Indebted Supply and Monetary Policy: A Theory of Financial Dominance*

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Abstract

We develop a New Keynesian model with financial frictions to explore the concept of "financial dominance" in monetary policy. Our theory is based on how interest rates affect firms through both their ex-ante capital structure decisions and their ex-post financial constraints. Ex ante, firms have a "market timing" motive to exploit differences between the cost of debt and equity, leading to increased leverage during periods of monetary easing. Ex post, when a large share of firms' assets have been encumbered to finance long-term investments through debt, rising interest rates reduce firms' remaining debt capacity, diminishing their ability to finance production. Monetary policy contractions thus induce an endogenous cost channel whose strength depends on past financial conditions. Financial dominance takes two forms: (i) responding to inflationary shocks when supply is indebted requires a higher policy rate and a starker drop in output, which makes the central bank less willing to tame inflation; (ii) when faced with negative demand shocks a priori, the central bank encounters a dilemma between easing the current demand-driven recession and tightening future constraints driven by indebted supply. Our model highlights how the effectiveness of monetary policy in managing inflation and output may be constrained by past policy decisions and their impact on firms' capital structures.

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1 Introduction

Recent economic events, including the Global Financial Crisis of 2008, the COVID-19 pandemic, and the subsequent inflationary pressures, have highlighted significant gaps in our understanding of the intricate relationship between monetary policy, financial markets, and the real economy. One crucial aspect that standard models often overlook is the role of corporate capital structure and financial constraints in shaping central banks' ability to respond to macroeconomic shocks. In particular, the way firms choose to become indebted in response to interest rates can have profound implications for future constraints they might face in their ability to supply goods and services, and in turn, for the conduct of monetary policy. We fill this gap in the literature by exploring how corporate financial choices can constrain conventional monetary policy and alter its transmission mechanisms, resulting in a form of "financial dominance."

Financial dominance refers to a situation where firms' past and current capital structure decisions affect aggregate supply and demand, and limit the central bank's ability to achieve its macroeconomic objectives. Our framework goes beyond the familiar idea of financial stability concerns, as ultimately, the central bank we consider only cares about financial frictions in so far as they affect inflation and economic activity. Instead, we highlight how the accumulated effects of monetary policy on corporate balance sheets can create new intertemporal inflation-output trade-offs for policymakers, forcing them to balance current macroeconomic goals against future supply constraints.

To explore these ideas, we develop a tractable New Keynesian model with financial frictions that captures rich interactions between monetary policy, firms' capital structure decisions, and macroeconomic outcomes. We introduce two novel ingredients that are crucial for understanding the concept of financial dominance.

First, we model firms' capital structure choices as a trade-off between the benefits of cheaper debt in time of monetary easing against the costs of potential future financial distress. This approach allows us to capture the "market timing" behavior documented in the corporate finance literature, where firms exploit fluctuations in the relative costs of debt and equity.

Second, we introduce a key mechanism through which firms' past leverage decisions affect their current productive capacity: when a large share of firms' assets have been encumbered to finance long-term investments through debt, rising interest rates reduce the value of firms' remaining pledgeable assets, diminishing their ability to finance short-term production needs. This creates a link between interest rates and aggregate supply that

depends on the state of firms' balance sheets.

Our model yields three main results that shed new light on the conduct of monetary policy in an increasingly financialized world.

The first step of our argument is that a variety of frictions (e.g., adverse selection, agency costs, illiquidity, mispricing due to "market sentiment", or a convenience yield on debt) can cause a wedge between the risk-adjusted costs of debt and equity. Therefore, when choosing their capital structure, firms must trade off the lower cost of debt against any higher costs of future financial distress (e.g., in response to future rate hikes). Our focus is on how interest rates affect this tradeoff. Importantly, our model clarifies that it is not low rates per se that tilt firms' capital structure, but asymmetric effects of interest rates on the costs of debt and equity. For instance, a parallel fall in the costs of debt and equity would not alter firms' optimal leverage: even though borrowing costs are lower, issuing equity also becomes cheaper. However, if the policy rate has a stronger pass-through to the cost of debt than to the cost of equity, then firms find it profitable to increase leverage when the interest rate declines. Using high-frequency monetary shocks, we provide empirical evidence that monetary easing indeed lowers the cost of debt more than the cost of equity, and increases debt issued by firms to finance investments.

We then show that the Phillips curve becomes "kinked" when firms are highly levered: at low interest rates, firms have sufficient pledgeable income left (or their assets have a sufficient collateral value) to produce at full scale, but high interest rates force indebted firms to scale down production in response to binding financial constraints. The kinked Phillips curve leads to our first notion of financial dominance: outstanding corporate debt worsens the central bank's inflation-output tradeoff and amplifies the costs of inflationary pressures arising from positive demand shocks or negative supply shocks. When firms are indebted, the "divine coincidence" breaks down and it becomes impossible to stabilize both output and inflation. Maintaining output at its potential comes at the cost of high inflation, while taming inflation requires a severe contraction in output. Our framework does not imply that higher rates are inflationary, as the negative effect of rates on aggregate demand still dominates; but we show that a larger outstanding corporate debt burden implies that a higher policy rate—and thus a more severe contraction in output—are required to maintain price stability in the face of inflationary pressures. Since, as explained above, the state of corporate balance sheets is in part determined by past interest rates, the location of the kink in the Phillips curve, and thus the inflation-output trade-off faced by the central bank, depend on the path of prior interest rates. Conversely, inflationary shocks dissipate in part

thanks to a dynamic adjustment of corporate leverage. Keeping the policy rate high allows the kink in the Phillips curve to shift back to its original position.

Our second notion of financial dominance highlights that monetary easing, for instance aimed at stimulating the economy following negative demand shocks, can lead to a "leverage boom" that weakens the current expansionary effects and constrains future policy options. Monetary easing today sows the seeds for future financial constraints, as low rates induce a rise in corporate leverage with the potential for indebted supply in the future. This reduces the effectiveness of monetary policy in stimulating output, because the anticipation of future financial distress undermines the current response of aggregate demand to interest rates (through standard intertemporal substitution or wealth effects). As a result, in response to large negative demand shocks, the central bank needs to ease policy more aggressively than in standard models to achieve the same output stabilization. However, this comes at the cost of a lower future productive capacity. The central bank's dilemma is between cutting rates aggressively at the cost of a slower recovery, and restricting easing to prevent aggregate supply from becoming indebted.

These findings have important implications for our understanding of historical episodes and current policy challenges. For instance, our model can help explain how the prolonged period of low interest rates and high corporate leverage following the Global Financial Crisis made the subsequent normalization of monetary policy so challenging for many central banks. Moreover, our results speak to the more recent debate on the appropriate monetary policy response to supply chain disruptions and inflationary pressures in the wake of the COVID-19 pandemic. The model suggests that policymakers need to carefully consider how past expansionary policies may have affected corporate balance sheets and how these financial conditions might influence the effectiveness and risks of current policy choices.

Related literature

Our work builds on the extensive literature on the macroeconomic implications of financial frictions, pioneered by Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). This work, further developed by Bernanke, Gertler and Gilchrist (1999), emphasizes how firms' balance sheet conditions can amplify and propagate macroeconomic shocks. While these seminal papers focus on how net worth affects firms' ability to borrow, our model introduces a novel mechanism whereby firms choose between different forms of external finance and past capital structure decisions directly constrain their current production capacity.

Our work is also closely related to the literature on the "cost channel" or "working

capital channel" of monetary policy, as developed by Barth and Ramey (2001), Christiano, Eichenbaum and Evans (2005), and Ravenna and Walsh (2006). These papers highlight how interest rates directly affect firms' costs when they need to borrow to finance inputs (often focusing on wages) before production. Our model builds on this insight but introduces two key innovations. First, in our framework, the relevance of the cost channel depends endogenously on firms' past capital structure decisions: firms' productive capacity only suffers from higher rates if outstanding debt is high. Second, we show how current monetary policy affects the future strength of the cost channel through its impact on firms' leverage choices.

We also contribute to the literature on corporate finance and monetary policy. In Graham and Harvey (2001)'s influential survey, firms report that the level of interest rates is an important driver of firms' decision to issue debt. Firms try to time the market by issuing debt when they believe interest rates are particularly low, and by issuing more short-term debt when short-term rates are low relative to long-term rates. This parallels the market timing theory of capital structure driven by fluctuations in asset prices (e.g., Baker and Wurgler, 2002; Ma, 2019). Baker, Greenwood and Wurgler (2003) and Greenwood, Hanson and Stein (2010) provide evidence that corporate debt maturity responds to movements in the yield curve, connecting these findings to fiscal policy and the maturity of government debt. Our model formalizes the macroeconomic and dynamic consequences of this market-timing motive, and focuses on implications for monetary policy.

Our paper also relates to the extensive literature on the nexus between monetary policy and financial intermediaries. Adrian and Shin (2010), Borio and Zhu (2012) and Farhi and Tirole (2012) focus on how low interest rates, or the anticipation thereof, may induce excessive risk-taking by financial intermediaries causing future financial instability. We argue, using a framework closer to the canonical New Keynesian analysis of monetary policy, that low rates can lead to higher corporate leverage and worsen the future inflation-output tradeoff and monetary policy effectiveness. Another strand of the literature focuses on various manifestations of the "bank lending channel" describing how bank credit supply responds to monetary policy (Bernanke and Blinder, 1988; Kashyap and Stein, 2000; Drechsler et al., 2017). In particular, Drechsler, Savov and Schnabl (2022) argue that tight monetary policy in the 1970s combined with a regulatory cap on deposit rates (Regulation Q) led to stark deposit outflows and credit crunches, ultimately hurting aggregate supply.[1]

Recent work has emphasized the path-dependent effects of monetary policy operating

[1]Our baseline model abstracts from financial intermediaries. In Section 6.2 we extend our framework to incorporate bank-driven credit supply shocks.

through the household sector. Berger, Vavra, Milbradt and Tourre (2021) and Eichenbaum, Rebelo and Wong (2022) highlight how past interest rate decisions affect current policy effectiveness through mortgage refinancing incentives: a given rate cut is less expansionary if a large share of mortgages have already been refinanced in response to recent cuts. McKay and Wieland (2021) show that monetary policy has "limited ammunition" because any past durable purchases induced by monetary easing crowd out future durable consumption. Mian, Straub and Sufi (2021) emphasize the key role of *household balance sheets* and show that aggregate demand can become "indebted" in response to low rates in a model when borrowers and savers have different marginal propensities to consume out of permanent income. High household debt then dampens the effect of future rate cuts on aggregate consumption. Our paper complements this literature by focusing on *corporate balance sheets*, showing how past interest rates affect future policy space through their impact on firms' "indebted supply".[2]

Finally, our work contributes to the literature on how firm heterogeneity affects monetary policy transmission. Ottonello and Winberry (2020) study how firms' leverage and credit risk affect their investment response to monetary shocks, while Jeenas (2024) emphasizes the role of corporate liquidity. Our model differs by focusing on how leverage affects firms' production decisions rather than just investment, and by examining the implications of these dynamic effects for monetary policy. Cloyne, Ferreira, Froemel and Surico (2023) document a strong impact of monetary policy on young firms' investment working through collateral values, consistent with our model's mechanism.[3]

Outline

The remainder of the paper is organized as follows. Section 2 presents empirical motivation for our theoretical framework. Section 3 presents our baseline model of production and capital structure decisions in the presence of financial frictions. Section 4 analyzes the equilibrium under flexible prices, highlighting the key mechanisms through which corporate balance sheets affect aggregate supply. Section 5 introduces nominal rigidities and explores the implications for monetary policy transmission and the optimal response to

[2] Jiménez, Kuvshinov, Peydró and Richter (2023) study the interaction between monetary policy paths and financial instability using international historical data. They find that rate cuts lead to credit booms that leave the banking sector vulnerable to future rate hikes. This pattern is consistent with our mechanism, although we focus on the capital structure of nonfinancial firms.

[3] More broadly, Chaney, Sraer and Thesmar (2012) show how real estate prices affect corporate investment through a collateral channel.

macroeconomic shocks. Section 6 discusses several extensions of the basic model, including the role of banks and credit crunches and potential macroprudential interventions.

2 Empirical motivation

In this section, we provide two sets of novel empirical facts that motivate the key mechanisms in our theoretical framework.

First, we show that monetary policy shocks have a stronger pass-through to firms' cost of debt than to their cost of equity, and that due to this asymmetry, monetary policy can affect firms' capital structure decisions. This finding will map into our model's "ex-ante" stage, whereby firms distort their capital structure in response to fluctuations in relative asset prices.

Second, we document that in sectors experiencing higher financial distress, contractionary monetary policy shocks exhibit weaker disinflationary effects; this is precisely the phenomenon we label as indebted supply constraining the economy. This finding corresponds to our model's "ex-post" stage, whereby firms' outstanding capital structure—in part determined by past policies through the first channel—affects their response to monetary policy.

2.1 Data and variable construction

Firm's cost of capital and capital structure: We construct cost of capital measures following Acharya, Byoun and Xu (2024). We combine data from Compustat for balance sheet and income variables, from the Center for Research in Security Prices (CRSP) for stock prices, and from the Institutional Brokers Estimate System (I/B/E/S) for analysts' earnings and growth forecasts. The resulting annual dataset features an average of 2303 firms between 1994 and 2019. From the initial sample, we exclude firms with asset value below $5 million and negative values for equity, cash holdings and net sales (Compustat); financial firms (SIC codes 6000-6799) and regulated utilities (SIC codes 4900-4999); observations with missing net income and stock price (CRSP); observation with missing data for the prior year's book value, earnings and dividends (I/B/E/S).

For the cost of debt (COD), we use the average yield on debt. The cost of equity (COE) is constructed using the "market-implied cost of capital" method, shown by Frank and Shen (2016) and Hommel, Landier and Thesmar (2023) to outperform CAPM-based measures when explaining corporate investment and valuation. We sketch the estimation procedure

here and refer to Acharya et al. 2024 for further details. For each firm and at each date, the COE is defined as the discount rate that can rationalize the observed stock price of the company through the lens of a discounted cash flow model based on analysts' earnings and growth forecasts. We follow the standard discounted cash flow model in Gebhardt, Lee and Swaminathan (2001); see also Claus and Thomas (2001) and Li, Ng and Swaminathan (2013) for alternative models that differ slightly in the mapping between analysts' earnings forecasts and expected cash flows used in the discounted cash flow formula, and yield very similar series for COE, as shown in Acharya et al. (2024). By construction, this measure of COE reflects movements in equity valuations that are not driven by movements in earnings forecasts and thus attributed to discount rates.

Sectoral inflation: We obtain monthly Producer Price Index (PPI) Industry Data from the Bureau of Labor Statistics (BLS). This dataset reports PPI data at the three-, four-, and five-digit NAICS industries codes level. For each sector, we keep the highest aggregation available (i.e., three digits NAICS when available, otherwise four- or five-digits). We merge the aggregated sectors with the annual dataset of firms' balance sheet statistics and keep only sector-year pairs with at least 5 firms with non-missing data. The raw PPI data is not well-populated before 2003; for these years, we obtain sectoral inflation from Rubbo (2023).

Financial distress: We proxy for corporate financial distress using Altman's Z-Score (Altman 1968; 2013), which is a standard measure of credit risk constructed using a linear combination of income and balance sheet variables from Compustat. For each sector-quarter we take the average of firm-level Altman Z-scores. Since the convention is that higher Z-Score means lower credit risk, we use (−Z-score) as regressor, so that a higher (−Z-score) corresponds to higher credit risk.

Monetary policy shocks: We use monetary policy shocks (MPS) from Bu, Rogers and Wu (2021) which they characterize as a unified measure taking account Fed funds rate changes, forward guidance, and large scale asset purchases after FOMC meetings, purged from the Fed information effect.

