Price Rigidities and Credit Risk[*]

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Abstract

We develop a capital structure model in which firms differ in their ability to adjust output prices. Firms with inflexible prices are more exposed to both nominal and real shocks, which endogenously leads to lower financial leverage, shorter debt maturity, higher cost of debt, tighter debt covenants, and greater precautionary cash holdings. Shocks to cash-flow volatility raise the cost of debt more for firms with less pricing flexibility. We empirically confirm these predictions: firms with inflexible prices experience significantly larger increases in credit spreads following monetary policy shocks and the 2008 Lehman Brothers bankruptcy—particularly when they face high pre-shock rollover risk.

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1 Introduction

The COVID-19 pandemic once again underscored the central role of monetary policy as a key instrument for stabilizing the economy—supporting consumption, investment, and production, while also calming financial and credit markets. Beyond its stabilizing role, monetary policy is also a major driver of asset prices and risk premia (see, e.g., Lucca and Moench, 2015; Ozdagli and Velikov, 2020; Savor and Wilson, 2014; Neuhierl and Weber, 2018).

The leading mechanism through which monetary policy affects the real economy is nominal price rigidity, that is, the inability of firms to immediately adjust output prices to nominal shocks. The degree of price stickiness is not only important for the transmission of monetary policy shocks in the aggregate, but is also important for cross-sectional differences in the reaction to shocks. A recent literature using micro data underlying official price statistics documents, indeed, a significant relation between the degree of price stickiness at the firm level, the cross section of stock returns, firms' optimal leverage choices, and the propagation of fiscal and monetary policy shocks.[1] So far, little evidence exists, however, on the role of output-price stickiness on firms' corporate policies and characteristics such as their credit risk, their cash holdings, or the properties of their debt choices.

We develop a capital structure model to study how price stickiness affects firms' optimal financing choices and credit risk. Firms produce differentiated goods using a risky production technology, financed using a mix of short-term and long-term debt, equity, and cash. In particular, they optimally choose their leverage and debt maturity by weighing the debt's tax benefits against bankruptcy costs. To avoid default, firms can issue seasoned equity, subject to flotation costs. Firms hold cash to insulate against future adverse shocks and avoid costly external financing, subject to agency costs. Importantly, we allow for heterogeneity in firms' ability to adjust their output prices in response to shocks. The degree of output-price rigidity

[1] Gorodnichenko and Weber (2016) show that firms with sticky output prices have higher conditional volatilities following monetary policy shocks; Weber (2015) associates price stickiness with an annual cross-sectional return premium of 4%; D'Acunto, Liu, Pflueger, and Weber (2018) find sticky-price firms increase leverage more following a relaxation of borrowing constraints despite lower unconditional leverage; and Pasten et al. (2020, 2023) show that heterogeneity in output price stickiness interacts with other heterogeneous features across firms and sectors and shapes the reaction to idiosyncratic and monetary policy shocks.

affects firms' operating flexibility and, therefore, their default risk.

Our model offers several predictions. Specifically, firms with more flexible-output prices have higher leverage and more long-term debt, but lower precautionary cash holdings, lower costs of debt, and less stringent covenants associated with their debt contracts. In addition, following an exogenous shock of equal magnitude to the cash-flow volatility of both types of firms, the cost of debt increases more for sticky-price than for flexible-price firms.

To test these new predictions, we use micro data underlying the producer price index (PPI) at the Bureau of Labor Statistics (BLS) that allow us to construct measures of nominal price rigidities. We merge these measures with financial and balance sheet data from CRSP and Compustat. We also source information on the cost of debt from Mergent FISD and TRACE, and on loan covenants from Thomson-Reuters LPC DealScan.

We first show that firms with the most sticky prices have higher precautionary cash holdings. Specifically, inflexible-price firms have cash buffers that are about 22% larger than those of flexible-price firms. These results are robust to accounting for a battery of well-known determinants of cash holdings, and after controlling for the influence of unobserved common macroeconomic or financial risk factors, as well as unobserved industry characteristics.

In a second step, we test the differential predictions for debt characteristics of firms with high and low nominal output price rigidity. Specifically, we show that it is more expensive for sticky-price firms to issue debt since they face greater issuance yield spreads. Relatedly, bonds of sticky-price firms trade at lower prices in secondary markets. We further show that sticky-price firms have shorter debt maturities and tighter loan covenants, on average.

After documenting these unconditional differences, we study the conditional response to shocks. We first show that nominal rigidities are an important channel of the monetary policy transmission to asset prices and firm decisions. In particular, we follow Gorodnichenko and Weber (2016) to construct monetary policy shocks and examine the differential reaction of flexible- and inflexible-price firms' squared credit spreads to monetary policy surprises. We find a differential increase in conditional volatility around 9 bps between fully flexible and fully sticky price firms to a hypothetical 25 basis points (bps) monetary policy shock.

Second, our framework generates additional testable predictions for the dynamics of credit spreads. Specifically, the response of credit spreads to heightened uncertainty (e.g., volatility of cash flows or profitability) should be amplified for firms that face higher nominal price rigidities. To support this prediction, we exploit the 2008 Lehman Brothers bankruptcy as an uncertainty shock (e.g., Chodorow-Reich, 2014; Ivashina and Scharfstein, 2010). As the largest bankruptcy filing in U.S. history, it caught market participants by surprise and the Dow Jones recorded its largest points drop since the September 11 terrorist attacks in 2001.

Consistent with the model's predictions, we document that, following the Lehman Brothers crash, credit spreads of inflexible-price firms increased significantly more than those of flexible-price firms. The immediate differential reaction from two months before to two months after the shock ranges between 172 bps to 243 bps using bond level data.

Third, as a refinement of our analysis, we exploit additional cross-sectional variation based on firms' financial constraints. Specifically, our model predicts sticky-price firms with higher refinancing costs should experience a greater increase in credit spreads in response to uncertainty shocks. We test this prediction using exposure to rollover risk (He and Xiong, 2012) around the Lehman Brothers' bankruptcy in a triple difference-in-differences specification.

All else equal, firms with refinancing needs when credit spreads hiked following the bankruptcy arguably faced higher refinancing costs. In fact, Almeida et al. (2011) and Nagler (2020) document that rollover risk is a predetermined channel that may amplify credit risk. Thus, we measure firms' rollover risk using the fraction of their debt maturing in 2009. Inflexible-price firms with high rollover risk experience a significantly larger increase in credit spreads following the Lehman Brothers bankruptcy, in line with the model prediction.

Together, the evidence confirms our model's predictions and highlights that output price rigidity is not only an important determinant of firms' financial policies and credit risk, but also an central channel that modulates the impact of monetary policy on asset prices.

We contribute to the literature that studies the role of nominal rigidities for financial outcomes. Using the micro data underlying the PPI in high-frequency event studies around the press releases of the Federal Open Market Committee, Gorodnichenko and Weber (2016) provide evidence consistent with a New Keynesian interpretation of price stickiness. Weber

(2015) shows that price stickiness earns a return premium of 4% per year in the cross section of stock returns, whereas D'Acunto et al. (2018) document that price stickiness is an important determinant of persistent differences in financial leverage across firms.

Our key contribution is to show that output price stickiness also affects firms' credit risk, their cash holdings, and debt characteristics including maturity, pricing, and covenants. We document a persistent wedge in issuance and secondary market yield spreads between flexible- and sticky-price firms. We further document a larger sensitivity in yield spreads of sticky-price firms to uncertainty shocks based on differential price reactions around the Lehman Brothers default. The higher sensitivity of sticky-price firms to uncertainty shocks leads these firms to accumulate more precautionary cash holdings. As a result, creditors are more likely to ask for tighter covenants and the issued debt is more likely to be short term.

Although price stickiness has been the focus of the modern New Keynesian literature on the real effects of nominal shocks, wage rigidities can play a similar role on the cost side. Indeed, a recent literature documents that across-industry heterogeneity in the degree of wage rigidity and labor shares results in return predictability, differences in credit risk, and helps resolve asset pricing puzzles (Belo et al., 2014, Belo et al., 2023, Favilukis and Lin, 2016a,b; Favilukis et al., 2020). As these papers, we study the impact of nominal rigidities on financial markets, but focus on frictions on the revenue rather than on the cost side. We show in robustness tests that both wage and price stickiness are important, complementary sources of credit risk.

Our paper also relates to studies on the effect of sticky leverage on credit risk. Bhamra et al. (2011), Kang and Pflueger (2015) and Gomes et al. (2016) model how nominal debt contracts can affect firms' credit risk in response to unexpected price level changes. Corhay and Tong (2021) find that sticky leverage can disrupt aggregate credit supply in the presence of constrained financial intermediaries. Bhamra et al. (2018) show how sticky leverage and cash-flows impact credit risk and equity valuations.[2] Table 1 highlights our contribution.

In contrast to these papers, we focus on the effect of sticky output prices on credit risk and provide new results for both the pricing and characteristics of debt in the cross-section of

[2]Our work also builds on the literature embedding dynamic capital structure decisions into equilibrium asset pricing models, including Bhamra et al. (2010b), Chen (2010), and Bhamra et al. (2010a).

firms. In related work, Gu et al. (2018) and Gu et al. (2017) study how scale irreversibility affects firm risk and financial leverage. Like these studies, we document how firm-level frictions modulate the exposure to aggregate risk and risk pricing in financial markets.

Given our focus on the relation between nominal price rigidities and credit risk, we also contribute to a voluminous literature on the determinants of credit spreads (e.g., Merton, 1974; Collin-Dufresne et al., 2001; Campbell and Taksler, 2003; Blanco et al., 2005; Chen et al., 2007; Bharath and Shumway, 2008; Zhang et al., 2009; Bongaerts et al., 2011; Acharya et al., 2013; Corhay, 2017; Siriwardane, 2019; Chen et al., 2020; Augustin and Izhakian, 2020). We contribute by documenting that the inability of firms to adjust their output prices leads to a permanent wedge in the cost of debt between sticky- and flexible-price firms.

We further document that sticky-price firms hold more cash due to their greater sensitivity to cash-flow shocks. This finding relates to the literature that rationalizes precautionary savings due to higher current and future credit risk (e.g., Bolton et al., 2014). Firms may also hold more cash when they face more exacting creditors (Subrahmanyam et al., 2017) or higher refinancing risk (Harford et al., 2014). That evidence is consistent with the view that firms favor cash over lines of credit for liquidity management (Acharya et al., 2012, 2013).

Lin et al. (2020) empirically show that higher production price risk leads to higher cash holdings in the electricity industry. We complement their work in that we motivate our empirical analysis with a theoretical framework and focus on output-price flexibility as opposed to flexibility in the production technology. Moreover, in contrast to their focus on one industry, we measure the frequency of price adjustment for many firms across different industries. Besides our results on the relation between price stickiness and cash holdings, we also examine its relation with debt maturity, the cost of debt, and covenant tightness.

Finally, we build on a large literature in macroeconomics on the determinants and role of output price stickiness. Zbaracki et al. (2004) estimate, for a large U.S. manufacturer, that the total costs of nominal price adjustments amount to 1.22% of total revenue and 20.03% of the net profit margin. Bils and Klenow (2004) and Nakamura and Steinsson (2008) use the micro data underlying the Consumer Price Index (CPI) at the BLS to show that prices are fixed for roughly six months, with substantial heterogeneity in price stickiness across industries. Goldberg and Hellerstein (2011) confirm these findings for producer prices.

Other recent contributions include Eichenbaum, Jaimovich, and Rebelo (2011); Anderson, Jaimovich, and Simester (2015); and Kehoe and Midrigan (2015). Pasten et al. (2020), Pasten et al. (2023) and Cox et al. (2020) study the role of heterogeneity in output price stickiness for the propagation of idiosyncratic, monetary policy, and fiscal shocks, respectively. Klenow and Malin (2010) review the recent literature on price rigidity using micro price data.

2 Model

This section presents a partial equilibrium model to highlight the key economic channels through which price stickiness affects a firm's financing policies and credit risk. Firms with greater price rigidity have lower operational flexibility. As a result, sticky-price firms become endogenously more exposed to adverse shocks and are, therefore, riskier. In equilibrium, price stickiness leads to lower financial leverage, more precautionary cash holdings, a higher probability of default, higher credit spreads, and a shorter average debt maturity. Since debt covenants can mitigate agency problems between shareholders and creditors, firms with inflexible-output prices have tighter covenants than firms with flexible prices.

2.1 Economic environment

The economy contains a continuum of firms with access to a linear production technology. Firms live for three periods and their ability to adjust nominal output prices in response to shocks is modulated by their degree of price stickiness. All claims are held by a representative investor whose preferences are summarized by an exogenous pricing kernel. Figure 1 provides a timeline of events.

At $t = 0$, firms finance by issuing equity, one-, and two-period debt. They also choose the amount of cash to hold as a buffer against future shocks.

At $t = 1$, each firm observes its productivity shock as well as all aggregate shocks and decides on the optimal amount of production and the nominal price. The price setting is inflexible, because with a positive probability the firm is unable to change its output price in response to the shock. The firm needs to repay its one-period debt obligation and can update its optimal level of cash holdings. When a firm falls short of cash, it has the option to issue new equity or to default on its debt. Any residual free cash flow at the end of the period is paid out as dividend to shareholders.

At $t = 2$, surviving firms experience a second firm-specific productivity shock as well as a series of aggregate shocks, they choose their output price (subject to price rigidity), realize profits, and decide on their default strategy. If the firm does not default, it repays the face value of long-term debt and distributes the remaining cash flows to equity holders as dividends. The firm then ceases operations.

2.1.1 Production

Each firm i operates a linear production technology that produces output y_{it}^s using a pre-determined capital stock k_{i0} and a variable input l_{it} (e.g., labor), which is purchased in a competitive market at a real unit cost of W:

$$y_{it}^s = \widetilde{X}_{it} k_{i0} l_{it}. \tag{1}$$

Here, $\widetilde{X}_{it}$ denotes a firm-specific i.i.d. log-normal productivity shock, i.e., $\log(\widetilde{X}_{it}) \sim \mathcal{N}(\mu_t, \sigma_t^2)$. While the realizations of $\widetilde{X}_{it}$ are not known in advance, their distribution is common knowledge and identical across firms. We allow the conditional moments of productivity, μ_t and σ_t, to vary over time, capturing aggregate productivity or uncertainty shocks (e.g., see Bloom (2009)). We denote the normal cumulative and probability distribution function by $\Phi(\cdot)$ and $\phi(\cdot)$, respectively.

The real demand for firm i's product, y_{it}^d, depends on the nominal price p_{it} it charges relative to the aggregate price level P_t:

$$y_{it}^d = \left(\frac{p_{it}}{P_t}\right)^{-\nu}, \tag{2}$$

where $\nu > 1$ is the elasticity of demand. A higher value of ν implies more elastic demand and, therefore, less market power for the firm.

Imposing the equilibrium condition that demand equals supply, i.e., $y_{it}^d = y_{it}^s = y_{it}$, the firm's real profit (i.e., normalized by P_t) is defined as revenues net of operating costs:

$$h_{it} = p_{it} y_{it} - P_t W l_{it} - P_t f k_{i0} \times \mathbb{1}_{t=1}, \tag{3}$$

where p_{it} is firm's i nominal output price and P_t is the aggregate price level. f is a fixed cost associated with maintaining the capital stock for the next period. Since the firm operates for three periods, it incurs this fixed cost only in periods 0 and 1. Without loss of generality, we normalize the initial capital stock k_{i0} to one.

2.1.2 Price stickiness

Following Calvo (1983), we assume that at the beginning of each period–after the realization of all relevant shocks–each firm faces an additional idiosyncratic shock, $\zeta_{it} \in 0, 1$, which determines its ability to adjust output prices. When $\zeta_{it} = 1$, the firm can freely re-optimize and choose a new output price. In contrast, when $\zeta_{it} = 0$, the firm is unable to adjust its price and must continue selling at the previous period's price, p_{it-1}. The conditional probability of being unable to adjust prices is denoted by $\theta \in [0, 1]$, which captures the degree of price rigidity. The limiting case of $\theta = 0$ corresponds to fully flexible prices.

2.1.3 Financing

***Debt*:** At $t = 0$, the firm decides on the issuance of short- and long-term real debt. Short-term debt matures at $t = 1$, while long-term debt matures at $t = 2$. Following Leland (1994, 1998), we assume the firm commits to this initial debt schedule but is allowed to issue new equity in future periods. Importantly, equity holders retain the option to default when the equity value becomes negative, with zero recovery for creditors in the event of default.[3] These deadweight default costs raise the effective cost of debt financing relative to equity.

To ensure an interior solution for the optimal debt–equity mix at $t = 0$, we assume that debt provides benefits to shareholders. For example, interest payments are tax-deductible,

[3] This assumption improves tractability, but our results remains if we assume partial recovery.

creating a tax advantage relative to equity financing. However, prior research suggests that tax benefits alone are insufficient to explain observed leverage levels (see, e.g., Graham (2000)). More broadly, the benefits of debt may also stem from its ability to mitigate agency or informational frictions, as argued by Myers and Majluf (1984) and Jensen (1986).

Following Gourio (2013) and Kang and Pflueger (2015), we capture the present value of all these benefits in reduced-form by assuming that the firm receives $(1 + \chi_S) > 1$ and $(1+\chi_L) > 1$ for each dollar of short-term and long-term debt issuance, respectively.[4] Higher values of χ_S and χ_L increase the attractiveness of debt financing and thus lead to higher leverage. The difference between χ_S and χ_L governs the relative appeal of short- versus long-term debt and determines the firm's optimal debt maturity structure. In our numerical analysis, we calibrate these parameters jointly to match observed firm-level leverage and the ratio of long- to short-term debt.

The total proceeds from debt issuance at time $t = 0$ are given by:

$$(1 + \chi_S)\, q_{i0}^S b_i^S + (1 + \chi_L)\, q_{i0}^L b_i^L, \tag{4}$$

where b_i^S (b_i^L) denotes the amount of short-term (long-term) real debt issued, and q_{i0}^S (q_{i0}^L) is its corresponding market price at $t = 0$.

Debt is issued in a competitive and rational lending market. Let $\mathbb{1}_{it}^{\text{survival}}$ denote a survival indicator that equals 1 if firm i does not default in period t, and 0 otherwise. The market value of debt corresponds to the expected present value of future cash flows:

$$q_{it}^S = \mathbb{E}_t\left[M_{t+1} \times \mathbb{1}_{i,t+1}^{\text{survival}}\right], \quad \text{for } t = 0, 1, \tag{5}$$

$$q_{i0}^L = \mathbb{E}_0\left[M_1 \times q_{i1}^S\right], \tag{6}$$

where M_t is the real stochastic discount factor. The firm's default decision is endogenous and determined by the equity holders' optimization problem as discussed later.

