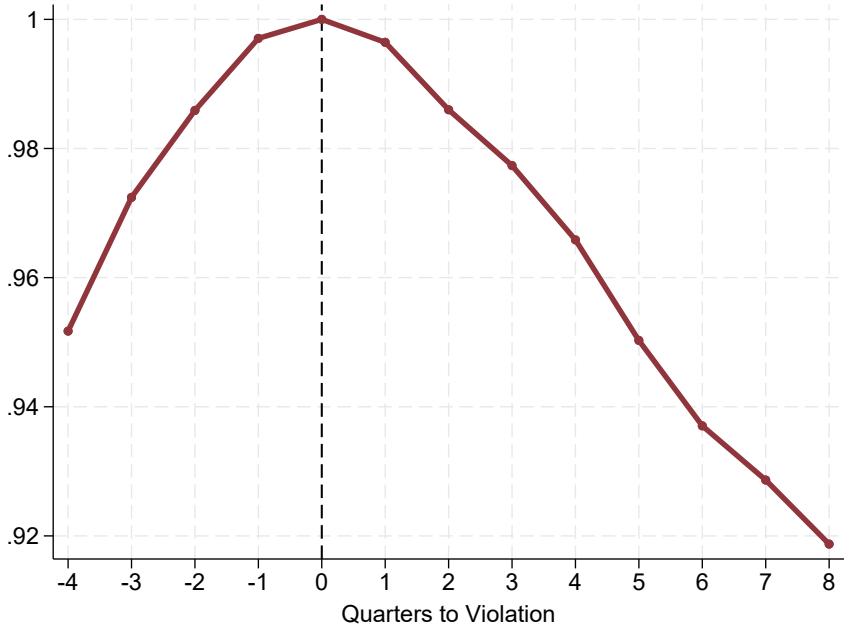
Panel B. Cumulative Abnormal Returns (Net of Beta)



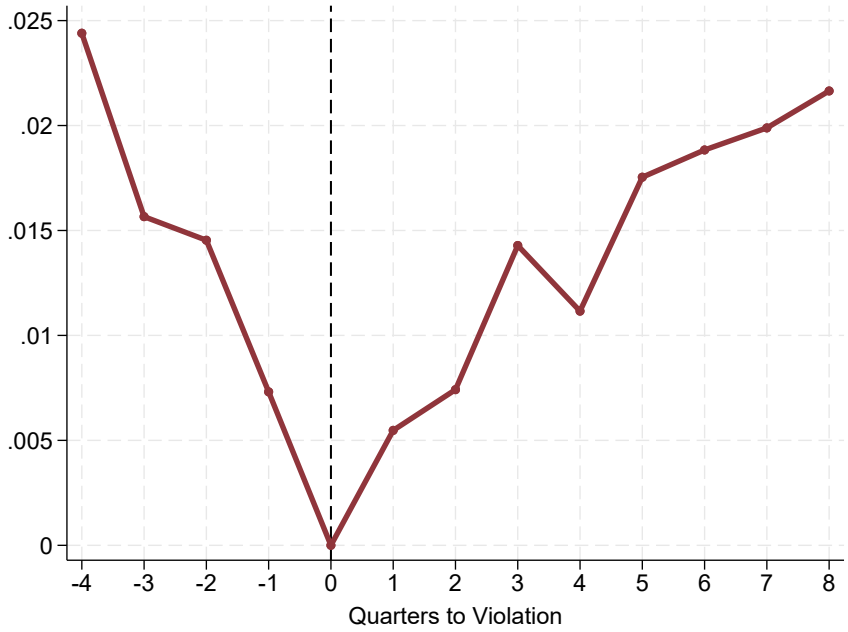
Notes: Panel A shows firms' cumulative stock returns from quarter t (when they initially report a covenant violation) to quarter $t+h$. Specifically, we use each quarter's returns R_{t+s} (including dividends) from Center for Research in Security Prices (CRSP) and then calculate the cumulative sum of log returns as $\sum_{s=1}^{h} \log R_{t+s}$ for $h \geq 1$, $-\sum_{s=h+1}^{0} \log R_{t+s}$ for $h \leq -1$, and 0 for $h = 0$. Panel B shows firms' cumulative abnormal stock returns (raw returns net of beta times market returns) from quarter t (when they initially report a covenant violation) to quarter $t+h$. The line shows the median value for each quarter $t+h$. The sample includes US Compustat firms that have all types of financial covenants in quarter t (according to DealScan data). Covenant violation data are kindly shared by Greg Nini and cover 1996 to 2016.

Figure A.2: Firm Outcomes around Covenant Violations: Firms with All Financial Covenants

Panel A. Cumulative Capital Changes k_{t+h}/k_t



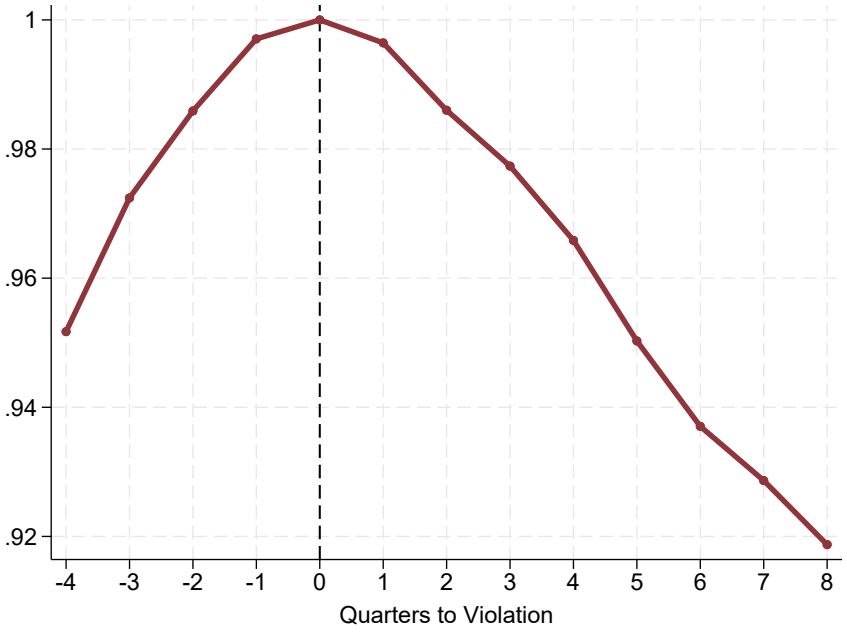
Panel B. Earnings Changes $(EBITDA_{t+h} - EBITDA_t)/k_t$



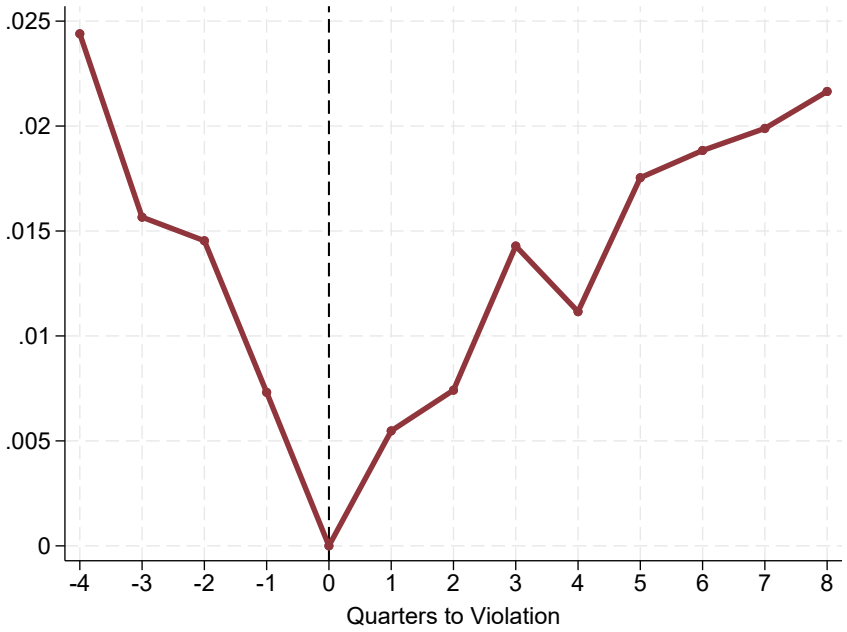
Notes: Panel A shows firms' capital in quarter $t+h$ relative to quarter t when they initially report a covenant violation (normalized by capital at the beginning of quarter t so that the differences over time come from the numerator rather than the denominator). Panel B shows firms' quarterly earnings in quarter $t+h$ relative to quarter t (normalized by capital at the beginning of quarter t). The line shows the median value for each quarter $t+h$. The sample includes US Compustat firms that have all types of financial covenants in quarter t (according to DealScan data). Covenant violation data are kindly shared by Greg Nini and cover 1996 to 2016.

Figure A.3: Firm Outcomes around Covenant Violations: Firms with All Earnings-Based Financial Covenants

Panel A. Cumulative Capital Changes $k_{i,t+h}/k_{i,t}$



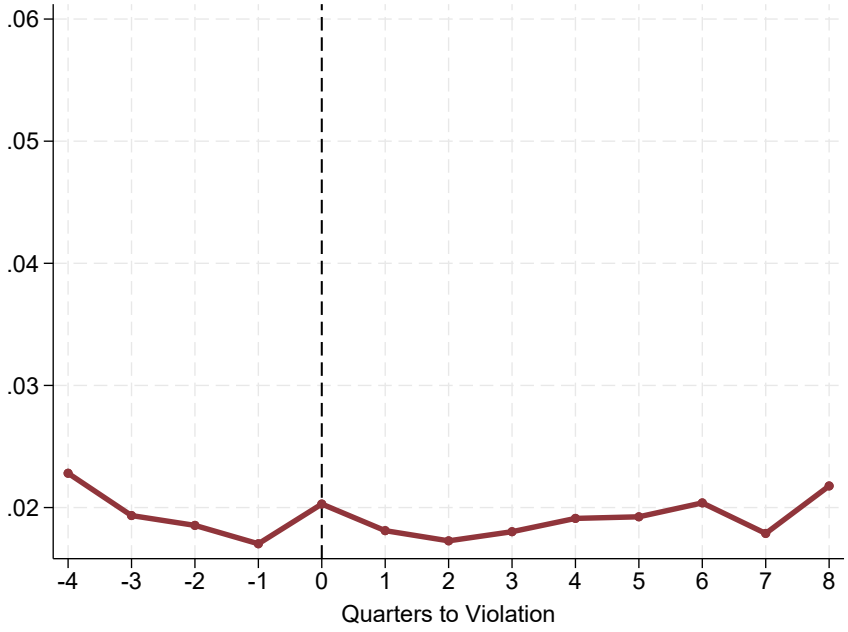
Panel B. Earnings Changes $\left(EBITDA_{i,t+h} - EBITDA_{i,t}\right)/k_{i,t}$