2.2 Ex ante: Monetary policy and corporate market timing

We start by examining how monetary policy shocks impact firms' cost of equity (COE), cost of debt (COD), and capital structure. Our main empirical specification uses data on firms' balance sheets, costs of capital, and market characteristics from Acharya et al. (2024). We measure monetary policy shocks (MPS) using the methodology in Bu et al. (2021). Figure 1 shows simple annual scatterplots of the spread between aggregate COE and COD against

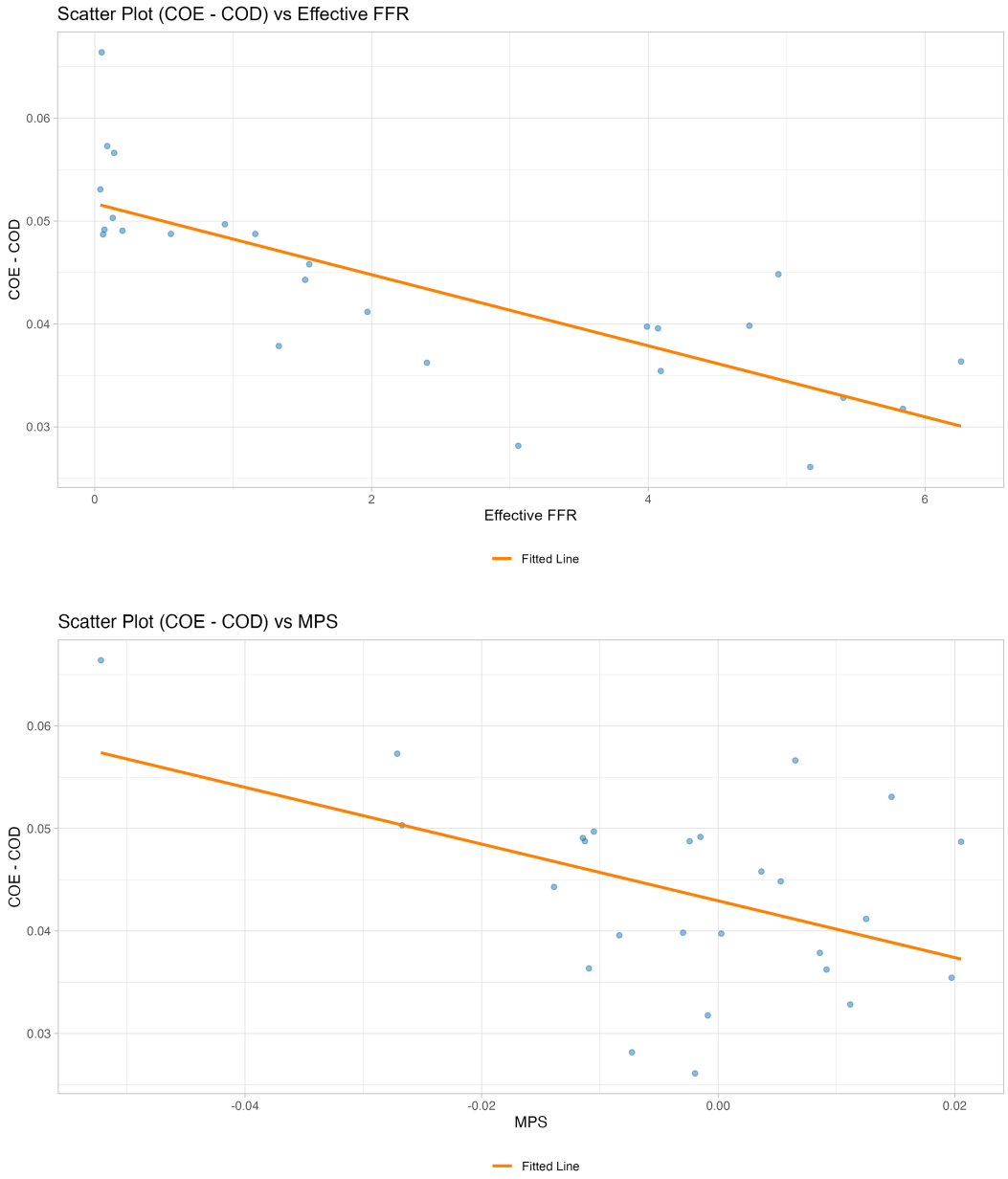


Figure 1: Spread between COE and COD as a function of Fed funds rate (top panel) and monetary policy shock from Bu et al. (2021) (bottom panel).

Table 1: Monetary Policy Shocks and Firm Capital Structure

	COE (1)	COD (2)	(COE - COD) (3)	$\Delta D/A$ (4)	D/E (5)	Inv/A (6)
Lag MPS > 0	0.249***	0.410***	-0.160***	-0.462***	-0.00447***	-0.248**
	(0.033)	(0.018)	(0.037)	(0.087)	(0.001)	(0.104)
Balance Sheet Controls	Yes	Yes	Yes	Yes	Yes	Yes
Company FEs	Yes	Yes	Yes	Yes	Yes	Yes
N	49,565	49,565	49,565	49,565	49,565	49,565
Adj. R^2	0.481	0.507	0.441	0.151	0.826	0.296

Standard errors, in parentheses, are clustered at the firm level. $^{*}p < 0.10$, $^{**}p < 0.05$, , $^{***}p < 0.01$. The table reports coefficient estimates of ordinary least square regressions at the firm-year level. The period considered is 1994-2019. All specifications include controls for balance sheet measures (market-to-book asset ratio, cash-to-asset ratio, leverage ratio, total assets, net working capital, dividends and cash flow volatility). The MPS variable is computed following Bu et al. (2021). See Acharya et al. (2024) for further details on COE, COD, COE-COD calculations. All the variables are winsorized at the 2% level.

the raw Fed funds rate and the MPS. In both cases, the spread declines with rates, consistent with our model assumption that the pass-through of interest rates to the different components of firms' capital structure is asymmetric and stronger for the COD than the COE.

Table 1 presents the results of the regressions

$$Y_t = \alpha + \beta \mathbf{1}_{\text{MPS}_{t-1}>0} + \Gamma' \cdot \text{controls}_{t-1} + \epsilon_t$$

where we now include standard controls for standard firm-level balance-sheet variables (e.g., market-to-book assets, cash holdings, net working capital, dividends, and cash flow volatility). A positive monetary policy shock (i.e., a surprise rate hike) raises both the COE and the COD, but the effect on COD is substantially larger, causing the difference (COE–COD) to decline (column 3). As a result, the relative attractiveness of debt financing diminishes. Consistent with this mechanism, we see that debt issuance and overall leverage (D/E) fall significantly following a contractionary shock (columns 4–5). These findings support the key premise of our model that monetary policy operates asymmetrically on debt versus equity financing costs, influencing firm leverage decisions and shaping future production capacity.

Table 2: One-quarter inflation response

	Inflation			
	(1)	(2)	(3)	(4)
MPS × Average(-Z)	4.012	4.023*	4.508*	4.508*
	(2.562)	(2.350)	(2.657)	(2.459)
Time FEs	No	Yes	No	Yes
Sector FEs	No	No	Yes	Yes
Sector Cluster	Yes	Yes	Yes	Yes
N	3,436	3,436	3,435	3,435
Adj. R^2	0.010	0.032	0.064	0.085

Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

2.3 Ex post: Financial distress and the transmission of monetary policy

Next, we explore the second main implication of our theory: high corporate leverage and financial distress can cause firms' productive capacity to contract in response to monetary tightening, which in turn weakens the disinflationary effects of monetary policy, effectively shifting the supply curve of the economy.

We merge monthly producer price index (PPI) inflation data from the BLS and Rubbo (2023) with quarterly sector-level measures of firms' Altman Z-scores (our proxy for financial distress). We compute sector-level average Z-scores and drop sector-quarter observations with less than five firms. We obtain an unbalanced sample dataset containing quarterly measures of sectoral PPI and Z-score, with an average of 40 sectors each quarter between 1994 and 2019. Most of the sectors are three-digits NAICS, only a few of them are four-digits and two are five-digits.

Table 2 illustrates how contractionary monetary policy shocks interact with financial distress. The regression equation is

$$\Delta \log P_{s,t} = \beta\, MPS_{t-1} \times (-Z)_{s,t-1} + \Gamma' \cdot \text{controls}_{s,t-1} + \epsilon_{s,t}.$$

The key independent variable is the interaction between the MPS and the negative of the sector's average Z-score, MPS × Average(−Z). A higher (-Z) score means more financial distress. Across specifications, this interaction has a positive and significant effect on sectoral inflation. In other words, in sectors where firms exhibit higher financial fragility,

Table 3: Average inflation response over different horizons

	Average inflation			
	(1) 1 quarter	(2) 2 quarters	(3) 3 quarters	(4) 4 quarters
MPS × Average(-Z)	4.508*	2.974*	1.838**	0.910**
	(2.459)	(1.739)	(0.838)	(0.424)
Time FEs	Yes	Yes	Yes	Yes
Sector FEs	Yes	Yes	Yes	Yes
N	3,435	3,413	3,392	3,370
Adj. R^2	0.0847	0.0908	0.0976	0.108

Robust standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

contractionary monetary policy translates into more inflation or weaker disinflation (note that we control for time fixed effects and thus for the average inflation response). These results align with the intuition in our theoretical model: when firms' supply capacity is encumbered by outstanding debt, tighter monetary policy exacerbates production bottlenecks, thereby limiting any downward pressure on prices and potentially pushing inflation higher.

Table 3 shows the impulse response over one year using the regression equation

$$\frac{1}{h+1}\sum_{j=0}^{h} \log P_{s,t+h} - \log P_{s,t-1} = \beta^h \, MPS_{t-1} \times (-Z)_{s,t-1} + \Gamma' \cdot \text{controls}_{s,t-1} + \epsilon^h_{s,t}.$$

The columns correspond to the estimates β^h for horizons $h = 0, \ldots, 3$ quarters. We use the average inflation to make the estimates comparable across horizons. The results show that the differential inflation response of more distressed firms, i.e., with high (−Z) score, is persistent but normalizes over time, peaking in the first quarter.

Taken together, the two empirical findings presented in Tables 1 and 2 are consistent with the two core mechanisms that motivate our theoretical analysis. First, monetary policy exerts a stronger influence on the cost of debt relative to the cost of equity, impacting firm leverage and future supply conditions. Second, in the presence of widespread financial distress caused by previous capital structure decisions, contractionary monetary policy may fail to control inflation as effectively. Financial dominance arises from this intertemporal feedback loop between corporate financial structure and monetary policy.

3 Model

This section introduces our model of production and capital structure decisions of firms in the presence of two financial frictions: limited pledgeability of cash flows, and differences in the expected returns on different claims in the capital structure that generate a market-timing motive.

These financial frictions lead to the following central tradeoff regarding capital structure. Each firm must fund an initial fixed investment outlay and a subsequent variable one that determines its production capacity. The former can be funded with debt and more expensive equity, while the latter can only be funded with debt. Firms thus face a tradeoff between minimizing the cost of initial investment with a high initial leverage and sparing borrowing capacity to maximize scale at $t + 1$.

Although our ultimate goal is to analyze the transmission of monetary policy, we start with a real model (i.e., flexible prices) in order to focus on the supply side of the economy, which is the novel part of our model, and defer the New Keynesian block to Section 5.

Preferences. The economy is populated by a representative household with preferences over streams of consumption and labor $\{C_t, N_t\}_{t\geq 0}$:

$$\sum_t \beta^t \left(\log C_t - \chi N_t\right), \tag{1}$$

where $\beta \in (0, 1)$ and $\chi > 0$.[4]

The final consumption good combines a continuum of varieties indexed by $i \in [0, 1]$ according to a constant elasticity of substitution (CES) aggregator

$$C_t = \left(\int_0^1 C_{i,t}^{1-1/\epsilon} di\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{2}$$

where $C_{i,t}$ is the consumption of variety i and $\epsilon > 1$ is the elasticity of substitution between varieties. The only purpose of introducing differentiated varieties is to model nominal rigidities later as in the standard New Keynesian model. Equivalently, we could assume that varieties correspond to intermediate goods that are combined into the final consumption good C_t by competitive firms.

[4]We assume a unit elasticity of intertemporal substitution to simplify expressions but it is straightforward to allow for more general CRRA preferences, cf. Appendix A.3.

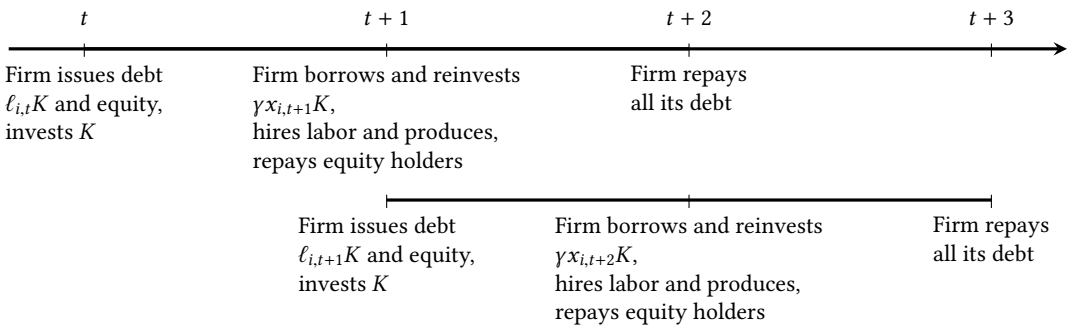


Figure 2: Timing of investment and production for firms born at t and $t+1$.

Production technology. There are overlapping generations of firms present for three periods, as depicted in Figure 2. Each variety $i \in [0,1]$ is produced at date $t+1$ by a firm set up at the previous date t as follows. Entry entails an initial real investment outlay $K > 0$ at date t. At date $t+1$, the firm must invest an additional amount $\gamma_{i,t+1}x_{i,t+1}K$ before generating any operating income, where $x_{i,t+1} \in [0,1]$ denotes the continuation scale. The reinvestment needs $\gamma_{i,t+1}$ are i.i.d. across firms, distributed according to the c.d.f. $\Gamma(\cdot)$ with compact support in $[0,+\infty)$. To simplify the exposition, in the main text we focus on the case of a degenerate distribution, with $\gamma_{i,t+1} = \gamma$ for all firms, i.e., a deterministic reinvestment need.

Our model of reinvestment is in the spirit of the liquidity shocks in Holmström and Tirole (1998), that could be interpreted as affecting the cost of inputs necessary to production (e.g., materials, energy, or inventories) or a decline in productivity (e.g., failing projects) that can be partly offset with new investments. A higher γ means that the firm needs more funds to produce the same amount at $t+1$, and if it is unable to raise a sufficient amount from investors it needs to reduce its production scale. For our purposes, it is sufficient to consider a parameter γ that is deterministic and common to all firms; we discuss below how our results extend to the more realistic case of a stochastic γ.

The reinvestment $\gamma_{i,t+1}x_{t+1}K$ is not produced by the same financially constrained firms but takes the form of a different good, e.g., an input produced by competitive "wholesalers" as in the working capital literature (Christiano, Eichenbaum and Evans, 2005). As a result, a lower continuation scale x_{t+1} induced by binding financial constraints will act as a pure supply shock, that is, a contraction in the productive capacity but not in the demand for each variety's output. In Section 6.1, we relax this assumption so that a share of the reinvestment $\gamma_{i,t+1}x_{t+1}K$ is produced by sticky-price firms. In that case, a lower x_{t+1} acts simultaneously as a negative supply shock and a negative demand shock.

After the reinvestment, the firm can convert $N_{i,t+1}$ units of labor into

$$Y_{i,t+1} = A x_{i,t+1}^{\nu} K^{\alpha} N_{i,t+1}^{1-\alpha}$$

units of its variety, where $A > 0$ is the total factor productivity and $\alpha, \nu \in [0, 1]$. When $x_{i,t+1} < 1$, the firm scales down relative to its full capacity.

Finally, at date $t + 2$, the firm generates a liquidating real cash flow worth K units of the final good and exits. One simple interpretation is that K is an initial capital investment (e.g., land or real estate as in Kiyotaki and Moore 1997) that does not depreciate and can be resold after production; alternatively, K can be viewed as a safe cash flow that is not subject to any informational friction and is thus fully pledgeable.

Financial frictions. Each firm is owned by a single household who is a residual claimant on its cash flows but with negligible resources relative to the needs of the firm. Therefore, firms need to raise raise external funds to fund their investment and reinvestment needs. They do so subject to the following financial frictions:

1. Firms can issue securities against the terminal value K at both dates (t and $t + 1$). Initial claims issued at t cannot be diluted at $t + 1$.

2. At the initial date t, firms can also issue securities backed by all cash flows, including date $t + 1$ operating profits. However, once at $t + 1$, they cannot issue claims backed by their current date-$t + 1$ profits.

For concreteness and mapping to our empirical evidence, we deem the first kind of securities "debt," with a required return R_t between t and $t + 1$. The simplest interpretation is short-term debt, that must be repaid at $t + 1$ by issuing new debt against K. But this hard debt also includes secured debt maturing at $t + 2$, so that the assets already pledged at t are encumbered; and unsecured debt maturing at $t + 2$ with high seniority or covenants against future dilution (Smith and Warner, 1979; Donaldson et al., 2022).