[4]This specification is equivalent to assuming that the benefits of debt are realized in the future, that is, that the net cost of debt to the firm at $t = 1$ and $t = 2$ is $(1 - \chi_S)b^S$ and $(1 - \chi_L)b^L$, respectively. This is because, under this formulation, the present value of the tax benefits at $t = 0$ is $\chi_S\, b^S\, q_0^S$ and $\chi_L\, b^L\, q_0^L$, which yields an identical optimization problem.

***Equity*:** At time $t = 0$, the firm can finance through equity issuance without cost. Additionally, it has the option to raise external equity in subsequent periods, subject to a cost λ for each dollar of seasoned equity issued (e.g., Jermann and Quadrini (2012), Eisfeldt and Muir (2016)). This assumption is motivated by the presence of flotation costs or agency frictions associated with equity issuance (Hennessy and Whited (2007)). As we show below, when external equity financing is costly, a wedge arises between the shadow value of $1 of external and internal funds. This wedge effectively induces risk aversion and makes precautionary cash holdings a key mechanism for avoiding costly external financing. Unlike debt holders, equity holders are entitled to residual cash flows and hold a limited liability option–allowing them to walk away with zero payout in the event of default.

***Cash*:** Each period, firms also decide whether to hold cash as precautionary savings against future productivity shocks. Holding cash can help reduce future financing costs. To prevent firms from excessively relying on cash–thereby neutralizing financing frictions–we introduce an agency problem following Nikolov and Whited (2014), whereby managers may divert free cash flows for private benefits. We model these agency costs in reduced form, analogous to the treatment of debt benefits. Let x_{it} denote the firm's real cash balance at the end of period t. We assume the firm incurs a cost of $\frac{\psi x_{it}}{2}$ per dollar of cash held, where $\psi > 0$. The net cash flow associated with cash balances is given by:

$$x_{it-1} - x_{it}\left(1 + \frac{\psi}{2}x_{it}\right). \tag{7}$$

This specification implies a quadratic cost of holding cash, governed by the parameter ψ. In our numerical analysis, we calibrate ψ to match the average level of cash holdings observed in the data.

2.2 Objective function

The firm's objective is to maximize the value of equity by taking a series of financing and production decisions, subject to the demand for the firm's product and the fair pricing of debt. Below, we drop the i-subscript, unless it is necessary to avoid confusion.

In period $t = 0$, the entrepreneur is unlevered and does not produce. The maximization problem therefore reduces to choosing the levels of short- and long-term debt, b^S and b^L, as well as initial cash holdings x_0, to maximize total proceeds from debt and equity issuance:

$$\max_{b^S,b^L,x_0} \Big\{ \mathbb{E}_0 \left[M_1 V_1(\tilde{\zeta}_1, \widetilde{X}_1, z_1, \Upsilon_1) \right] - x_0 - \frac{\psi}{2}(x_0)^2 \\ +(1+\chi^S) q_0^S(\tilde{\zeta}_1, \widetilde{X}_1, z_1, \Upsilon_1) \times b^S + (1+\chi^L) q_0^L(\tilde{\zeta}_1, \widetilde{X}_1, z_1, \Upsilon_1) \times b^L - f \Big\}, \tag{8}$$

subject to the breakeven conditions (5) and (6), which determine the equilibrium prices of short- and long-term debt, respectively.

The value of equity V_1, along with the debt prices q_0^S and q_0^L, depends on a set of state variables summarized by the vector $(\tilde{\zeta}_t, \widetilde{X}_t, z_t, \Upsilon_t)$. Specifically, $z_t \equiv (b^S, b^L, x_{t-1}, p_{t-1})$ captures the firm-specific state variables, while Υ_t denotes the vector of aggregate state variables. As a result, when making its financing decisions, the firm internalizes the impact of those choices on the market value of both its equity and debt claims.

In periods $t > 0$, the firm chooses the quantity and nominal price of its production and decides on its cash holdings x_t to maximize the equity value. It also has the option to issue seasoned equity when its dividend is negative, subject to a flotation cost λ. Alternatively, the firm declares bankruptcy when the firm value is negative. The firm faces two types of firm-level uncertainty– a shock $\widetilde{X}_t \in [0, +\infty)$ that impacts the firm's productivity and a shock $\zeta_t = \{0, 1\}$ that determines if the firm can change its product price, as well as a series of aggregate shocks. The real market value of equity satisfies the following recursive formulation for $t = 1, 2$:

$$V_t(\tilde{\zeta}_t, \tilde{X}_t, z_t, \Upsilon_t) = \max_{x_t, p_t(\tilde{\zeta}_t=1), l_t} \Big\{ \max\Big(d_t(\tilde{\zeta}_t, \tilde{X}_t, z_t, \Upsilon_t) + \mathbb{E}_t \left[M_{t+1} V_{t+1}(\tilde{\zeta}_{t+1}, \tilde{X}_{t+1}, z_{t+1}, \Upsilon_{t+1}) \right], 0 \Big) \Big\},$$

$$\text{subject to:} \qquad y_t(\tilde{\zeta}_t) = \left(\frac{p_t(\tilde{\zeta}_t)}{P_t} \right)^{-\nu} \tag{9}$$

where $p_t(\tilde{\zeta}_t) = \mathbb{1}_{\{\tilde{\zeta}_t=0\}} \times p_{t-1} + \mathbb{1}_{\{\tilde{\zeta}_t=1\}} \times p_t$ captures the fact that the firm can only optimize its nominal output price when $\tilde{\zeta}_t = 1$. The real dividends (i.e., normalized by P_t) paid by the firm at $t = 1, 2$ are:

$$d_1(\tilde{\zeta}_1, \widetilde{X}_1, z_1, \Upsilon_1) \quad = \quad \frac{h_1(\tilde{\zeta}_1, \widetilde{X}_1, z_1, \Upsilon_1) + x_0 - x_1(1+\psi) - b^S - f}{1 - \lambda \times \mathbb{1}_{\{d_1<0\}}}, \tag{10}$$

$$d_2(\tilde{\zeta}_2, \widetilde{X}_2, z_2, \Upsilon_2) \quad = \quad \frac{h_2(\tilde{\zeta}_2, \widetilde{X}_2, z_2, \Upsilon_2) + x_1 - x_2(1+\psi) - b^L}{1 - \lambda \times \mathbb{1}_{\{d_2<0\}}}. \tag{11}$$

2.3 Optimal policies

We next describe the firm's optimal policies. The firm's optimization with respect to labor is static, allowing us to solve the model in two steps.

First, we consider the cost-minimization problem in which the firm chooses the optimal amount of labor to minimize production costs, given a target level of output. This yields the firm's marginal cost, $\tilde{c}_t$, as a function of firm-level productivity:

$$\tilde{c}_t = \frac{W}{\widetilde{X}_t}. \tag{12}$$

The log of marginal cost therefore inherits the log-normal distribution of $\widetilde{X}_t$, specifically, $\log(\tilde{c}_t) \sim \mathcal{N}(\log(W) - \mu_t, \sigma_t^2)$. For expositional clarity, we will refer to marginal cost rather than productivity throughout the remainder of the draft, with the understanding that the two are inversely related: a decline in productivity corresponds to an increase in marginal cost.

In the second step, we jointly solve for the firm's optimal pricing, financing, and default decisions. Given the finite horizon of the problem, this step can be solved recursively. We summarize the resulting policy functions below and provide economic intuition and leave the full derivation details in Appendix A.1.

Pricing policy: We first solve for the optimal output price in each period, after substituting in the demand schedule. At $t = 2$, the flexible-price firm recognizes that it will cease operations after this period and therefore chooses its nominal price to maximize current profits. This yields a pricing policy in which the firm charges a constant markup of $\nu/(\nu-1)$ over the nominal marginal cost of production, $\tilde{c}_2 P_2$, that is,

$$p_2^{\star}(\tilde{c}_2) = \frac{\nu}{\nu-1}\tilde{c}_2 P_2. \tag{13}$$

In contrast, if the firm is unable to adjust its output price due to price rigidity, it must continue selling at the previously set nominal price p_1. This price may be suboptimal if either the marginal cost $\tilde{c}_2$ or the aggregate price level P_2 changes, exposing the firm to both real and nominal risk.

At $t = 1$, a flexible-price firm chooses its output price to maximize the present discounted value of dividends, resulting in the following optimal pricing policy:

$$\frac{p_1^{\star}(\tilde{c}_1)}{P_1} = \left(\frac{\nu}{\nu-1}\right) \frac{\tilde{c}_1 + \theta\left(1 - \lambda \times \mathbb{1}_{\{d_1<0\}}\right) \mathbb{E}_1\left[M_2\left(\int_0^{c^d_{\zeta_2=0}} \tilde{c}_2 d\Phi(\tilde{c}_2)\right)(\Pi_2)^{\nu}\right]}{1 + \theta\left(1 - \lambda \times \mathbb{1}_{\{d_1<0\}}\right) \mathbb{E}_1\left[M_2\left(\Phi\left(c^d_{\zeta_2=0}\right)(\Pi_2)^{\nu-1}\right)\right]}, \tag{14}$$

where $\Pi_2 \equiv P_2/P_1$ is the gross inflation rate between $t = 1$ and $t = 2$.

As in the case of $p_2^{\star}$, the optimal price at $t = 1$ consists of a markup over the nominal marginal cost of production. However, because of potential price rigidity in the next period, the firm now takes into account the possibility that the price it sets today may remain fixed at $t = 2$. This exposes the firm to both real marginal cost risk, via changes in $\tilde{c}_2$, and nominal risk, via inflation Π_2. The extent to which the firm incorporates these future risks into its pricing decision depends on two key forces, both ultimately shaped by the degree of price rigidity. First, a higher value of θ increases the likelihood that the firm will be unable to adjust its price in the future, making it more forward-looking in its pricing strategy today. Second, if the firm requires external equity financing (i.e., $d_1 < 0$) or faces a higher probability of default, it shifts its focus toward maximizing immediate cash flows, becoming more myopic in the process.

In short, price inflexibility affects the firm's pricing behavior both directly–through the probability of being stuck with today's price–and indirectly–by influencing the firm's financing and default decisions. Note that in the absence of price inflexibility, i.e., if $\theta = 0$, or in the absence of real and nominal risk, i.e., if $\tilde{c}_1 = \tilde{c}_2$ and $\Pi_2 = 1$, the firm would simply set

$$p_1^{flex} = \frac{\nu}{\nu - 1}\tilde{c}_1 P_1. \tag{15}$$

In contrast, the non-price optimizing firm sells its output at a nominal price of $\bar{p}_0$, which we normalize to 1.

Default and financing policy: In each period $t > 0$, the firm defaults when the marginal cost shock $\tilde{c}_t$ is sufficiently high to generate a negative equity value. Specifically, as long as $\tilde{c}_t$ remains below the default threshold $c_t^d(\tilde{\zeta}_t, z_t, \Upsilon_t)$, the firm continues operating. If the marginal cost shock leads to a liquidity shortfall—i.e., a negative dividend—the firm raises funds through costly external equity issuance. Combining these cases, the firm's financing decision rules can be summarized as follows:

$$\begin{cases} \text{default} & \text{if } \tilde{c}_t \geq c_t^d(\tilde{\zeta}_t, z_t, \Upsilon_t) \\ \text{issue new equity} & \text{if } c_t^d(\tilde{\zeta}_t, z_t, \Upsilon_t) > \tilde{c}_t \geq c_t^e(\tilde{\zeta}_t, z_t, \Upsilon_t) \\ \text{no financing} & \text{if } \tilde{c}_t < c_t^e(\tilde{\zeta}_t, z_t, \Upsilon_t), \end{cases} \tag{16}$$

where the equity issuance threshold $c_t^e(\cdot)$ and the default threshold $c_t^d(\cdot)$ are implicitly defined by the following conditions (see Appendix A.1.2.1 for a detailed derivation):

$$c_t^e := d_t(\tilde{\zeta}_t, c_t^e, z_t, \Upsilon_t) = 0, \tag{17}$$

$$c_t^d := V_t(\tilde{\zeta}_t, c_t^d, z_t, \Upsilon_t) = 0. \tag{18}$$

The endogenous thresholds in equations (17)–(18) determine the default probability, $1 - \Phi(c_t^d)$, and the probability of external equity financing, $1 - \Phi(c_t^e)$. Both probabilities depend on the full set of state variables $(\tilde{\zeta}_t, z_t, \Upsilon_t)$. Notably, the degree of price inflexibility θ plays a central role in shaping these probabilities. Price-inflexible firms are unable to adjust prices in response to real or nominal shocks, which increases their exposure to risk. For example, when facing an adverse cost shock, a firm with sticky prices cannot raise its output price, leading to larger losses. Conversely, when experiencing a favorable cost shock, it cannot lower its price to stimulate demand and capitalize on the opportunity. As a result, sticky-price firms are endogenously riskier, all else equal.

Figure 2 illustrates this mechanism by comparing the probability density function (pdf) of equity at $t = 2$ for a perfectly flexible firm (solid black line) versus a perfectly inflexible firm (dashed red line). The vertical line denotes the default threshold. The pdf of the inflexible firm is skewed to the left and exhibits a higher probability of default. This highlights how price stickiness, by increasing default risk and the need for liquidity, influences the firm's optimal financing decisions—including leverage and cash holdings—and ultimately affects the equilibrium price of debt as we show next.

Debt policy: We now turn to the firm's optimal decision regarding long-term debt, b^L, which we obtain by taking the first-order condition with respect to b^L at time $t = 0$:

$$\chi^L q_0^L = -(1+\chi^L)\frac{\partial q_0^L}{\partial b^L} b^L - (1+\chi^S)\frac{\partial q_0^S}{\partial b^L} b^S. \tag{19}$$

Equation (19) shows that optimal leverage is determined at the point where the marginal benefit of issuing long-term debt (left-hand side) equals its marginal cost (right-hand side). The marginal benefit arises from the additional proceeds per dollar of long-term debt raised, given by $\chi^L q_0^L$. The marginal cost reflects the firm's increased default incentives from additional debt issuance, which lowers the market value of both long- and short-term debt, as captured by the fact that $\partial q_0^H / \partial b^L < 0$ for $H = L, S$.

The optimal decision for short-term debt, b^S, is given by:

$$\chi^S q_0^S = -(1+\chi^L)\frac{\partial q_0^L}{\partial b^S} b^L - (1+\chi^S)\frac{\partial q_0^S}{\partial b^S} b^S + \underbrace{\left[\frac{\lambda}{1-\lambda}\left(\mathbb{P}_1(\text{financing}) - \mathbb{P}_1(\text{default})\right)\right]}_{\text{rollover cost}}, \tag{20}$$

where the probabilities of raising external financing and defaulting are given by $\mathbb{P}_1(\text{financing}) = 1 - \mathbb{E}_0\Phi(c_1^e(\tilde{\zeta}_1, z_1, \Upsilon_1))$ and $\mathbb{P}_1(\text{default}) = 1 - \mathbb{E}_0\Phi(c_1^d(\tilde{\zeta}_1, z_1, \Upsilon_1))$, respectively.

As with long-term debt, the marginal benefit of issuing an additional dollar of short-term debt (left-hand side) is the extra inflow, $\chi^S q_0^S$. The marginal cost (right-hand side) consists of two parts. The first two terms mirror the default-related costs seen in the long-term debt condition, arising from the deterioration in debt prices due to increased default risk. The third term—the rollover cost—captures the additional risk of needing to raise costly external equity in the next period. In essence, issuing more short-term debt today not only increases the probability of default, but also raises the likelihood of a liquidity shortfall that forces the firm to rely on costly external financing.

The degree of price stickiness plays a central role in shaping both the level and composition of corporate debt. Firms facing higher price rigidity (i.e., higher θ) are endogenously riskier, which reduces the net benefits of debt—both short- and long-term. This results in lower leverage, higher default risk, and wider credit spreads. Moreover, because long-term debt is only repaid if the firm survives for two periods, it is more sensitive to credit risk than short-term debt. As a consequence, and as we show later, firms with a higher degree of price stickiness tend to choose shorter average debt maturities.

Cash-holdings The firm's optimal cash holding decision is determined by equating the marginal benefits of holding an additional dollar in cash (left-hand side) with its marginal costs (right-hand side):

$$\frac{\lambda}{1-\lambda} \times \mathbb{P}_1(\text{financing}) + (1+\chi^L)\frac{\partial q_0^L}{\partial x_0} b^L + (1+\chi^S)\frac{\partial q_0^S}{\partial x_0} b^S = \psi x_0 + \mathbb{P}_1(\text{default}) \times \frac{1}{1-\lambda}. \quad (21)$$

Holding an additional unit of cash generates two main benefits. First, it reduces the likelihood that the firm will need to raise costly external equity in the future. Second, it lowers the probability of default, which increases the market value of both short- and long-term debt. These effects raise total debt proceeds. However, cash holdings also entail costs. On the one hand, they exacerbate agency frictions, captured by the term ψx_0. On the other hand, in the event of default, a larger portion of cash is lost, further reducing equity value.

Because sticky-price firms are endogenously riskier, they face a higher likelihood of both default and external financing. As a result, such firms optimally accumulate more precautionary cash in equilibrium to relax future financing constraints.

2.4 Monetary policy, SDF, and aggregate processes

In this section, we close the model by specifying a monetary policy rule and the stochastic discount factor (SDF), and by introducing a set of aggregate processes that will be useful for deriving additional predictions on the relationship between price flexibility and credit risk.

Monetary policy: Following the New Keynesian literature, we specify a Taylor rule for the nominal short-term interest rate:

$$r_t^{\$} = \bar{r}^{\$} + \phi_\pi \left(\log(\Pi_t) - \log(\bar{\Pi})\right) + x_{rt}, \tag{22}$$

where $\bar{r}^{\$}$ is the long-run nominal interest rate, $\phi_\pi > 0$ captures the sensitivity of the policy rate to deviations of inflation from its target, $\bar{\Pi}$ is the central bank's inflation target, and x_{it} represents an exogenous monetary policy shock. The Taylor rule allows us to generate surprise change in inflation via monetary policy shocks.