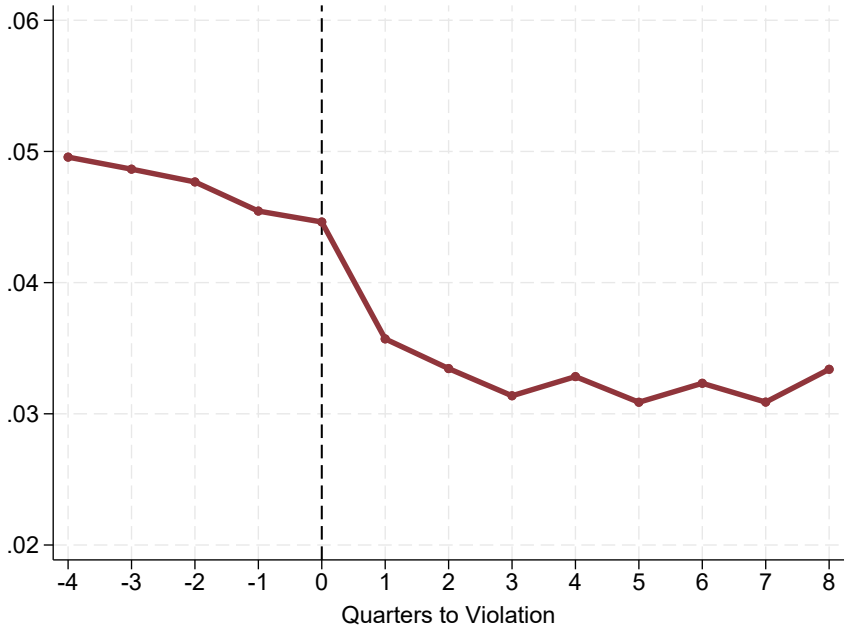
Notes: Panel A shows firms' capital in quarter $t+h$ relative to quarter t when they initially report a covenant violation (normalized by capital at the beginning of quarter t so that the differences over time come from the numerator rather than the denominator). Panel B shows firms' quarterly earnings in quarter $t+h$ relative to quarter t (normalized by capital at the beginning of quarter t). The line shows the median value for each quarter $t+h$. The sample includes US Compustat firms that have earnings-based covenants (including debt-to EBITDA covenants and interest coverage ratio covenants) in quarter t (according to DealScan data). Covenant violation data are kindly shared by Greg Nini and cover 1996 to 2016.

Figure A.4: R&D Expenditures vs Capital Expenditures around Covenant Violations

Panel A. R&D Expenditures $R\&D_{t+h}/k_t$



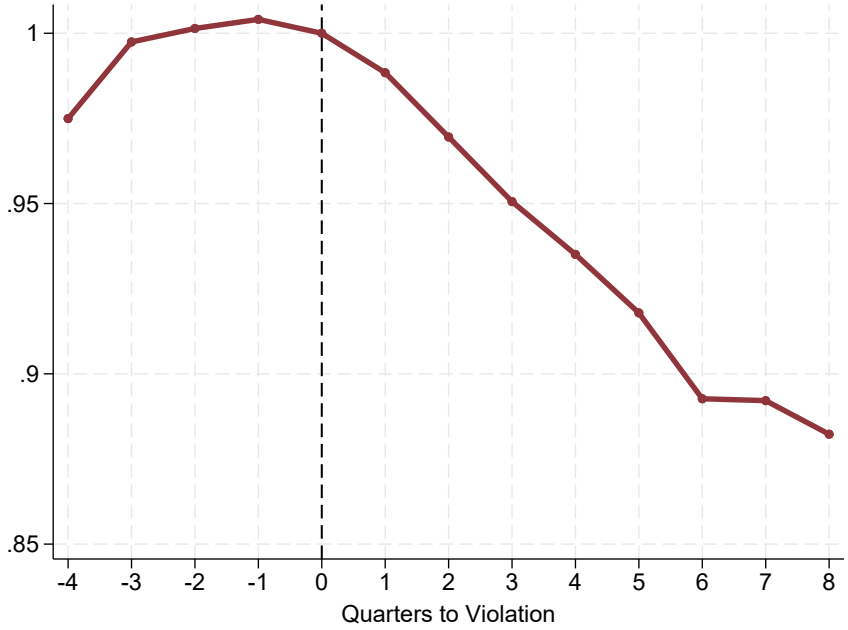
Panel B. Capital Expenditures $CAPX_{t+h}/k_t$



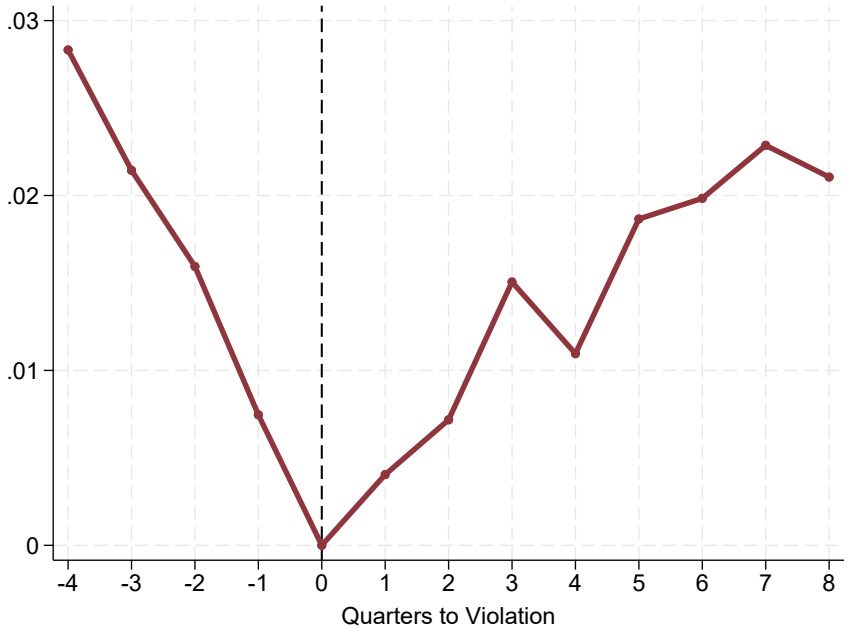
Notes: Panel A shows firms' quarterly research and development (R&D) expenditures in quarter $t+h$ (normalized by capital at the beginning of quarter t). Panel B shows firms' quarterly capital expenditures (CAPX) in quarter (normalized by capital at the beginning of quarter t). The line shows the median value for each quarter $t+h$. The sample includes US Compustat firms that have debt-to-EBITDA covenant in quarter t (according to DealScan data). Covenant violation data are kindly shared by Greg Nini and cover 1996 to 2016.

Figure A.5: Firm Outcomes around Covenant Violations: Macro Recessions

Panel A. Cumulative Capital Changes k_{t+h}/k_t

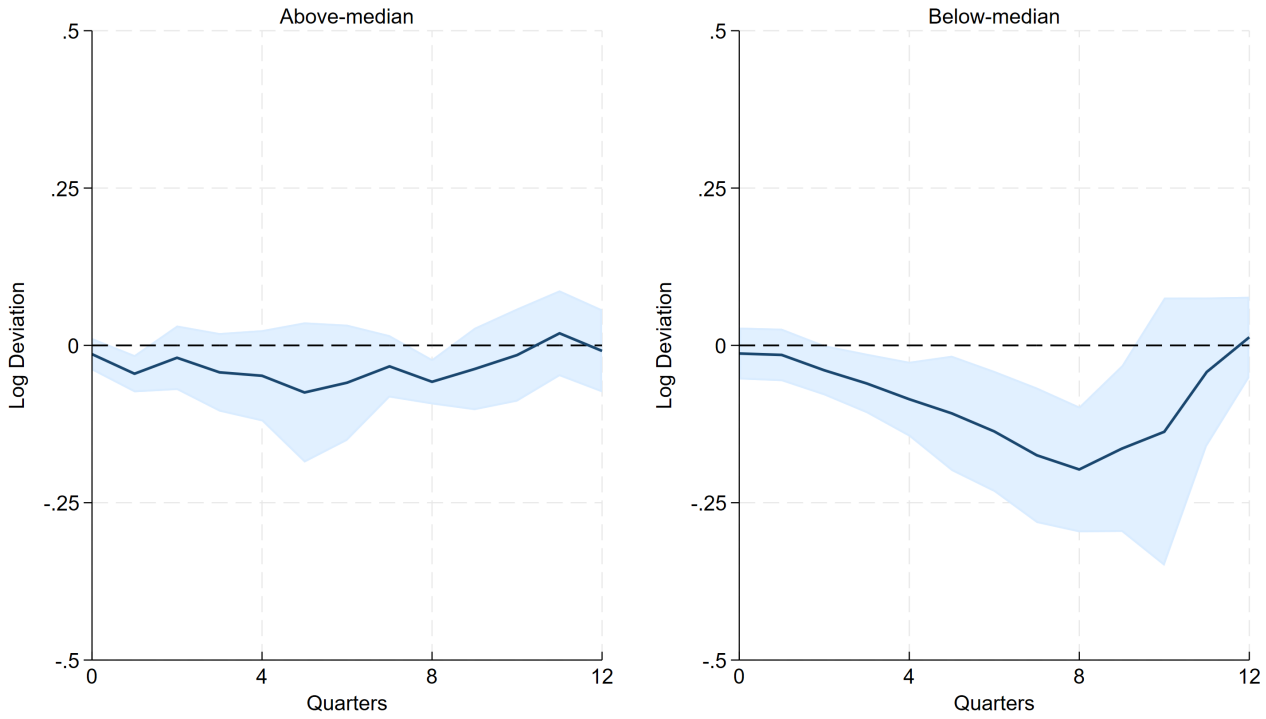


Panel B. Earnings Change $(EBITDA_{t+h} - EBITDA_t)/k_t$



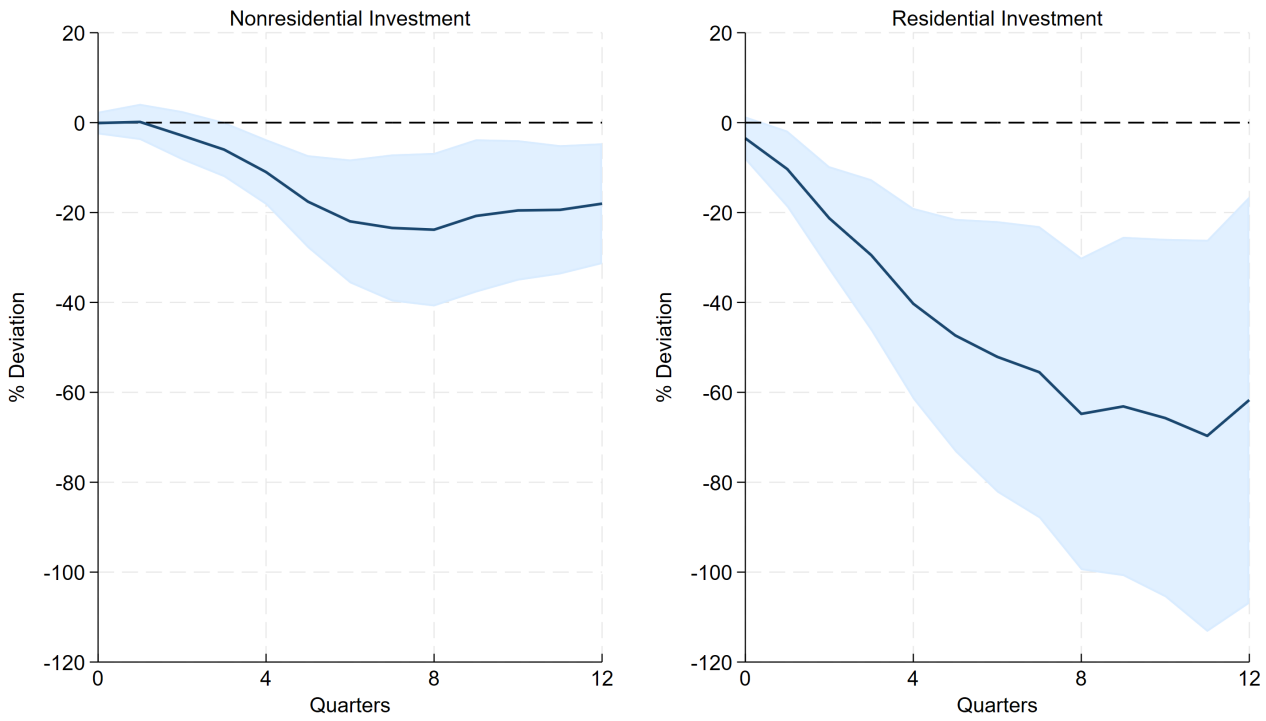
Notes: This figure shows the same plot of capital and earnings around covenant violation as Figure 1, restricted to covenant violations during macro recessions (2001 to 2002 and 2007 to 2009).