We refer to the second kind of securities as "outside equity" or simply "equity," with a required return R_t^E. This latter convention is consistent with the standard definition of equity because it will indeed be optimal for firms to pledge the entire date-$t + 2$ value K to debt investors, thus making the other investors residual claimants. The lumpy issuance concentrated at date t can be thought of as stemming from fixed costs of equity issuance as in Hennessy and Whited (2007) and Bolton, Chen and Wang (2011)—motivated by empirical

and theoretical work on the pecking order theory dating back to Myers and Majluf (1984)—or infrequent access to equity markets as in, e.g., Hugonnier, Malamud and Morellec (2014) and Hartman-Glaser, Mayer and Milbradt (2022).

We assume that debt is a less expensive source of external finance than equity:[5]

Assumption 1. *The required return on equity between t and $t+1$ exceeds the required return on debt by a spread $\kappa_t \geq 0$.*

In other words, firms can issue perfectly liquid debt at any time but cannot use their entire cash flows to back it. Encumbering assets early on can restrict future continuation. By contrast, their operating profits can back equity claims that can only be sold at the outset and command a higher return, which captures that equity is a less liquid form of external finance than debt. For instance, the date-$t+1$ operating cash flows could become more difficult to pledge if insiders receive private information over time. Note that the equity claims can also be viewed as cash flow-based debt; the key feature is that they are not backed by the collateral K. Cash flow-based debt and equity both rely on firms' ability to generate future cash flows, which contrasts with asset-based debt, which is more focused on the liquidation value of specific assets. In the baseline model, we assume that κ_t can be time-varying but does not depend directly on the interest rate R_t; later we discuss how the model can be extended to allow for some dependence $\kappa(R_t)$.

Remark 1 (Foundations for the spread κ_t). The spread κ_t has several interpretations. What matters is the total spread between debt and equity above and beyond the standard risk premium, which could stem from a combination of compensation for additional costs borne by equity investors on the one hand, and attractive properties that allow debt to pay a lower return on the other hand. First, it could be viewed as a transaction or illiquidity cost for equity. For instance, equity holders face their own liquidity shocks and sometimes need to sell their shares to consume early. In that case, κ_t could capture the expected transaction cost or search cost, which is then priced in the initial cost of equity capital. Second, κ_t could be a compensation for the cost of verifying the firm's date-$t+1$ income, or more generally, monitoring and information acquisition costs (see Appendix A.1 for such a microfoundation), whereas the terminal cash flow K is perfectly verifiable at no cost and not subject to agency costs.

[5]For instance due to interest-payment related tax-shields or agency and informational financial frictions as described below.

In addition, the spread could incorporate a convenience yield that lowers the required return on debt relative to equities as in Diamond (2020), Mota (2023) and Di Tella, Hébert, Kurlat and Wang (2023), who point out that the high equity premium puzzle may in part reflect a low safe debt rate puzzle instead. Finally, κ could simply reflect mispricing that potentially fluctuates over time as in the "market timing" literature that analyzes fluctuations in both "equity-market sentiment" (Baker and Wurgler 2002, Ma 2019) and "credit-market sentiment" (López-Salido, Stein and Zakrajsek 2017, Greenwood, Hanson and Jin 2023, Krishnamurthy and Li 2024).

Remark 2 (Microfoundations.). We adopt this general and parsimonious specification of the financial frictions for simplicity and to highlight that these are the only ingredients that we need. In the Appendix we offer several non-exclusive microfoundations for them. First, we model the impossibility to pledge operational cash flows at the outset of date $t+1$ as resulting from a lemons problem. Some firms privately observe that they are unable to produce at date $t+1$. Productive firms have no credible way to signal it to households at this point. When seeking to issue claims against their operational cash flows, they are mimicked by the unproductive ones, and so they must face a prohibitive adverse-selection discount that makes the issuance unprofitable in the first place. Second, we offer three microfoundations for the direct assumption that $R_t^E > R_t$. The first one also relies on these two types of firms. We posit that firms receive noisy private signals about their productivity at the outset. Sufficiently noisy signals pave the way to a pooling equilibrium whereby firms with good signals accept to pool with the others despite the resulting higher perceived cost of pledging operational cash flows. Notice that under this microfoundation, the aggregate expected return on these cash flows is R_t, only the firms with positive signals perceive $R_t^E > R_t$. A second microfoundation for $R_t^E > R_t$ simply assumes that paying out operational cash flows entails verification costs that are recouped with a fee on the claims that they back. The third microfoundation posits that the gap between R_t^E and R_t is not due to the fact that operational cash flows are "expensive", but rather that the terminal cash flow is "cheap" because the claims that it backs enter households' utility, thereby earning a convenience yield in equilibrium.

4 Production and capital structure under flexible prices

We start by solving for the equilibrium of the model under flexible prices. In Section 5, we will introduce nominal rigidities that allow monetary policy to control the real interest rate

and aggregate demand.

Given the initial outstanding debt $F_{-1} = R_{-1}\ell_{-1}$ (measured as a fraction of K), a flexible-price equilibrium corresponds to sequences of allocations and prices

$$\left\{C_t, Y_t, x_t, \ell_t, N_t, W_t, P_t, R_t, R_t^E\right\}_{t\geq 0}$$

such that households choose $\{C_t, N_t\}$ to maximize (1) subject to their budget constraints, each firm i born at t chooses $(\ell_{i,t}, x_{i,t+1}, P_{i,t+1}, N_{i,t+1})$ to maximize profits under monopolistic competition subject to their financial constraints, and all markets clear. We assume that the transaction cost on equity are transfers to another agent and thus they do not affect aggregate output.

Households. The household side is standard. We assume complete risk sharing between the households who own a firm and those who don't, so that all households share the same consumption level C_t. Given a gross interest rate R_t between t and $t+1$, households' Euler equation for the liquid asset (debt) is given by

$$\beta R_t C_t = C_{t+1}. \tag{3}$$

Optimal labor supply yields

$$\frac{W_t}{P_t} = \chi C_t \tag{4}$$

where W_t is the nominal wage and P_t is the aggregate price level.

Given prices $\left\{P_{j,t}\right\}_{j\in[0,1]}$, the CES aggregator (2) implies a standard isoelastic demand for each variety i:

$$C_{i,t} = C_t \left(\frac{P_{i,t}}{P_t}\right)^{-\epsilon}$$

where P_t is the price index satisfying $P_t = \left(\int_0^1 P_{j,t}^{1-\epsilon} dj\right)^{\frac{1}{1-\epsilon}}$.

The interesting and novel features of our model are all about the supply side of the economy. We analyze firms' problem in three steps, by backward induction. We first derive firms' pricing policies conditional on a continuation scale $x_{i,t+1}$, before turning to their optimal constrained scale, and finally characterizing their optimal ex-ante capital structure.

Firms' optimal pricing. Given a continuation scale $x_{i,t+1}$ and aggregate variables (P_{t+1}, W_{t+1}, Y_{t+1}), a generation-t firm i sets its price $P_{i,t+1}$ at $t+1$ to maximize its real profits $\Pi_{i,t+1}$:

$$\Pi_{i,t+1} = \frac{P_{i,t+1}Y_{i,t+1} - W_{t+1}N_{i,t+1}}{P_{t+1}},$$

where in our notation $\Pi_{i,t+1}$ does not include the reinvestment cost $\gamma x_{i,t+1}K$, which is sunk at the time the firm sets its price. Thus at the end of period $t+1$ the resources left in the firm (i.e., real profits net of any reinvestment costs) are equal to $\Pi_{i,t+1} - \gamma x_{i,t+1}K$.

The optimal flexible price follows from standard monopolistic competition with decreasing returns to scale:

Lemma 1 (Optimal flexible price)**.** *The optimal flexible price $P^*_{i,t+1}$ of a firm with continuation scale $x_{i,t+1}$ is*

$$P^*_{i,t+1} = P_{t+1}\left(\frac{\epsilon}{\epsilon-1}\right)^{\phi(1-\alpha)}\left(\frac{\chi}{(1-\alpha)K^{\frac{\alpha}{1-\alpha}}}\right)^{\phi(1-\alpha)}\left(\frac{Y_{t+1}}{x^{\nu}_{i,t+1}A}\right)^{\phi}, \tag{5}$$

where we define $\phi = 1/(1+(\epsilon-1)\alpha) \in [0,1]$.

The only part in equation (5) that is specific to our model is that a lower continuation scale $x_{i,t+1}$ acts as an increase in marginal cost. Indeed, ex post it is equivalent to a lower total factor productivity A.

Remark 3 (Costs vs. markups). Chevalier and Scharfstein (1996) and Gilchrist, Schoenle, Sim and Zakrajsek (2017) study pricing by financially constrained firms, focusing on the tension between withstanding financial shocks and preserving the customer base (which is persistent due to, e.g., customer switching costs). In this context, constrained firms may increase markups to generate short-term liquidity, at the expense of reducing their customer base. Theoretically, our setup is quite different as prices increase only due to higher costs, while markups remain unchanged. In practice, however, under imperfect measurement of marginal costs, higher prices are likely to be interpreted as a combination of higher marginal costs and higher markups.

Aggregate output. When prices are flexible, as we currently assume, the left-hand side of (5) always equals P_{t+1}, as the price level aggregates the optimal price of each firm and firms are symmetric. Moreover all firms choose the same continuation scale $x_{i,t+1} = x_{t+1}$.

We denote the equilibrium output under flexible prices, or *natural output*, Y^n_{t+1}. It satisfies

$$Y^n_{t+1} = x^v_{t+1}\bar{Y},$$

where *potential output* $\bar{Y}$

$$\bar{Y} = AK^\alpha \left(\frac{\epsilon - 1}{\epsilon}\right)^{1-\alpha} \left(\frac{1-\alpha}{\chi}\right)^{1-\alpha} \tag{6}$$

is defined as the frictionless output that prevails when the financial constraint at $t+1$ is not binding and thus all firms can continue at full scale $x_{t+1} = 1$. When the date-$t+1$ financial constraint is binding, equilibrium output Y^n_{t+1} can fall strictly below $\bar{Y}$.

4.1 Indebted supply: financially-constrained productive capacity

We now derive the economy's productive capacity, or aggregate supply, as a function of outstanding leverage. Throughout the paper, we maintain the assumption that parameters are such that firms always seek to maximize their continuation scale $x_{i,t+1}$ at date $t+1$ subject to their financial constraints, that is:

Assumption 2. *Profits net of the reinvestment cost,* $\Pi^*_{i,t+1} - \gamma x_{i,t+1}K$*, are increasing in* $x_{i,t+1}$.

A sufficient condition for Assumption 2 to hold around an unconstrained steady state (i.e., with $x = 1$) is

$$Av\left(\frac{\epsilon - 1}{\epsilon}\right)^{2-\alpha} \left(\frac{1-\alpha}{\chi K}\right)^{1-\alpha} > \gamma.$$

Let $\ell_{i,t}$ denote the ex-ante leverage, i.e., the share of the initial investment K that is financed by asset-based long-term debt. Recall that at $t+1$, the reinvestment can only be financed by borrowing against the date-$t+2$ cash flow K. It cannot be financed by issuing new equity against the date-$t+1$ cash flow $\Pi(x)$. The firm must repay $R_t R_{t+1}\ell_{i,t}$ at $t+2$, hence at date $t+1$ it can continue at full scale $x_{i,t+1} = 1$ if and only if its remaining pledgeable income $\frac{1}{R_{t+1}}\left[K - R_t R_{t+1}\ell_{i,t}K\right]$ can cover the maximal reinvestment need γK. Otherwise, the firm is financially constrained, and the maximal (and optimal) continuation scale satisfies

$$x_{i,t+1}\gamma K = \frac{1}{R_{t+1}}\left[K - R_t R_{t+1}\ell_{i,t}K\right].$$

This implies that the optimal continuation scale $x_{i,t+1}$ (whether the firm can adjust its price

or not) can be written as

$$x_{i,t+1} = \min\left\{1; \frac{1}{\gamma}\left[\frac{1}{R_{t+1}} - R_t \ell_{i,t}\right]\right\}, \tag{7}$$

which decreases with the new interest rate R_{t+1} and with outstanding debt $R_t \ell_t$.

The pledgeability constraint

$$\gamma x_{i,t+1} + R_t \ell_{i,t} \leq \frac{1}{R_{t+1}}$$

implies that the higher the initial leverage $\ell_{i,t}$, the lower the maximal continuation scale $x_{i,t+1}$ because a larger share of pledgeable assets K is already encumbered. A higher interest rate R_{t+1} decreases the value of the pledgeable income K/R_{t+1}, and therefore the constrained continuation scale. A high interest rate can thus create a negative supply shock by forcing firms to scale down if they are already highly levered. Existing debt depletes the pledgeable income left to finance new operating expenses.

Proposition 1 (Interest rates and aggregate supply)**.** *Given date-t leverage choice ℓ_t and interest rate R_t, the equilibrium output at $t+1$ is*

$$Y^n_{t+1} = x^{\nu}_{t+1} \bar{Y},$$

where $\bar{Y}$ is given by (6) and the optimal continuation scale x_{t+1} is

$$x_{t+1} = \min\left\{1; \frac{1}{\gamma}\left[\frac{1}{R_{t+1}} - R_t \ell_t\right]\right\}.$$

Therefore:

- *for low interest rates $R_{t+1} \leq \frac{1}{\gamma + R_t \ell_t}$, firms are unconstrained at $t+1$ and $x_{t+1} = 1$.*
- *for high interest rates $R_{t+1} > \frac{1}{\gamma + R_t \ell_t}$, firms are constrained and x_{t+1} is strictly below 1 and decreasing in R_{t+1}.*

We find it useful to describe the quantities x_{t+1} and Y_{t+1} as a function of the real interest rate R_{t+1} although, under flexible prices, R_{t+1} is an endogenous outcome and all variables are jointly determined.[6] The reason is that we will use the expressions as building blocks

[6] In Section A.2 we solve for the full equilibrium path (including real interest rates) under flexible prices and study the propagation of shocks.

in the New Keynesian version of the model in Section 5, in which R_{t+1} can be taken as an exogenous policy choice.

Discussion. The direct interpretation is that a higher interest rate R_{t+1} tightens firms' financial constraints through the collateral value K/R_{t+1}, consistent with standard models of the financial effects of monetary policy (Farhi and Tirole, 2012) and empirical evidence (Cloyne, Ferreira, Froemel and Surico, 2023). Alternatively, the higher rate R_{t+1} could be viewed as leading to higher payments on floating rate debt, which affect real activity by tightening firms' financial constraints. The only difference is in the timing: our simple formulation lets us concentrate the impact of R_{t+1} on the contemporaneous production scale x_{t+1}, whereas higher debt repayments at date-$t+2$ may have a delayed impact (for instance in a model that also allows for production at $t+2$).

4.2 Optimal capital structure: market timing vs. financial distress

Optimal capital structure. We solve for the optimal capital structure in two standard steps. We first derive an optimal abstract contract, and then we implement it with standard securities.

Optimal contract. The optimal contract for a date-t firm consists in a continuation scale $x(\gamma)$ and transfers from households backed by K that we denote $F_t,\ F_{t+1}(\gamma),\ F_{t+2}(\gamma)$ that solve:

$$\max_{x(.),F_t,F_{t+1}(.),F_{t+2}(.)} \int \left(\Pi(x(\gamma)) - \gamma x(\gamma)K + F_{t+1}(\gamma) + \frac{F_{t+2}(\gamma)}{R_{t+1}}\right) d\Gamma(\gamma)$$
$$+ \frac{K}{R_{t+1}} + R_t^E(K - F_t) \tag{8}$$
$$s.t.\ R_t F_t + \int \left(F_{t+1} + \frac{F_{t+2}}{R_{t+1}}\right) d\Gamma \leq 0, \tag{9}$$
$$For\ all\ \gamma,\ F_{t+2}(\gamma) + K \geq 0, \tag{10}$$
$$For\ all\ \gamma,\ F_{t+1}(\gamma) - \gamma x(\gamma)K \geq 0. \tag{11}$$

Notice that we focus for brevity on situations in which the optimal contract requires pledging operational cash flows ($F_t < K$). The first constraint is households' participation constraint. The last two are the firm's liquidity constraints at $t+1$ and $t+2$. It is easy to see that all constraints optimally bind. Using them to eliminate $F_t,\ F_{t+1},\ F_{t+2}$ from the objective, the

optimal continuation scale solves for each γ

$$\max_x \Pi(x) - \gamma \frac{R_t^E}{R_t} xK, \tag{12}$$

andisthusoftheform

$$x(\gamma) = \min\{1, X\gamma^{-\frac{1-\alpha}{1+\nu-\alpha}}\}. \tag{13}$$

for some constant $X > 0$.

Remark: The difference with deterministic γ is that there is probability no closed form for X as the fixed-point between $x(\gamma)$ and output is less easy to solve for.