Aggregate processes: Our economy includes four exogenous aggregate processes: μ_t, σ_t, λ_t, and x_{rt}. We model each of these as persistent AR(1) processes:

$$\mu_t = (1-\rho_\mu)\bar{\mu} + \rho_\mu \mu_{t-1} + \sigma_\mu \varepsilon_{\mu t}, \tag{23}$$

$$\ln(\sigma_t) = (1-\rho_\sigma)\ln(\bar{\sigma}) + \rho_\sigma \ln(\sigma_{t-1}) - \rho_{\mu\sigma}\varepsilon_{\mu t} + \sigma_\sigma \varepsilon_{\sigma t}, \tag{24}$$

$$\ln(\lambda_t) = (1-\rho_\lambda)\ln(\bar{\lambda}) + \rho_\lambda \ln(\lambda_{t-1}) + \sigma_\lambda \varepsilon_{\lambda t}, \tag{25}$$

$$x_{rt} = \rho_r x_{rt-1} + \sigma_r \varepsilon_{rt}, \tag{26}$$

where ρ_m and σ_m denote the persistence and conditional volatility of each process, for $m = \mu, \sigma, \lambda$, and r, respectively.

The parameter $\rho_{\mu\sigma} > 0$ introduces a countercyclical component to volatility by allowing adverse productivity shocks (i.e., negative $\varepsilon_{\mu t}$) to increase uncertainty. This reduced-form specification captures the well-documented empirical regularity that uncertainty rises during recessions (e.g., see Bloom (2014)). Moreover, Chen (2010) and Bhamra et al. (2010a) show that this channel is useful for generating a sizable credit risk premium.[5]

Stochastic discount factor: Our focus is on the impact of price inflexibility on the cross-section of credit spreads. To this end, we specify an exogenous SDF process:

$$\ln(M_t) = -\bar{r} - \gamma \times \sigma_\mu \varepsilon_{\mu t}, \tag{27}$$

where $\bar{r}$ denotes the steady-state risk-free rate and γ is the price of risk associated with productivity shocks. We assume $\gamma > 0$, reflecting the notion that positive productivity shocks correspond to good states of the world and are therefore associated with lower values of the SDF.

Importantly, we remain agnostic about the sign of inflation risk in the SDF. This allows us to isolate and compare the effects of two distinct sources of aggregate risk on the cross-section of credit spreads: (i) real productivity shocks, which are priced in the SDF, and (ii) purely nominal shocks, which are not priced.

2.5 Numerical exercise and empirical predictions

The model is solved numerically using a second-order perturbation method. Additional details on the solution strategy, parameter calibration, and model fit are provided in online Appendix A.2. Our primary objective is to generate a set of qualitative, testable predictions regarding the impact of price rigidity on firms' financing decisions and credit risk in the cross-section of firms.

First, we examine how price rigidity influences firm-level risk by analyzing the response of credit spreads to a surprise increase in marginal costs—equivalent to a negative productivity shock $\varepsilon_{\mu t} < 0$—immediately after financing decisions are made. The results are shown in Figure 3. Following the shock, expected real marginal costs rise persistently across firms, reducing valuations and widening credit spreads. Flexible-price firms can partially offset

[5]This feature is included primarily for quantitative purposes. All results are robust to setting $\rho_{\mu\sigma} = 0$.

the shock by increasing their prices, whereas sticky-price firms are unable to re-optimize and must absorb the full cost increase. This leads to larger declines in firm value and a more pronounced rise in credit spreads for sticky firms. Importantly, since recessions are associated with a higher price of risk as reflected by the increase in the stochastic discount factor (SDF)—the debt of sticky-price firms not only carries higher average credit risk, but also earns a larger risk premium. In short, sticky-price firms are more exposed to both idiosyncratic (see Figure 2) and aggregate productivity shocks, making them riskier.

Anticipating this heightened risk exposure, firms adjust their financing decisions based on their degree of price flexibility. Figure 4 plots optimal financing policies and equilibrium credit spreads at $t = 0$ as a function of θ. Sticky-price firms (i.e., those with higher θ) are riskier and therefore issue less, and more expensive, debt—resulting in lower average leverage and higher credit spreads. Moreover, due to the greater countercyclicality of credit spreads, the debt of sticky-price firms commands a higher credit risk premium. Since long-term creditors are repaid only if the firm survives for two periods, long-term debt is more sensitive to default risk than short-term debt. Consequently, inflexible firms rely more heavily on short-term debt to take advantage of the tax benefits of debt financing, which reduces average debt maturity. To offset both the elevated credit risk and the increased rollover risk associated with shorter-term debt, sticky-price firms accumulate more precautionary savings—resulting in higher average cash holdings.

We summarize our model's findings in three novel testable hypotheses that we aim to validate empirically in the next section. We omit the prediction that greater nominal price rigidity is associated with lower leverage, as this relationship has already been documented by D'Acunto et al. (2018):

H1: *Sticky-price firms have higher cash holdings than flexible-price firms.*

H2: *Sticky-price firms have higher credit spreads and risk premium than flexible-price firms.*

H3: *Sticky-price firms have lower average debt maturity than flexible-price firms.*

While not explicitly modeled, debt covenants would allow long-term creditors to restructure outstanding debt in the event of a covenant violation, thereby reducing credit risk. Given that sticky-price firms face greater cash-flow uncertainty and higher credit risk, they are likely to benefit more from tighter covenants than flexible-price firms. In effect, covenants serve a role similar to shortening debt maturity by reducing creditors' exposure to default risk. This logic leads to a fourth testable prediction:[6]

H4: *Sticky-price firms have tighter covenants than flexible-price firms.*

Another testable implication of 3 is that the debt prices of sticky-price firms should be more sensitive to productivity shocks. However, identifying such shocks empirically is challenging. To address this issue, we turn to alternative exogenous shocks in the model that are arguably easier to isolate in the data—namely, monetary policy and volatility shocks.

Figure 5 examines how credit spreads respond to a surprise monetary policy shock that leads to an increase in inflation. The SDF is not affected by the shock so that it can be interpreted as a pure nominal shock which raises inflation and thus the nominal marginal costs. Flexible-price firms can adjust their output prices accordingly, passing the higher price level on to customers. As a result, they are insulated from the effects of the nominal shock, and their credit spreads remain unchanged (see blue solid line). In contrast, sticky-price firms are unable to re-optimize their prices, so nominal shocks directly affect firm valuations. For firms that are currently overpricing relative to the flexible firm's optimal price (red dashed line), the inflation shock reduces the wedge between their actual and optimal prices, improving valuations and lowering credit spreads. Conversely, firms charging below the optimal price are pushed further away from optimality, which reduces firm value and raises credit spreads (see dotted black line).

While the direction of the response may vary, the magnitude of the effect is consistently larger for sticky-price firms. This asymmetry leads to our next empirical prediction:

[6]Our framework could be extended to include an additional constraint on earnings, such that renegotiation is triggered if $d_1(\zeta_1, p_1) < \alpha$, where α captures the tightness of the covenant. Tighter covenants benefit both shareholders and creditors by reducing ex-ante credit risk, thereby allowing for higher leverage and greater debt benefits. However, covenants also impose costs on shareholders, such as disutility from reduced control. The optimal level of covenant tightness would then be characterized by the value of α that maximizes firm value. Since sticky-price firms gain more from a marginal reduction in credit risk, the optimal covenant would be tighter for these firms (i.e., a higher α).

H5: *The magnitude of the change in credit spreads in response to a monetary policy shock is lower for flexible-price firms than for sticky-price firms.*

Figure 6 repeats the exogenous shock experiment but using a positive uncertainty shock, which increases the volatility of profits. The effect of this shock is likely to depend on the level of price rigidity for two reasons. First, sticky-price firms have a higher likelihood of default, making their debt value more sensitive to changes in volatility.[7] Second, higher uncertainty implies a higher chance of being stuck at inefficient price levels, further increasing the risk of a sticky-price firm relative to that of a flexible-price firm. In panel A of Figure 6, we compare the impulse response function of credit spreads to an increase in uncertainty for a flexible- vs. a sticky-price firm. As for the demand shock, the increase is comparatively higher for sticky-price firms. Panel B of Figure 6 reports the difference in responses between the flexible- and sticky-price firms, which is noticeably negative. Thus, we posit the following hypothesis:

H6: *The increase in credit spreads in response to an uncertainty shock is lower for flexible-price firms than for sticky-price firms.*

The amplified reaction of inflexible-price firms' credit spreads to an uncertainty shock is likely more pronounced for firms that face a higher rollover risk, because those firms cannot freely use external financing to meet their liquidity needs. Thus, they have a higher increase in credit risk, all else being equal. Therefore, we expect the positive relation between price inflexibility and the sensitivity of credit spreads to uncertainty shocks conjectured in H6 to be amplified for firms with a higher cost of external financing λ. Panel C of Figure 6 formally tests this prediction in our model. In particular, we replicate Panel A for two types of firms: firms with a high cost of external financing, λ, (red lines) and those with a low λ (blue lines). Panel D reports the differential responses between flexible- and sticky-price firms, conditional on λ. Consistent with the intuition above, higher external financing cost further amplifies the relation described in H6. Our final testable hypothesis is, therefore:

[7] As an analogy, consider the Merton (1974) model, in which corporate debt is a default-free bond minus a put option on the firm's assets. Since sticky-price firms default more often, they are more likely to "exercise" the default put option. This makes corporate debt values more sensitive to changes in volatility.

H7: *The additional sensitivity of credit spreads in response to an uncertainty shock for sticky-price firms is amplified for firms facing a higher cost of external financing.*

3 Data

This section outlines the data used to test the model's predictions. A key input is confidential micro-level pricing data from the BLS underlying the PPI. We merge firm-level measures of price flexibility with balance sheet information on cash holdings and debt maturity from Compustat. Bond and loan characteristics, including issuance costs and covenants, are sourced from Mergent FISD and Thomson Reuters LPC DealScan. We also construct a range of financial ratios. Appendix Table A.3 provides detailed variable definitions.

Our sample includes all firms that were part of the S&P 500 during the period for which pricing data are available, following Gorodnichenko and Weber (2016) and D'Acunto et al. (2018). Following standard practice, we also exclude financial and utility firms (SIC 6000–6999 and 4900–4999).

3.1 Micro pricing data

Our analysis relies on measures of nominal price rigidity at the granular six-digit NAICS industry level, as constructed by Pasten et al. (2023, 2020). These measures are based on monthly price data for individual goods, covering the period from 1982 to 2018.

The BLS defines prices as "net revenue accruing to a specified producing establishment from a specified kind of buyer for a specified product shipped under specified transaction terms on a specified day of the month." Unlike the Consumer Price Index, the PPI measures the prices from the perspectives of producers. The PPI tracks prices of all goods-producing industries such as mining, manufacturing, gas and electricity, and the service sector.[8]

[8]The BLS samples service sector prices since 2005 and the PPI covers about 75% of its output.

The BLS uses a three-stage procedure to construct their sample of products. First, it compiles a list of all firms filing with the Unemployment Insurance system to construct the universe of all establishments in the United States. Then, the BLS probabilistically selects sample establishments and goods based on the total value of shipments, or, on the number of employees. The final data set covers 25,000 establishments and 100,000 individual items. Prices are collected through a survey, which is emailed or faxed to participating establishments. Individual establishments remain in the sample for an average of seven years, until a new sample is selected to account for changes in the industry structure.

Our analysis is based on granular industry-level aggregates of product-specific frequencies of price adjustment (FPA). FPA is computed using the frequency of price adjustment at the good level as the ratio of price changes to the number of sample months. For example, if an observed price path is $4 for two months and then $5 for another three months, one price change occurs during five months and the frequency is 1/5. For details, see Gorodnichenko and Weber (2016) and Weber (2015).

Price stickiness may vary across narrowly-defined industries. Such heterogeneity may arise because of different degrees of concentration, differential negotiation power with customers and suppliers, the physical costs of changing prices, or the managerial costs associated with information gathering, decision making, and communication (Zbaracki et al., 2004). To ensure that measures of price stickiness do not simply capture differential degrees of market power or industry concentration, we directly control for price-cost margins at the firm level as well as measures of industry concentration in all our regressions. Another potential concern is that a higher level of FPA captures higher volatility in the price markup or marginal cost of production instead of output price flexibility (see Eq.**??**). However, this heterogeneity is unlikely to rationalize our findings because a higher volatility would mean higher risk and result in higher cash holdings and credit spreads, the opposite of what we find empirically.

3.2 Cash holdings

To measure a firm's cash holdings, we use the net cash ratio, defined as the log ratio of cash and marketable securities over net assets (i.e., total assets net of cash and marketable securities), which is widely used in the literature (Opler et al., 1999; Bates et al., 2009; Harford et al., 2008). Our results are robust to other measures of cash holdings, such as the ratio of cash over assets. To compute the net cash ratio, we retrieve fundamental balance sheet data at the annual frequency from the CRSP-Compustat Merged Database between 1982 and 2018, the period over which we can measure nominal price rigidities.

3.3 Debt maturity

We approximate a firm's debt maturity using the ratio of long-term debt to total debt, i.e., the long-term debt ratio, from Compustat between 1982 to 2018. For accuracy, we validate the debt maturity data with information from Capital IQ, which, however, has comprehensive coverage of debt only since 2001.

3.4 Cost of debt

We use two data sets to test our prediction on the relation between the cost of debt and FPA. First, we examine the cost of debt in the primary market using bond issuance data. Second, we examine it in the secondary market using bond transactions data.

We retrieve corporate bond issuance data between 1982 and 2018 from Mergent FISD. We exclude U.S. government bonds, asset-backed, floating-rate, exchangeable, convertible, perpetual bonds, and bonds in a unit deal, with credit enhancement, or denominated in foreign currency. We also eliminate issues with missing offering date, offering price, maturity, or offering amount. We merge the issuance data with fundamental balance sheet data from Compustat based on the latest fiscal-year-end preceding the issuance date (within 1 year).

We examine debt issuance cost using the spread of a debt contract's offering yield over the benchmark Treasury yield from FRED on the issuance date. In our main results, we use the linearly interpolated rate from the U.S. Treasury constant maturity yield curve based on the maturity of the bond to proxy for the benchmark risk-free rate, but our results are similar if we use the yield of a maturity-matched U.S. Treasury bond.

We source transactions for U.S. corporate bonds from the TRACE Enhanced database between July 2002 and December 2018. We apply the same filters as for the bond issuance sample except for the requirement of non-missing offering prices. We remove canceled records and adjust corrected or reversed transactions following Dick-Nielsen (2009, 2014).

To construct a monthly sample of bond credit spreads, we first compute the daily volume-weighted average transaction price. Then, we use information from Mergent FISD to calculate the yield to maturity. We obtain daily credit spreads by subtracting the benchmark Treasury yield as a proxy variable for the risk-free interest rate. Finally, we compute monthly credit spreads using equally-weighted average daily spreads. Our results are similar if we construct monthly spreads using volume-weighted daily data. As for the bond issuance sample, we aggregate the bond-level data at the firm level by calculating the weighted average credit spreads using the outstanding bond amounts as weights.

3.5 Covenants

We examine whether sticky-price firms are more likely to have tighter covenants using loan covenants data from Thomson-Reuters LPC DealScan.[9] Evidence exists that loan covenants are more prevalent and effective than bond covenants due to lower renegotiation costs by banks (Gilson and Warner, 1998; Bradley and Roberts, 2015).

The loan issuance sample is available from 1992 to 2018. DealScan includes detailed information on each loan deal (or package) and the corresponding loan facilities, including the deal activation date, maturity date, deal amount, and details on covenants. We merge each loan from DealScan with its borrowing firm in Compustat using the link table provided by Chava and Roberts (2008).[10] We merge the information on loan covenants at the deal level with the latest quarterly fundamental data prior to the deal activation date (within 1 year).

We focus on covenants related to leverage, senior leverage, debt/equity, debt/tangible net worth, interest coverage, fixed coverage, cash interest coverage, debt/EBITDA, senior

[9] The bond issuance data from Mergent FISD only contains information on the existence of covenants, whereas DealScan provides more detailed information on loan covenants, including the covenant thresholds.

[10] The link table provided by Chava and Roberts (2008) ends in mid-2017. We match the remaining loans in 2017 and 2018 with companies in Compustat based on company names.

debt/EBITDA, current ratio, quick ratio, net worth, tangible net worth, EBITDA and capital expenditures. We provide definitions of all variables in Panel C of Appendix Table A.3.

We follow Murfin (2012) in measuring covenant tightness. For each loan deal, each covenant requires that some financial ratio or other metric be greater than (or less than) some threshold. Murfin (2012) defines covenant tightness of a loan as the probability that any covenant is violated. Specifically, let r_i and $\underline{r}_i$ be the financial ratio and threshold, respectively, for covenant i so that $r_i \leq \underline{r}_i$ triggers a covenant violation. Then, assuming joint normality of the financial ratios, tightness is measured by the probability that at least one of the covenants is violated. Thus, we have that:

$$\text{Tightness} = 1 - \Phi_N(\mathbf{r} - \underline{\mathbf{r}}), \tag{28}$$

where Φ_N is the cumulative distribution function of a multivariate normal distribution with mean zero and covariance matrix Σ, and $\mathbf{r} = [r_1, \ldots, r_n]'$ and $\underline{\mathbf{r}} = [\underline{r}_1, \ldots, \underline{r}_n]'$ are the vectors of the covenant variables and their required thresholds, respectively.

We estimate Σ using quarterly changes in the log financial ratios and allow for variation across 1-digit SIC industries and over time. Specifically, for each firm-quarter observation matched to a loan, we estimate Σ using past 10-year quarterly data among firms in the same 1-digit SIC industry. If there are less than 20 observations, we estimate Σ using the sample covariance matrix among firms in the same 1-digit SIC industry. We remove the loan observation if any covenant is violated in the first quarter.

3.6 Descriptive statistics

We report in Table 2 summary statistics for our baseline sample from 1982 to 2018. Our matched sample of annual fundamental data contains 1,045 unique firms with 21,291 firm-year observations. Among these, 21,273 have information on cash ratios. Long-term debt ratios exist for 1,016 firms and 17,172 firm-year observations. Our bond issuance sample includes 6,858 bonds from 676 firms with available cost of debt. Our monthly bond transactions sample contains 541,798 observations for 12,500 bonds issued by 493 firms. The loan issuance sample includes 2,968 loans from 621 borrowers with available tightness measure.[11]

We first discuss statistics on firm fundamentals reported in Panel A. The average industry-level FPA in our sample is 0.241, suggesting that firms in our sample keep their output prices unchanged, on average, for a period of 3.6 months $(-1/(log(1-FPA))$. The large standard deviation of 0.179 relative to the average level of price rigidity indicates a substantial amount of variation in FPA across firms.