Figure A.6: Impulse Response of Firm Capital to Monetary Policy Shock



Notes: This figure shows the impulse response of firm-level deflated capital (property, plant, and equipment) to monetary policy shocks (Bauer and Swanson, 2023). We estimate Jordà (2005) local projections $y_{i,t+h} = \alpha_i + \beta mps_t + \gamma z_{i,t} + \varepsilon_{i,t}$. The outcome variable $y_{i,t+h}$ is log deflated capital of firm i in quarter $t+h$. The left panel plots the coefficient β among firms with above median share of cash flow-based debt in total debt, and therefore more subject to sophisticated borrowing constraints. The right panel plots the coefficient β among firms with below median share of cash flow-based debt in total debt, and therefore less subject to sophisticated borrowing constraints. The control variables $z_{i,t}$ include 4 lags of the outcome variable, 4 lags of the monetary policy shock, and 4 lags of the Fed Funds rate, log real GDP, log CPI, unemployment rate, the excess bond premium (Gilchrist and Zakrajšek, 2012), book leverage, EBITDA (normalized by capital), and Tobin's Q. The sample covers Compustat firms from 2002 (beginning of firm debt composition data) to 2016. Standard errors are Driscoll and Kraay (1998) with a bandwidth of 8 quarters. The shaded area represents the 90% confidence interval.

Figure A.7: Impulse Response of Nonresidential vs Residential Investment to Monetary Policy Shock



Notes: This figure shows the impulse response of aggregate nonresidential and residential investment to monetary policy shocks (Bauer and Swanson, 2023). We estimate quarterly Jordà (2005) local projections $y_{t+h} = \alpha + \beta mps_t + \gamma z_t + \varepsilon_t$, and plot the regression coefficient β on the monetary policy shock. The outcome variable y_{t+h} is log deflated nonresidential investment in the left panel, and log deflated residential investment in the right panel. The control variables z_t include 4 lags of the outcome variable, 4 lags of the monetary policy shock, and 4 lags of the Fed Funds rate, log real GDP, log CPI, unemployment rate, and the excess bond premium (Gilchrist and Zakrajšek, 2012). The sample covers 1988 (the beginning of Bauer and Swanson (2023) monetary policy shocks) to 2016. Standard errors are Eicker-Huber-White following Montiel Olea and Plagborg-Møller (2021). The shaded area represents the 90% confidence interval.

B Supplementary Theoretical Details

B.1 Distribution of Firms

Let $F_t(\omega, x)$ denote the measure of firms at time t (after the allocation of control rights and liquidation), where $x = (b, k, \tau, z, a)$ and $\omega \in \{n, v\}$. Let $x' = (b', k', \tau', z', a')$. The distribution evolves according to

$$\begin{aligned}
F_{t+1}(n,x') = \left(1-\chi^l_{t+1}(n,x')\right)\int \mathbb{I}\left(n=\Gamma_b\left(b'_t(n,x),\overline{b}_{t+1}\left(x'\right)\right)\right) Q_z(z'|z)Q_a(a'|a)\mathbb{I}\left(b'_t(n,x)=b', k'_t(n,x)=k', \tau'_t(n,x)=\tau'\right) dF_t(n,x) \\
+\left(1-\chi^l_{t+1}(n,x')\right)\int \lambda Q_z(z'|z)Q_a(a'|a)\mathbb{I}\left(b'_t(v,x)=b', k'_t(v,x)=k', \tau'_t(v,x)=\tau'\right) dF_t(v,x) \\
+F^0_{t+1}F^{\text{ent}}_{t+1}(n,x'),
\end{aligned}$$

$$\begin{aligned}
F_{t+1}(v,x') = \left(1-\chi^l_{t+1}(v,x')\right)\int \mathbb{I}\left(v=\Gamma_b\left(b'_t(n,x),\overline{b}_{t+1}\left(x'\right)\right)\right) Q_z(z'|z)Q_a(a'|a)\mathbb{I}\left(b'_t(n,x)=b', k'_t(n,x)=k', \tau'_t(n,x)=\tau'\right) dF_t(n,x) \\
+\left(1-\chi^l_{t+1}(v,x')\right)\int (1-\lambda) Q_z(z'|z)Q_a(a'|a)\mathbb{I}\left(b'_t(v,x)=b', k'_t(v,x)=k', \tau'_t(v,x)=\tau'\right) dF_t(v,x),
\end{aligned}$$

$$F^{\text{ent}}_{t+1}(n,x) = \frac{\mathbb{I}\left(V_{s,t+1}(n,x)+V_{c,t+1}(n,x) \geq V^l_{s,t+1}(x)+V^l_{c,t+1}(x)\right)\cdot dF_t(n,x)}{\int \mathbb{I}\left(V_{s,t+1}(n,x)+V_{c,t+1}(n,x) \geq V^l_{s,t+1}(x)+V^l_{c,t+1}(x)\right) dF_t(n,x)},$$

$$\begin{aligned}
F^0_{t+1} = \int\left\{\int \chi^l_{t+1}(n,x')Q_z(z'|z)Q_a(a'|a)\mathbb{I}(b'_t(n,x)=b', k'_t(n,x)=k', \tau'_t(n,x)=\tau')dF_t(n,x)\right\}dx' \\
+\int\left\{\int \chi^l_{t+1}(v,x')Q_z(z'|z)Q_a(a'|a)\mathbb{I}(b'_t(v,x)=b', k'_t(v,x)=k', \tau'_t(v,x)=\tau')dF_t(v,x)\right\}dx',
\end{aligned}$$

where $Q_z(z'|z)$ and $Q_a(a'|a)$ denote the Markov transition kernels for idiosyncratic productivity z and the agency shock a, respectively, F^0_{t+1} is the implied mass of entrants (equal to the mass liquidated) at $t+1$, and $F^{\text{ent}}_{t+1}(n,x')$ is the entrants' initial distribution over (n,x'). The first two terms in the law of motion track surviving incumbents. The last term in $F_{t+1}(n,x')$ adds entrants that replace liquidated firms; entrants start in the normal state.[19]

B.2 Extensive and Intensive Decompositions

We explain the extensive-intensive margin decomposition in this section. The aggregate shock occurs at $t=0$. If we discretize the state space, we can express the evolution of the vector $\mathbf{F}_{t+1}$ as

$$\mathbf{F}_{t+1} = \mathbf{M}_{t+1}\mathbf{Q}_t\mathbf{F}_t + F^0_{t+1}\mathbf{F}^{\text{ent}}_{t+1}.$$

Here, $\mathbf{F}_t$ denotes the distribution over states at time t and $\mathbf{F}^{\text{ent}}_{t+1}$ the distribution of entrants. The matrix $\mathbf{Q}_t$ is the transition matrix induced by policy choices, mapping the state $(\omega, b, k, \tau, z, a)$ at time t into the post-decision state $(\omega, b', k', \tau', z, a)$. In contrast, $\mathbf{M}_{t+1}$ maps the post-decision state

[19] The formula for $F^{\text{ext}}_{t+1}(n,x)$ reflects the fact that each entrant starts in the normal state, and its initial borrowing, capital, fraction of capital in unproductive use, and technology and agency shocks are drawn from the distribution of x of firms in the normal state in the previous period. If a drawn x results in the firm being liquidated at $t+1$, we immediately redraw x.

$(\omega, b', k', \tau', z, a)$ into the next-period state $(\omega', b', k', \tau', z', a')$ after earnings are realized and sophisticated borrowing constraints are evaluated. The matrix $\mathbf{Q}_t$ is measurable with respect to information available at time t, since policy choices made at t determine the evolution of debt, capital, and the diversion share τ into period $t+1$. By contrast, $\mathbf{M}_{t+1}$ is measurable with respect to information at time $t+1$, as changes in aggregate prices (p_{t+1}, w_{t+1}) affect realized earnings and therefore the allocation of control rights. Thus, $\mathbf{Q}_t$ captures endogenous transitions due to agents' decisions, while $\mathbf{M}_{t+1}$ captures ex post transitions arising from realized outcomes and covenant enforcement.

Given this notation, aggregate capital chosen for period $t+1$ is

$$K_{t+1} = \mathbf{F}_t' \mathbf{k}_{t+1},$$

where $\mathbf{k}_{t+1} = \left[k_t'(\omega, x)\right]_{(\omega,x)}$. Taking a total differential yields[20]

$$dK_{t+1} = (d\mathbf{F}_t)' \mathbf{k}_{t+1} + \mathbf{F}_t' d\mathbf{k}_{t+1}.$$

Using the recursion $\mathbf{F}_t = \mathbf{M}_t \mathbf{Q}_{t-1} \mathbf{F}_{t-1}$, we have

$$d\mathbf{F}_t = d\mathbf{M}_t \mathbf{Q}_{t-1} \mathbf{F}_{t-1} + \mathbf{M}_t d\mathbf{Q}_{t-1} \mathbf{F}_{t-1} + \mathbf{M}_t \mathbf{Q}_{t-1} d\mathbf{F}_{t-1}.$$

Iterating backward (and, for notational simplicity, suppressing time subscripts on steady-state objects $\mathbf{M}$, $\mathbf{Q}$, and $\mathbf{F}$) gives

$$dK_{t+1} = \underbrace{\sum_{j=0}^{t} \left[(\mathbf{MQ})^j \, d\mathbf{M}_{t-j} \mathbf{QF} \right]' \mathbf{k}}_{\text{extensive}} + \underbrace{\sum_{i=0}^{t-1} \left[(\mathbf{MQ})^j \, \mathbf{M} d\mathbf{Q}_{t-1-j} \mathbf{F} \right]' \mathbf{k} + \mathbf{F}' d\mathbf{k}_{t+1}}_{\text{intensive}},$$

where we take advantage of $d\mathbf{F}_{-1} = 0$ and $d\mathbf{Q}_{-1} = 0$, as any shock at $t = 0$ does not change the initial distribution. The extensive term captures changes in aggregate capital driven by shifts in $\mathbf{M}$, i.e., changes in the ex post mapping that reallocates firms across control states when sophisticated borrowing constraints are evaluated. This corresponds to the extensive margin in the decomposition of impulse response functions (IRFs). The intensive terms capture changes in aggregate capital driven by policy adjustments holding the constraint-evaluation mapping fixed: the term involving $d\mathbf{Q}$ reflects how past changes in decision rules reshape the distribution over states, while $\mathbf{F}' d\mathbf{k}_{t+1}$ captures the direct effect of contemporaneous changes in the capital policy. Such a decomposition into extensive and intensive components can then be done analogously for other variables.