Implementation with equity and short-term risky debt. We will focus on a simple implementation whereby firms issue equity and risky short-term debt—due at the outset of date $t+1$ before production takes place—with face value K/R_{t+1} at date t, and safe short-term debt with face value K at date $t+1$. Unless they receive no interim shock, firms partially default on the initial short-term debt. Given a shock realization γ, a firm defaults on its early debt with a haircut equal to $\gamma x(\gamma)K = \min\{\gamma K, X\gamma^{\frac{\nu}{1+\nu-\alpha}}K\}$. It borrows K/R_{t+1} and uses the proceeds for reinvestment $\gamma x(\gamma)K$ and partial debt repayment.

The firm must fund its initial investment K by selling securities. Let $\ell_{i,t} \in [0,1]$ be the leverage ratio chosen by firm i at date-t, so that the firm raises $\ell_{i,t}K$ in debt and $(1-\ell_{i,t})K$ in equity. The cost of debt is R_t and the cost of equity is $R_t^E = R_t + \kappa_t$.

The optimal leverage ratio solves

$$\max_{\ell_{i,t}\in[0,1]} \Pi_{i,t+1}\left(x_{i,t+1}(\ell_{i,t})\right) - R_t^E(1-\ell_{i,t})K + \frac{K - R_{t+1}\left[\gamma x_{i,t+1}(\ell_{i,t})K + R_t\ell_{i,t}K\right]}{R_{t+1}}, \tag{14}$$

where the continuation scale $x_{i,t+1}$ is a weakly decreasing function of outstanding leverage $\ell_{i,t}$ given by (7), and we write real profits given optimal pricing as an increasing function of the continuation scale $\Pi^*_{i,t+1}(x_{i,t+1})$, omitting the dependence in aggregate variables to ease notation.

To understand better the firm's problem, we can rewrite the firm's objective function,

up to constant terms not affecting the optimization problem, as:

$$\underbrace{\left[\Pi_{i,t+1}(x_{i,t+1}(F_{i,t})) - \gamma x_{i,t+1}(F_{i,t})K\right]}_{\text{net profits from production}} + \underbrace{\left[\frac{R_t^E}{R_t} - 1\right] F_{i,t}K}_{\text{profits from cheaper debt financing}} \tag{15}$$

where $F_{i,t} = R_t \ell_{i,t}$ is the date-$t+1$ face value, and we use the fact that $x_{i,t+1}$ only depends on $\ell_{i,t}$ through the face value $F_{i,t}$. Equation (15) highlights that firms balance two objectives. The first bracket corresponds to choosing a leverage that maximizes the continuation scale, and this term is maximized at $x_{t+1} = 1$. The second term shows the financial gains from leverage, coming from the fact that debt allows the firm to finance its long-term investment K at a cheaper rate.

Importantly, the relevant variable for firms' ex-ante capital structure is the spread between R_t and R_t^E, and not the interest rate R_t per se. Thus our model does not predict that low interest rates necessarily lead firms to borrow more because the cost of debt is lower; if the cost of equity falls by the same amount then firms' capital structure is unaffected.

Our model captures in a simple form insights from the "market timing" theory of capital structure. Baker and Wurgler (2002) show that firms repurchase their shares when equity valuations are low and issue more when equity valuations are high. Ma (2019) extends this logic to pricing fluctuations in both stock and bond prices, showing that firms act as cross-market arbitrageurs in their own securities. In our model, these findings can be interpreted as fluctuations in the wedge κ_t: a higher κ_t (that makes debt more attractive) could correspond to either low equity valuations or high debt valuations. Recent work by Mota (2023) and Di Tella, Hébert, Kurlat and Wang (2023) argues that just like Treasury bonds, corporate bonds bear a "convenience yield" which could again be interpreted as one component of the spread κ_t, i.e., an increase in κ_t corresponds to a higher convenience yield on debt leading firms to issue more debt.

Remark 4 (Corporate liquidity hoarding). In our framework, it is without loss of generality to assume that the firm invests the entirety of the equity raised at t in its long-term investment K, and in particular does not hoard liquidity from t to $t+1$. Indeed, suppose that the firm raises $L_{i,t}K$ in debt and $(1 - L_{i,t})K + w_{i,t}K$ in equity, and invests the additional amount $w_{i,t}K$ in other firms' liquid debt in order to cover part of its future reinvestment need. The key point is that the firm earns a low return R_t on these liquid savings between t and $t+1$. If the firm issues new debt $d_{i,t+1}K = \gamma x_{i,t+1}K - R_t w_{i,t}K$ and continues at scale $x_{i,t+1}$, its total

debt repayment at $t+2$ equals

$$R_t R_{t+1} L_{i,t} K + R_{t+1} d_{i,t+1} K = R_{t+1} \left[\gamma x_{i,t+1} + R_t \ell_{i,t} \right] K$$

where $\ell_{i,t} = L_{i,t} - w_{i,t}$ is the net leverage per unit of K. As a result, the problem is equivalent to simply choosing $\ell_{i,t}$ as in (14). Intuitively, as in Holmström and Tirole (1998), liquidity hoarding is costly and there is no advantage in issuing more equity ex ante to save more. If the liquidity premium (here κ) is too high, firms will voluntarily under-insure against the date-$t+1$ liquidity need, implying $x_{t+1} < 1$.[7] In practice, there may be considerations outside of our model–such as uncertain cash flows, investment needs and financing costs—that generate market-timing incentives to hoard cash buffers for future investments (see, e.g., Acharya, Byoun and Xu 2024). We discuss next the role of such uncertainty and induced liquidity risk.

Remark 5 (Liquidity risk). Our framework can be extended to allow for risk, including in the cash flows and the reinvestment need. The literature on corporate risk management (Froot, Scharfstein and Stein 1993, Holmström and Tirole 1998) emphasizes that the interaction of future shocks and financial constraints creates an ex-ante demand for insurance even though firms are risk-neutral. In our context, suppose that each firm's liquidity shock γ_{it+1} is drawn from a distribution $G(\cdot)$ so that the firm's ex-ante objective is

$$\int \left\{ \Pi^*_{i,t+1} \left(x_{i,t+1}(F_{i,t}, \gamma_{it+1}) \right) - \gamma_{i,t+1} x_{i,t+1}(F_{i,t}, \gamma_{it+1}) K \right\} dG(\gamma_{i,t+1}) + \left[\frac{R^E_t}{R_t} - 1 \right] F_{i,t} K,$$

where $x_{i,t+1} = \min \left\{ 1; \frac{1}{\gamma_{i,t+1}} \left[\frac{1}{R_{t+1}} - F_{i,t} \right] \right\}$ depends on both the face value $F_{i,t}$ and the realized shock $\gamma_{i,t+1}$. Relative to our baseline model without uncertainty, this expression still highlights the trade-off between continuation scale and the lower cost of debt. The only difference is that firms have an additional precautionary savings motive to preserve debt capacity which leads them to choose a lower $F_{i,t}$ than without uncertainty, and that in general we cannot obtain a closed-form for the optimal solution $F_{i,t}$. However, even without explicit solution, the qualitative properties of the solution are exactly the same as in Proposition 2. The objective function is supermodular in $F_{i,t}$ and R^E_t/R_t, in the sense that the cross partial derivative with respect to these two variables is positive. Therefore, the solution $F_{i,t}$ is a weakly increasing function of the spread R^E_t/R_t (Milgrom and Shannon, 1994). Firms

[7] Rampini and Viswanathan (2010) model optimal hedging under ex-ante financial constraints, and Eisfeldt and Muir (2016) show that firms are more likely to raise external finance and accumulate liquidity when κ_t is low.

choose $x_{i,t+1} = 1$ in all states if R_t^E/R_t is low enough, and if R_t^E/R_t is high enough they choose to under-insure and allow $x_{i,t+1} < 1$ in some states (high $\gamma_{i,t+1}$). The same point applies in the presence of risk affecting the profits $\Pi_{i,t+1}$, for instance aggregate risk affecting Y_{t+1} or idiosyncratic risk to firms' demand or productivity.

Solution. We focus on a perfect foresight path starting at date t. Suppose that

$$\gamma \leq \frac{1}{R_{t+1}} < \gamma + R_t. \tag{16}$$

The first inequality implies that when the firm is fully equity-funded ($\ell_{i,t} = 0$), it always has enough debt capacity at $t+1$ to continue at full scale $x_{i,t+1} = 1$; the second inequality implies that at the maximal leverage $\ell_{i,t} = 1$, the firm is constrained and must downscale to $x_{i,t+1} < 1$. Then there exists a maximal leverage

$$\bar{\ell}_t = \frac{1}{R_t}\left[\frac{1}{R_{t+1}} - \gamma\right] > 0 \tag{17}$$

below which full continuation at $t+1$ is possible, i.e., $x_{i,t+1} = 1$ for $\ell_{i,t} \leq \bar{\ell}_t$. The maximal leverage that allows full continuation is decreasing in R_t because a lower R_t implies a lower repayment and thus more debt capacity going forward, and in R_{t+1} as a lower new interest rate boosts the collateral value of the date-$t+2$ pledgeable income K.

The following result derives the firm's optimal ex-ante capital structure, and shows that firms are willing to accept a continuation scale $x_{i,t+1} < 1$ in the next period if at the investment date t, the cost of debt is sufficiently low relative to the cost of equity:

Proposition 2 (Optimal capital structure)**.** *The date-t optimal ex-ante choice of leverage ℓ_t implies a date-$t+1$ continuation scale*

$$x_{t+1}^* = \min\left\{1, \bar{x}\left(\frac{1}{1+\kappa_t/R_t}\right)^{\frac{1}{1-\nu}}\right\}$$

where $\bar{x} = \frac{\nu}{\gamma}\left(\frac{\epsilon-1}{\epsilon}\right)^{2-\alpha}\left(\frac{1-\alpha}{\chi}\right)^{1-\alpha}\frac{A}{K^{\frac{1}{1-\alpha}}} > 1.$

- *If the interest rate is high enough, $R_t \geq \frac{\kappa_t}{\bar{x}^{1-\nu}-1}$ (in particular if $\kappa_t = 0$), then the firm sets $\ell_t = \bar{\ell}_t$ defined in (17), or equivalently chooses to continue at full scale in the next period, $x_{t+1}^* = 1$.*

- *If the interest rate is low enough,* $R_t < \frac{\kappa_t}{\bar{x}^{1-\nu}-1}$*, then the firm chooses a high leverage*

$$\ell_t = \frac{1}{R_t}\left[\frac{1}{R_{t+1}} - \frac{\gamma\bar{x}}{(1+\kappa_t/R_t)^{\frac{1}{1-\nu}}}\right] > \bar{\ell}_t$$

which implies financial distress and partial continuation in the next period, $x^*_{t+1} < 1$*. In that region, a lower rate* R_t *leads to a higher leverage* ℓ_t *and a lower continuation scale* x^*_{t+1}*.*

This is a key insight: in our model, it is not low interest rates per se that cause a leverage boom, but a high spread between the cost of illiquid equity and the cost of liquid debt. Intuitively, if $\kappa_t = 0$ then a lower interest rate makes both debt and equity cheaper and there is no implication for firms' capital structure. In the simplest case with a fixed positive spread $\kappa > 0$, low rates compress the cost of debt by more than the cost of equity, consistent with our motivating evidence in Section 2. In that case, monetary easing at date t "sows the seeds" of a date-$t+1$ vulnerability to shocks through a change in the composition of corporate liabilities.

Our results relate to López-Salido, Stein and Zakrajsek (2017), who show that elevated credit-market sentiment, which could be viewed as an increase in the debt-equity spread κ, predicts a decline in future economic activity. Building on these empirical findings, Greenwood, Hanson and Jin (2023) and Krishnamurthy and Li (2024) incorporate credit-market sentiment in a macro-finance model and study boom-bust cycles, focusing on the dynamics of beliefs about credit risk. As pointed out earlier, the spread κ can reflect the type of credit-market sentiment (or equity-market sentiment) driving these findings. Our simpler structure can be embedded in a New Keynesian model to discuss the role to monetary policy in affecting both ex-ante corporate capital structures and the ex-post costs of leverage.

Remark 6 (Variable spread). In our baseline model, the spread between debt and equity κ is fixed, but (A.8) does not depend on this assumption and holds for any κ. Thus the comparative statics with respect to R_t in Proposition 2 can be generalized to allow the spread κ to depend on R_t. As long as the ratio $\kappa(R_t)/R_t$ decreases with R_t then we have the same effects: lower rates decrease the cost of debt relative to the cost of equity and lead firms to choose a higher leverage ℓ_t at the cost of a lower future continuation scale x^*_{t+1}. Note that when $\kappa(R_t)/R_t$ is constant we have a permanent relative wedge that can lead firms to choose an interior ℓ_t (i.e. $x^*_{t+1} < 1$) but it is unaffected by monetary policy.

The empirical literature has emphasized the effect of monetary policy on various spreads,

e.g., the equity risk premium (Bernanke and Kuttner, 2005) and the term premium (Hanson and Stein, 2015). In both cases, monetary easing is amplified through a compression in risk premium, making the premium an increasing function of R_t. However, the spread κ should be viewed as *relative* premium, hence even if all risk premia fall, it still matters whether monetary policy has heterogeneous effects across different securities. This is the same point as saying that a fall in rates, on its own, does not lead to a leverage boom.

4.3 Steady state

Outstanding corporate debt is the only state variable F_{t-1} of the model. In Appendix (A.2) we study the full dynamical system. The propagation of shocks under flexible prices turns out to be extremely simple when the role of financial frictions is not too large, more precisely when $\nu < 1/2$ (with $\nu = 0$ corresponding to a standard model without financial frictions).

Here we only describe the steady state of this economy, before turning to our analysis of monetary policy. We look for conditions ensuring that the steady state is unconstrained (i.e., with $x = 1$). In that case we must have

$$R = 1/\beta$$
$$\ell = \bar{\ell} = \beta(\beta - \gamma)$$

hence $F = R\ell = \beta - \gamma$. We can verify that the steady state is indeed unconstrained as long as

$$\bar{x}\left(\frac{1}{1+\beta\kappa}\right)^{\frac{1}{1-\nu}} \geq 1$$

which holds if κ is low enough since we already have $\bar{x} > 1$ by Assumption 2. We assume that condition (16) holds around the steady state, that is:

$$\gamma \leq \beta < \gamma + 1/\beta.$$

The steady state is particularly simple in part because we abstract from idiosyncratic risk. Since firms face deterministic liquidity needs, they can choose leverage to minimize their cost of capital while perfectly avoiding suboptimal continuation scale. A generalized model with risky liquidity needs would make it impossible to avoid $x < 1$ with certainty and generate a precautionary motive to decrease ℓ relative to the deterministic case, which

would then imply an interior steady state.

5 Monetary policy

We can now turn to our main macroeconomic analysis, in which the real interest rate can be affected by monetary policy. Introducing nominal rigidities turns our model into a New Keynesian model with financial frictions, which we use to study how the central bank's trade-off between inflation and output is affected by corporate capital structure.

We find that capital structure matters in two ways. First, the central bank may be constrained by past increases in leverage, which is itself a function of past interest rates. This implies that monetary policy has history-dependent effects. Second, the response of capital structure to interest rates dampens the output effects of monetary easing.

Nominal rigidities. We depart from flexible prices by assuming that prices are set one period in advance, and can only be revised for a fraction of the firms.

When firms are first set up at date t, they quote a price $\bar{P}_{i,t}$ for their date-$t+1$ output at date t. At date $t+1$, after choosing the continuation scale $x_{i,t+1}$, they get to set a new price with probability $\lambda \in [0,1)$ where $\lambda < 1$. Firms always accommodate the demand they receive.

Under perfect foresight, the price set in advance by firms born at date t equals the ex-post optimal flexible price, $\bar{P}_{i,t} = P^*_{i,t+1}$, hence $\mathbf{E}_t \Pi_{i,t+1} = \Pi^*_{i,t+1}$. As a result, in this formulation nominal rigidities will only be relevant at $t = 0$ when unanticipated shocks (to fundamentals or to monetary policy) occur.

Monetary policy. The central bank sets a nominal interest rate i_0 at $t = 0$. Given the nominal rigidities, for any real rate R_0 there is a nominal interest rate i_0 such that the equilibrium real rate is equal to R_0. Thus it is without loss of generality to assume that the central bank controls the real rate R_0 directly.

Equilibrium. Given the initial outstanding debt $F_{-1} = R_{-1}\ell_{-1}$, a sticky prices equilibrium corresponds to sequences of allocations and prices

$$\left\{C_t, Y_t, x_t, \ell_t, N_t, W_t, P_t, R_t, R^E_t\right\}_{t\geq 0}$$

such that households choose $\{C_t, N_t\}$ to maximize (1) subject to their budget constraints, each firm i born at t chooses $(\ell_{i,t}, x_{i,t+1}, \bar{P}_{i,t}, N_{i,t+1})$ to maximize expected profits under monopolistic competition subject to their financial constraints and is able to reset its price at $t+1$ with probability λ, and all markets clear.