The average firm has a cash to assets ratio of 13%, and that ratio is 30% if measured as a fraction of net assets. The median firm has a cash ratio less than 8%. The long-term debt ratio is 0.64, suggesting that firms have, on average, 64% of their debt maturing in more than 3 years. A significant amount of heterogeneity, however, exists in the long-term debt ratio, which ranges from 0% to more than 99% at the 5th and 95th percentiles of the distribution, respectively. All other information for firm fundamentals is standard.

In Table 3, we show the pairwise correlation coefficients for all variables. FPA is negatively correlated with the cash ratio measured in levels (−23%) and in logs (−26%), and it is positively correlated with the long-term debt ratio (14%). These statistics provide preliminary suggestive evidence that sticky-price firms indeed hold more cash and more short-term debt than flexible price firms. In addition, FPA is positively correlated with leverage (12%), consistent with the findings of D'Acunto et al. (2018).

In Panel B of Table 2, we show summary statistics related to the cost of debt. The average yield spread at issuance is 1.54%, with a standard deviation of 1.43%. Issuance spreads range from less than 40 bps to more than 430 bps. The average bond in our sample has an issuance amount of $546 million and has an ordinal credit rating of 7.68, corresponding to a rating of Baa1 or BBB+ by Moody's and Standard & Poor's, respectively. About 75.6% of all bonds are callable, which motivates us to retain this important segment of the market in our sample. To control for the feature of embedded options in our analysis, we add to all our specifications an indicator variable that is equal to one if the bond is callable and zero otherwise. Most of the bonds are senior and are not putable. Among all bond issues in our sample, 11.6% correspond to private placements.

[11] Detailed definitions of all variables are available in Appendix Table A.3.

In Panel C, we report summary statistics for the bond transactions sample. The distribution of bond characteristics in the secondary market resembles that in the primary market reported in Panel B. Hence, for brevity we only include statistics for the monthly yield spreads. The average yield spread is 1.95% and ranges from less than 38 bps to over 550 bps at the 5th and 95th percentiles of the distribution, respectively.

Finally, we provide in Panel D of Table 2 summary statistics for the variables relating to loan covenants. We estimate an average covenant tightness of 0.11, with a range between 0 and more than 0.44. Our sample contains only S&P500 firms, which are large and have, therefore, typically less tight covenants than small firms. The average loan maturity is 3.80 years and the average deal amount is 1,196 million. A loan deal contains approximately 11 bank participants, and 22% of all loans in our sample are secured.

4 Empirical Analysis

In our baseline analysis, we investigate the relation between price stickiness and cash holdings, debt maturity, cost of debt, and covenant tightness. Our most general specification is the following OLS regression specification:

$$Characteristic_{i,t} = \alpha + \beta FPA_{j,t} + \gamma \cdot X_{i,t} + \eta_t + \nu_k + \varepsilon_{i,t}, \tag{29}$$

where $Characteristic_{i,t}$ is one of the outcome variables of interest measured at the firm or bond level i, that is, the net cash ratio, the long-term debt ratio, the yield spread (at issuance or in the secondary market), and loan covenant tightness, i.e., $Characteristic_{i,t} \in \{cashratio, maturity, yieldspread, tightness\}$.

$FPA_{j,t}$ is the frequency of price adjustment, which is higher for firms in six-digit NAICS industries with more flexible prices; $X_{i,t}$ contains a set of standard control variables; η_t refers to year (year-month for the bond transactions sample) fixed effects, which absorb time-varying shocks faced by all firms or bonds, such as changes in economy-wide interest rates; ν_k contains industry fixed effects defined at the one-digit SIC level. These fixed effects absorb time-invariant unobservable characteristics that differ across industries.

For our firm-year sample, both dependent and firm-level control variables are measured at a yearly frequency, using information at the fiscal-year end. We use firm-level control variables that are suggested by the previous literature, including firm size, leverage, market-to-book (M/B) ratio, return on assets (ROA), equity volatility, intangibility, firm age, not-rated dummy, interest coverage, loss dummy, and z-score dummy. Following D'Acunto et al. (2018), we include two measures of market power and industry concentration as those may affect firms' price-setting strategies, namely, the price-to-cost margin and the Herfindahl-Hirschman index (HHI) of sales measured at the Fama-French 48 industry level.

For our bond (loan) issue sample, control variables include both bond (loan) characteristics and firm-level control variables. The bond-level control variables include bond rating, size, maturity, and indicator variables for callable, senior, putable, and private-placed bonds. The loan-level control variables include loan maturity, deal amount, number of bank participants, and indicator variables for secured loans and different loan types and purposes. The firm-level control variables are measured at the fiscal-year end (fiscal-quarter end) prior to the bond (loan) issuance date. We use the same control variables for our bond transactions sample, for which we measure firm-level variables at the fiscal-year end prior to the month for which we observe transactions. The definitions of all bond-level (loan-level) variables are listed in Panel B (C) of the Appendix Table A.3.

We run panel regressions, and, across all specifications, double cluster standard errors at the firm and year (year-month for the bond transactions sample) level. To remove the impact of outliers, we winsorize all variables at the 1% and 99% levels, except for indicator variables, categorical variables, and variables transformed using the natural logarithm.

4.1 Nominal rigidities and cash holdings

In Table 4, we report the panel regression results for the net cash ratio as the dependent variable, which we define as the natural logarithm of the ratio of cash to net total assets.

In column (1) of Table 4, we report our baseline results keeping constant firm characteristics that the previous literature associated with differences in cash holdings but without fixed effects. The coefficient of FPA is negative and significant at the 1% level, which is consistent with the model's prediction that flexible-price firms have fewer precautionary savings motives than sticky-price firms. A one standard deviation increase in FPA corresponds to a 22% ($1 - e^{0.18\times(-1.41)} = 22.4\%$) reduction in the net cash ratio, which suggests an economically meaningful difference in precautionary cash holdings between flexible- and inflexible-price firms. The benchmark specification in column (1) yields an adjusted R^2 of 27.8%. In the unreported univariate regression without control variables, we obtain an adjusted R^2 of 6.6%, which reflects a noteworthy correlation of 26% between FPA and cash holdings, consistent with the statistics reported in Table 3.

In columns (2) to (5) of Table 4, we successively add year fixed effects, industry fixed effects, both year and industry fixed effects, and their interaction. We find that FPA is consistently significant across these different specifications, and that the coefficient estimate changes little in magnitude. Accounting for common variation across firms using year fixed effects in column (2) has no impact on the coefficient. Adding industry fixed effects in column (3) reduces the coefficient of FPA from -1.41 to -1.01, implying that industry fixed effects partly subsume the explanatory power of FPA. We obtain a similar result when we absorb both time-invariant industry and macroeconomic variation in column (4). In column (5), we add the interaction of year and industry fixed effects to absorb any latent trends at the industry level. The estimated coefficient indicates significant within-industry differences in precautionary cash holdings between flexible- and inflexible-price firms. Overall, the evidence supports the model prediction that more flexible-price firms hold less cash.

4.2 Nominal rigidities and debt maturity

In Table 5, we report results for the long-term debt ratio, which we measure at fiscal year end, based on the fraction of total debt that matures in more than three years. However, our results are robust to using five or seven years as cut-off levels for long-term debt.[12]

Column (1) shows that FPA is positively and significantly related to the long-term debt ratio, after controlling for a host of firm characteristics. This association supports the model

[12] For brevity, we refrain from reporting estimates on control variables in this and subsequent tables.

in that firms with more flexible prices have longer debt maturity. The coefficient estimate of 0.11 implies that the difference in the long-term debt ratio between a perfectly flexible ($FPA = 1$) and perfectly inflexible ($FPA = 0$) firm is around 11%, on average.

When we control for common trends across firms over time via year fixed effects in column (2), the coefficient estimate for FPA remains significant and does not change in magnitude. In columns (3) to (5), we add industry fixed effects and their interaction with year fixed effects. The coefficients on FPA remain significant and the magnitude barely changes.

4.3 Nominal rigidities and cost of debt

Table 6 shows the relation between nominal price rigidity and a firm's credit spreads. In Panels A and B, we focus on the primary market using the cost of debt at issuance. In Panels C and D, we focus on the secondary market using prices from bond transactions.

In columns (1) to (3) of Panel A in Table 6, we successively include control variables, year and industry fixed effects. In all these specifications, the coefficient is significant and ranges between -0.37 and -0.47. These coefficients imply that a one standard deviation difference in price rigidity translates into an average difference in issuance costs of 6 to 8 bps. Since the average issuance amount in our sample is \$546 million, this number corresponds to an annual differential borrowing cost between approximately \$327,600 and \$436,800. In column (4), we obtain similar results when we control for both time and industry fixed effects

In column (5), we add the interaction between year and industry fixed effects. The coefficient of FPA remains negative and significant in this most stringent specification, which accounts for unobserved time-varying industry-level trends in the cost of debt. Results are similar when we aggregate the data at the firm level (see Panel B of Table 6).

In Panels C and D of Table 6, we report results using the secondary market data. In Panel C, we report results at the bond level. In Panel D, we aggregate credit spread data at the firm level using the weighted average credit spreads across a firm's bond transactions with the amounts outstanding as weights. The magnitudes of the coefficients across Panels C and D are remarkably similar, while the statistical significance is stronger for the results reported in Panel D. The higher significance is indicative of measurement noise in bond prices that focusing on firm level data can reduce. We therefore focus on the results in Panel D. The coefficients in columns (1) to (5) in Panel D of Table 6 range between -0.43 and -0.50 suggesting a differential yield spread in secondary bond markets of about 7 to 9 bps for firms that have a one standard deviation difference in their FPA.

Overall, we find supportive evidence in both the primary and secondary bond markets that sticky-price firms have a higher cost of debt than flexible-price firms.

4.4 Nominal rigidities and loan covenants

In Table 7, we examine the relation between price flexibility and covenant tightness. In column (1) of Table 7, the coefficient on FPA is negative and significant, indicating that flexible-price firms have less tight covenants than sticky-price firms. In column (2), after adding year fixed effects, the coefficient for FPA remains negative and significant with a similar economic magnitude.

The coefficient estimates on FPA remain significant when we control for industry or industry and year fixed effects (see columns (3) and (4)). When we exploit the within-industry and time variation of price flexibility through interactions of year and industry fixed effects in column (5), the coefficient of FPA remains significant at the 1% level.

Murfin (2012) refers to covenant tightness as a "stylized probability of lender control based on covenant violation, or more generally, the inverse of a borrower's distance to technical default." In line with that interpretation, our results suggest that flexible price firms are less likely to trigger technical defaults. Thus, the coefficient of -0.07 in column (5) indicates that a fully flexible-price firm has a technical default probability that is 7 percentage points lower than that of a perfectly inflexible-price firm.

In unreported results, we examine which type of covenant is driving the relation between price inflexibility and covenant tightness. We follow Prilmeier (2017) and group covenants into 7 categories related to balance sheet variables (leverage, senior leverage, debt/equity, debt/tangible net worth), coverage ratios (interest coverage, fixed coverage, cash interest coverage), debt to cash flow ratios (debt/EBITDA, senior debt/EBITDA), liquidity ratios (current ratio, quick ratio), net worth (net worth, tangible net worth), EBITDA and capital expenditures (CapEx). We find a significant relation between FPA and the covenants associated with the debt to balance sheet ratios, debt to cash flow ratios, and net worth.

4.5 Discussion and robustness

In our framework, price inflexibility is the fundamental driver of cross-sectional differences in firm policies and credit risk. The effect of price stickiness on these variables operates through its effects on the firm's operating flexibility, which endogenously increases the exposure to shocks and potentially affects cash-flow volatility.

To isolate the effect of price inflexibility from other potential drivers of cash-flow risks, we control for firms' equity volatility in all regressions. We find that it does not affect the economic or statistical significance of our results (see, e.g., Table 4). As a persistent firm characteristic, price stickiness is likely a fundamental driver of firm policies (Nakamura et al., 2018). Firms are unlikely to adjust corporate policies to short-term time-varying changes in cash-flow volatility, which are, therefore, less likely to determine corporate policies.

To strengthen the evidence that price stickiness affects firms' policies differently than other drivers of volatility, we replace FPA by other measures of cash-flow and sales-growth volatility.[13] Table A.4 compares the coefficients of interest using our benchmark measure, FPA, versus alternative volatility measures. While price rigidity is consistently significant with the expected sign, the coefficients associated with alternative volatility predictors are mostly insignificant or have signs that run opposite to standard economic intuition. Overall, these results support the view that price flexibility is a fundamental source of risk for firm policies and credit risk rather than other determinants of cash-flow volatility. These results also align with our predictions in Figure 2, which suggests that FPA positively affects the first and third moment of profitability over and above any effect on second moments.

[13] Cash-flow volatility is defined as the standard deviation of the ratio of cash flows to assets over the past 10 years, with cash flows defined as earnings after interest, dividends, and taxes but before depreciation. Sales-growth volatility is defined as the standard deviation of annual sales growth over the past 10 years.

Since the distribution of FPA is right-skewed, we also verify that our results are not driven by firms with disproportionally high price flexibility. In Table A.5, we report our most conservative specifications using the natural logarithm of FPA instead of FPA. Using this alternative measures of FPA does not affect the significance of our findings.

Finally, to distinguish the effect of price stickiness from other forms of nominal rigidities, we compare in Table A.6 the relation between our outcome variables and FPA to that with wage rigidity (Panel A) and sticky leverage (Panel B). We follow Favilukis and Lin (2016a) and measure wage rigidity using both the standard deviation and the first-order autocorrelation coefficient (AC1) of annual wage growth at the 2-/3-digit NAICS industry level from the NIPA tables between 1998 and 2019. In a similar way, we measure sticky leverage using both the five-year rolling-window standard deviation and the AC1 of debt growth, where debt growth is defined as the first difference of the natural logarithm of total debt (Lyandres et al., 2008). These results support the view that price stickiness is an independent nominal rigidity and that both wage and price rigidities are complementary drivers of credit risk, consistent with Favilukis et al. (2020).

4.6 Nominal rigidities and monetary policy transmission

This section tests Hypothesis H5, which predicts that the credit spreads of flexible-price firms exhibit smaller absolute responses to monetary policy shocks.

Our MPS follows Gorodnichenko and Weber (2016) and is defined as the scaled change in the federal funds futures rate in a 30-minute window around the announcement of federal funds target rate by the Federal Open Market Committee (FOMC). We identify 133 announcements with non-overlapping event windows and available corporate bond transactions data between July 2002 and December 2018. For each firm, we compute the weighted average (by amount outstanding) yield spread in the 10 days before and after the announcement and examine the differential squared change by flexible and inflexible firms in response to MPS. Specifically, we estimate the following model for firm i around the FOMC meetings at time t:

$$\Delta CreditSpread_{i,t}^2 = \alpha + \beta MPS_t^2 \times FPA_{j,t} + \delta_1 FPA_{j,t} + \delta_2 MPS_t^2 + \gamma \cdot X_{i,t} + \chi_{k,t} + \varepsilon_{i,t}, \quad (30)$$

where MPS^2 denotes the squared monetary policy shock, and $\chi_{k,t}$ represents industry-time and/or event-time fixed effects. Standard errors are clustered at both the firm and event levels. Following Gorodnichenko and Weber (2016) and in line with Hypothesis H5, we focus on squared shocks and changes in credit spreads, as price flexibility primarily affects the magnitude of the response. The direction of the response is ambiguous and depends on whether a firm is initially overpricing or underpricing relative to its optimal price.

The first column of Table 8 reports the coefficient estimates, including our firm and bond controls. Squared surprises are associated with an increase in squared spread changes (i.e., $\delta_2 > 0$), this increase is muted for flexible-price firms (i.e., $\beta < 0$). The coefficients are both economically and statistically significant and survive the inclusion of various fixed effects in columns (2)-(6). Our estimates suggest that fully flexible-price firms see their credit spreads increase by around 9 bps less than fully sticky-price firm, in response to a 25 bps MPS. Recall that the FOMC has eight scheduled meetings per year and hence, these changes in credit spreads to MPS as a function of FPA are sizable economically. Note that the coefficient estimate on FPA in isolation is insignificant because we focus on changes in credit spreads, as opposed to levels in previous tables.

In short, we show that MPS have important heterogeneous effects on firms' credit risk and that the degree of price stickiness is a key driver of these differences.

5 Evidence from the Lehman Brothers' Bankruptcy

Finally, we propose a difference-in-differences strategy to provide additional evidence on the relation between output price rigidity and credit risk. To do so, we rely on two model predictions which state that the debt value of sticky-price firms, as measured by the credit spread, is more sensitive to an exogenous increase in uncertainty than that of flexible-price firms (Figure 6, Panel B). In addition, this additional sensitivity is more pronounced for firms facing a higher cost of external financing (Figure 6, Panel D). Following Chodorow-Reich (2014), we exploit the Lehman Brothers bankruptcy as an exogenous uncertainty shock. We measure the price impact around the shock using our panel of bond transactions data.

5.1 Empirical model

Our identification strategy relies on comparing cross-sectional differences in the sensitivity of credit spreads between flexible- and sticky-price firms around the Lehman Brothers' bankruptcy. We consider two specifications. We first expand Equation (29) with an indicator variable $Post_t$ that equals 1 after and 0 before September 2008, yielding the following regression model for credit spreads measured for bond ℓ of firm i in month t:

$$\begin{aligned} CreditSpread_{\ell,i,t} &= \alpha + \beta \times Post_t \times FPA_{j,t} + \delta_1 \times FPA_{j,t} \\ &\quad + \delta_2 \times Post_t + \gamma \cdot X_{\ell,i,t} + \eta_t + \nu_k + \varepsilon_{\ell,i,t}, \end{aligned} \tag{31}$$

where $X_{\ell,i,t}$ is a vector of controls, η_t captures year-month fixed effects, and ν_k characterizes industry fixed effects. Our model predicts that $\beta < 0$, since the increase in credit spreads around the Lehman bankruptcy should be lower for flexible- than for sticky-price firms.

We also implement a cross-sectional regression using the change in credit spreads in a tight window around the Lehman bankruptcy ($\Delta CreditSpread_{\ell,i}$). We allow for two months around the event window to capture a possible delayed reaction. Thus, credit spreads before (after) the bankruptcy are based on monthly averages computed using the July and August (October and November) 2008 data. Specifically, we implement the following regression:

$$\Delta CreditSpread_{\ell,i} = \alpha + \beta \times FPA_j + \gamma \cdot X_{\ell,i} + \nu_k + \varepsilon_{\ell,i}, \tag{32}$$

where all of the independent variables are measured prior to the bankruptcy.