[20] For exposition, we detract from explicitly tracking entry and exit as quantitatively the first order contribution is approximately zero.

B.3 Computation Details

Calibration. We match the event study for capital and earnings growth within a 1-year window around violation. To do this, we simulate a panel of firms from the model's steady state. For firm i, let $h = 0$ identify the violation event and compute for this firm $\frac{k_{i,h}}{k_{i,0}}$ and $\frac{\pi_{i,h}-\pi_{i,0}}{k_{i,0}}$ for $h \in \{-4,-3,\ldots,3,4\}$. From the simulated panel, compute the median capital and earnings growth rates at h quarters from violation:

$$m_h^k = \text{median}\left(\frac{k_{i,h}}{k_{i,0}}\right) \qquad m_h^\pi = \text{median}\left(\frac{\pi_{i,h}-\pi_{i,0}}{k_{i,0}}\right)$$

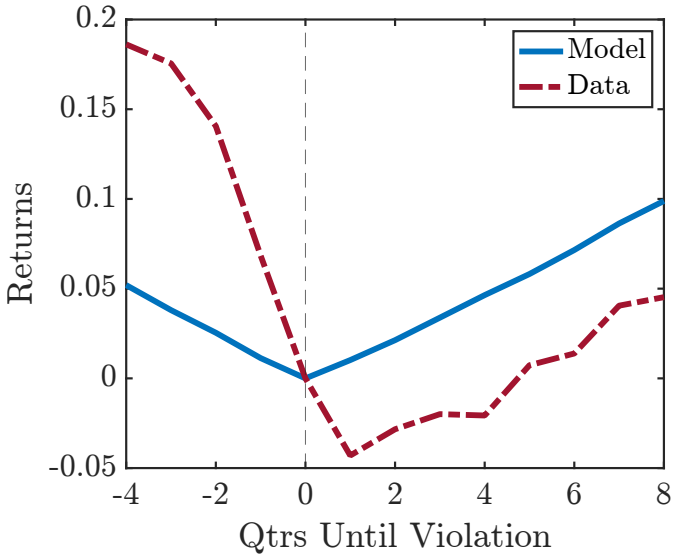
In addition, we have unconditional moments of the cross-section to match. From the same simulation, we compute median leverage (m^{lev}), fraction of firms in violation (m^{ν}), new violation rate ($m^{n\to\nu}$), median dividend-to-capital ratio (m^d), and median equity-issuance-to-capital ratio (m^e). This is a total of 21 moments. Enumerate these moments m_i for $i = 1,\ldots,21$ and let their empirical counterparts be denoted by $\hat{m}_i$. We calibrate our parameters to minimize the distance between the model moments and their empirical counterparts. The objective is

$$\sum_{i=1}^{19} w_i \left(\frac{m_i - \hat{m}_i}{1+\hat{m}_i}\right)^2 \tag{B.1}$$

where we introduce weights w_i which may differ across moments. We choose w_i to ensure we capture salient features of the targeted dynamics around covenant violations in Figure 1. To that end, we set $w_i = 1$ for m^e and m^d, $w_i = 2$ for m^{ν}, $m^{n\to\nu}$, and m^{lev}, $w_i = 4$ for m_h^k and m_h^π with $h \in \{1,2,3,4\}$, and $w_i = 8$ for m_h^k and m_h^π with $h \in \{-4,-3,-2,-1\}$. We minimize the objective in equation (B.1) using a multi-step approach. First, we do a broad parameter search by generating candidate parameters using Sobol sequences. We generate 5000 combinations for the calibrated parameters. From this set, we return the best 30 calibrations according to the objective (B.1). We then search locally around these calibrations. For each candidate parameter from this set, we draw 100 candidate parameters again constructed with Sobol sequences and construct a convex combination with the candidate calibration. We evaluate the objective again, compare with all candidate parameters, and repeat the process until convergence.

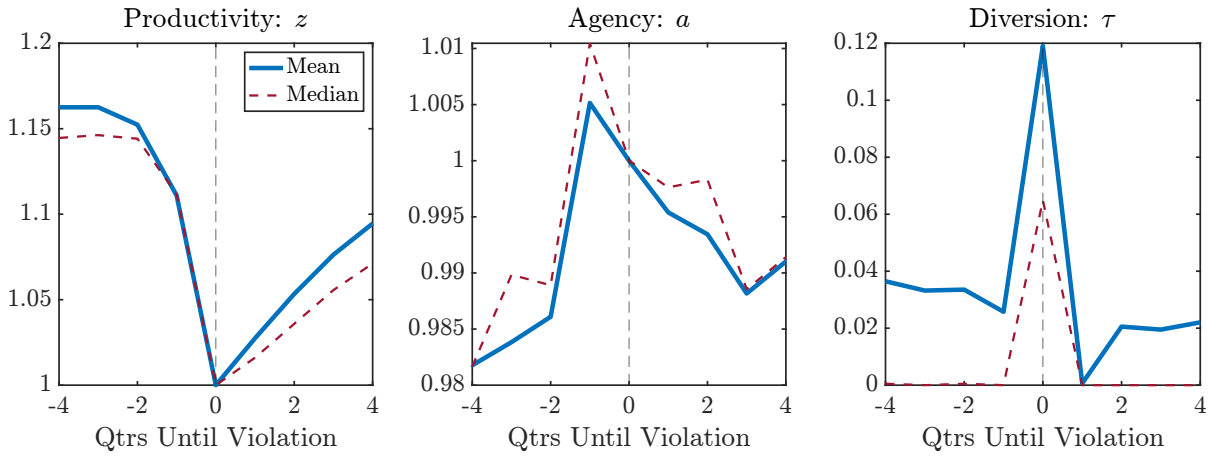
C Additional Results for Quantitative Analysis

Figure C.1: Cumulative Shareholder Returns around the Violation of Sophisticated Borrowing Constraints



Notes: The solid blue line plots the median firm's cumulative shareholder returns in each period $t+h$ relative to period t when it initially violates the sophisticated borrowing constraint. Specifically, we first calculate each period t's dividend-inclusive log return: $\log R^e_t \equiv \log \frac{d_t + V_{s,t+1}}{V_{s,t}}$, and then calculate the cumulative log return: $\sum_{s=1}^{h} \log R^e_{t+s}$ for $h \geq 1$, $-\sum_{s=h+1}^{0} \log R^e_{t+s}$ for $h \leq -1$, and 0 for $h = 0$. The blue line is based on all firms violating the sophisticated borrowing constraint in the steady state of the model. The red dashed line corresponds to the empirical counterparts, i.e., the median lines in Panel A of Figure A.1.

Figure C.2: Model Fit: Shocks around Covenant Violation



Notes: The left panel plots the average and median firm's idiosyncratic productivity shocks z in period $t+h$ normalized by its productivity shocks at t, i.e., z_{t+h}/z_t in the model. The middle panel plots the average and median firm's idiosyncratic agency shock a in period $t+h$ normalized by its agency shock at t when they initially violate the sophisticated borrowing constraint, i.e., a_{t+h}/a_t in the model. The right panel plots the average and median firm's fraction of unproductive capital use τ in period $t+h$, i.e., τ_{t+h} in the model. The lines are based on all firms violating the sophisticated borrowing constraint in the steady state of the model.

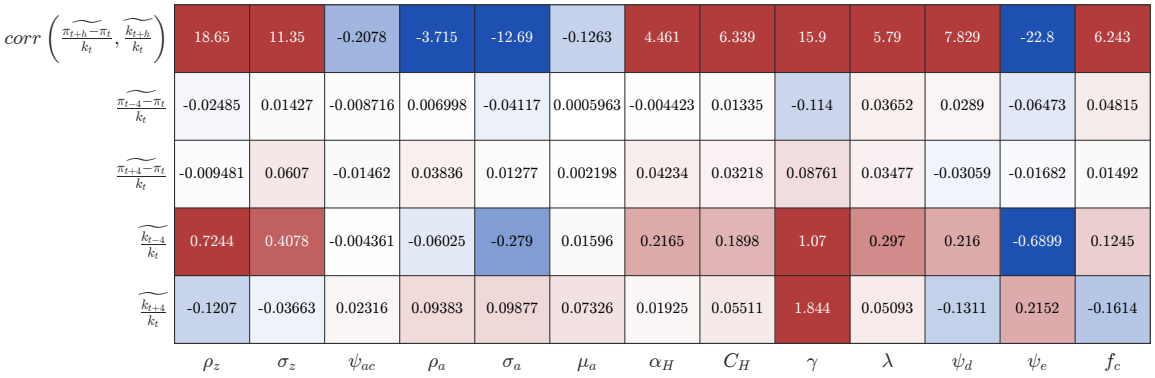
Table C.1: Non-Targeted Moments

	Model	Data
Standard Deviation		
Investment Rate	0.081	0.056
Earnings-to-Capital	0.028	0.028
Correlation with Earnings-to-Capital		
Investment Rate	0.518	0.095
Violation	-0.069	-0.163
Autocorrelation		
Investment Rate	0.290	0.340
Earnings-to-Capital	0.782	0.350
Capital Distribution		
Median to 25th pct	1.182	1.320
75th pct to Median	1.162	1.230

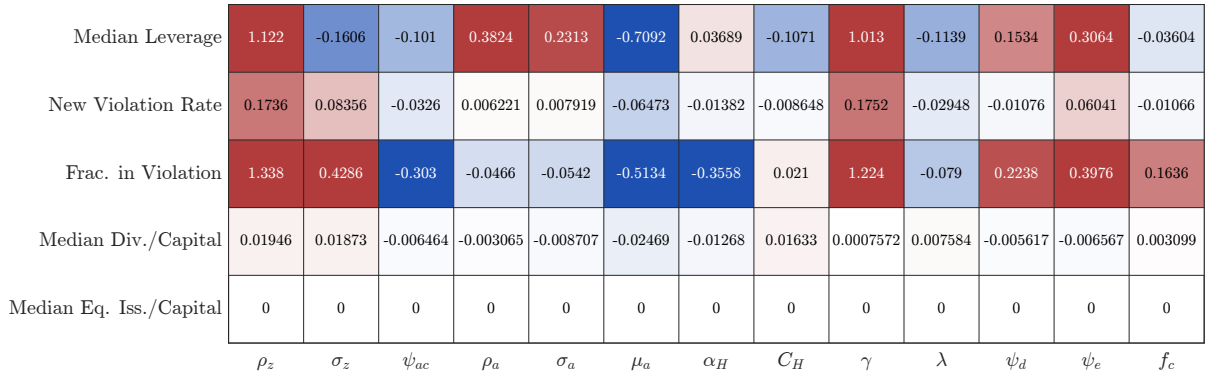
Notes. This table displays the empirical moments not included in the calibration targets and the corresponding values generated by the steady state of our model. Investment rate is defined as $\frac{k'-(1-\delta)k}{k}$, earnings-to-capital ratio is $\frac{\pi}{k}$, and violation is an indicator for whether the firm has violated the sophisticated borrowing constraint. Autocorrelation and correlation are averaged both across firms and over time (in the steady state without aggregate shocks).