The only difference with the flexible prices equilibrium is that R_0 is an exogenous policy variable, while date-0 output Y_0 is demand-determined. Firms with sticky prices accommodate the demand they receive, hence the equilibrium output Y_0 can depart from $x_0^{\nu}\bar{Y}_0$, which would be the equilibrium under flexible prices.

5.1 Financial frictions and the kinked Phillips curve

We start by solving for the dynamics of the price level. The optimal flexible price P_t^* is still given by equation (5), but now only a fraction $\lambda < 1$ of firms is able to set this optimal price. Therefore the aggregate price level follows

$$P_t^{1-\epsilon} = \lambda (P_t^*)^{1-\epsilon} + (1-\lambda)\bar{P}_{t-1}^{1-\epsilon} \tag{18}$$

where $\bar{P}_{t-1}$ is the price set by firms at date $t-1$. By replacing P_t^* using (5) we can relate the aggregate price level P_t to output Y_t and the continuation scale x_t

$$\frac{P_t}{\bar{P}_{t-1}} = \left(\frac{1 - \lambda x_t^{\nu\phi(\epsilon-1)} \left(\frac{\bar{Y}}{Y_t}\right)^{\phi(\epsilon-1)}}{1-\lambda} \right)^{\frac{1}{\epsilon-1}}. \tag{19}$$

Equation (19) can be interpreted as a Phillips curve (not linearized) that maps measures of economic activity to inflation. In the absence of binding financial frictions, we have $x_t = 1$ in (19), corresponding to the usual Phillips curve that gives inflation as an increasing function of the output gap $\bar{Y}/Y_t$, i.e., the ratio between potential output and actual output. With binding financial frictions that lead to $x_t < 1$, the measure of economic activity relevant for inflation depends on both the standard output gap $\bar{Y}/Y_t$ due to excess demand, and on a "supply gap" captured by the term $x_t^{\nu\phi(\epsilon-1)}$. A lower continuation scale x_t increases firms' marginal costs and thus the prices charged by resetting firms.

Without further shocks at $t = 1, 2, \ldots$, firms always set in advance their ex-post optimal flexible price hence the equilibrium is the same as under flexible prices at all dates $t \geq 1$. In other words, nominal rigidities and the Phillips curve are only relevant at $t = 0$.

Proposition 1 implies that x_0 is a kinked function of the interest rate R_0: for sufficient

low R_0, firms have sufficient debt capacity to finance a full continuation $x_0 = 1$, but if R_0 is high enough, the binding financial constraint implies that x_0 is below 1 and decreasing in R_0. Therefore the supply gap term $x_0^{\nu\phi(\epsilon-1)}$ introduces a "kink" in the Phillips curve, in the sense that there is a discontinuity in the slope of the relationship between output and inflation (conditional on movements in the interest rate; more on this below). We summarize this discussion in the following proposition:

Proposition 3 (Kinked Phillips curve)**.** *At $t = 0$, the price level P_0 satisfies*

$$\frac{P_0}{P_{-1}} = \left(\frac{1 - \lambda x_0^{\nu\phi(\epsilon-1)} \left(\frac{\bar{Y}}{Y_0} \right)^{\phi(\epsilon-1)}}{1 - \lambda} \right)^{\frac{1}{\epsilon-1}} \tag{20}$$

where $x_0 = \min \left\{ 1; \frac{1}{\gamma_0} \left[\frac{1}{R_0} - F_{-1} \right] \right\}$. In periods $t = 1, 2, \ldots$ all equilibrium allocations are the same under flexible prices.

Figure 3 illustrates how inflation depends on the interest rate R_0 by plotting aggregate demand, denoted Y_0^d, and aggregate supply, denoted Y_0^s and given by $x_0^\nu \bar{Y}$. Equilibrium output Y_0 is equal to aggregate demand Y_0^d and does not necessarily correspond to the intersection between the two curves. Inflation increases with the gap between Y_0^d and Y_0^s as in (20), and there is no inflation if and only if the two curves intersect. If $Y_0^d > Y_0^s$ there is inflation and if $Y_0^d < Y_0^s$ there is deflation.

The dotted lines correspond to the frictionless New Keynesian model (or equivalently $\nu = 0$). Figure 4 shows the resulting Phillips curve mapping output Y_0 to inflation P_0, when movements in Y_0 are due to interest rates R_0, again contrasting the solid lined implied by our model with the dotted line in the frictionless New Keynesian model. Note that the kink in the Phillips curve, which depends crucially on the outstanding debt F_{-1}, arises because for low output $Y_0 < \bar{Y}$ (i.e., at high policy rates R_0) the Phillips curve is *flatter* than without financial frictions, and not because the Phillips curve becomes steeper at high output. In fact, the figure shows that the Phillips curve is also flatter than in a frictionless model when R_0 falls below some threshold $\underline{R}$ (defined below). As we explain in the next section, this is due to the effect of monetary easing on future potential output as firms lever up to take advantage of lower borrowing costs.

A large literature (with recent examples motivated by the post-pandemic inflation surge, e.g., Benigno and Eggertsson 2024, Fornaro 2024) studies kinked or "slanted" Phillips curves wherein the price level or inflation is a highly non-linear function of output Y. In these mod-

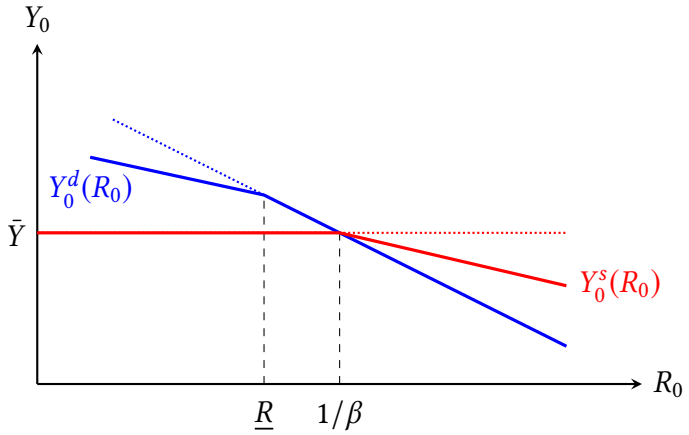


Figure 3: Aggregate demand Y_0^d and aggregate supply Y_0^s as functions of R_0 given steady state leverage. The dotted lines correspond to the frictionless New Keynesian model ($\nu = 0$).

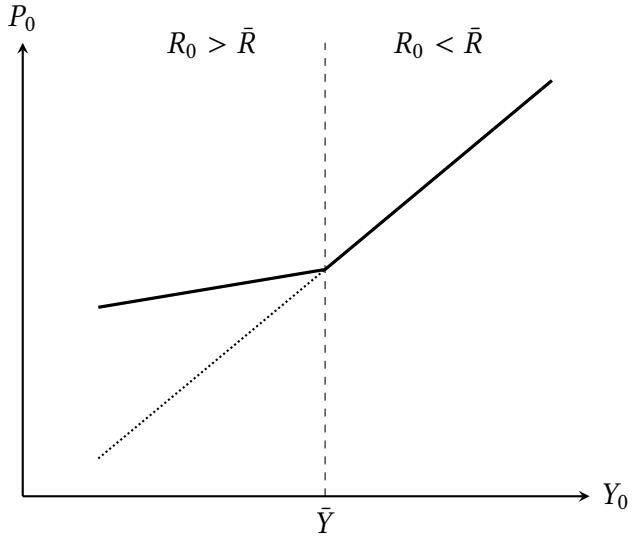


Figure 4: Kinked Phillips curve: $P_0(Y_0)$ when Y_0 is shifted by movements in R_0. The dotted line corresponds to the frictionless New Keynesian model ($\nu = 0$).

els, the kink arises from broad supply constraints or the nature of nominal rigidities, and the relationship does not depend on the particular source of variation in aggregate demand. For instance, in the presence of downward nominal wage rigidities (as in, e.g., Schmitt-Grohé and Uribe, 2016; Guerrieri et al., 2021), there is little disinflation or deflation in a recession yet inflation can increase sharply in a boom, but this asymmetry is independent of past monetary policy and of the type of demand shock.

A crucial distinction is that in our model the shape of the Phillips curve is both *shock-* and *history-dependent*. The shock-dependence means that shifts in demand caused by interest rates do not have the same effect as shifts in demand caused by, e.g., fiscal stimulus, because interest rates play a special role for indebted firms' supply constraints. The history-dependence means that the locus of the kink is affected by outstanding debt F_{-1}, which itself depends on past interest rates.

Moreover, in our baseline model the kink is not just a remote possibility that can only be reached following large disruptions in goods or labor markets. On the contrary, we showed that the economy endogenously ends up exactly at the kink in steady state; this means the kink in the Phillips curve is always relevant, even when looking at small shocks around a seemingly unconstrained steady state. The fact that the steady state is exactly at the kink is of course a simplification due to the perfect-foresight environment, but the more general insight is that firms' optimal capital structure choices imply that the economy will endogenously spend most of its time around the kink in the Phillips curve.

5.2 The transmission of monetary policy

We now illustrate how monetary policy transmission is affected by corporate capital structures. We describe the response of output Y_0 and inflation (or equivalently P_0) to an unanticipated monetary policy shock R_0, and explain how they differ from the standard New Keynesian model.

Output Y_0 follows the "IS curve"

$$Y_0 = \frac{x_1 (R_0)^{\nu} \bar{Y}}{\beta_0 R_0}, \tag{21}$$

where we replaced $Y_1 = x_1^{\nu} \bar{Y}$, using the fact that under perfect foresight from $t = 0$ onward, firms always set their optimal flexible price in advance hence the equilibrium output at $t = 1$ must be the same as under flexible prices.

Consider first the case of monetary easing, that is, a decrease in the policy rate R_0. The

standard effect is to stimulate consumption and thus output Y_0 through an intertemporal substitution channel, that is, by lowering the denominator in equation (21). If future aggregate supply is unconstrained ($x_1 = 1$) then this is the only effect of the rate cut, and we recover the standard IS curve. The interest-elasticity of output $-\frac{d \log Y_0}{d \log R_0}$ in this case is equal to 1, which is the elasticity of intertemporal substitution given our logarithmic preferences.

Suppose now that $x_1 < 1$ and future supply is constrained. In that case, the date-0 rate cut also has a counterveiling *negative* effect on output Y_0 as a lower rate R_0 decreases the numerator in (21). Proposition 2 shows that the monetary shock affects the capital structure of new firms ℓ_0, and therefore next period's continuation x_1 via

$$x_1(R_0) = \min \left\{ 1, \bar{x} \left(\frac{1}{1 + \kappa / R_0} \right)^{\frac{1}{1-\nu}} \right\} \tag{22}$$

which is increasing in R_0 at sufficient low rates, more precisely when

$$R_0 < \underline{R} = \frac{\kappa}{\bar{x}^{1-\nu} - 1}.$$

Following this pure monetary policy shock (i.e., there is no simultaneous shock to fundamentals, which is the configuration we study in the next section), firms view the lower rate R_0 as an opportunity to time the market and the rate cut spurs a corporate leverage boom because the cost of debt falls by more than the cost of equity. The shift towards debt, in turn, makes the future supply "indebted" and causes a contraction in future output Y_1, that cannot be undone by future monetary policy because prices are not sticky anymore at $t = 1$.

As a result, in the constrained region $R_0 < \underline{R}$, aggregate output Y_0 is less responsive to monetary policy because the impact of R_0 on young firms' leverage and thus the date-1 production capacity mitigates the impact on current demand. The response of corporate balance sheets undermines the stimulative effect of the rate cut Y_0:[8]

Proposition 4. *The interest-elasticity of output around an arbitrary rate R_0 is*

$$-\frac{d \log Y_0}{d \log R_0} = \begin{cases} 1 - \frac{\nu \kappa}{(1-\nu)(R_0 + \kappa)} & \text{if } R_0 < \underline{R} \\ 1 & \text{if } R_0 > \underline{R} \end{cases} \tag{23}$$

[8] In Appendix A.3 we extend Proposition 4, which is written with log-utility, to the case of a general elasticity of intertemporal substitution (EIS) σ.

where $\underline{R} = \frac{\kappa}{\bar{x}^{1-\nu}-1}$.

The effect of monetary policy on output Y_0 depends on what happens to the *future* productive capacity x_1, whereas the response of inflation P_0 depends on what happens to the *current* productive capacity $x_0 = \min\left\{1; \frac{1}{\gamma}\left[\frac{1}{R_0} - F_{-1}\right]\right\}$. Given outstanding debt F_{-1}, firms' productive capacity is constrained at $t = 0$ if the interest rate R_0 is sufficiently high:

$$x_0 < 1 \Leftrightarrow R_0 > \bar{R}(F_{-1}) = \frac{1}{\gamma + F_{-1}}.$$

The current continuation scale x_0 does not affect output Y_0, which is fully determined by the IS curve (21), as in the standard New Keynesian model. However, x_0 is crucial in determining date-0 inflation through the Phillips curve (20). The analytical expression for $d\log P_0/d\log R_0$ is less tractable than (23) so we will directly analyze instead what interest rate is required to maintain price stability. Intuitively, a rate hike that leads to lower x_0 is equivalent to a cost-push shock, which leads to more inflation even holding output Y_0 fixed. The effect of cost-push shocks in the standard New Keynesian model is well-understood; what is key here is that the magnitude of the "effective cost-push shock" depends on both current monetary policy R_0 and outstanding corporate debt F_{-1}. In principle, with extremely strong financial frictions (i.e., high ν), an increase in R_0 could even be inflationary if it contracts aggregate supply more than aggregate demand. In the rest of the paper, we assume that ν is sufficiently small to rule out this perverse effect:

Assumption 3. $\nu < \min\left\{\frac{\gamma}{\beta}, \frac{1+\beta\kappa}{1+2\beta\kappa}\right\}$.

Assumption 3 ensures that financial frictions are sufficiently small that inflation responds with the same sign as in the the frictionless New Keynesian model with $\nu = 0$. More precisely, under Assumption 3, a local rate cut $dR_0 < 0$ around the steady state is inflationary while a local rate hike $dR_0 > 0$ is deflationary, as we assumed in Figure 3.

Discussion. Cost-push shocks in the monetary economics literature can arise from markup shocks (e.g., modeled in reduced form as stemming from a lower elasticity of substitution ϵ between varieties, cf. Galí 2015), real wage rigidities (Blanchard and Galí, 2007) and asymmetric shocks in multi-sector models (Guerrieri, Lorenzoni, Straub and Werning, 2021; Rubbo, 2024; Afrouzi, Bhattarai and Wu, 2024). Our model features endogenous cost-push shocks due to financial frictions, closer to the "cost channel" or "working capital channel" of

monetary policy (Barth and Ramey, 2001; Ravenna and Walsh, 2006), with three main differences. First, in these models firms always have to pay for a share of wages and inventories in advance hence the cost channel is a permanent feature of the economy, whereas in our framework the precise level of interest rates and corporate leverage matter. Put differently, the interest rate is not always part of firms' marginal costs, and only becomes relevant for firms' pricing and aggregate inflation in the event of heavily indebted supply. Second and relatedly, current interest rates affect firms' capital structure going forward, which, as we showed, can dampen the output effects of monetary easing. Third, when financial frictions are not too extreme (i.e., Assumption 3 holds), our model does not imply that increasing the policy rate raises inflation; in fact, we will reach the opposite conclusion that maintaining price stability in response to positive demand shocks calls for an even higher policy rate than in the frictionless New Keynesian model.

5.3 Financial dominance

We described the range of possible outcomes given a shock to the policy rate R_0 holding fundamentals fixed. We now analyze how the policy rate should be set in response to shocks according to some policy objective, such as inflation-targeting or output-stabilization.

We start from an arbitrary level of the model's single state variable F_{-1}, which does not necessarily correspond to the steady state level. This allows us to illustrate the concept of "financial dominance": both *existing* private debt and the *current* response of corporate leverage worsen the inflation-output tradeoff faced by the central bank, thereby constraining how well monetary policy can respond to macroeconomic shocks.