5.2 Results

In Table 9, we report the results from the difference-in-differences specification using bond-level data. For brevity, we only include the main coefficient of interest.

Column (1) reports the coefficient estimate when we include various firm- and bond-level controls but exclude fixed effects. The coefficient on the interaction term is negative and significant, which corroborates the model predictions, illustrated in Panel B of Figure 6, that more flexible-price firms are less exposed to uncertainty shocks than sticky price firms. The economic magnitude of the effect is large – the credit spreads of a firm with completely sticky prices increase by 67 bps more than those of a firm with fully flexible prices in response to the uncertainty triggered by the Lehman crash.

In columns (2) to (5), we successively add year-month, industry fixed effects, and their interactions. The coefficient estimates on the interaction term remains negative and significant in all specifications, with similar economic magnitudes. In columns (6) and (7), we report the estimation results for the cross-sectional regression with the change in credit spreads as the dependent variable. This specification has the advantage of controlling for any unobserved bond-level, time-invariant determinant. Similar to our difference-in-differences specification, the coefficient on FPA is negative and highly significant. Theses findings further support the model prediction that flexible-price firms are more resilient than sticky-price firms in response to uncertainty shocks and that price flexibility is an important driver of credit risk.

We graphically illustrate our results in Figure 7. Specifically, we plot the estimated coefficients on the interaction term $Quarter \times FPA$ from 8 quarters before to 8 quarters after the Lehman Brothers' bankruptcy, that is, we estimate the following regression:

$$CS_{i,t} = \beta_0 + \sum_{\substack{\tau=-8 \\ \tau\neq 0}}^{8} \beta_{1,\tau} \times Quarter_\tau \times FPA_{j,t} + \beta_2 \times FPA_{j,t} + \gamma \cdot X_{i,t} + \eta_t + \nu_k + \varepsilon_{i,t}. \quad (33)$$

Each coefficient $\hat{\beta}_{1,\tau}$ captures the differential impact of price flexibility on credit spreads, relative to the event quarter, which is centered on a three-month window around the bankruptcy, i.e., August, September, and October 2008. We plot the estimated coefficients for $\tau = -8, ..., 8$ together with their two standard deviation confidence bands.

Before the bankruptcy, all coefficients are statistically indistinguishable from zero, supporting the absence of a differential pre-trend in credit spreads for sticky- and flexible-price firms. After the crash, however, the coefficients become negative and are statistically different from zero. These results align with our prediction that credit spreads of sticky-price firms (low FPA) increase more in response to an uncertainty shock than those of flexible-price firms (high FPA). It takes about 6 quarters for the gap in credit spreads to close. This reversal closely mirrors the model-implied credit spread reaction illustrated in Panel B of Figure 6.

5.3 Refinements based on the refinancing cycle

The effect of a change in uncertainty on credit spreads is likely to depend on the extent to which a firm has access to external financing. In fact, as Panel D of Figure 6 shows, firms that face a higher cost of external financing have a higher rollover cost and are thus more likely to suffer from an uncertainty shock. The Lehman Brothers' bankruptcy sent a shock wave throughout financial markets, increasing the cost of financing for all firms. However, those in need of debt refinancing shortly after the event were more likely to be impacted by this shock and thus to have a higher cost of external financing. Almeida et al. (2011) show that companies with long-term debt maturing shortly after the credit crisis cut investment more than otherwise similar firms without such debt rollover risk. Similarly, Nagler (2020) documents that companies with high debt rollover exposure face larger increases in yield spreads around the Lehman Brothers' bankruptcy.

Motivated by these facts, we exploit additional cross-sectional variation based on firms' rollover risk. Specifically, we expect the negative relation between price inflexibility and the sensitivity of credit spreads around the Lehman Brothers' bankruptcy to be more pronounced for companies with higher rollover risk. Following Nagler (2020), we calculate the rollover risk exposure as the ratio of the amount of bonds maturing in 2009 to the total amount of bonds outstanding. We obtain the outstanding bond amounts by merging Compustat data with TRACE and Mergent FISD. We classify a company as treated if its rollover exposure is greater than 10%, but our results are robust to higher and lower threshold levels. In our sample, we have 63 treated companies and 229 control firms.

We report the results in Panel A of Table 10. Focusing on the panel regressions in columns (1) to (4), the coefficient on the triple interaction term $Post \times Treated \times FPA$ is negative and significant in all specifications. Hence, among firms with high rollover risk, flexible-price firms are more resilient to the uncertainty shock. Importantly, these results further support the idea that price stickiness amplifies credit risk. In column (5), we add interactions of industry and time fixed effects and the coefficient estimate remains economically significant.

Columns (6) and (7) in Panel A of Table 10 provide the result for the cross-sectional regression. Consistent with our prediction, the coefficient of the interaction term is negative and highly statistically significant, implying that the negative relation between FPA and the change in credit spreads is more pronounced for treated companies.

Due to the uneven sample composition of treated and control firms, we provide robustness tests using a matched sample. We match firms with replacement based on a series of firm characteristics observed within one year prior to Lehman Brothers' bankruptcy using the Mahalanobis distance measure.[14] For the covariate-matched sample, we find 51 uniquely identified firms that are matched with the 63 treated firms. In unreported results, we verify the firm characteristics between both groups are statistically indistinguishable from each other. Panel B of Table 10 reports the results, which confirm our findings from Panel A.

Overall, our results provide supporting evidence that output-price flexibility is an important determinant of firms' credit risk. Sticky-price firms have a higher cost of debt that is more sensitive to uncertainty shocks.

6 Conclusion

This paper studies the effects of nominal price rigidity on credit risk and firm financing policies. Using a capital structure model, we show that firms with inflexible output prices have lower operational flexibility, which makes them more exposed to shocks. The increased cash-flow risk creates a precautionary savings motive, resulting in higher cash holdings. At the same time, inflexible-price firms face higher credit risk that makes debt less attractive to creditors. Thus, inflexible firms use less financial leverage, issue debt at higher costs, and tend to borrow using shorter-term debt. As the incentive to mitigate default is higher for inflexible-price firms, they are more likely to accept tighter debt covenants.

We test these new predictions using a panel of publicly traded companies and find supporting evidence. Our framework also suggests that the reaction of credit spreads to uncertainty shocks is amplified for firms with higher output price rigidity. Thus, to strengthen the

[14]Firm characteristics include size, leverage, M/B ratio, ROA, credit rating, and equity return volatility.

empirical support for our predictions, we use the 2008 Lehman Brothers bankruptcy as a shock to uncertainty. We indeed find that credit spreads increase more for sticky-price firms than for flexible-price firms. Using a triple difference-in-differences setting, this amplification mechanism is even more pronounced for firms with high rollover risk.

We show that output price rigidity is central for understanding many corporate policies such as optimal leverage, cash holdings, and the credit risk of firms. Price rigidity also plays a key role for the real effects of monetary policy shocks and its impact on asset prices. We provide new evidence that monetary policy shocks have heterogeneous impacts in the cross-section of firms' credit spreads and that price rigidity is a crucial driver of these differences. In particular, we show that the reaction of squared credit spreads to squared monetary policy surprises is more pronounced for inflexible-price firms.

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Figure 1: Timeline of Firm Decisions.

This figure illustrates the timeline of events in the firm's decision-making process. At $t = 0$, firms choose their optimal capital structure, including the levels of equity, debt, and precautionary cash holdings. At $t = 1$, a first i.i.d. profit shock is realized. Firms revise their output prices with probability $(1 - \theta)$ and determine their production capacity. They also decide whether to adjust their precautionary cash holdings, raise external equity, or default. If no default occurs, short-term debt is repaid, and any residual cash flow is distributed to shareholders as dividends. At $t = 2$, a second i.i.d. profit shock is realized. As in $t = 1$, firms revise prices with probability $(1-\theta)$, choose production capacity, and decide whether to adjust cash holdings, raise external equity, or default. If the firm does not default, long-term debt is repaid and remaining cash flows are again distributed to shareholders as dividends.

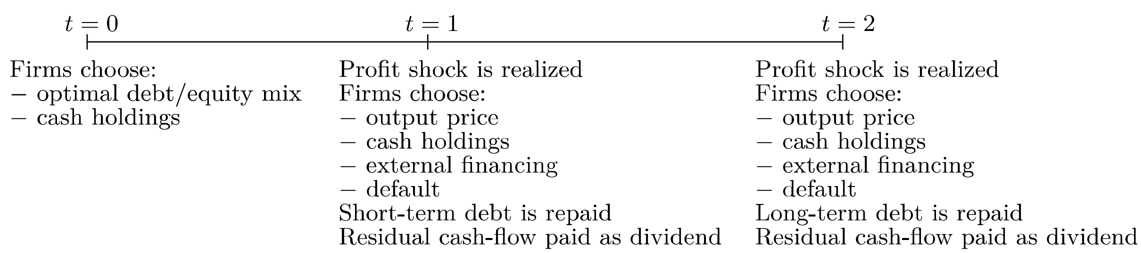

Figure 2: Price Inflexibility and Default Risk.

This figure compares the probability density function of the equity value at time $t = 2$, for a perfectly flexible firm (solid black line) and a perfectly inflexible firm (dashed red). The vertical dotted line represents the default threshold, i.e. $V_2 = 0$. The calibration used to obtain these graphs is summarized in Section 2.5.

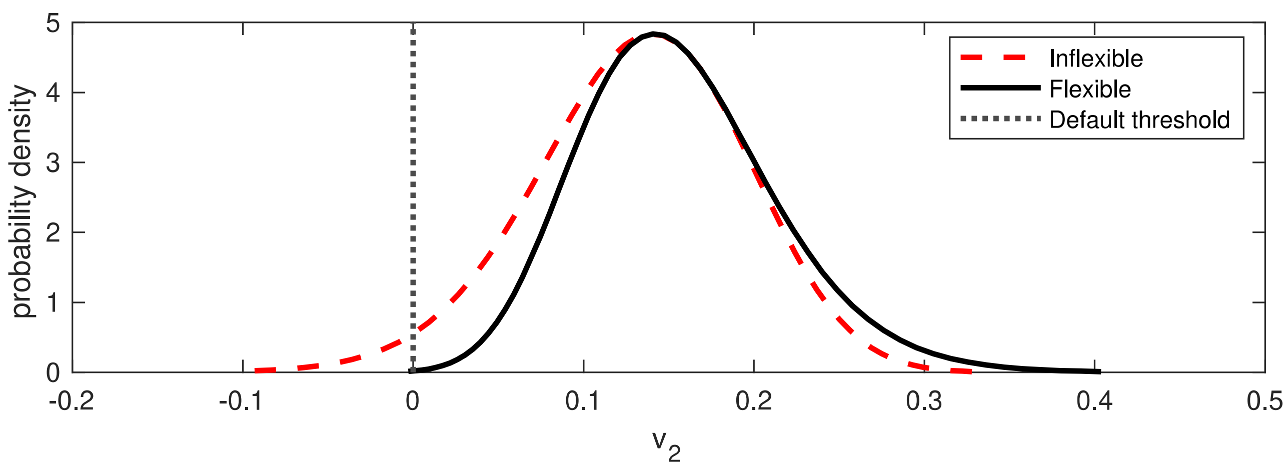

Figure 3: Impact of Technology Shocks on Credit Spreads.

This figure compares the impulse responses of credit spreads to a productivity shock for three types of firms: sticky-price firms (dashed red), medium flexible price firms (dotted black), and flexible-price firms (solid blue). Price flexibility is governed by θ, which is set to 0 for flexible firms, 0.5 for medium firms, and 1 for sticky firms. The shock—a surprise decline in productivity $\varepsilon_\mu < 0$—is introduced at the end of $t = 0$, after financing decisions have been made. The y-axis reports credit spreads in basis points, while the x-axis shows the number of periods from the shock.

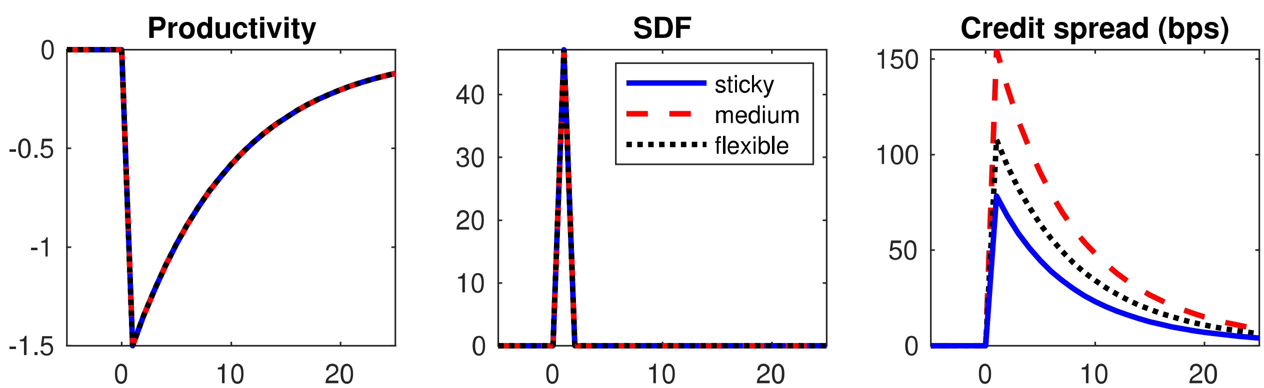

Figure 4: Model Predictions.

This figure shows the model-implied effects of price rigidity on several key firm variables: leverage, cash-to-assets, the total credit spread and credit risk premium at issuance, and the average debt maturity. Total debt-to-assets is defined as $b^S + b^L$, cash holdings-to-assets as $b^S - x_0$, the credit spread is computed for long-term debt, and the average maturity as $b^S \times 1 + b^L \times 2$. Price rigidity is governed by the parameter θ. The plots are generated by solving for the firm's optimal decisions across different levels of price stickiness (θ ranging from 0 to 1), and then simulating the model over 10,000 periods following a burn-in period of 2,000 periods.

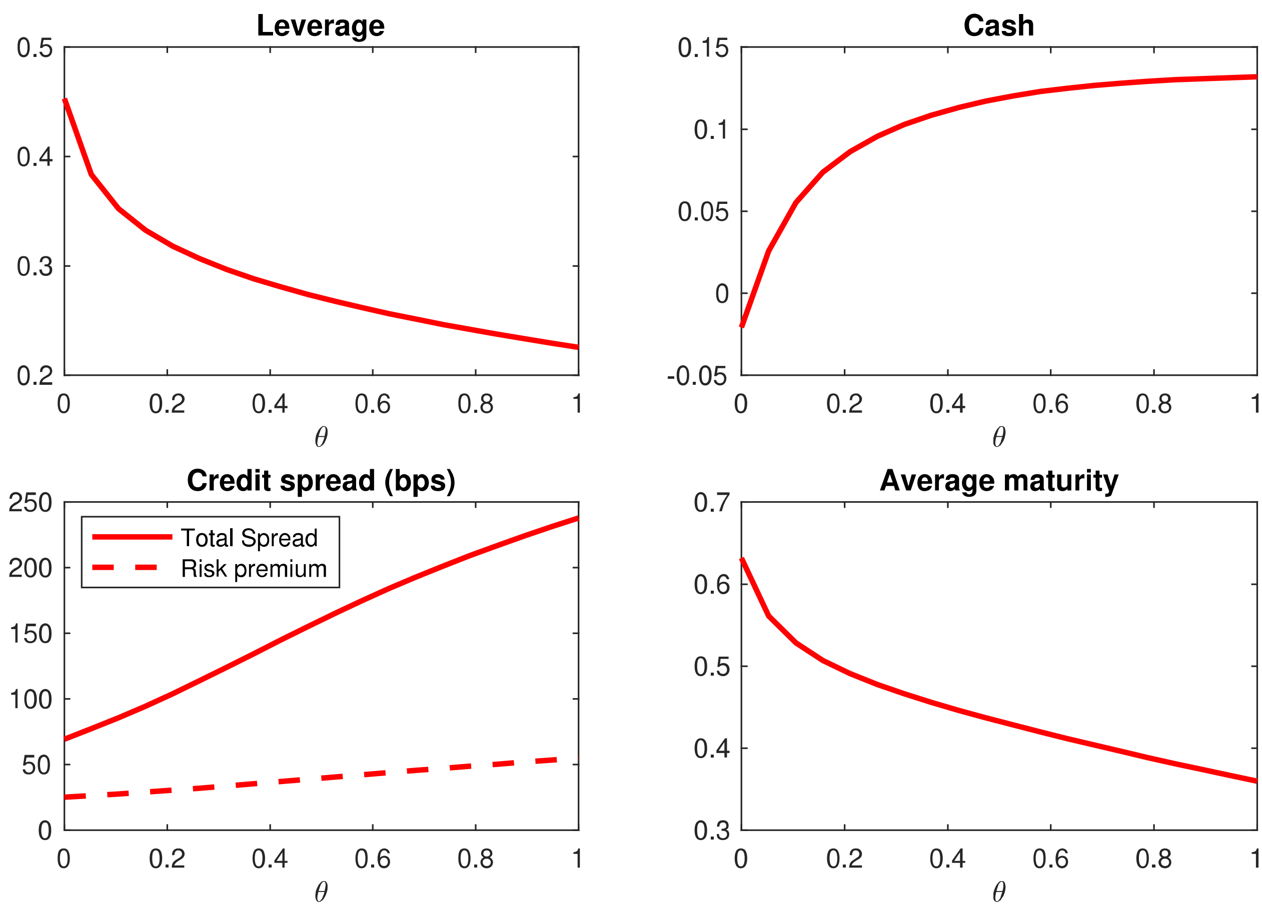

Figure 5: Impact of Monetary Policy Shocks on Credit Spreads.

This figure compares the impulse responses of credit spreads to a monetary policy shock for three types of firms: flexible-price firms (solid blue), sticky-price firms charging a high initial price at $t = 0$ (red dashed), and sticky-price firms charging a low initial price at $t = 0$ (black dotted). Price flexibility is governed by θ, which is set to 0 for flexible firms and 1 for sticky firms. High- and low-price firms are defined as having initial prices p_0 that are 25% above and 10% below the steady state, respectively. The shock—a surprise increase in inflation—is introduced at the end of $t = 0$, after financing decisions have been made. The y-axis reports credit spreads in basis points, while the x-axis shows the number of periods from the shock.