Figure C.3: Identification: Sensitivities of Moments to Parameters

(a) Target Dynamics Around Covenant Violation



(b) Unconditional Targeted Moments



Notes. The figure displays the local level–log semi-elasticity of moments of targeted dynamics around covenant violations (panel a)) and unconditional targeted moments (panel b)) with respect to parameters. In panel a), a tilde over a variable corresponds to the median value of that variable across all firms violating the sophisticated borrowing constraint in the steady state of the model, where t denotes the period when they initially violate the sophisticated borrowing constraint. The correlation is computed over $h \in \{-4,-3,-2,-1,1,2,3,4\}$. In panel b), leverage, dividend to capital ratio, and equity issuance to capital ratio correspond to $\tilde{q}_b^{\text{face}} b/k$, $\max\{d,0\}/k$, and $\max\{-d,0\}/k$ in the model, respectively.

Table C.2: Fitted Parameters: No Agency Frictions

ρ_z	0.860	Persistence of TFP Shocks
σ_z	0.107	SD of TFP Shocks
ψ_{ac}	0.055	Capital Adj Cost
γ	0.969	Coupon Decay Rate
λ	0.173	Prob. of Transition to Normal from Violation
ψ_d	0.460	Dividend Adj Cost
ψ_e	0.646	Equity Issuance Cost
f_c	0.060	Fixed Operating Cost

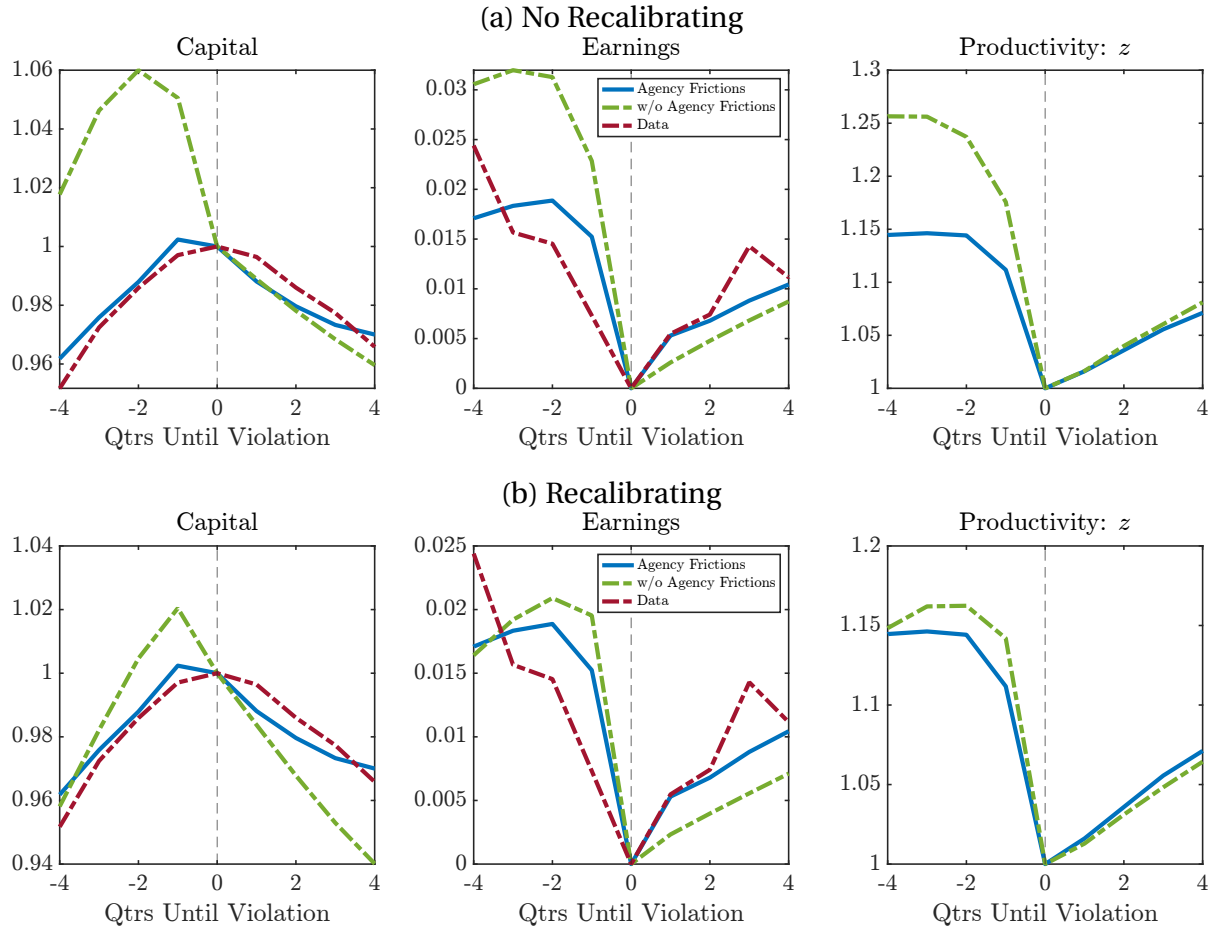
Notes. This table displays parameters that are chosen to match moments in Table 3 and Figure 1 in a variant of our model without agency frictions.

Table C.3: Unconditional Targeted Moments and Model Fit: No Agency Frictions

	Model	Data
Median Leverage	0.346	0.320
New Violation Rate	0.034	0.025
Frac. in Violation	0.161	0.150
Median Dividend to Capital	0.030	0.000
Median Equity Issuance to Capital	0.000	0.001

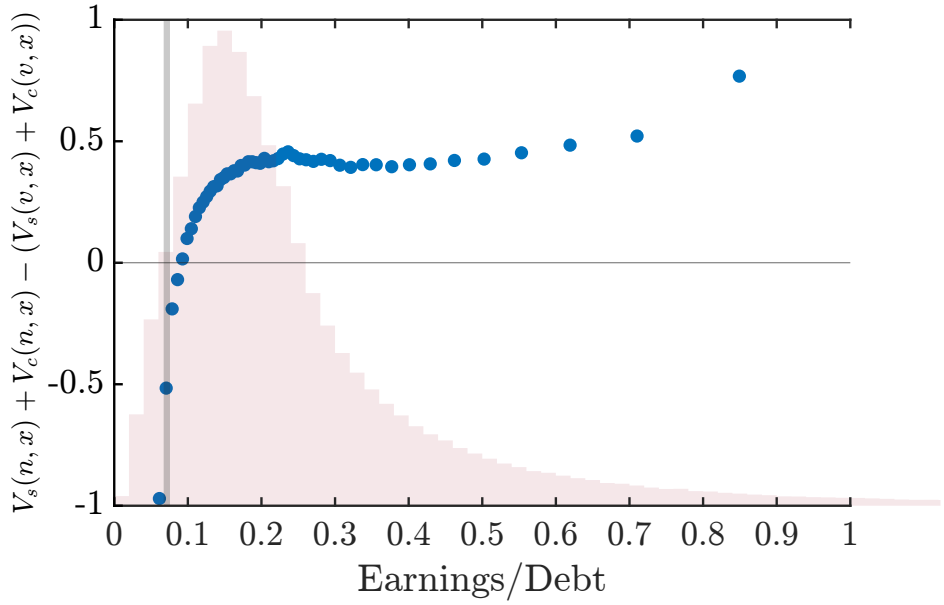
Notes. This table displays the empirical moments targeted in our calibration and the corresponding values generated by the steady state of a variant of our model without agency frictions. Leverage, dividend to capital ratio, and equity issuance to capital ratio correspond to $\tilde{q}_b^{\text{face}} b/k$, $\max\{d,0\}/k$, and $\max\{-d,0\}/k$ in the model, respectively. We use assets as a proxy for capital when calculating unconditional moments in this table.

Figure C.4: Targeted Dynamics Around Covenant Violations and Model Fit: No Agency Frictions



Notes: The left panel plots the median firm's capital in period $t+h$ normalized by its capital at t, i.e., k_{t+h}/k_t in the model. The middle panel plots the median firm's earnings in period $t+h$ relative to period t, normalized by capital at t, i.e., $(\pi_{t+h}-\pi_t)/k_t$ in the model. The right panel plots the median firm's idiosyncratic productivity shocks z in period $t+h$ normalized by its productivity shocks at t, i.e., z_{t+h}/z_t in the model. t captures when firms initially violate the sophisticated borrowing constraint. The blue lines are based all firms violating the sophisticated borrowing constraint in the steady state of our baseline model. The green lines are based on all firms violating the sophisticated borrowing constraint in the steady state of a variant of our model without agency frictions. The green line in Panel A keeps all parameter values the same as in the baseline model, except for those governing agency frictions. The green line in Panel B recalibrates this model using the same procedure as in our baseline model, matching both the unconditional empirical moments in Table 3 and the firm outcomes around covenant violations in Figure 1. The red lines correspond to their empirical counterparts, i.e., the median lines in Figure 1.

Figure C.5: Differences in Total Value between Manager and Creditor Control



Notes: The figure plots the difference in total shareholder and creditor values, $V_s(n,\cdot)+V_c(n,\cdot)-(V_s(v,\cdot)+V_c(v,\cdot))$, under manager and creditor control, as a function of firms' earnings-to-debt ratios ($\pi/\tilde{q}_b^{\text{face}}b$ in the model). Each dot represents a percentile of the earnings-to-debt ratio in the ergodic distribution of our model. The pink bar plot shows the probability density of the earnings-to-debt ratio in the ergodic distribution of our model. The grey line indicates the earnings-to-debt ratio corresponding to $1/\phi$.

Table C.4: Fitted Parameters: The Hard-Constraint Model

ρ_z	0.863	Persistence of TFP Shocks
σ_z	0.053	SD of TFP Shocks
ψ_{ac}	0.179	Capital Adj Cost
γ	0.942	Coupon Decay Factor
ψ_d	0.069	Dividend Adj Cost
ψ_e	0.604	Equity Issuance Cost
f_c	0.026	Fixed Operating Cost
ϕ	5.770	Debt to Earnings Limit

Notes. This table displays parameters that are chosen to match moments in Table 3 and and Figure 1 in the hard-constraint model described in Section 3.3.