We start by analyzing the impact of demand shocks, i.e., transitory shocks to the discount factor β_0. A fall in β_0 corresponds to a positive demand shock, as output increases if monetary policy keeps the rate R_0 constant. An increase in the discount factor $\beta_0 > \beta$ corresponds to a negative demand shock: as is well-known (Eggertsson and Krugman, 2012; Guerrieri and Lorenzoni, 2017), this can be viewed as a reduced form for a household deleveraging shock in models focusing on household debt. Without the supply-side financial frictions in our model, the standard policy response is to set $R_0 = 1/\beta_0$, and the "divine coincidence" holds as the central bank can accommodate the demand shock perfectly, stabilizing both output (at $\bar{Y}$) and inflation (at zero).[9]

[9]The literature (Eggertsson and Woodford, 2003; Werning, 2011) has studied how large negative demand shocks may call for such a low rate R_0 that the zero lower bound (ZLB) binds, in which case it is impossible to maintain $Y_0 = \bar{Y}$ and a recession and deflation must ensue due to insufficient aggregate demand. We abstract away from the ZLB and assume that the central bank is always able to achieve $Y_0 = \bar{Y}$.

Outstanding debt constrains the policy response to positive demand shocks. Consider first a positive demand shock, i.e., a fall in β_0. We illustrate the first side of "financial dominance": higher outstanding debt acts as a constraint on the central bank's ability to tame inflationary pressures.

There are three cases, depending on the size of the demand shock. First, if the rate $R^* = 1/\beta_0$ that would be optimal in the frictionless model is still lower than $\bar{R}(F_{-1}) = \frac{1}{\gamma + F_{-1}}$, then supply-side financial constraints are not binding, and firms can continue at full scale $x_0 = 1$, and hence monetary policy can stabilize both output and inflation. For completeness we describe this case which can arise for small levels of debt F_{-1}, but if we start from the steady state debt F_{-1} then this case is never relevant. In steady state, firms always choose a sufficiently high leverage such that the steady state real rate $1/\beta$ is exactly $\bar{R}$ and any positive demand shock $\beta_0 < \beta$ will make the supply-side financial constraints bind.

Second, if the positive demand shock is large and $1/\beta_0$ rises above $\bar{R}(F_{-1})$, which is more likely when there is more outstanding corporate debt F_{-1}, then the date-0 interest rate $R_0 = 1/\beta_0$ that stabilizes output at $Y_0 = \bar{Y}$ necessarily leads to date-0 inflation, and the "divine coincidence" fails. Controlling inflation calls for a more restrained policy $R^{**} > 1/\beta_0$ that solves

$$x_0(R_0)^\nu = \frac{1}{\beta_0 R_0}. \tag{24}$$

The side-effect is that this policy implies a drop in output Y_0 below $\bar{Y}$, as shown in Figure 5. Equation (24) has a solution if $\beta_0 > \underline{\beta}(F_{-1})$ where $\underline{\beta}$ is an increasing function of outstanding debt F_{-1} (whose closed-form expression is given in Proposition 5 below).

The third and worst case scenario occurs if the positive demand shock is even larger, $\beta_0 < \underline{\beta}(F_{-1})$, as then it becomes simply impossible to maintain price stability, even if the central bank is willing to accept a drop in output.

Future debt constrains the policy response to negative demand shocks. Consider next a negative demand shock, i.e., a rise in β_0. If the date-0 shock is small, i.e., $\beta_0 > 1/\underline{R}$, then setting $R_0 = 1/\beta_0$ does not affect capital structure choices going forward. Thus in the next period, we still have full capacity $x_1 = 1$ and $Y_1 = \bar{Y}$, and the economy reverts to the steady state at $t = 1$. Thus if $\beta_0 < 1/\underline{R}$ it remains optimal to set $R_0 = 1/\beta_0$ regardless of the policy weights on inflation and output, and the "divine coincidence" still holds. The central bank can achieve "full employment" $Y_0 = \bar{Y}$ while avoiding inflation at both $t = 0$ and $t = 1$.

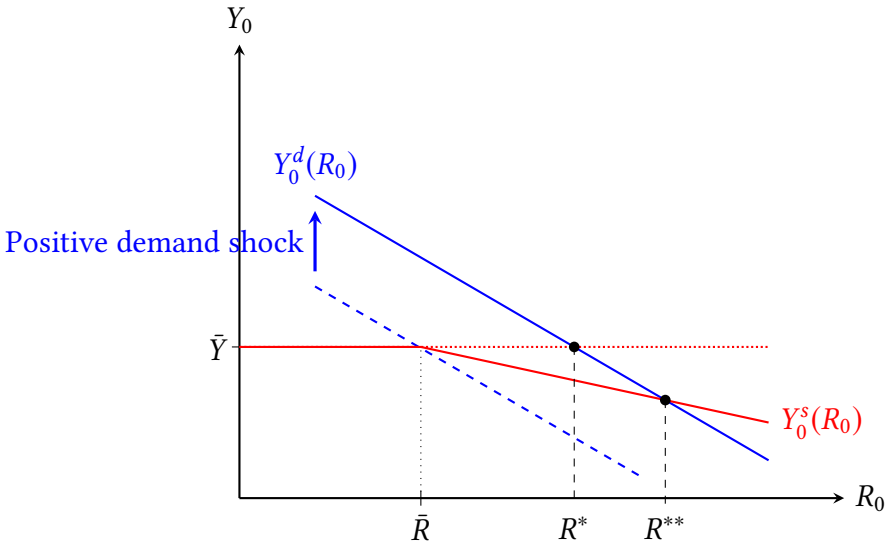


Figure 5: Binding current constraint ($x_0 < 1$) following large positive demand shock $\beta_0 < 1/\bar{R}(F_{-1})$. Here R^* is the rate ensuring $Y_0 = \bar{Y}$ while R^{**} is the rate ensuring no inflation.

If, however, the negative demand shock is sufficiently strong, i.e., β_0 is such that

$$\beta_0 > 1/\underline{R},$$

the central bank runs into a trade-off between aggregate demand management and financial stability concerns, that mirrors its dampened effectiveness shown in Proposition 4. Suppose, for instance, that monetary policy sets $R_0 = 1/\beta_0$, which would be optimal without financial frictions. In our model, firms respond to monetary easing by tilting their capital structure towards more debt, sacrificing future capacity x_1 to take advantage of the cheap rate R_0 relative to the cost of cash flow-based claims R_0^E. The negative supply shock at $t = 1$ (due to the rate-driven leverage boom at $t = 0$ inducing "indebted future supply") acts a negative demand shock already at $t = 0$: future financial distress $x_1 < 1$ hurts households' future income in general equilibrium, and thus they respond by consuming less at $t = 0$ already. We frame this intuition in the standard New Keynesian tradition emphasizing intertemporal substitution, but an equivalent interpretation is that the future financial distress $x_1 < 1$ creates a negative wealth effect that undermines consumption, as in Chodorow-Reich, Nenov and Simsek (2021) and Caballero and Simsek (2024).

Moreover, the fact that x_1 falls below 1 in this case implies that setting $R_0 = 1/\beta_0$ (i.e., the rate that would perfectly offset the negative demand shock absent financial frictions) is

not even sufficient to achieve $Y_0 = \bar{Y}$, as this would imply

$$Y_0 = x_1(1/\beta_0)^\nu \bar{Y} < \bar{Y}.$$

To prevent the date-0 recession, the central bank thus needs to ease *even more* at $t = 0$ than in the absence of financial constraints, i.e., attaining full employment $Y_0 = \bar{Y}$ requires setting a rate R_0 even lower than $1/\beta_0$. But this comes at the expense of an even larger increase in leverage ℓ_0 and thus and even tighter future financial constraints and lower x_1.

This forward-looking logic is the other side of "financial dominance": financial decisions by firms (and financial intermediaries) in response to interest rates end up weakening the power of monetary policy and may lead to a form of "over-accommodation". Our model isolates carefully demand and supply factors, and in particular how the interaction between monetary policy and financial constraints generates supply shocks that worsen the tradeoff between inflation and economic activity. More precisely, achieving $Y_0 = \bar{Y}$ requires a rate R_0 that solves

$$x_1(R_0)^\nu = \beta_0 R_0. \tag{25}$$

The left-hand side of (25) is increasing in R_0 (because a higher R_0 deters leverage, allowing more capacity at $t = 1$), and so is does the right-hand side. Both converge to 0 as $R_0 \to 0$ and the slope of the left-hand side is infinite around $R_0 = 0$. Moreover, given the condition $\beta_0 > 1/\underline{R}$, the left-hand side is below 1 when $R_0 \to 1/\beta_0$. Therefore there exists a unique solution $R^* < 1/\beta_0$ such that (25) holds, as depicted in Figure 6. But perfect macroeconomic stabilization at $t = 0$ can only be achieved by sacrificing future supply, i.e., allowing $x_1 < 1$.

Our model, therefore, generates an endogenous "slow recovery" in response to large negative demand shocks, consistent with the historical evidence in Cerra and Saxena (2008), Reinhart and Rogoff (2009), and especially Ivashina, Kalemli-Ozcan, Laeven and Mueller (2024) who emphasize the role of corporate debt booms. In our case, the key driver is the effect of monetary easing in response to the date-0 shock on corporate capital structure and thus future (date-1) financial stress. In the extreme, perfect stabilization generates a potentially large corporate recession in the next period. More broadly, if the central bank balances the current and future output loss, it will set R_0 above R^*, trading off a Keynesian (demand-side) recession at $t = 0$ in order to mitigate the corporate (supply-side) recession at $t = 1$.

We summarize this discussion in the following proposition, which is our main result:

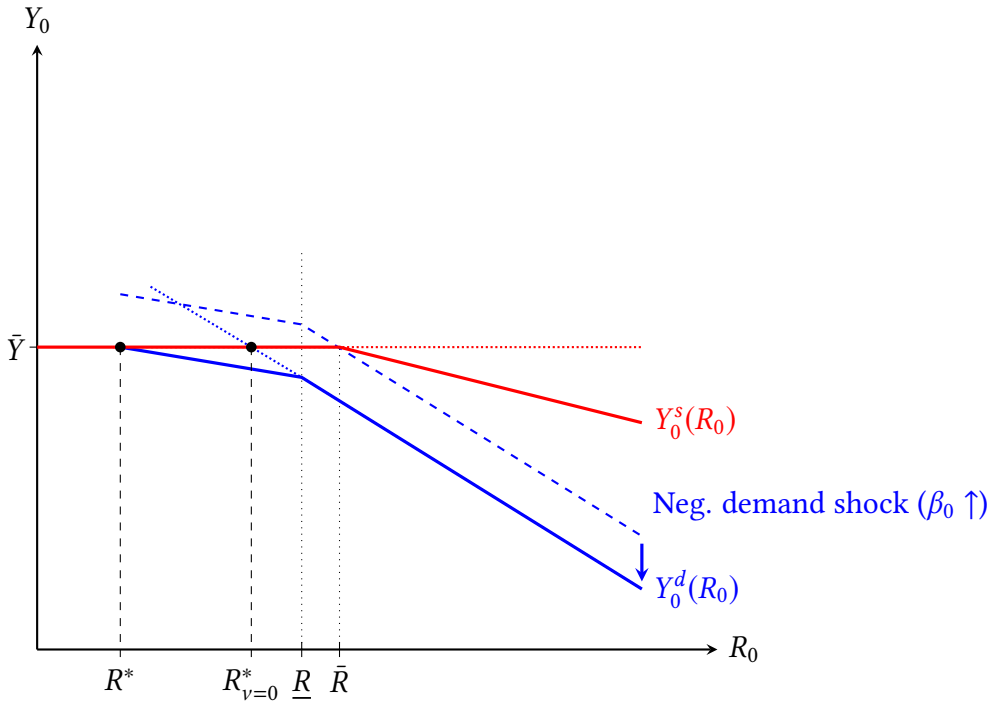


Figure 6: Binding future constraint ($x_1 < 1$) following large negative demand shock $\beta_0 > 1/\underline{R}$. The rate R^* allows to stabilize date-0 output and inflation, at the cost of a fall in x_1. The rate $R^*_{\nu=0}$ would stabilize date-0 output and inflation in the frictionless model.

Proposition 5 (Financial dominance and the response to demand shocks)**.** *Suppose the initial state is F_{-1} and consider an unanticipated shock to households' date-0 discount factor β_0, which then reverts permanently to its steady state value β at $t = 1$. Define*

$$\begin{aligned}\underline{R} &= \frac{\kappa}{\bar{x}^{1-\nu} - 1},\\ \bar{R}(F_{-1}) &= \frac{1}{\gamma + F_{-1}},\\ \underline{\beta}(F_{-1}) &= F_{-1}^{\frac{1-\nu}{\nu^2}} \left[\frac{\gamma}{(1-\nu)^{\frac{1}{\nu}-1}\,\nu}\right]^{1/\nu}.\end{aligned}$$

(i) For moderate demand shocks $\beta_0 \in [1/\bar{R}(F_{-1}), 1/\underline{R}]$, the central bank can achieve perfect macroeconomic stabilization at all dates $Y_0 = Y_1 = \bar{Y}$, $x_0 = x_1 = 1$, with zero inflation, by setting $R_0 = 1/\beta_0$.

(ii) ***Financial dominance and overheating****: For sufficiently large positive demand shocks $\beta_0 < 1/\bar{R}(F_{-1})$ then it is impossible to have both $Y_0 = \bar{Y}$ and no inflation at $t = 0$. Setting $R_0 = 1/\beta_0$ achieves $Y_0 = \bar{Y}$ but implies positive inflation.*

- *For $\beta_0 \in [\underline{\beta}, 1/\bar{R}(F_{-1})]$, there exists a rate $R_0 > 1/\beta_0$ that achieves zero inflation at $t = 0$, at the cost of a drop in output.*
- *For $\beta_0 < \underline{\beta}(F_{-1})$, it is impossible to achieve zero inflation at $t = 0$.*

(iii) ***Financial dominance and recessions****: For sufficiently large negative demand shocks $\beta_0 > 1/\underline{R}$, monetary policy can achieve perfect stabilization at $t = 0$ ($Y_0 = \bar{Y}$ and no inflation) if and only if R_0 is equal to the unique solution R_0^* to equation (21). R_0^* is below $1/\beta_0$, decreases with β_0, increases with $\bar{x}$, and decreases with κ.*

However, setting $R_0 = R_0^*$ to achieve $Y_0 = \bar{Y}$ necessarily entails indebted supply and a corporate recession in the next period, $x_1 < 1$.

Proposition 5 focuses on demand shocks arising from households' discount factor. Fiscal shocks such as increases in government spending G_0 have a very similar effect.

Suppose a date-0 public-spending shock $G_0 > 0$. Aggregate demand still determines output $Y_0 = G_0 + C_0$, and in the relevant range of interest rates $R_0 > 1/\beta$, we have $C_0 = \bar{Y}/(\beta R_0)$. The policy rate that leaves output unchanged at $Y_0 = \bar{Y}$ is:

$$R_0 = \frac{\bar{Y}}{\beta(\bar{Y} - G_0)}. \tag{26}$$

In a New Keynesian model without financial frictions, the central bank could offset any inflationary effects of the fiscal stimulus by stabilizing output. However, indebted supply implies that under this monetary policy reaction, the fiscal shock is still inflationary as x_0 falls below 1. Inflation increases with the size of government spending since $x_0 = 1 - \frac{\beta G_0}{\gamma \bar{Y}}$.

Therefore, our framework predicts that a fiscal shock can cause inflation in spite of monetary tightening that is sufficiently reactive to keep output at its potential. Moreover, the inflationary consequences are larger if firms have borrowed a lot recently, for instance following a period of low rates.

Supply shocks. We now consider how financial dominance affects the response of monetary policy to *supply* shocks. Our model features two potential sources of negative supply shocks: a fall in total factor productivity A, or an increase in the reinvestment need γ. At a general level, both can be viewed as an adverse shift in the production possibility frontier once we take into account the two stages of production.

A negative date-0 shock on productivity A_0 is a pure downward shift in potential output $\bar{Y}_0$, that leaves the threshold interest rate $\bar{R}(F_{-1})$ (corresponding to the kink in the aggregate supply curve) unchanged; in Figure 3 this corresponds to a parallel fall in the red aggregate supply curve Y_0^s. As in the standard (one-sector) New Keynesian model, a transitory negative shock to A_0 implies an increase in the natural interest rate. This is because the economy is expected to grow back to a higher potential output, which means that in partial equilibrium (for a given rate R_0) households would like to borrow to smooth consumption between dates 0 and 1, hence in general equilibrium the interest rate must adjust upwards. Financial frictions imply that the natural rate increases by even more due to an adverse feedback loop. As the higher rate tightens firms' liquidity constraints and makes households poorer at $t = 0$, the desire to borrow from future income Y_1 is stronger. This adds to the upward pressure on the equilibrium rate, which further tightens firms' constraints, and

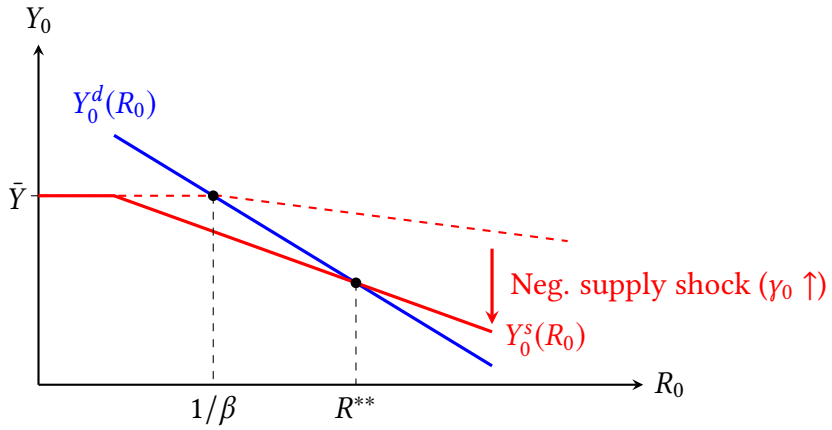


Figure 7: Binding constraint ($x_0 < 1$) following a supply shock $\gamma_0 > \gamma$. R^{**} is the policy rate ensuring price stability after the shock.

so on.