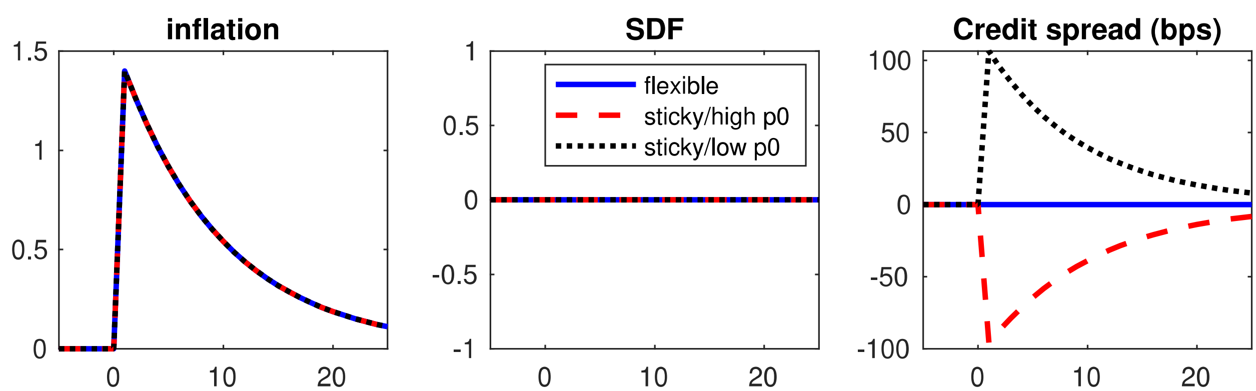

Figure 6: The Impact of Uncertainty Shocks on Credit Spreads.

This figure plots the response functions of credit spreads to an uncertainty shock in the cross-section of firms. Panel A compares the credit spread responses of sticky-price (dashed) vs. flexible-price (solid) firms. Panel B reports the difference between the flexible- and sticky-price firm responses from Panel A. Panel C performs the same comparison as in Panel A, but for firms sorted based on their cost of external financing, λ. High (low) λ firms are plotted in red (blue). Panel D reports the difference between the flexible- and sticky-price firm responses, depending on the cost of external financing λ. The impulse-response functions are obtained by shocking the economy with a surprise increase in volatility, $\varepsilon_\sigma > 0$, at the end of $t = 0$, after financing decisions have been made. Financially constrained (unconstrained) firms are characterized by having λ equal to 0.95 (0) at the time of the shock. Credit spread on the y-axis are reported in basis points. The y-axis reports credit spreads in basis points, while the x-axis shows the number of periods from the shock.

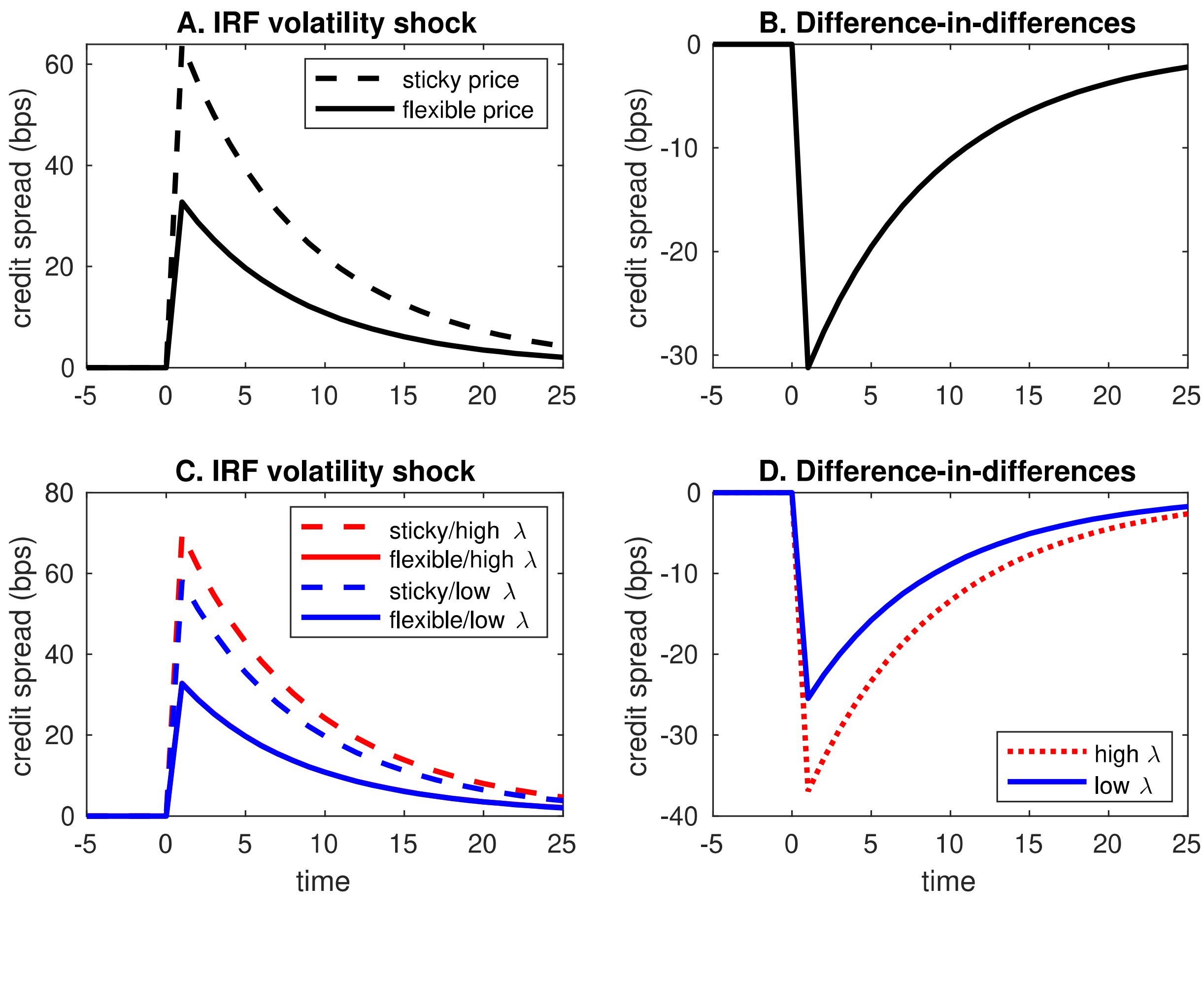

Figure 7: Differential Credit Spread Reactions to Lehman Brothers Bankruptcy.

In this figure, we report the results from a difference-in-differences regression between sticky and flexible price firms around the Lehman Brothers bankruptcy. Specifically, this figure shows the estimated coefficients $\{\hat{\beta}_{1,\tau}\}$ and their confidence intervals (± 2 standard errors) from the following regression: $CreditSpread_{i,t} = \beta_0 + \sum_{\substack{\tau=-8 \\ \tau\neq 0}}^{8} \beta_{1,\tau} \times Quarter_\tau \times FPA_{j,t} + \beta_2 \times FPA_{j,t} + \gamma \cdot X_{i,t} + \eta_t + \nu_k + \varepsilon_{i,t}$, where $Quarter_\tau$ is a dummy variable for Quarter τ ranging from 8 quarters before to 8 quarters after the Lehman Brothers bankruptcy, $X_{i,t}$ includes control variables, η_t captures quarter fixed effects, and ν_k captures 2-digit SIC industry fixed effects. We measure all impacts relative to Quarter 0. Standard errors are clustered by firm. We define May 2008 to July 2008 as Quarter -1, August 2008 to October 2008 as Quarter 0, November 2008 to January 2009 as Quarter 1, and so on for other Quarters.

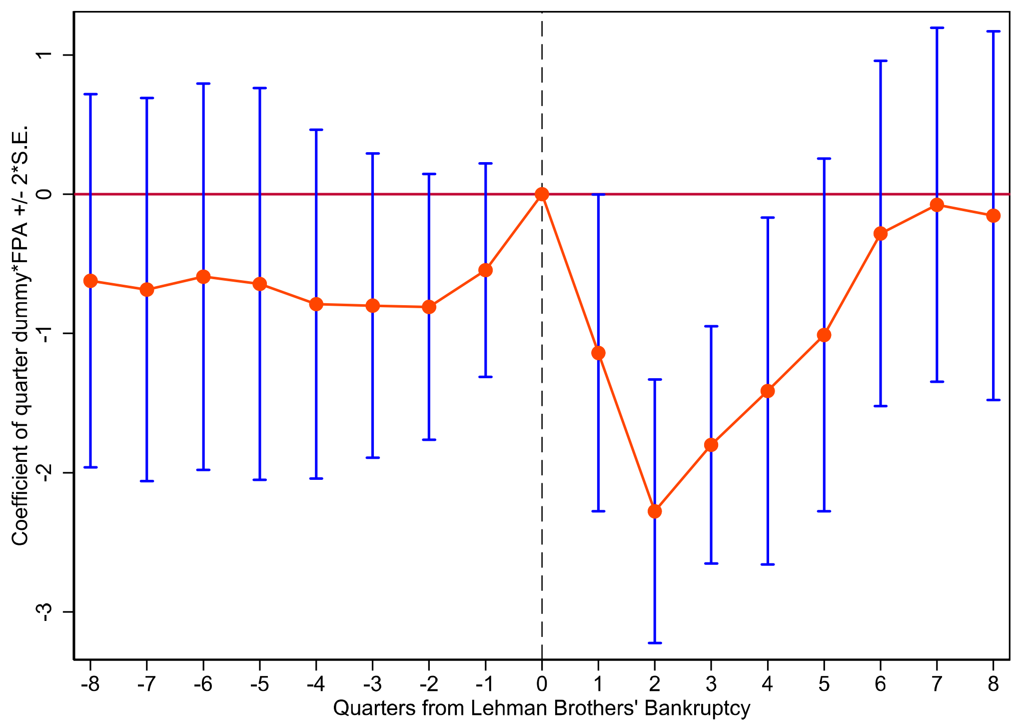

Table 1: Literature on Nominal Rigidities, Asset Prices and Capital Structure

This table summarizes key studies that explore the relation between nominal price rigidities and asset prices and/or capital structure. We describe the type of nominal rigidity (price, wage, debt), the type of study (empirical or theoretical), the asset pricing focus (equity/credit), and the characteristics of capital structure decisions.

	Nominal Rigidity			Type		Asset Risk		Coporate Decision				
Study	Debt	Wage	Price	Theory	Empirics	Equity	Credit	Investment	Leverage	Cash	ST Debt	Covenant
Bhamra et al. (2011)	✓			✓			✓					
Gomes et al. (2016)	✓			✓				✓				
Kang and Pflueger (2015)	✓			✓	✓		✓					
Bhamra et al. (2018)	✓			✓	✓	✓	✓					
Favilukis and Lin (2016b)		✓		✓		✓						
Favilukis and Lin (2016a)		✓		✓	✓	✓						
Favilukis et al. (2020)		✓		✓	✓		✓		✓			
Weber (2015)			✓	✓	✓	✓						
D'Acunto et al. (2018)			✓		✓				✓			
This study			✓	✓	✓		✓		✓	✓	✓	✓

Table 2: Descriptive Statistics.

This table presents the summary statistics of our sample. Panel A shows the statistics of variables in our annual fundamental data sample, including FPA, cash ratios, debt maturity, and other control variables. Panel B shows the summary statistics of our bond issuance sample. Panel C shows the summary statistics of our bond transactions sample. Panel D displays the statistics of our loan issuance sample. The sample period is from 1982 to 2018. The definitions of all variables are listed in Appendix Table A.3.

	count	mean	sd	p5	p25	p50	p75	p95
Panel A: Fundamentals								
FPA	21,291	0.241	0.179	0.088	0.132	0.188	0.266	0.699
Cash/assets	21,273	0.130	0.155	0.005	0.025	0.072	0.173	0.471
Cash/net assets	21,273	0.301	6.445	0.005	0.026	0.078	0.209	0.892
Long-term debt ratio	17,172	0.636	0.277	0.010	0.486	0.700	0.849	0.991
Size	21,279	8.288	1.565	5.622	7.373	8.312	9.288	10.772
Leverage	21,200	0.247	0.186	0.000	0.119	0.229	0.340	0.565
M/B	21,231	2.178	2.135	0.957	1.249	1.658	2.425	5.016
ROA	21,275	0.050	0.126	-0.096	0.024	0.058	0.096	0.171
Equity vol.	21,247	0.379	0.216	0.180	0.251	0.328	0.450	0.742
Intangibility	20,913	0.278	0.204	0.033	0.107	0.230	0.415	0.673
Firm age	21,291	3.259	0.853	1.609	2.773	3.434	3.932	4.317
Not-rated	21,291	0.358	0.480	0.000	0.000	0.000	1.000	1.000
Interest coverage	21,219	23.318	31.088	1.138	4.904	9.684	22.746	100.000
Loss dummy	21,276	0.149	0.356	0.000	0.000	0.000	0.000	1.000
Z-score dummy	19,747	0.887	0.317	0.000	1.000	1.000	1.000	1.000
Price-to-cost margin	21,274	0.349	1.651	0.095	0.238	0.364	0.529	0.785
HHI	21,142	0.098	0.087	0.029	0.048	0.070	0.111	0.273
Panel B: Bond Issuance								
Yield spread (%)	6,858	1.539	1.430	0.374	0.754	1.161	1.847	4.356
Bond size (mill.)	6,860	545.9	610.3	100.0	200.0	375.0	700.0	1500.0
Rating	5,258	7.681	2.977	3.000	6.000	7.500	9.000	13.500
Maturity	6,860	13.263	11.237	3.014	5.642	10.012	15.009	30.038
Callable	6,860	0.756	0.430	0.000	1.000	1.000	1.000	1.000
Senior	6,860	0.990	0.099	1.000	1.000	1.000	1.000	1.000
Putable	6,860	0.013	0.112	0.000	0.000	0.000	0.000	0.000
Private dummy	6,860	0.116	0.320	0.000	0.000	0.000	0.000	1.000
Panel C: Bond Transaction								
Yield spread (%)	541,798	1.954	1.909	0.380	0.835	1.365	2.302	5.497
Panel D: Loan Issuance								
Tightness	2,968	0.105	0.152	0.000	0.000	0.028	0.160	0.438
Maturity (years)	2,960	3.798	1.725	1.000	2.837	4.917	5.000	5.250
Deal amount (mill.)	2,968	1196.4	1626.0	100.0	301.6	742.9	1500.0	4000.0
No. of participants	2,968	10.989	14.158	0.000	3.000	7.000	14.000	35.000
Secured	2,968	0.216	0.412	0.000	0.000	0.000	0.000	1.000

Table 3: Cross-correlation Table.

This table presents pairwise Pearson correlation coefficients among variables in our firm-year fundamental data sample. The definitions of all variables are listed in Appendix Table A.3.

	FPA	Cash/assets	log(cash/net assets)	LT debt ratio	Size	Leverage	M/B	ROA	Equity vol.	Intangibility	Firm age	Not-rated	Interest coverage	Loss dummy	Z-score dummy	Price-to-cost margin	HHI (FF48)
FPA	1.00																
Cash/assets	-0.23	1.00															
log(cash/net assets)	-0.26	0.85	1.00														
LT debt ratio	0.14	-0.13	-0.13	1.00													
Size	0.18	-0.31	-0.25	0.17	1.00												
Leverage	0.12	-0.29	-0.33	0.24	0.21	1.00											
M/B	-0.14	0.37	0.30	-0.15	-0.18	-0.16	1.00										
ROA	-0.06	-0.00	0.04	-0.05	0.04	-0.20	0.16	1.00									
Equity vol.	-0.04	0.25	0.20	-0.07	-0.31	0.00	0.10	-0.28	1.00								
Intangibility	-0.25	-0.16	-0.09	0.05	0.29	0.14	-0.02	-0.02	-0.12	1.00							
Firm age	0.10	-0.31	-0.21	0.06	0.46	0.11	-0.24	0.02	-0.27	0.09	1.00						
Not-rated	-0.13	0.29	0.25	-0.26	-0.54	-0.33	0.17	0.03	0.16	-0.23	-0.33	1.00					
Interest coverage	-0.18	0.44	0.42	-0.30	-0.24	-0.55	0.37	0.25	0.05	-0.07	-0.24	0.37	1.00				
Loss dummy	0.04	0.08	0.05	0.01	-0.10	0.17	-0.08	-0.55	0.33	-0.01	-0.05	0.02	-0.16	1.00			
Z-score dummy	-0.14	0.06	0.09	-0.09	-0.10	-0.45	0.15	0.29	-0.21	-0.06	0.01	0.08	0.21	-0.34	1.00		
Price-to-cost margin	-0.01	-0.06	-0.03	0.00	0.05	-0.03	0.03	0.07	-0.03	0.05	0.00	-0.02	0.05	-0.07	0.06	1.00	
HHI	-0.11	-0.01	0.02	-0.05	-0.06	-0.03	-0.02	0.03	0.00	0.05	0.03	0.04	-0.02	-0.03	0.02	0.01	1.00

Table 4: Nominal Rigidities and Cash Holdings.

This table provides the panel regressions results for the relation between the natural logarithm of the net cash ratio and the price flexibility measure FPA. FPA measures the frequency of price adjustment. Control variables include firm size, leverage, M/B ratio, ROA, equity volatility, intangibility, firm age, not-rated dummy, interest coverage, loss dummy, z-score dummy, price-to-cost margin, and HHI. The definitions of all variables are provided in the Appendix Table A.3. Standard errors are clustered by firm and by year. In column (1), we include the FPA and all control variables; in column (2), we include year fixed effects; in column (3), we include 1-digit SIC industry fixed effects instead; in column (4) we add both year and industry fixed effects; in column (5), we use the interaction between year and industry fixed effects instead.