Table C.5: Unconditional Targeted Moments and Model Fit: The Hard-Constraint Model

	Model	Data
Median Leverage	0.371	0.320
New Violation Rate	0.100	0.025
Frac. in Violation	0.105	0.150
Median Dividend/Capital	0.028	0.000
Median Equity Issuance	0.000	0.001

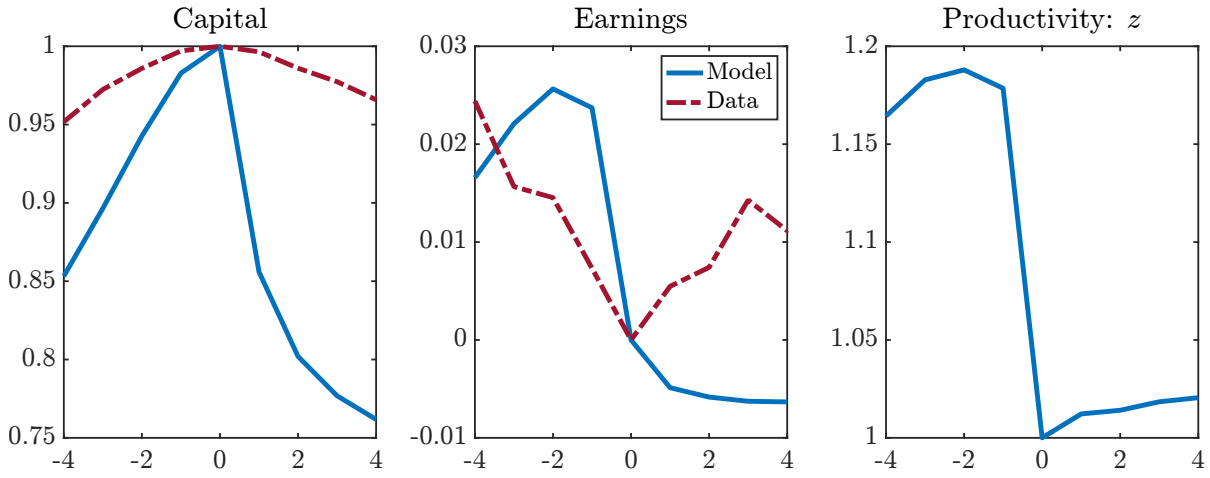
Notes. This table displays the empirical moments targeted in our calibration and the corresponding values generated by the steady state of the hard-constraint model described in Section 3.3. Leverage, dividend to capital ratio, and equity issuance to capital ratio correspond to $\tilde{q}_b^{\text{face}} b/k$, $\max\{d,0\}/k$, and $\max\{-d,0\}/k$ in the model, respectively. We use assets as a proxy for capital when calculating unconditional moments in this table.

Table C.6: Unconditional Targeted Moments and Model Fit: The Hard-Constraint Model Recaliberating ϕ^{hard} only

	Model	Data
Median Leverage	0.322	0.320
New Violation Rate	0.057	0.025
Frac. in Violation	0.064	0.150
Median Dividend/Capital	0.025	0.000
Median Equity Issuance	0.000	0.001

Notes. This table displays the empirical moments targeted in our calibration and the corresponding values generated by the steady state of the hard-constraint model where we recalibrate ϕ^{hard} such that its median leverage matches that of the sophisticated constraint model, while keeping all other parameters the same. Leverage, dividend to capital ratio, and equity issuance to capital ratio correspond to $\tilde{q}_b^{\text{face}} b/k$, $\max\{d,0\}/k$, and $\max\{-d,0\}/k$ in the model, respectively. We use assets as a proxy for capital when calculating unconditional moments in this table.

Figure C.6: Targeted Dynamics Around Covenant Violations and Model Fit: The Hard-Constraint Model Recaliberating ϕ^{hard} only



Notes: The blue solid line in the left panel shows the median firm's capital in period $t+h$ normalized by its capital at t (the initial period in which the hard constraint binds), i.e., k_{t+h}/k_t in the model. The blue solid line in the middle panel shows the median firm's earnings in period $t+h$ relative to period t, normalized by capital at t, i.e., $(\pi_{t+h}-\pi_t)/k_t$ in the model. The right panel plots the median firm's idiosyncratic productivity shocks z (solid line) in period $t+h$ normalized by its productivity shocks at t, i.e., z_{t+h}/z_t in the model. The lines are based on all firms hitting the hard borrowing constraint in the steady state of the hard-constraint model where we recalibrate ϕ^{hard} such that its median leverage matches that of the sophisticated constraint model, while keeping all other parameters the same. The red dashed lines in the first two panels correspond to their empirical counterparts, i.e., the median lines in Figure 1.

Table C.7: Fitted Parameters: The Hard-Constraint Model with Asset-based Lending

ρ_z	0.854	Persistence of TFP Shocks
σ_z	0.064	SD of TFP Shocks
ψ_{ac}	0.483	Capital Adj Cost
γ	0.941	Coupon Decay Factor
ψ_d	0.071	Dividend Adj Cost
ψ_e	0.393	Equity Issuance Cost
f_c	0.015	Fixed Operating Cost
ϕ	0.407	Debt to Earnings Limit

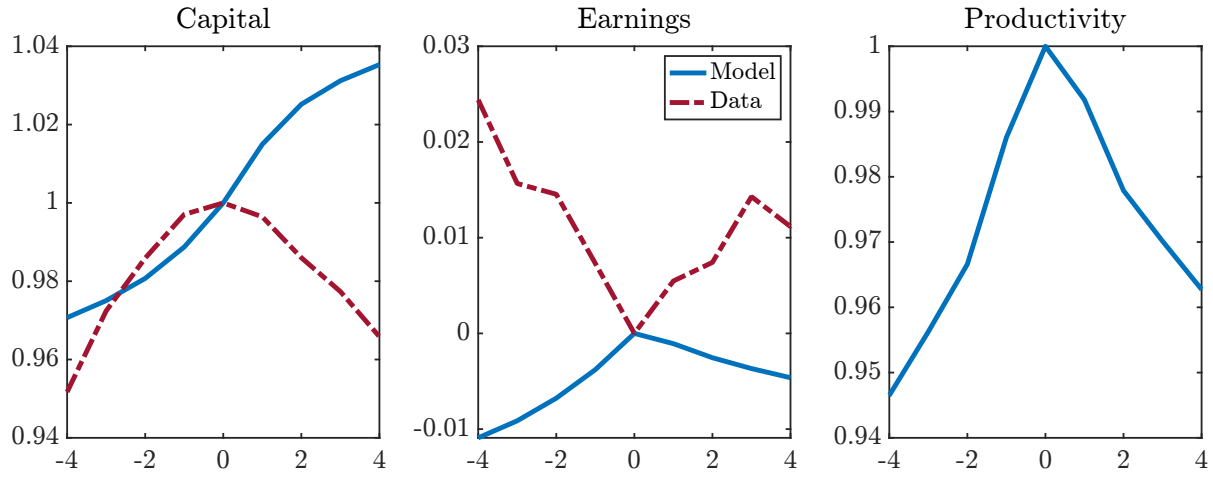
Notes. This table displays parameters that are chosen to match moments in Table 3 and and Figure 1 in the hard-constraint model with asset-based lending described in Section 3.3.

Table C.8: Unconditional Targeted Moments and Model Fit: The Hard-Constraint Model with Asset-based Lending

	Model	Data
Median Leverage	0.406	0.320
New Violation Rate	0.045	0.025
Frac. in Violation	0.054	0.150
Median Dividend/Capital	0.026	0.000
Median Equity Issuance	0.000	0.001

Notes. This table displays the empirical moments targeted in our calibration and the corresponding values generated by the steady state of the hard-constraint model with asset-based lending described in Section 3.3. Leverage, dividend to capital ratio, and equity issuance to capital ratio correspond to $\tilde{q}_b^{\text{face}} b/k$, $\max\{d,0\}/k$, and $\max\{-d,0\}/k$ in the model, respectively. We use assets as a proxy for capital when calculating unconditional moments in this table.

Figure C.7: Targeted Dynamics Around Covenant Violations and Model Fit: The Hard-Constraint Model with Asset-based Lending



Notes: The blue solid line in the left panel shows the median firm's capital in period $t+h$ normalized by its capital at t, i.e., k_{t+h}/k_t in the model. The blue solid line in the middle panel shows the median firm's earnings in period $t+h$ relative to period t, normalized by capital at t, i.e., $(\pi_{t+h}-\pi_t)/k_t$ in the model. The right panel plots the median firm's idiosyncratic productivity shocks z (solid line) in period $t+h$ normalized by its productivity shocks at t, i.e., z_{t+h}/z_t in the model. The lines are based on all firms hitting the hard borrowing constraint in the steady state of the hard-constraint model with asset-based lending described in Section 3.3. The red dashed lines in the first two panels correspond to their empirical counterparts, i.e., the median lines in Figure 1.

Table C.9: Fitted Parameters: The Hard-Constraint Model with Agency Frictions

[under construction]

Notes. This table displays parameters that are chosen to match moments in Table 3 and Figure 1 in a variant of the hard-constraint model with agency frictions recalibrated using the same procedure as in our baseline model.

Table C.10: Unconditional Targeted Moments and Model Fit: The Hard-Constraint Model with Agency Frictions

[under construction]