The most interesting kind of negative supply shock takes the form an increase in γ_0, which can be interpreted as higher input prices (e.g., due to an energy crisis or supply chain disruptions) or as an unusual need to reorganize firms and reorient production, as was the case post-pandemic. Unlike in the case of a TFP shock, here potential output (i.e., the output that would prevail absent financial frictions) is unaffected and remains at its steady state level $\bar{Y}$, and monetary policy could decide to maintain $Y_0 = \bar{Y}$ by keeping its rate unchanged at the steady state rate $R = 1/\beta$. That would be inflationary, however, as the threshold rate $\bar{R}$ above which financial frictions bind is now lower. Figure 7 shows how this corresponds to a leftward shift of the kink in the red aggregate supply curve Y_0^s , as well as a more negative slope in the downward sloping part. On the other side of the policy spectrum, ensuring price stability (and therefore replicating the flexible prices allocation) requires a higher interest rate (depicted as R^{**} in Figure 7) and an even lower continuation x_0. In general, a central bank that seeks to stabilize both output and inflation will thus set an intermediate policy rate $R_0 < R^{**}$.

One difference with the case of a TFP shock is that maintaining "full employment", interpreted as ensuring $Y_0 = \bar{Y}_0$, requires a higher rate and a drop in output in the case of a fall in TFP A_0, whereas it calls for a stable interest rate and no drop in output in the case of an increase in γ_0. Hence nominal rigidities together with the proper monetary policy response have potentially larger welfare benefits following a shock to γ_0.

Financial shocks. We can also consider shocks that fall outside the standard demand and supply shocks in macroeconomics. Consider an increase in κ_0 that can be viewed as either a financial shock that makes equity and cash flow based claims particularly expensive, or a "flight to safety" shock that makes debt particularly cheap. Surprisingly, such a shock may affect date-0 output and inflation even though balance sheets are pre-determined, solely through its impact on *future* corporate balance sheets. In fact, we find that financial shocks that make debt more attractive have particularly damaging intertemporal effects: their directly make future supply more indebted, and are difficult to address with conventional monetary policy, as rate cuts amplify the shift towards debt.

If firms' capital structures shift towards debt at $t = 0$, causing indebted supply at $t = 1$ and $x_1 < 1$, then the rise in κ_0 is effectively a negative demand shock at $t = 0$, and leads to a drop in output and deflation absent any monetary policy response, that is if R_0 is kept fixed. However, responding to the raise in κ_0 by easing monetary policy leads to the same dilemma as in Proposition 5, part (iii). The high spread κ_0 dampens the effect of monetary policy on output due to the endogenous response of corporate capital structures (Proposition 4). As a result, a more aggressive rate cut is required to stabilize output Y_0, but this can only be done at a larger cost in terms of future output Y_1.

Discussion. Kashyap and Stein (2023) analyze "monetary policy when the central bank shapes financial market sentiment." Kashyap and Stein (2023) abstract from inflation and focus on the "IS curve", which is allowed to depend not only on the policy rate but also on credit spreads, that are affected by fluctuations in credit-market sentiment. Kashyap and Stein (2023) focus on a "credit-bites-back" effect, by which credit spread reversals have negative effect on aggregate demand. This creates an intertemporal tradeoff for the central bank: cutting rates to offset a negative demand shock in the present compresses credit spreads, which creates the potential for a future credit spread reversal that will be impossible to offset if the zero lower bound (ZLB) ends up binding. Part (iii) of our Proposition 5 features a similar intertemporal tradeoff, although our emphasis is on firms' capital structure choices instead of credit spread reversals. While our model provides a foundation for the reduced-form credit-bites-back effect in Kashyap and Stein (2023), the resulting supply-side effects introduce a rich inflation-output tradeoff and generate harmful effects on future output even without binding ZLB.

In a different context, Farhi and Tirole (2012) highlight financial institutions' incentives to increase their maturity mismatch and correlated exposures when they anticipate future expansionary monetary policy, which can be seen as a form of untargeted bailout. Their

focus is on the lack of policy commitment which can lead to multiple, self-fulfilling, equilibria. By contrast, in Proposition 2 firms' choice of optimal continuation x_1 depends on *current* rates and spreads, and not on what firms expect about future policy, hence lack of commitment is not an issue.[10]

6 Extensions

6.1 Demand effects from financial frictions

By design, our baseline model abstracts away from the well-understood effect of financial frictions on aggregate *demand*. In the model, this complete separation is due to two assumptions: the long-term investment scale K is fixed, and the reinvestment $\gamma x_{t+1} K$ is produced by competitive suppliers (e.g., commodities or imports).

Naturally, we can generalize the model by relaxing either of these two assumptions. Suppose, for instance, that a fraction $\omega > 0$ of the reinvestment need $\gamma x_{t+1} K$ is produced by firms with sticky prices instead of coming from endowments or competitive wholesalers with flexible prices. In that case, the market-clearing condition for output becomes

$$Y_t = \omega \gamma x_t K + C_t$$

where aggregate consumption C_t follows the same Euler equation (3) as before, and the new term $\omega \gamma x_t K$ corresponds to the "investment" part of aggregate demand.[11] As Figure 8 shows, the only difference is that aggregate demand Y_0^d also has a more negative slope for rates $R_0 > \bar{R}$. If this demand effect is stronger than the supply effects in our baseline model (as in most macro-finance models that *only* feature demand effects), the resulting Phillips curve (when variations in economic activity are driven by interest rates) becomes concave, with a steeper slope when output is low.

6.2 Banks and credit crunches

Our baseline model contrasts the implications of different types of external finance for monetary policy transmission, but abstracts from financial intermediaries. "Debt" in our

[10] This stems from our assumption that only debt can be issued at $t + 1$, hence the only relevant return difference between debt and equity is about returns between t and $t + 1$.

[11] We still assume that the long-term investment K is fixed. Making it interest-sensitive would simply add a third component to aggregate demand with similar implications.

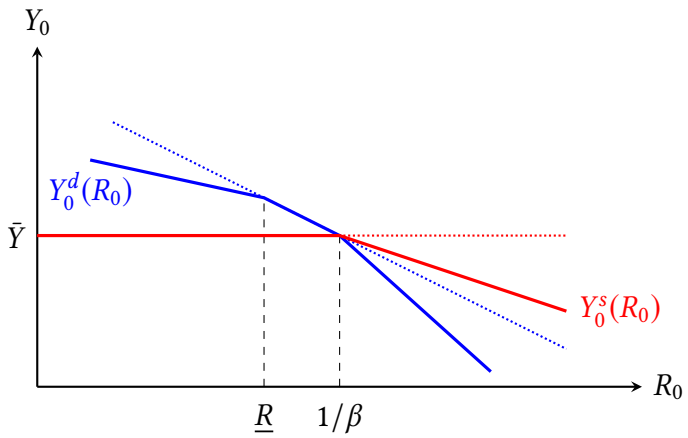


Figure 8: Aggregate demand Y_0^d and aggregate supply Y_0^s as functions of R_0 when financial frictions also have demand effects. The dotted lines correspond to the frictionless New Keynesian model ($\nu = 0$).

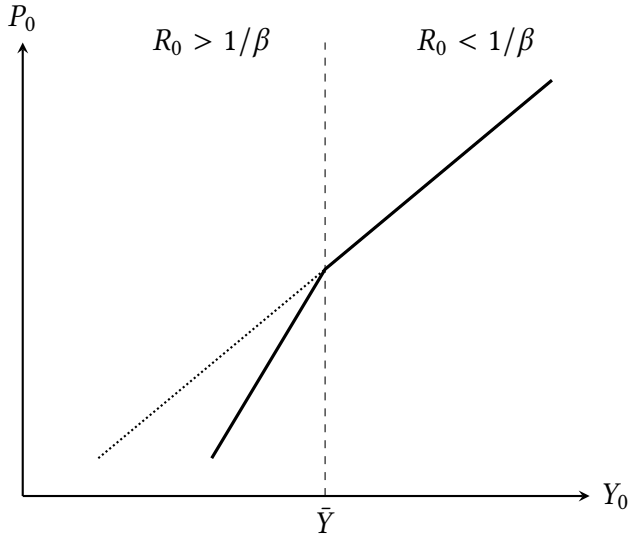


Figure 9: Phillips curve $P_0(Y_0)$ with strong demand effects of financial frictions, when Y_0 is shifted by movements in R_0. The dotted line corresponds to the frictionless New Keynesian model ($\nu = 0$).

model can thus be interpreted as bank loans, non-bank loans, or corporate bonds, and firms' binding constraints are due to previous leverage choices that limit the borrowers' remaining pledgeable income or collateral.

Here we show how to extend our framework to allow for amplification originating in the banking sector, consistent with the empirical findings in Drechsler, Savov and Schnabl (2022), who argue that due to a regulatory cap on deposit rates ("Regulation Q"), monetary tightening in the 1970s led to stark deposit outflows and credit crunches that contracted aggregate supply.[12] Our model can incorporate those additional frictions by assuming that the reinvestment must be funded by bank loans paying not just the policy rate R_0 but a loan rate $R_0 + \tau(R_0)$ that includes an additional loan spread τ.[13] It remains crucial that firms are unable to fund the reinvestment need by issuing equity against the operating cash flows. In that case, the continuation scale that determines ex-post aggregate supply becomes

$$x_0 = \min\left\{1; \frac{1}{\gamma}\left[\frac{1}{R_0 + \tau(R_0)} - F_{-1}\right]\right\}.$$

The key insight in Drechsler, Savov and Schnabl (2022) is that Regulation Q made the effective loan spread τ particularly sensitive to monetary policy, with the positive derivative τ' capturing the strength of the bank credit crunches induced by higher rates.

Denote R_Q the rate at which Regulation Q becomes binding.[14] Suppose that when R_0 is below R_Q, there is no loan spread and outstanding debt is small enough that $x_0 = 1$; but once R_0 exceeds R_Q, the loan spread τ increases with R_0 with a slope τ'. Then an increase in R_0 in the binding Regulation Q region is *inflationary* if

$$1 + \tau' > \frac{\gamma}{\beta\nu}$$

even though it would be deflationary with a low enough τ'. Figure 10 shows how in this case aggregate supply becomes even steeper as a function of R_0 (i.e., has a more negative

[12] Other work on the relation between monetary policy, bank lending and firms' liquidity constraints includes Kashyap, Stein and Wilcox (1993), who show that monetary tightening shifts firms' capital structure *within* debt types, from bank loans towards commercial paper, and Kashyap, Lamont and Stein (1994), who find that bank-dependent firms without internal liquidity saw an especially strong fall in their inventories during the 1981-1982 recession induced by monetary tightening.

[13] The loan spread τ should be viewed as encapsulating both a directly measurable higher rate but also the shadow cost of non-price rationing at the intensive or extensive margin, cf. Mabille and Wang (2022).

[14] Note that x_0 depends on firms' *real* borrowing costs. We write τ as a function of the real rate R_0, but what matters for deposit outflows and credit crunches is the *nominal* interest rate as Regulation Q applied to nominal deposit rates.

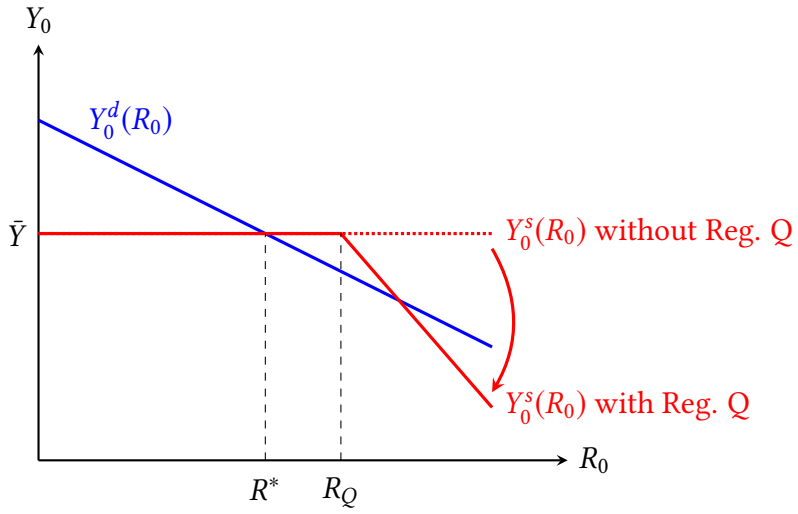


Figure 10: Aggregate demand Y_0^d and aggregate supply Y_0^s as functions of R_0 with and without Regulation Q, where R_Q is the rate above which a binding Regulation Q triggers credit crunches. The dotted lines correspond to the frictionless New Keynesian model ($\nu = 0$).

slope) than aggregate demand, due to the possiblity of credit crunches. Thus Regulation Q may have amplified the supply consequences of tight monetary policy that we argue are always present when firms face liquidity constraints.

In this extreme case, a rate cut would actually lead to both higher output and less inflation, and thus lowering rates to $R_0 = R^*$ in Figure 10 would be an improvement on both dimensions.[15] By contrast, in our model the central bank still faces the standard tradeoff between inflation and economic activity, and taming inflation requires increasing rates (as in Proposition 5). Moreover, unlike financial dominance that works through general equilibrium and dynamic effects, here the relevant kink in the Phillips curve is at an exogenous location determined by the Regulation Q cap, and not a function of past corporate leverage decisions.

6.3 Convenience yield on debt and equity-based Euler equation

One could also add a convenience yield on debt as a component of the spread κ_t on top of the (verification or transaction) costs associated with equity. Suppose for example that households have a flow utility $\log C_t + v(d_t/Y_t)$, where d_t is the real amount of debt holdings

[15] In case of a simultaneous positive demand shock making it impossible to stabilize inflation completely, the optimal rate would be $R_0 = R_Q$.

maturing at date t. This yields the Euler equation associated with debt:

$$R_t^D = \frac{C_{t+1}}{\beta C_t} - v'(d_{t+1}/Y_{t+1}), \tag{27}$$

where the first term $\frac{C_{t+1}}{\beta C_t}$ is the intertemporal rate of substitution of consumption and the second term is the convience yield. If we assume, following Di Tella, Hébert, Kurlat and Wang (2023), that households' Euler equation holds with respect to equity returns (which corresponds to what Di Tella, Hébert, Kurlat and Wang (2023) call the "zero beta rate" since we abstract from aggregate risk) then we obtain

$$R_t^E = R_t^D + \kappa_t$$
$$R_t^E = \frac{C_{t+1}}{\beta C_t}$$

where $\kappa_t = v'(d_t/Y_t)$. There are two differences relative to our baseline setup. First, κ_t depends on the amount of debt, as in, e.g., Krishnamurthy and Vissing-Jorgensen (2015). Since our focus is not on fiscal policy and debt issuance, this is a minor departure, and if we assume that v is linear in the relevant region of equilibrium debt holdings then this effect disappears. Second, the relevant intertemporal rate of substitution is now the higher rate R_t^E instead of the lower rate R_t^D. From the perspective of the central bank, however, with a fixed wedge κ then controlling R_t^D is equivalent to controlling R_t^E. Therefore the exact expressions for our results on monetary policy transmission (e.g., in Proposition 5) are different, but the qualitative patterns are unchanged.

A qualitative difference would arise if the convenience yield adjusts in a way that makes the intertemporal marginal rate of substitution R_t^E completely disconnected from monetary policy, which is a possibility suggested by Di Tella, Hébert, Kurlat and Wang (2023). In that knife-edge case, the standard transmission working through intertemporal substitution would disappear entirely, but our model still predicts that a lower policy rate R_0 (transmitted to the cost of debt) could affect aggregate demand through the impact on firms' capital structure choice and future supply x_1. The effect would be reversed: a higher R_0 increases corporate leverage, tightens future supply, and lowers date-0 output.