	(1)	(2)	(3)	(4)	(5)
FPA	−1.41***	−1.44***	−1.01***	−1.03***	−1.02***
	(−5.00)	(−4.91)	(−3.80)	(−3.78)	(−3.81)
Size	0.04	0.01	0.05	0.01	0.02
	(1.42)	(0.20)	(1.64)	(0.27)	(0.68)
Leverage	−1.65***	−2.09***	−1.50***	−1.96***	−2.03***
	(−6.34)	(−8.86)	(−5.67)	(−8.43)	(−8.77)
M/B	0.23***	0.24***	0.22***	0.23***	0.22***
	(7.51)	(10.50)	(7.39)	(10.62)	(10.34)
ROA	−0.81**	−0.49	−0.64	−0.29	−0.28
	(−2.07)	(−1.37)	(−1.61)	(−0.82)	(−0.80)
Equity vol.	1.24***	1.78***	1.16***	1.68***	1.77***
	(4.99)	(7.45)	(4.78)	(7.30)	(7.79)
Intangibility	−0.65***	−1.08***	−0.92***	−1.44***	−1.57***
	(−3.71)	(−6.25)	(−5.00)	(−7.83)	(−8.75)
Firm age	0.01	0.01	0.01	−0.01	−0.01
	(0.31)	(0.22)	(0.13)	(−0.24)	(−0.17)
Not-rated	0.06	0.11	0.04	0.09	0.08
	(0.93)	(1.60)	(0.55)	(1.46)	(1.22)
Int. cov. k1	−0.21***	−0.19***	−0.21***	−0.19***	−0.20***
	(−6.16)	(−6.71)	(−6.02)	(−6.71)	(−7.09)
Int. cov. k2	0.03*	−0.00	0.04**	0.00	0.00
	(1.96)	(−0.05)	(2.35)	(0.22)	(0.34)
Int. cov. k3	0.04***	0.02***	0.04***	0.02***	0.02***
	(4.97)	(3.30)	(4.90)	(3.22)	(3.19)
Int. cov. k4	0.00***	0.00**	0.00***	0.00**	0.00**
	(4.08)	(2.69)	(3.78)	(2.29)	(2.26)
Loss	0.03	−0.02	0.04	−0.02	−0.00
	(0.51)	(−0.42)	(0.65)	(−0.37)	(−0.03)
Z-score dummy	0.08	0.10	0.13	0.14	0.14
	(0.87)	(1.04)	(1.39)	(1.54)	(1.56)
Price-to-cost margin	1.02***	0.96***	0.95***	0.85***	0.91***
	(5.64)	(5.38)	(5.33)	(4.89)	(5.23)
HHI	0.31	0.37	−0.23	−0.16	−0.34
	(0.87)	(1.14)	(−0.66)	(−0.56)	(−1.05)
Constant	−2.87***	−2.51***	−2.88***	−2.38***	−2.43***
	(−8.43)	(−7.16)	(−8.48)	(−6.89)	(−7.13)
N	19,265	19,265	19,265	19,265	19,252
Adj. R^2	0.278	0.343	0.300	0.368	0.380
Year FE		X		X	
SIC1 ind. FE			X	X	
SIC1 × Year FE					X

Table 5: Nominal Rigidities and Debt Maturity.

This table provides the panel regressions results for the relation between the firm's debt maturity and the price flexibility measure FPA. FPA measures the frequency of price adjustment. Debt maturity is defined as the amount of debt maturing in more than 3 years divided by the amount of total outstanding debt, i.e., the long-term debt ratio. Control variables are the same as those in Table 4. Standard errors are clustered by firm and by year. In column (1), we include FPA and control variables. In column (2), we add year fixed effects. In column (3), we add 1-digit SIC industry fixed effects instead; in column (4) we add both year and industry fixed effects; in column (5), we use the interaction of year and industry fixed effects. For brevity, we do not report the coefficients of control variables in this table.

	(1)	(2)	(3)	(4)	(5)
FPA	0.11***	0.11***	0.10**	0.10**	0.10**
	(3.34)	(3.36)	(2.66)	(2.70)	(2.59)
N	16,657	16,657	16,657	16,657	16,644
Adj. R^2	0.155	0.180	0.162	0.186	0.183
Controls	X	X	X	X	X
Year FE		X		X	
SIC1 ind. FE			X	X	
SIC1 $\times$ Year FE					X

Table 6: Nominal Rigidities and Cost of Debt.

This table provides the regression results for the relation between a firm's cost of debt and the price flexibility measure FPA. FPA measures the frequency of price adjustment. In Panel A, we use the bond issue sample and the yield spread is defined as the offering yield minus the Treasury yield. In Panel C, we use the monthly bond transactions sample, where the monthly yield spread is the average of daily yield spreads calculated from bond transaction prices. In Panels B and D, we aggregate the bond-level data in Panels A and C, respectively, at the firm-month level by calculating the amount-weighted average of credit spreads and bond-level control variables. The definitions of all variables are provided in the Appendix Table A.3. The control variables include the same firm characteristics that we use in Table 4 and, in addition, bond characteristics (bond rating, size, maturity, callable dummy, senior dummy, putable dummy, and private placement dummy). Standard errors are clustered by firm and year for Panels A and B, and by firm and year-month for Panels C and D. In column (1), we include the FPA and all control variables; in column (2), we add time fixed effects (year fixed effects for Panels A and B and year-month fixed effects for Panels C and D); in column (3), we add 1-digit SIC industry fixed effects instead; in column (4), we include both time and industry fixed effects; in column (5), we use the interaction of time and industry fixed effects. For brevity, we do not report the coefficients of control variables in the table.

	(1)	(2)	(3)	(4)	(5)
Panel A. Bond issue sample (bond-level)					
FPA	−0.37**	−0.47***	−0.40***	−0.48***	−0.40***
	(−2.70)	(−3.48)	(−2.91)	(−3.64)	(−3.05)
N	5,078	5,077	5,078	5,077	5,065
Adj. R^2	0.604	0.696	0.606	0.700	0.715
Panel B. Bond issue sample (firm-level)					
FPA	−0.42***	−0.53***	−0.45***	−0.56***	−0.46***
	(−3.26)	(−4.81)	(−3.40)	(−4.64)	(−3.98)
N	3,366	3,365	3,366	3,365	3,353
Adj. R^2	0.627	0.710	0.629	0.713	0.721
Panel C. Bond transactions sample (bond-level).					
FPA	−0.73***	−0.56***	−0.61***	−0.35**	−0.36**
	(−3.32)	(−2.83)	(−2.85)	(−2.05)	(−2.21)
N	525,216	525,216	525,216	525,216	525,216
Adj. R^2	0.536	0.682	0.539	0.686	0.700
Panel D. Bond transactions sample (firm-level).					
FPA	−0.50***	−0.50***	−0.45***	−0.44***	−0.43***
	(−3.43)	(−3.42)	(−3.21)	(−3.13)	(−3.07)
N	54,747	54,747	54,747	54,747	54,735
Adj. R^2	0.559	0.729	0.565	0.733	0.744
Controls	X	X	X	X	X
Time FE		X		X	
SIC1 ind. FE			X	X	
SIC1 × Time FE					X

Table 7: Nominal Rigidities and Loan Covenants.

This table provides the panel regressions results for the relation between a firm's tightness of loan covenants and the price flexibility measure FPA. FPA measures the frequency of price adjustment. We measure covenant tightness as in Murfin (2012). We include the same control variables for firm characteristics as those in Table 4, and, in addition, loan characteristics (loan maturity, deal amount, number of bank participants, secured dummy, and indicator variables for loan types and loan purposes). Standard errors are clustered by firm and by year. In column (1), we include the FPA and all control variables; in column (2), we add year fixed effects; in column (3), we add 1-digit SIC industry fixed effects instead; in column (4), we include both year and industry fixed effects; in column (5), we use the interaction between year and industry fixed effects. For brevity, we do not report the estimation results of control variables.

	(1)	(2)	(3)	(4)	(5)
FPA	-0.10^{***}	-0.11^{***}	-0.06^{**}	-0.06^{***}	-0.07^{***}
	(-4.90)	(-5.37)	(-2.61)	(-3.09)	(-2.93)
N	2,511	2,511	2,511	2,511	2,503
Adj. R^2	0.373	0.384	0.392	0.403	0.415
Control	X	X	X	X	X
Year FE		X		X	
SIC1 ind. FE			X	X	
SIC1 $\times$ Year FE					X

Table 8: Nominal Rigidities, Monetary Policy Shocks, and Cost of Debt.

This table provides the regression results for the impact of the price flexibility measure FPA on the response of credit spreads to monetary policy shocks (MPS). The sample includes 133 FOMC announcements with non-overlapping event windows (minimum of 20 days between announcements) and available corporate bond transactions data. MPS is defined as the adjusted change in federal funds futures rates during a 30-minute window around the press release. FPA measures the frequency of price adjustment. The control variables include the same firm characteristics that we use in Table 4 and, in addition, weighted (by amount outstanding) average bond characteristics (bond rating, size, maturity, callable dummy, senior dummy, putable dummy, and private placement dummy). The definitions of all variables are provided in the Appendix Table A.3. In columns (1)-(6), the dependent variable is the squared change in the weighted-average firm-level credit spread during a $[-10, +10]$ days window around the announcement. In column (1), we include FPA, MPS^2 (squared) and their interaction and control variables; in column (2) we add event fixed effects; in column (3), we add 1-digit SIC industry fixed effects instead; in column (4), we include both event and industry fixed effects; in column (5), we use the interaction of event and industry fixed effects; in column (6), we use the interaction of year and industry fixed effects. Standard errors are clustered at the firm and event level. For brevity, we do not report the coefficients of control variables in the table.

	(1)	(2)	(3)	(4)	(5)	(6)
	$[-10, +10]$	$[-10, +10]$	$[-10, +10]$	$[-10, +10]$	$[-10, +10]$	$[-10, +10]$
$MPS^2 \times$ FPA	−12.08***	−12.22***	−12.04***	−12.19***	−12.20***	−12.73***
	(−5.50)	(−5.54)	(−5.51)	(−5.54)	(−5.51)	(−6.27)
FPA	0.03	0.02	−0.01	−0.00	0.00	0.00
	(0.45)	(0.37)	(−0.10)	(−0.07)	(0.06)	(0.05)
MPS^2	7.79***		7.77***			5.25***
	(10.56)		(10.46)			(6.16)
N	32,087	32,086	32,087	32,086	32,074	32,087
Adj. R^2	0.032	0.048	0.032	0.047	0.050	0.040
Control	X	X	X	X	X	X
Event FE		X		X		
SIC1 ind. FE			X	X		
SIC1 × Event FE					X	
SIC1 × Year FE						X

Table 9: Difference-in-differences Estimation around Lehman Brothers' Bankruptcy.

This table provides the difference-in-differences regressions results for the relation between a firm's monthly credit spread using bond-level data and the price flexibility measure FPA around the Lehman Brothers' bankruptcy. Columns (1) to (5) show the results for panel regressions that add a Post-Lehman indicator that equals 1 after September 2008 and 0 before September 2008, as well as its interaction term with FPA. The dependent variable is the monthly credit spread. In columns (6) and (7), we estimate cross-sectional regressions using the change in credit spreads from July and August, 2008 to October and November, 2008 as the dependent variable. FPA measures the frequency of price adjustment. The definitions of all variables are provided in the Appendix Table A.3. The control variables are the same as those in Table 6. Standard errors are clustered by firm and by year-month. In column (1), we include the FPA, the Post-Lehman dummy, and their interaction, as well as all control variables; in column (2), we add year-month fixed effects; in column (3), we add 1-digit SIC industry fixed effects instead; in column (4), we use both the year-month and industry fixed effects; in column (5), we include the interaction between year-month and industry fixed effects instead. In column (6), we include FPA and all control variables and in column (7), we add the industry fixed effects. For brevity, we do not report the coefficients of control variables in the table.

	Panel regression					Cross-sectional regression	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post × FPA	−0.67***	−0.86**	−0.64**	−0.88**	−1.08***		
	(−2.79)	(−2.50)	(−2.52)	(−2.53)	(−3.71)		
FPA						−1.72***	−2.43***
						(−3.14)	(−3.77)
N	484,785	484,785	484,785	484,785	484,785	2,257	2,257
Adj. R^2	0.543	0.689	0.546	0.693	0.707	0.470	0.499
Controls	X	X	X	X	X	X	X
Month FE		X		X			
SIC1 ind. FE			X	X			X
SIC1 × Month FE					X		

Table 10: Triple Difference-in-differences Estimation around Lehman Brothers' Bankruptcy.

This table provides the triple difference-in-differences regressions results for the relation between a firm's monthly credit spread and the price flexibility measure FPA around Lehman Brothers' bankruptcy. We define a *Post* indicator variable that equals 1 after September 2008 and equals 0 before September 2008 and a *Treated* indicator variable that equals 1 if the company has rollover exposure greater than 10% and equals 0 otherwise. In Panel A we use the full sample. In Panel B, we use the matched-sample by matching each treated firm with a control firm based on size, leverage, M/B ratio, ROA, credit rating, and equity return volatility. We match based on the Mahalanobis distance. Columns (1) to (5) show the panel regression results using bond-level data where the dependent variable is the monthly credit spread. Columns (6) and (7) show the cross-sectional regressions using the change in average credit spread between July/August and October/November 2008 as the dependent variable.FPA measures the frequency of price adjustment. The control variables are the same as those in Table 6. Standard errors are clustered by firm and by year-month. In column (1), we include the FPA, the Post-Lehman dummy, the Treated dummy, and their interactions, as well as all control variables; in column (2), we add year-month fixed effects; in column (3), we add 1-digit SIC industry fixed effects instead; in column (4), we use both the year-month and industry fixed effects; in column (5), we use the interaction between year-month and industry fixed effects. In column (6), we include FPA, the treated dummy, their interaction, and all control variables and in column (7), we add the industry fixed effects. For brevity, we only report the coefficients of the triple interaction term and the interaction term between Treated and FPA in the table.

	Panel regression					Cross-sectional regression	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Panel A. Full sample.						
Post × Treated × FPA	−0.74**	−1.21***	−0.76**	−1.24***	−1.12**		
	(−2.34)	(−2.97)	(−2.57)	(−3.05)	(−2.50)		
Treated × FPA						−2.78***	−2.02**
						(−2.96)	(−2.50)
N	475,170	475,170	475,170	475,170	475,170	2,257	2,257
Adj. R^2	0.544	0.694	0.547	0.698	0.711	0.484	0.506
	Panel B. Covariate-matched sample.						
Post × Treated × FPA	−1.54***	−2.15***	−1.49***	−2.17***	−1.80***		
	(−6.70)	(−4.21)	(−5.77)	(−4.09)	(−3.35)		
Treated × FPA						−1.48**	−1.40**
						(−2.48)	(−2.03)
N	332,634	332,634	332,634	332,634	332,634	1,520	1,520
Adj. R^2	0.544	0.706	0.548	0.710	0.724	0.625	0.631
Controls	X	X	X	X	X	X	X
Month FE		X		X			
SIC1 ind. FE			X	X			X
SIC1 × Month FE					X		

Internet Appendix

Price Rigidities and Credit Risk

A.1 Model Appendix

This section provides derivation details for our benchmark model. We start by providing an executive summary of the firm's optimization problem. Specific details are discussed in Section 2, and a timeline of decisions and events is available in Figure 1. We then proceed with solving for the firm's optimal production, financing, and default policies.

A.1.1 Firm's optimization problem

The firm's objective is to maximize the value of equity by taking a series of financing and production decisions, subject to the demand for the firm's product and the value of debt to creditors. We summarize the notation for the main variables of interest below:

- V: real market value of equity
- b^L: real face value of outstanding long-term corporate debt
- b^S: real face value of outstanding short-term corporate debt
- q^L: market price of \$1 of real long-term corporate debt
- q^S: market price of \$1 of real short-term corporate debt
- x: real cash holdings
- d: real dividend
- p: nominal output price charged by the firm
- P: aggregate price level
- M: real one-period stochastic discount factor
- Π: gross inflation rate

There are two sources of firm-specific uncertainty: the productivity shock $\widetilde{X}_t \in [0, +\infty)$ and the price inflexibility shock $\tilde{\zeta}_t \in \{0, 1\}$. Additionally, there are four sources of aggregate risk: aggregate inflation Π_t, external financing cost, λ_t, as well as the first and second moments of the firm-specific productivity shock $\widetilde{X}_t$, namely μ_t and σ_t. We summarize all aggregate state variables in the vector $\Upsilon_t \equiv (\Pi_t, \mu_t, \sigma_t, \lambda_t)$.

At $t = 0$, the firm is unlevered and none of the shocks have realized yet. The firm chooses its quantity of short-term and long-term debt (b^L and b^S) and cash-holdings (x_0) in order to maximize the total net proceeds from both debt and equity issuance, that is:

$$\max_{b^S, b^L, x_0} \left\{ \mathbb{E}_0 \left[M_1 V_1(\tilde{\zeta}_1, \widetilde{X}_1, z_1, \Upsilon_1) \right] - x_0 - \frac{\psi}{2} (x_0)^2 + (1 + \chi^S) q_0^S b^S + (1 + \chi^L) q_0^L b^L - f \right\}, \tag{A.1}$$

where $z_t \equiv (b^S, b^L, x_{t-1}, p_{t-1})$ is a vector summarizing all firm-specific state variables, ψ is the agency cost of holding cash and χ^L and χ^S characterize the net benefits of long-term and short-term debt, respectively. q_0^S and q_0^L are the market price of short- and long-term debt, respectively. Note that the real pricing kernel $M_t(\Upsilon_t)$ potentially depends on all aggregate state variables.

At $t > 0$, the firm begins production and chooses its optimal cash holdings x_t to maximize equity value. It inherits legacy long-term debt b^L and repays short-term debt b^S at $t = 1$. The firm cannot alter its capital structure at $t = 1$; however, it has the option to issue seasoned equity, subject to a flotation cost of λ per dollar issued. The firm also inherits a nominal output price set in the previous period, p_{t-1}, and is only allowed to re-optimize it at time t when $\tilde{\zeta}_t = 1$.

Note that the labor decision is static in each period. As a result, we can first solve the cost minimization problem of the firm and substitute the firm-specific shock $\widetilde{X}_t$ with the real marginal cost of production $\tilde{c}_t$ to enhance readability. In particular, the (real) cost minimization problem determines the optimal quantity of labor, l_t, to minimize production costs for a given target level of output, $y_t^\star$, as follows:

$$\min_{l_t} \quad W l_t + \tilde{c}_t \left(y_t^\star - \widetilde{X}_t l_t \right), \tag{A.2}$$

where $\tilde{c}_t$ is the Lagrange multiplier associated with the target output constraint, representing the firm's marginal cost of production.

The FOC with respect to l_t yields the real marginal cost:

$$\tilde{c}_t = \frac{W}{\widetilde{X}_t} \tag{A.3}$$

The log-marginal cost thus inherits the log-normal distribution of $\widetilde{X}_t$. Specifically, $\log(\tilde{c}_t) \sim \mathcal{N}(\log(W) - \mu_t, \sigma_t^2)$. For the remainder of the derivation, we will use marginal cost instead of productivity and replace for the inverse demand function for the firm's product as defined in Equation (2).