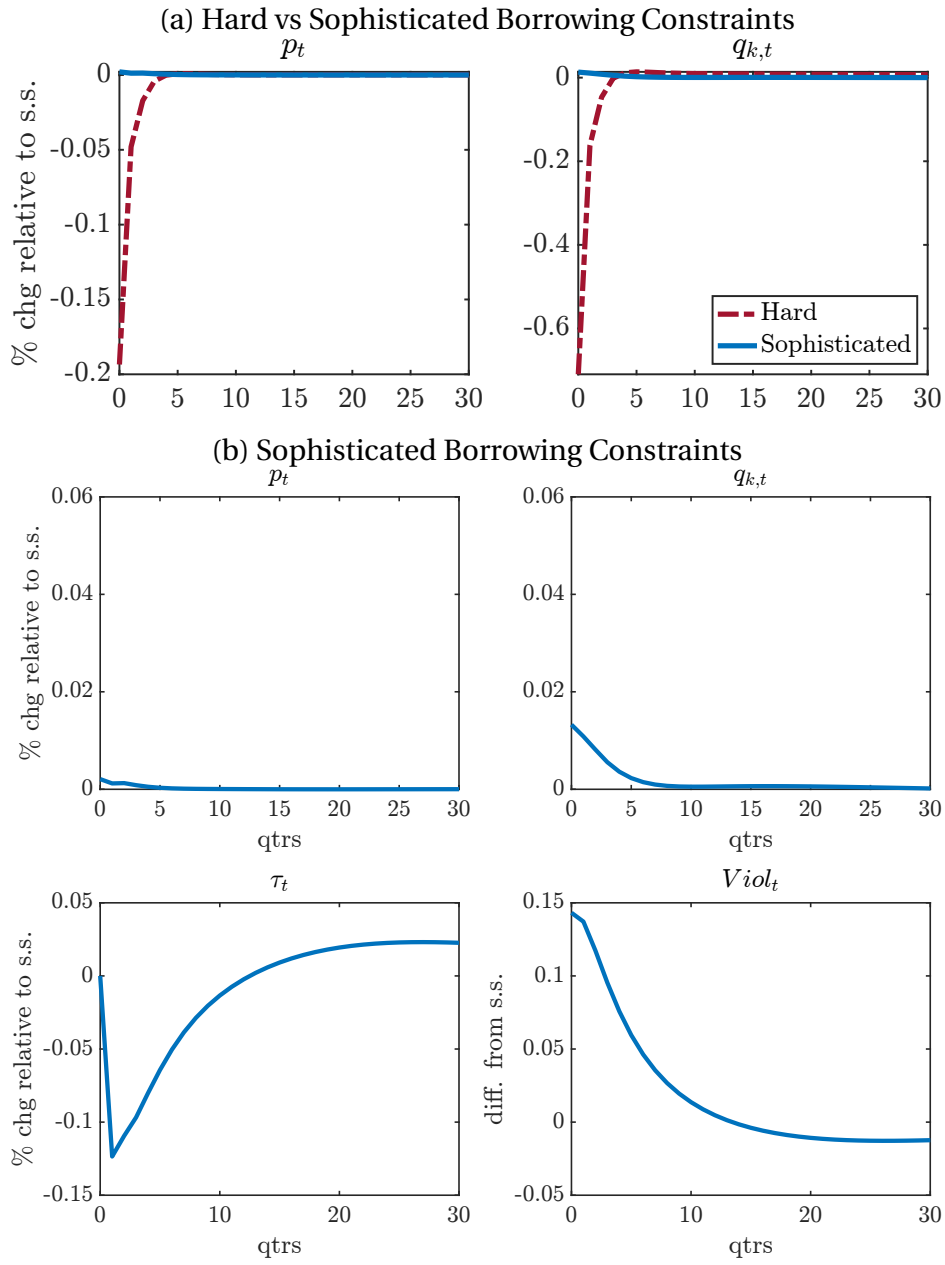
Notes. This table displays the empirical moments targeted in our calibration and the corresponding values generated by the steady state in a variant of the hard-constraint model with agency frictions recalibrated using the same procedure as in our baseline model. Leverage, dividend to capital ratio, and equity issuance to capital ratio correspond to $\tilde{q}_b^{\text{face}} b/k$, $\max\{d,0\}/k$, and $\max\{-d,0\}/k$ in the model, respectively. We use assets as a proxy for capital when calculating unconditional moments in this table.

Figure C.8: Targeted Dynamics Around Covenant Violations and Model Fit: The Hard-Constraint Model with Agency Frictions

[under construction]

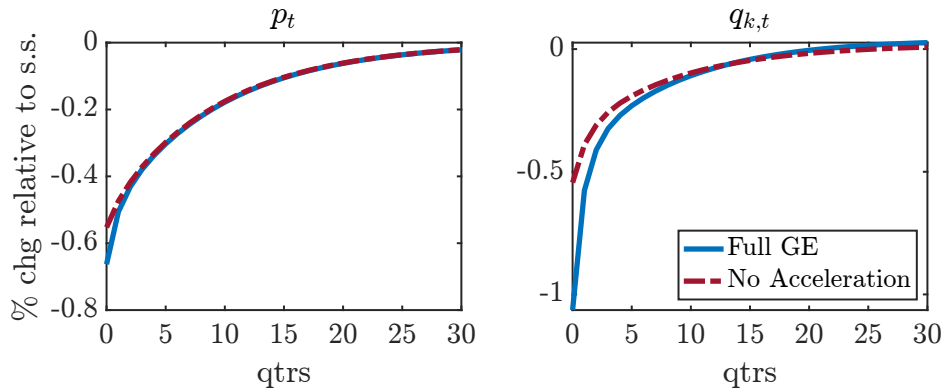
Notes: The blue solid line in the left panel shows the median firm's capital in period $t+h$ normalized by its capital at t (the initial period in which the hard constraint binds), i.e., k_{t+h}/k_t in the model. The blue solid line in the middle panel shows the median firm's earnings in period $t+h$ relative to period t, normalized by capital at t, i.e., $(\pi_{t+h}-\pi_t)/k_t$ in the model. The right panel plots the median firm's idiosyncratic productivity shocks z (solid line) in period $t+h$ normalized by its productivity shocks at t, i.e., z_{t+h}/z_t in the model. The lines are based on all firms hitting the hard borrowing constraint in the steady state of a variant of the hard-constraint model with agency frictions recalibrated using the same procedure as in our baseline model. The red dashed lines in the first two panels correspond to their empirical counterparts, i.e., the median lines in Figure 1.

Figure C.9: Macro Impacts of the Constraint Tightening Shock



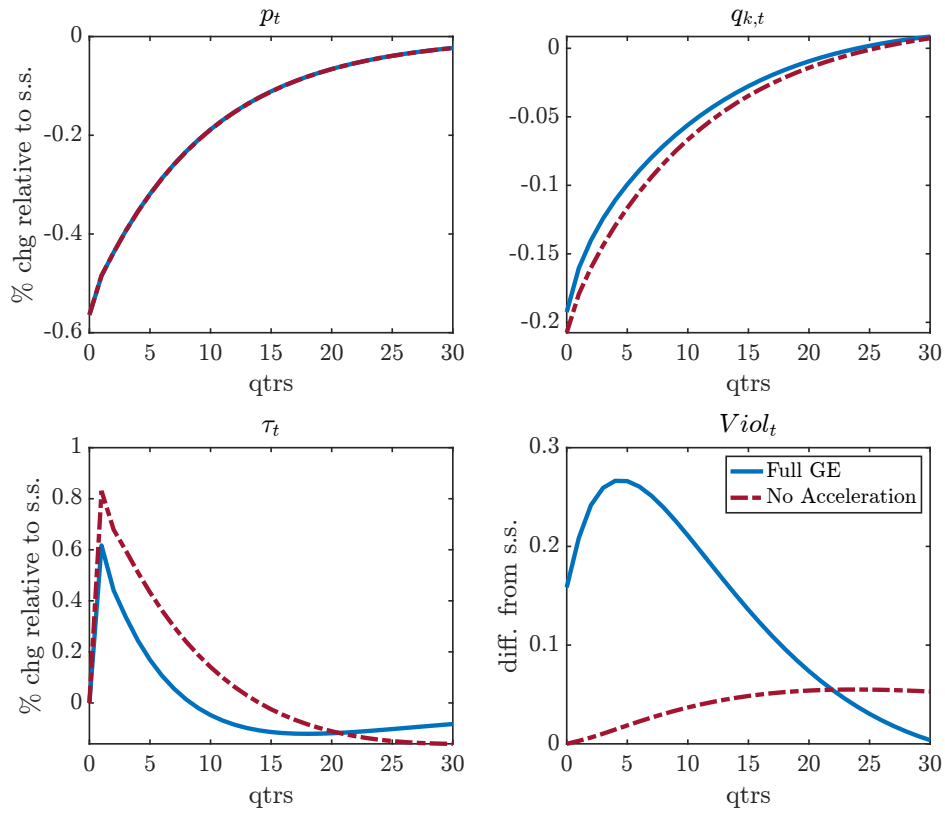
Notes: Panel A plots the responses of the relative price of goods produced by financially constrained firms p_t and the relative price of capital $q_{k,t}$ to a tightening of sophisticated borrowing constraints with initial magnitude $\Delta\phi_0 = -1\% \times \phi$ in the sophisticated-constraint model (solid blue lines), and the counterpart responses to a tightening of hard borrowing constraints with initial magnitude $\Delta\phi_0^{\text{hard}} = -1\% \times \phi^{\text{hard}}$ in the hard-constraint model (dashed red lines). The constraint tightening shock has a persistence of 0.5. Panel B zooms in on the responses in the sophisticated borrowing constraints model and also plots the average fraction of capital in unproductive use $\tau_t \equiv \int \tau_{jt} di$ and the aggregate fraction of firms in the violation state. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.10: Macro Impacts of the Monetary Policy Shock: Hard Borrowing Constraints



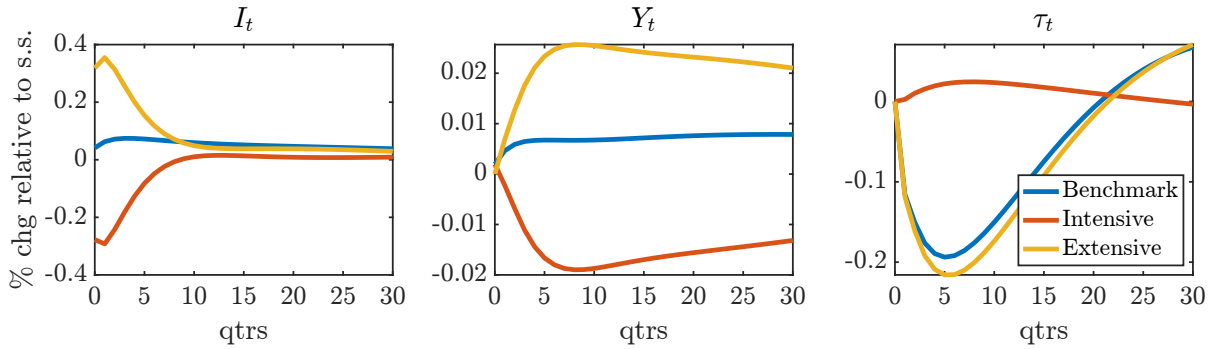
Notes: The figure plots the responses of the relative price of goods produced by financially constrained firms p_t and the relative price of capital $q_{k,t}$ to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under hard borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.11: Macro Impacts of the Monetary Policy Shock: Sophisticated Borrowing Constraints



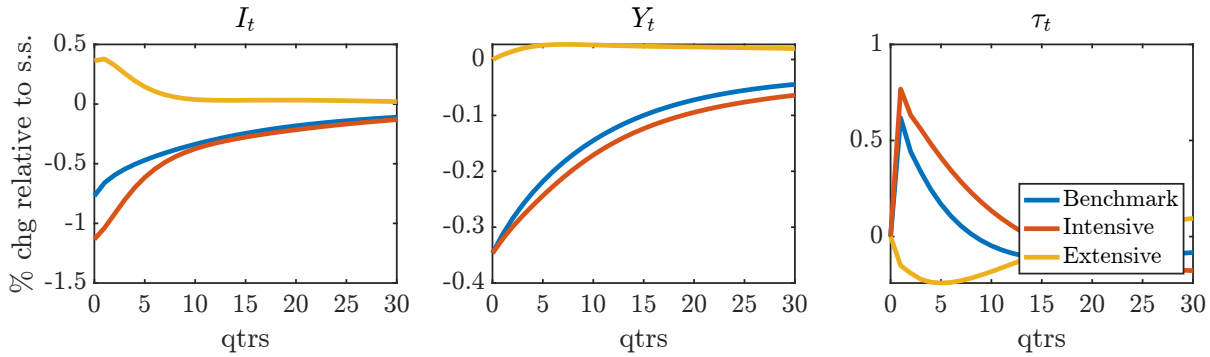
Notes: The figure plots the responses of the relative price of goods produced by financially constrained firms p_t, the relative price of capital $q_{k,t}$, the average fraction of capital in unproductive use $\tau_t \equiv \int \tau_{jt} di$, and the aggregate fraction of firms in the violation state to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under sophisticated borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.12: Decomposing the Macro Impacts of the Constraint Tightening Shock: Sophisticated Borrowing Constraints