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Online Appendix

A Additional results

A.1 Adverse selection and verification costs

There is a continuum with mass $1/q$ of desirable varieties, where $q \in (0,1)$. At date t, there are $1/q$ firms standing ready to produce one variety each at $t+1$. Each firm will actually be able to produce at $t+1$ with probability q only, whereas with probability $1-q$ it cannot. For example firms draw independently one of two values for γ, one is sufficiently small and the other arbitrarily large. There is no private information at date t so firms can issue equity, the only difference with the baseline model is that each firm produces cash flows only with probability q.

At the outset of $t+1$, at the refinancing stage, each firm privately observes whether it can produce. This creates adverse selection and a market breakdown in equity markets at this refinancing stage if q is sufficiently small.

Outside shareholders must rely on a firm which can verify the output of each firm to ensure that all the firms that can produce and sell pay their claims. This firm receives a total rent $C > 0$ by collecting a fixed fee per share of productive firms. (This could cover a fixed cost but then we would have to substract it from total output.) This yields:

$$R_t^E = R_t + \frac{C}{K(1-l_t)}, \tag{A.1}$$

where l_t is aggregate leverage. This yields a spread κ_t that actually increases in l_t and thus decreases in R_t thereby reinforcing the results that we obtain with a fixed κ_t in the body of the paper. This can even open up the possibility of multiple equilibria. A verification cost that increases in the size of total outside equity issued would yield a spread closer to the fixed one assumed in the paper.

A.2 Dynamics under flexible prices

Given initial conditions $F_{-1} = R_{-1}\ell_{-1}$, a (flexible-prices, perfect foresight) equilibrium is a sequence $\{x_t, R_t\}_{t\geq 0}$ satisfying the following system of equations for $t \geq 0$

$$\begin{aligned} x_{t+1}^{\nu} &= \beta_t R_t x_t^{\nu} \\ x_{t+1} &= \min\left\{1, \bar{x}_t \left(\frac{1}{1+\kappa_t/R_t}\right)^{\frac{1}{1-\nu}}\right\} \end{aligned}$$

that correspond respectively to households' Euler equation and firms' optimal capital structure decisions, with initial condition

$$x_0 = \min\left\{1; \frac{1}{\gamma_0}\left[\frac{1}{R_0} - F_{-1}\right]\right\}.$$

Combining the first two equations, we can solve out for the interest rate R_t to obtain a relation between x_{t+1} and x_t for all $t \geq 0$:

$$x_{t+1} = \min\left\{1, \bar{x}_t \left(\frac{1}{1+\beta_t\kappa_t \frac{x_t^{\nu}}{x_{t+1}^{\nu}}}\right)^{\frac{1}{1-\nu}}\right\}. \tag{A.2}$$

Therefore, either firms are unconstrained at $t+1$ and $x_{t+1} = 1$, or x_{t+1} is a function of x_t given by

$$x_{t+1}^{1-\nu} = \bar{x}_t^{1-\nu} - \beta_t\kappa_t x_t^{\nu} x_{t+1}^{1-2\nu}. \tag{A.3}$$

When $\nu < 1/2$ (i.e., financial frictions are moderate), equation (A.3) has a unique solution that we denote $\varphi_t(x_t)$, so that

$$x_{t+1} = \min\left\{1, \varphi_t\left(x_t\right)\right\}.$$

The time subscript in φ_t captures potential time-variation in the parameters $\bar{x}_t$ (through, e.g., financial shocks γ_t), β_t and κ_t. We always have $\varphi_t(0) = \bar{x}_t$ which we assumed to be above 1, hence $x_{t+1} = 1$ for sufficiently small x_t. Intuitively, a strong contraction at t increases the current interest rate R_t dramatically, which leads firms to reduce leverage so

much that they will be unconstrained in the next period.[16]

Thus we have

Proposition 6. *The continuation scale x_0 is always given by the minimum of 1 and the solution to*

$$\varphi_0(x_0) = (\beta_0)^{1/\nu} \frac{x_0}{(\gamma_0 x_0 + F_{-1})^{1/\nu}}.$$

(i) Suppose that $\frac{\bar{x}}{(1+\beta\kappa)^{\frac{1}{1-\nu}}} \geq 1$. Then the only steady state is $x = 1$. In any equilibrium, $x_t = 1$ for all $t \geq 1$.

(ii) Suppose that $\frac{\bar{x}}{(1+\beta\kappa)^{\frac{1}{1-\nu}}} < 1$. If $\nu \leq \frac{1}{2}$, then the unique steady state is $x = \frac{\bar{x}}{(1+\beta\kappa)^{\frac{1}{1-\nu}}}$. It is stable if $\nu \leq \frac{1+\beta\kappa}{1+3\beta\kappa}$ and unstable if $\nu > \frac{1+\beta\kappa}{1+3\beta\kappa}$.

In partial equilibrium, a higher spread κ_t increases the market-timing motive, and thus leads firms to issue more debt, which is equivalent to accepting a lower scale x_{t+1} in the future. In general equilibrium, there is a second effect. A higher current output, as captured by a higher x_t, lowers the real interest rate all else given. This also amplifies market-timing and leverage (later we will analyze the impact of monetary policy, which can affect the real rate independently of x_t). Thus there is a natural stabilizing force: in a period with low natural output, the real rate is high, which reduces the gap between the cost of equity and the cost of debt and thus disciplines leverage.

A.3 More general elasticity of intertemporal substitution

Here we sketch how the results extend to the case in which households derive a more general CRRA utility over consumption $\frac{C^{1-1/\sigma}}{1-1/\sigma}$ where σ is the elasticity of intertemporal substitution (EIS).

First, the output in the flexible-price case becomes

$$Y_{t+1} = x_{t+1}^{\frac{\nu\sigma}{\sigma\alpha+1-\alpha}} \bar{Y}, \tag{A.4}$$

with $\bar{Y} = \left[AK^{\alpha} \left[\frac{(\epsilon-1)(1-\alpha)}{\epsilon\chi} \right]^{1-\alpha} \right]^{\frac{\sigma}{\sigma\alpha+1-\alpha}}$. Denote

$$\tilde{\nu} = \frac{\nu}{\alpha + \sigma^{-1}(1-\alpha)}.$$

[16] In the limit $\nu \to 0$, financial frictions vanish and we have $x_{t+1} \to \min\left\{1, \frac{\bar{x}_t}{1+\beta_t\kappa_t}\right\}$ for any x_t.

Then the date-$t+1$ capacity x_{t+1} becomes

$$x_{t+1} = \min\left\{1, \frac{\bar{x}}{\left(1+\frac{\kappa_t}{R_t}\right)^{\frac{1}{1-\tilde{\nu}}}}\right\} \tag{A.5}$$

where $\bar{x}^{\frac{\sigma\alpha+1-\alpha}{\sigma}} = \left(\frac{\nu}{\gamma}\right)^{\frac{\sigma\alpha+1-\alpha}{\sigma}} \left(\frac{1-\alpha}{\chi}\right)^{1-\alpha} \left(\frac{\epsilon-1}{\epsilon}\right)^{\frac{\sigma+1-\alpha}{\sigma}} AK^{-\frac{1-\alpha}{\sigma}}$.

The date-0 Euler equation becomes

$$Y_0 = \frac{x_1^{\tilde{\nu}}\bar{Y}}{(\beta R_0)^{\sigma}} \tag{A.6}$$

hence the interest-elasticity of output is

$$-\frac{d\log Y_0}{d\log R_0} = \begin{cases} \sigma\left[1 - \frac{\nu\kappa}{[1-\alpha+\sigma(\alpha-\nu)](R_0+\kappa)}\right] & \text{if } R_0 < \underline{R} \\ \sigma & \text{if } R_0 > \underline{R} \end{cases}$$

Finally, the date-0 Phillips curve becomes

$$\frac{P_0}{P_{-1}} = \left[\frac{1-\lambda\left[x_0^{\nu}\left(\frac{\bar{Y}}{Y_0}\right)^{\frac{\sigma\alpha+1-\alpha}{\sigma}}\right]^{\phi(\epsilon-1)}}{1-\lambda}\right]^{\frac{1}{\epsilon-1}}. \tag{A.7}$$

Overall, a higher EIS implies that monetary policy affects supply relatively more than demand, all else equal.

B Proofs

B.1 Proof of Lemma 1

Nominal profits are given by

$$
\begin{aligned}
P_{t+1}\Pi_{i,t+1} &= P_{i,t+1}Y_{i,t+1} - W_{t+1}N_{i,t+1} \\
&= P_{i,t+1}Y_{t+1}\left(\frac{P_{i,t+1}}{P_{t+1}}\right)^{-\epsilon} - \frac{W_{t+1}}{x_{i,t+1}^{\frac{\nu}{1-\alpha}}K^{\frac{\alpha}{1-\alpha}}}\left[\frac{Y_{t+1}}{A}\left(\frac{P_{i,t+1}}{P_{t+1}}\right)^{-\epsilon}\right]^{\frac{1}{1-\alpha}} \\
&= P_{t+1}Y_{t+1}\left[\left(\frac{P_{i,t+1}}{P_{t+1}}\right)^{1-\epsilon} - \frac{W_{t+1}/P_{t+1}Y_{t+1}^{\frac{\alpha}{1-\alpha}}}{x_{i,t+1}^{\frac{\nu}{1-\alpha}}K^{\frac{\alpha}{1-\alpha}}}A^{\frac{-1}{1-\alpha}}\left(\frac{P_{i,t+1}}{P_{t+1}}\right)^{-\frac{\epsilon}{1-\alpha}}\right].
\end{aligned}
$$

The optimal price $P^*_{i,t+1}$ in (5) follows from the first-order condition and using (4) and the market clearing condition for output $C_{t+1} = Y_{t+1}$ to rewrite the real wage as $W_{t+1}/P_{t+1} = \chi Y_{t+1}$.

B.2 Proof of Proposition 2

Suppose first that we are in a case such that the ex-ante leverage $\ell_{i,t}$ implies full continuation $x_{i,t+1} = 1$ at date-$t+1$. Then the firm maximizes

$$
\left[\Pi_{i,t+1}(1) - \gamma K\right] + \left[R^E_t - R_t\right]\ell_{i,t}K
$$

which is highest when $\ell_{i,t} = \bar{\ell}_t$ if $R^E_t > R_t$, and is independent of $\ell_{i,t}$ if $R^E_t = R_t$. Therefore without loss of generality we can restrict attention to leverage choices $\ell_{i,t} \in [\bar{\ell}_t, 1]$.

Conversely, suppose that we are in an case such that the optimal leverage $\ell_{i,t}$ implies an interior continuation scale $x_{i,t+1} < 1$. Then we can substitute

$$
R_t\ell_{i,t} = \frac{1}{R_{t+1}} - \gamma x_{i,t+1}
$$

to rewrite the firm's objective function as a function of $x_{i,t+1}$

$$
\Pi_{i,t+1}(x_{i,t+1}) - x_{i,t+1}\frac{R^E_t}{R_t}\gamma K.
$$

The first-order condition with respect to $x_{i,t+1}$ is

$$\begin{aligned}\frac{R_t^E}{R_t}\gamma K &= \frac{\partial \Pi_{i,t+1}}{\partial x_{i,t+1}} \\ &= \frac{\nu}{1-\alpha} A^{\frac{-1}{1-\alpha}} x_{i,t+1}^{-\frac{1+\nu-\alpha}{1-\alpha}} \frac{\chi Y_{t+1}^{\frac{2-\alpha}{1-\alpha}}}{K^{\frac{\alpha}{1-\alpha}}}\end{aligned}$$

from the envelope theorem, given optimal pricing. With symmetric firms such that $x_{i,t+1} = x_{t+1}$, we can then replace aggregate output $Y_{t+1} = x_{t+1}^{\nu}\bar{Y}$ to get the optimal choice of future continuation:

$$x_{t+1}^* = \bar{x}\left(\frac{R_t}{R_t^E}\right)^{\frac{1}{1-\nu}} = \bar{x}\left(\frac{1}{1+\kappa_t/R_t}\right)^{\frac{1}{1-\nu}}, \tag{A.8}$$

where

$$\bar{x} = \frac{\nu}{\gamma}\left(\frac{\epsilon-1}{\epsilon}\right)^{2-\alpha}\left(\frac{1-\alpha}{\chi}\right)^{1-\alpha}\frac{A}{K^{\frac{1}{1-\alpha}}}.$$

is higher than 1 by Assumption 2. If (A.8) implies $x_{t+1}^* < 1$, then this is the optimum, since by concavity this dominates $x_{t+1} = 1$.

B.3 Proof of Proposition 5

In the relevant region $x_0 < 1$, solving (24) corresponds to finding a zero for the function $\zeta(R_0) = R_0^{\frac{1}{\nu}-1} - R_0^{\frac{1}{\nu}}F_{-1} - \gamma\beta_0^{-\frac{1}{\nu}}$, which is negative at $R_0 = 1/\beta_0$. The function ζ is maximized when

$$R_0 = \frac{(1-\nu)}{F_{-1}} = \frac{(1-\nu)}{\beta-\gamma}$$

hence there is no zero if the maximum of ζ is negative, i.e. if

$$\beta_0 < \underline{\beta}(F_{-1}) = F_{-1}^{\frac{1-\nu}{\nu^2}}\left[\frac{\gamma}{(1-\nu)^{\frac{1}{\nu}-1}\nu}\right]^{1/\nu} \tag{A.9}$$

which is increasing in outstanding debt F_{-1}. At the steady state level $F_{-1} = \beta - \gamma$, we have $\underline{\beta} = \left(\frac{\gamma}{\left(\frac{(1-\nu)}{\beta-\gamma}\right)^{\frac{1-\nu}{\nu}} - \left(\frac{(1-\nu)}{\beta-\gamma}\right)^{\frac{1}{\nu}}(\beta-\gamma)}\right)^{1/\nu}$.

B.4 Proof of Proposition 6

If a constrained steady state $x < 1$ exists, it must satisfy

$$x = \frac{\bar{x}}{(1+\beta\kappa)^{\frac{1}{1-\nu}}}.$$

Hence if $\frac{\bar{x}}{(1+\beta\kappa)^{\frac{1}{1-\nu}}} > 1$ the only possible steady state is $x = 1$.

In addition we have another relation between x_1 and x_0. Given F_{-1}, either $x_0 = 1$ or

$$x_0 = \frac{1}{\gamma_0}\left[\frac{1}{R_0} - F_{-1}\right] \Rightarrow R_0 = \frac{1}{\gamma_0 x_0 + F_{-1}}$$

hence using households' Euler equation

$$x_1 = (\beta_0)^{1/\nu}\frac{x_0}{(\gamma_0 x_0 + F_{-1})^{1/\nu}}. \tag{A.10}$$

Therefore if $x_0 < 1$ it solves

$$\varphi_0(x_0) = (\beta_0)^{1/\nu}\frac{x_0}{(\gamma_0 x_0 + F_{-1})^{1/\nu}}$$

or

$$\left[(\beta_0)^{1/\nu}\frac{x_0}{(\gamma_0 x_0 + F_{-1})^{1/\nu}}\right]^{1-\nu} = \bar{x}_0^{1-\nu} - \beta_0\kappa_0 x_0^{\nu}\left[(\beta_0)^{1/\nu}\frac{x_0}{(\gamma_0 x_0 + F_{-1})^{1/\nu}}\right]^{1-2\nu}.$$

If $\kappa > 0$, then with a sufficiently high ν we must have $\frac{\bar{x}}{(1+\beta\kappa)^{\frac{1}{1-\nu}}} < 1$. The slope φ' around a constrained steady state is

$$\varphi' = \frac{-\beta\kappa\nu}{1-\nu+\beta\kappa(1-2\nu)}$$

hence $\varphi' < -1$ if $\nu > \frac{1+\beta\kappa}{1+3\beta\kappa}$. Hence in principle if we have

$$\frac{1+\beta\kappa}{1+3\beta\kappa} < \nu < \frac{1}{2}$$

we could have an unstable constrained steady state.

If $\nu \leq \frac{1}{2}$ then the right-hand side of (A.3) is decreasing in x_{t+1} and decreasing in x_t, hence φ is decreasing in x_t. When firms are highly constrained at t (low x_t), the interest rate is high, and firms reduce their leverage ℓ_t.

If $\nu > \frac{1}{2}$ then the right-hand side of (A.3) is increasing in x_{t+1} and decreasing in x_t, hence φ_t is increasing in x_t. But since $\varphi_t(0) = \bar{x}_t > 1$ we have $x_{t+1} = 1$ for any x_t.