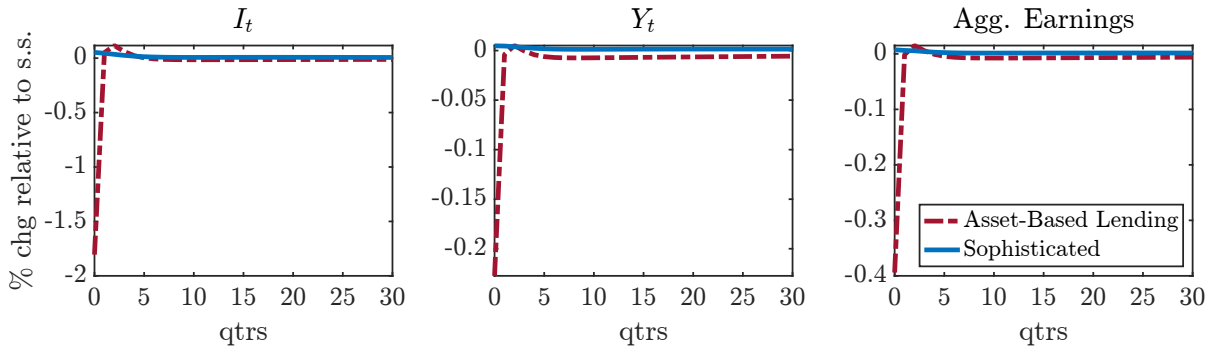
Notes: The figure plots the responses of aggregate investment, output, and fraction of capital for unproductive use to a tightening of borrowing constraints with an initial magnitude $\Delta\phi_0 = -1\% \times \phi$ and a persistence of 0.5 under sophisticated borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The extensive and intensive margins are defined in Appendix B.2. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.13: Decomposing the Macro Impacts of the Monetary Policy Shock: Sophisticated Borrowing Constraints



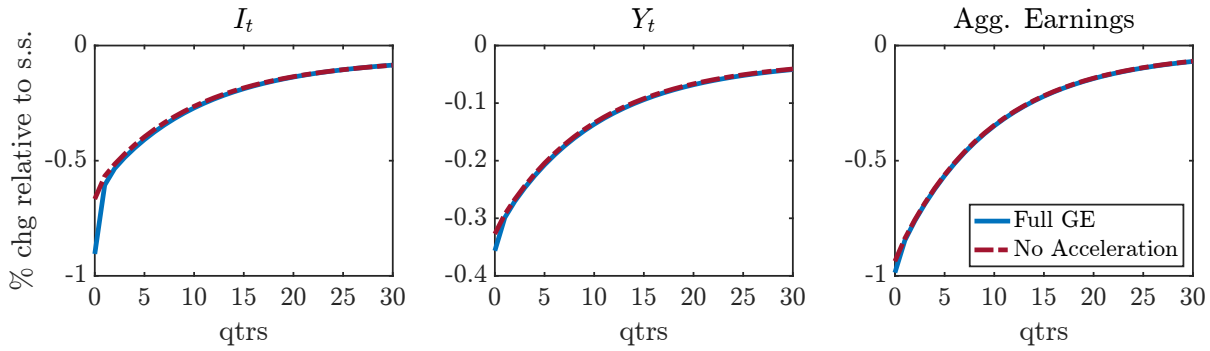
Notes: The figure plots the responses of aggregate investment, output, and fraction of capital for unproductive to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under sophisticated borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The extensive and intensive margins are defined in Appendix B.2. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.14: Macro Impacts of the Constraint Tightening Shock: Hard Borrowing Constraints with Asset-based Lending



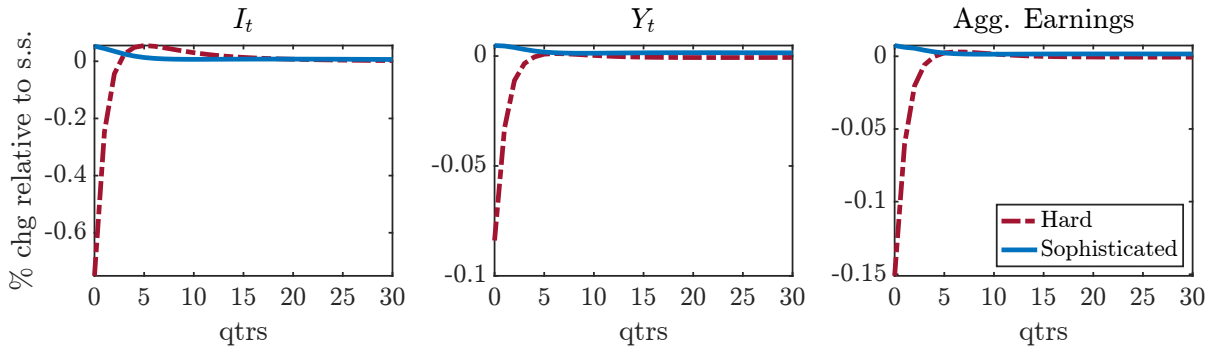
Notes: This figure plots the responses of aggregate investment, output, and earnings to a tightening of borrowing constraints, with initial magnitudes $\Delta\phi_0 = -1\% \times \phi$ in the sophisticated-constraint model and $\Delta\phi_0^{\text{hard}} = -1\% \times \phi^{\text{hard}}$ in the hard-constraint model, and with a persistence of 0.5, under both hard (dashed red lines) and sophisticated borrowing constraints (solid blue lines). The hard-constraint model with asset-based lending is described in Section 3.3. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.15: Macro Impacts of the Monetary Policy Shock: Hard Borrowing Constraints with Asset-based Lending



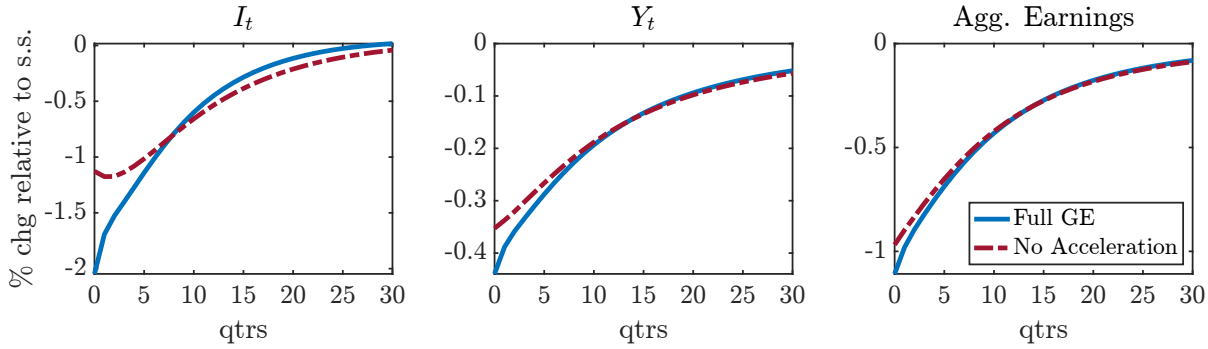
Notes: The figure plots the responses of aggregate investment, output, and earnings to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under hard borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The hard-constraint model with asset-based lending is described in Section 3.3. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.16: Macro Impacts of the Constraint Tightening Shock: Hard Borrowing Constraints Recalibrating ϕ^{hard} only



Notes: This figure plots the responses of aggregate investment, output, and earnings to a tightening of borrowing constraints, with initial magnitudes $\Delta\phi_0 = -1\% \times \phi$ in the sophisticated-constraint model and $\Delta\phi_0^{\text{hard}} = -1\% \times \phi^{\text{hard}}$ in the hard-constraint model, and with a persistence of 0.5, under both hard (dashed red lines) and sophisticated borrowing constraints (solid blue lines). The hard-constraint model is based on a variant where we recalibrate ϕ^{hard} such that its median leverage matches that of the sophisticated constraint model, while keeping all other parameters the same. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.17: Macro Impacts of the Monetary Policy Shock: Hard Borrowing Constraints Recalibrating ϕ^{hard} only



Notes: The figure plots the responses of aggregate investment, output, and earnings to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under hard borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The hard-constraint model is based on a variant where we recalibrate ϕ^{hard} such that its median leverage matches that of the sophisticated constraint model, while keeping all other parameters the same. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.18: Macro Impacts of the Constraint Tightening Shock: Hard Borrowing Constraints with Agency Frictions

[UNDER CONSTRUCTION]

Notes: This figure plots the responses of aggregate investment, output, and earnings to a tightening of borrowing constraints, with initial magnitudes $\Delta\phi_0 = -1\% \times \phi$ in the sophisticated-constraint model and $\Delta\phi_0^{\text{hard}} = -1\% \times \phi^{\text{hard}}$ in the hard-constraint model, and with a persistence of 0.5, under both hard (dashed red lines) and sophisticated borrowing constraints (solid blue lines). The hard-constraint model is based on a variant with agency frictions and is recalibrated using the same procedure as in our baseline model. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

[UNDER CONSTRUCTION]

Figure C.19: Macro Impacts of the Monetary Policy Shock: Hard Borrowing Constraints with Agency Frictions

Notes: The figure plots the responses of aggregate investment, output, and earnings to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under hard borrowing constraints. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The hard-constraint model is based on a variant with agency frictions and is recalibrated using the same procedure as in our baseline model. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

Figure C.20: Macro Impacts of the Constraint Tightening Shock: Sophisticated Borrowing Constraints without Agency Frictions

[UNDER CONSTRUCTION]

Notes: This figure plots the responses of aggregate investment, output, and earnings to a tightening of borrowing constraints, with initial magnitudes $\Delta\phi_0 = -1\% \times \phi$ and with a persistence of 0.5, under a variant of the sophisticated borrowing constraints model without agency friction recalibrated using the same procedure as in our baseline model. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.

[UNDER CONSTRUCTION]

Figure C.21: Macro Impacts of the Monetary Policy Shock: Sophisticated Borrowing Constraints without Agency Frictions

Notes: The figure plots the responses of aggregate investment, output, and earnings to a 30 bps monetary tightening ($\epsilon_0^m = 0.3\%$) with a persistence of 0.9 under a variant of the sophisticated borrowing constraints model without agency friction recalibrated using the same procedure as in our baseline model. It is computed as the perfect foresight transition in response to an unexpected shock from the steady state. The units of responses are expressed in terms of percentage deviations relative to steady state.