The real dividend (i.e., normalized by P_t) paid by the firm in periods 1 and 2 is:

$$d_1(\tilde{\zeta}_1, \tilde{c}_1) = \frac{\left(\frac{p_1(\tilde{\zeta}_1)}{P_1} - \tilde{c}_1\right)\left(\frac{p_1(\tilde{\zeta}_1)}{P_1}\right)^{-\nu} + x_0 - x_1(1+\psi) - f - b^S}{1 - \lambda \times \mathbb{1}_{\{d_1<0\}}}, \tag{A.4}$$

$$d_2(\tilde{\zeta}_2, \tilde{c}_2) = \frac{\left(\frac{p_2(\tilde{\zeta}_2)}{P_2} - \tilde{c}_2\right)\left(\frac{p_2(\tilde{\zeta}_2)}{P_2}\right)^{-\nu} + x_1 - x_2(1+\psi) - b^L}{1 - \lambda \times \mathbb{1}_{\{d_2<0\}}}, \tag{A.5}$$

where $p_t(\tilde{\zeta}_t) = \mathbb{1}_{\{\tilde{\zeta}_t=0\}} \times p_{t-1} + \mathbb{1}_{\{\tilde{\zeta}_t=1\}} \times p_t$ captures the fact that the firm can only optimize its nominal output price when $\tilde{\zeta}_t = 1$.

Equity holders have limited liability and declare bankruptcy when the firm value is negative. Accordingly, the market value of equity at time $t = 1, 2$ satisfies the following recursive formulation:

$$V_t(\tilde{\zeta}_t, \tilde{c}_t, z_t, \Upsilon_t) = \max_{x_t, p_t(\tilde{\zeta}_t=1)} \left\{ \max\left(d_t(\tilde{\zeta}_t, \tilde{c}_t) + \mathbb{E}_t\left[M_{t+1} V_{t+1}(\tilde{\zeta}_{t+1}, \tilde{c}_{t+1}, z_{t+1}, \Upsilon_{t+1}) \right], 0 \right) \right\}. \tag{A.6}$$

A.1.2 Derivations of the firm's optimal policies

Given the finite nature of the firm optimization problem, we can solve the model recursively.

A.1.2.1 Optimal policies at $t = 2$

After the final period (i.e., after $t = 2$), the firm ceases operations, so the continuation value is null. This implies that the value of the firm is equal to the value of the dividend. The zero continuation value implies that there are no benefits to holding cash, nor issue equity in the final period. Thus, the optimal cash policy is $x_{2,\zeta_t} = 0$ for $\tilde{\zeta}_t = 0, 1$. The optimization problem of the firm in Equation (A.6) simplifies to:

$$V_2(\tilde{\zeta}_2, \tilde{c}_2, z_2, \Upsilon_2) = \max_{p_2(\tilde{\zeta}_2=1)} \Big\{ \max\Big(d_2(\tilde{\zeta}_2, \tilde{c}_2), 0\Big)\Big\}. \tag{A.7}$$

Next, we solve for the optimal decisions and firm value of both a fully flexible firm ($\tilde{\zeta}_2 = 1$) and an inflexible firm ($\tilde{\zeta}_2 = 0$).

Flexible firm. First, we solve for the optimal output price, p_2. The optimizing firm chooses the output price to maximize period dividends. Replacing for the optimal cash holdings decision, the firm maximizes:

$$\max_{p_2} \left(\frac{p_2}{P_2} - \tilde{c}_2\right)\left(\frac{p_2}{P_2}\right)^{-\nu} + x_1 - b^L. \tag{A.8}$$

Taking the first order condition with respect to p_2, and solving for the optimal price yields:

$$p_2 = \frac{\nu}{\nu - 1}\tilde{c}_2 P_2. \tag{A.9}$$

Equation (A.9) shows that the optimizing firm chooses a nominal price that reflects a constant markup over its nominal marginal cost of production, $\tilde{c}_2 P_2$. Replacing for the optimal price into Equation (A.8), we obtain the real firm value V_2:

$$V_2(\tilde{\zeta}_2 = 1, \tilde{c}_2, z_2, \Upsilon_2) = \max\left(\frac{1}{\nu}\left(\frac{\nu}{\nu-1}\right)^{1-\nu}\tilde{c}_2^{1-\nu} + x_1 - b^L, 0\right). \tag{A.10}$$

Finally, we can solve for the optimal default decision, which consists of a threshold rule, $c^d_{\zeta_2=1}$ such that the firm defaults when $\tilde{c}_2 > c^d_{\zeta_2=1}$ and does not default otherwise. The default threshold is determined such that $V_2(\tilde{\zeta}_2 = 1, c^d_{\zeta_2=1}, z_2, \Upsilon_2) = 0$, which yields

$$c^d_{\zeta_2=1} = \left(\left(b^L - x_1\right)\nu\left(\frac{\nu}{\nu-1}\right)^{\nu-1}\right)^{\frac{1}{1-\nu}} . \tag{A.11}$$

The probability of survival when $\zeta_2 = 1$ is $\Phi\left(c^d_{\zeta_2=1}\right)$, where $\Phi(\cdot)$ is the cumulative density function of the log normal distribution of $\tilde{c}_t$. This survival probability is endogenous and depends on both the firm's financing decision and the degree of price rigidity.

Inflexible firm. The non-optimizing firm charges its lagged nominal price p_1 and cannot optimize. The real value of the firm is:

$$V_2(\tilde{\zeta}_2 = 0, \tilde{c}_2, z_2, \Upsilon_2) = \max\left(\left(\frac{p_1}{P_2} - \tilde{c}_2\right)\left(\frac{p_1}{P_2}\right)^{-\nu} + x_1 - b^L, 0\right) . \tag{A.12}$$

Similarly, we can derive the default threshold, which solves $V_2(\tilde{\zeta}_2 = 0, c^d_{\zeta_2=0}, z_2, \Upsilon_2) = 0$ and obtain:

$$c^d_{\zeta_2=0} = \frac{p_1}{P_2} - \left(b^L - x_1\right)\left(\frac{p_1}{P_2}\right)^{\nu} . \tag{A.13}$$

Equity value. Given the optimal default decision, the value of equity at $t = 2$, before both firm-specific shocks $(\tilde{\zeta}_t, \widetilde{X})$ are realized, is equal to the expected value of cash-flows:

$$\begin{aligned} \bar{V}_2(z_2, \Upsilon_2) \quad = \quad & \left(\theta \int_0^{c^d_{\zeta_2=0}} \left(c^d_{\zeta_2=0} - \tilde{c}\right)\left(\frac{p_1}{P_2}\right)^{-\nu} d\Phi(\tilde{c}) \right. \\ & \left. + (1-\theta)\int_0^{c^d_{\zeta_2=1}} \frac{1}{\nu}\left(\frac{\nu}{\nu-1}\right)^{1-\nu}\left(\tilde{c}^{1-\nu} - c^{d\,1-\nu}_{\zeta_2=1}\right) d\Phi(\tilde{c})\right) , \end{aligned} \tag{A.14}$$

where θ is the probability of being an inflexible firm.

A.1.2.2 Optimal policies at $t = 1$

In period $t = 1$, the firm makes the following financing decisions: (i) whether to issue new equity, (ii) whether to default, and (iii) how much cash to hold for period $t = 2$. Additionally, the firm can adjust its nominal output price when $\tilde{\zeta}_1 = 1$. If $\tilde{\zeta}_1 = 0$, the firm must sell its output at the previous nominal price, p_0. Since the firm never issues costly external equity in period $t = 2$, precautionary cash is useless. Therefore, the optimal cash holding decision is $x_{1,\tilde{\zeta}_1} = 0$ for $\tilde{\zeta}_1 = 0, 1$. The optimization problem of the firm simplifies to:

$$V_1(\tilde{\zeta}_1, \tilde{c}_1, z_1, \Upsilon_1) = \max_{p_t(\tilde{\zeta}_1=1)} \left\{ \max\left(d_1(\tilde{\zeta}_1, \tilde{c}_1) + \mathbb{E}_1\left[M_2 \bar{V}_2(z_2, \Upsilon_2) \right], 0 \right) \right\}, \tag{A.15}$$
$$\text{where } \; d_1(\tilde{\zeta}_1, \tilde{c}_1) = \frac{\left(\frac{p_1(\tilde{\zeta}_1)}{P_1} - \tilde{c}_1 \right) \left(\frac{p_1(\tilde{\zeta}_1)}{P_1} \right)^{-\nu} + x_0 - f - b^S}{1 - \lambda \times \mathbb{1}_{\{d_1<0\}}}.$$

Next, we solve for the optimal decisions and firm value of both a fully flexible firm ($\tilde{\zeta}_1 = 1$) and an inflexible firm ($\tilde{\zeta}_1 = 0$).

Flexible firm. The flexible firm sets its new nominal output price, p_1, to maximize equity value, while enjoying limited liability and the option to issue new equity. Substituting the expression for the dividend, the firm's objective is to maximize:

$$\max_{p_1} \left\{ \max\left(\frac{\left(\frac{p_1}{P_1} - \tilde{c}_1 \right) \left(\frac{p_1}{P_1} \right)^{-\nu} + x_0 - f - b^S}{1 - \lambda \times \mathbb{1}_{\{d_1<0\}}} + \mathbb{E}_1\left[M_2 \bar{V}_2(z_2, \Upsilon_2) \right], 0 \right) \right\}. \tag{A.16}$$

The first-order condition with respect to p_1 is:

$$\frac{(1-\nu)\left(\frac{p_1}{P_1} \right)^{-\nu} \frac{1}{P_1} + \nu \tilde{c}_1 \left(\frac{p_1}{P_1} \right)^{-\nu-1} \frac{1}{P_1}}{1 - \lambda \times \mathbb{1}_{\{d_1<0\}}} + \mathbb{E}_1\left[M_2 \frac{\partial \bar{V}_2(z_2, \Upsilon_2)}{\partial p_1} \right] \quad = \quad 0, \tag{A.17}$$

where

$$\frac{\partial \bar{V}_2(z_2, \Upsilon_2)}{\partial p_1} \quad = \quad \theta \left[\frac{(1-\nu)}{P_2} \Phi\left(c^d_{\zeta_2=0} \right) \left(\frac{p_1}{P_2} \right)^{-\nu} + \frac{\nu}{P_2} \left(\int_0^{c^d_{\zeta_2=0}} \tilde{c}_2 d\Phi(\tilde{c}_2) \right) \left(\frac{p_1}{P_2} \right)^{-\nu-1} \right], \tag{A.18}$$

where we used Leibniz integral rule and the definition of $c^d_{\zeta_2=0}$. Solving for p_1, we obtain the following pricing policy:

$$\frac{p_1^\star(\tilde{c}_1)}{P_1} \quad = \quad \left(\frac{\nu}{\nu-1}\right) \frac{\tilde{c}_1 + \theta\left(1 - \lambda \times \mathbb{1}_{\{d_1<0\}}\right) \mathbb{E}_1 \left[M_2 \left(\int_0^{c^d_{\zeta_2=0}} \tilde{c}_2 d\Phi(\tilde{c}_2)\right) (\Pi_2)^\nu\right]}{1 + \theta\left(1 - \lambda \times \mathbb{1}_{\{d_1<0\}}\right) \mathbb{E}_1 \left[M_2 \left(\Phi\left(c^d_{\zeta_2=0}\right) (\Pi_2)^{\nu-1}\right)\right]}. \tag{A.19}$$

As before, the optimal price consists of a markup over the marginal cost of production. However, due to potential future price inflexibility, the firm takes into account the possibility that the price set today may remain unchanged in the next period if it is unable to adjust, which occurs with probability θ. Additionally, when the firm issues equity (i.e., $d_1 < 0$), it becomes more impatient and prioritizes maximizing current cash flows at the expense of the future. Note that in the absence of price inflexibility, i.e., if $\theta = 0$, the firm would simply set $p_1 = \nu/(\nu-1)P_1$, following the standard markup rule over the current marginal cost of production.

The decision to issue external equity or default is determined by two different thresholds for $\tilde{c}_1$. Specifically, the firm defaults when $\tilde{c}_1 > c^d_{\tilde{\zeta}_1=1}$, and it issues new equity when $c^d_{\tilde{\zeta}_1=1} \geq \tilde{c}_1 > c^e_{\tilde{\zeta}_1=1}$. When $\tilde{c}_1 \leq c^e_{\tilde{\zeta}_1=1}$, the firm pays a positive dividend to shareholders. The equity financing threshold is defined by the condition $d_1(\tilde{\zeta}_1 = 1, c^e_{\tilde{\zeta}_1=1}) = 0$, which, in the presence of price stickiness (i.e., $\theta > 0$), must be solved numerically. Specifically, $c^e_{\zeta_1=1}$ is the solution to:

$$\left(\frac{p^e_{\zeta_1=1}}{P_1} - c^e_{\zeta_1=1}\right)\left(\frac{p^e_{\zeta_1=1}}{P_1}\right)^{-\nu} + x_0 - f - b^S = 0, \tag{A.20}$$

$$\text{where} \qquad \frac{p^e_{\zeta_1=1}}{P_1} = \left(\frac{\nu}{\nu-1}\right) \frac{c^e_{\zeta_1=1} + \theta\mathbb{E}_1 \left[M_2 \left(\int_0^{c^d_{\zeta_2=0}\left(c^e_{\zeta_1=1}\right)} \tilde{c}_2 d\Phi(\tilde{c}_2)\right) (\Pi_2)^\nu\right]}{1 + \theta\mathbb{E}_1 \left[M_2 \left(\Phi\left(c^d_{\zeta_2=0}\left(c^e_{\zeta_1=1}\right)\right) (\Pi_2)^{\nu-1}\right)\right]}.$$

Note that in solving this equation, we account for the fact that today's marginal cost affects tomorrow's default decision through sticky prices, i.e., $c^d_{\zeta_2=0}\left(c^e_{\zeta_1=1}\right)$.

Similarly, the default threshold, $c^d_{\zeta_1=1}$ solves:

$$\frac{\left(\frac{p^d_{\zeta_1=1}}{P_1} - c^d_{\zeta_1=1}\right)\left(\frac{p^d_{\zeta_1=1}}{P_1}\right)^{-\nu} + x_0 - f - b^S}{1-\lambda} = -\mathbb{E}_1\left[M_2 \bar{V}_2(b^S, b^L, x_1, p^d_{\zeta_1=1}, \Upsilon_2)\right],$$

$$\text{where} \qquad \frac{p^d_{\zeta_1=1}}{P_1} = \left(\frac{\nu}{\nu-1}\right)\frac{c^d_{\zeta_1=1} + \theta(1-\lambda)\mathbb{E}_1\left[M_2\left(\int_0^{c^d_{\zeta_2=0}\left(c^d_{\zeta_1=1}\right)} \tilde{c}_2 d\Phi(\tilde{c}_2)\right)(\Pi_2)^{\nu}\right]}{1+\theta(1-\lambda)\mathbb{E}_1\left[M_2\left(\Phi\left(c^d_{\zeta_2=0}\left(c^d_{\zeta_1=1}\right)\right)(\Pi_2)^{\nu-1}\right)\right]}. \quad \text{(A.21)}$$

Inflexible firm. The non-optimizing firm charges its lagged nominal price p_0 and cannot optimize. The real value of the firm is:

$$V_1(\tilde{\zeta}_1 = 0, \tilde{c}_1, z_1, \Upsilon_1) = \max\left(\frac{\left(\frac{p_0}{P_1} - \tilde{c}_1\right)\left(\frac{p_0}{P_1}\right)^{-\nu} + x_0 - f - b^S}{1-\lambda \times \mathbb{1}_{\{d_1<0\}}} + \mathbb{E}_1\left[M_2 \bar{V}_2(z_2, \Upsilon_2)\right], 0\right). \quad \text{(A.22)}$$

The equity financing and default thresholds are:

$$c^e_{\zeta_1=0} = \frac{p_0}{P_1} - \left(b^S + f - x_0\right)\left(\frac{p_0}{P_1}\right)^{\nu}, \text{ and} \quad \text{(A.23)}$$

$$c^d_{\zeta_1=0} = \frac{p_0}{P_1} - \left(b^S + f - x_0 - (1-\lambda)\mathbb{E}_1\left[M_2 \bar{V}_2(z_2, \Upsilon_2)\right]\right)\left(\frac{p_0}{P_1}\right)^{\nu}. \quad \text{(A.24)}$$

Equity value. Given the optimal default and refinancing decisions, the value of equity at $t=1$, before both firm-specific shocks $(\tilde{\zeta}_t, \widetilde{X})$ are realized, is:

$$\begin{aligned}
\bar{V}_1(z_1, \Upsilon_1) \;=\; & \theta\left(\int_0^{c^e_{\zeta_1=0}}\left(\left(\frac{p_0}{P_1} - \tilde{c}_1\right)\left(\frac{p_0}{P_1}\right)^{-\nu} + x_0 - f - b^S + \mathbb{E}_1\left[M_2\bar{V}_2(z_2,\Upsilon_2)\right]\right)d\Phi(\tilde{c}_1)\right. \qquad \text{(A.25)}\\
& \left. + \int_{c^e_{\zeta_1=0}}^{c^d_{\zeta_1=0}}\left(\frac{\left(\frac{p_0}{P_1} - \tilde{c}_1\right)\left(\frac{p_0}{P_1}\right)^{-\nu} + x_0 - f - b^S}{1-\lambda} + \mathbb{E}_1\left[M_2\bar{V}_2(z_2,\Upsilon_2)\right]\right)d\Phi(\tilde{c}_1)\right)\\
& +(1-\theta)\left(\int_0^{c^e_{\zeta_1=1}}\left(\left(\frac{p_1^\star(\tilde{c}_1)}{P_1} - \tilde{c}_1\right)\left(\frac{p_1^\star(\tilde{c}_1)}{P_1}\right)^{-\nu} + x_0 - f - b^S + \mathbb{E}_1\left[M_2\bar{V}_2(z_2(\tilde{c}_1),\Upsilon_2)\right]\right)d\Phi(\tilde{c}_1)\right.\\
& \left. + \int_{c^e_{\zeta_1=1}}^{c^d_{\zeta_1=1}}\left(\frac{\left(\frac{p_1^\star(\tilde{c}_1)}{P_1} - \tilde{c}_1\right)\left(\frac{p_1^\star(\tilde{c}_1)}{P_1}\right)^{-\nu} + x_0 - f - b^S}{1-\lambda} + \mathbb{E}_1\left[M_2\bar{V}_2(z_2(\tilde{c}_1),\Upsilon_2)\right]\right)d\Phi(\tilde{c}_1)\right).
\end{aligned}$$

Note that replacing for the optimal default threshold, $\bar{V}_1(z_1, \Upsilon_1)$ can be rewritten as:

$$\begin{aligned}
\bar{V}_1(z_1, \Upsilon_1) \;=\;& \theta \left(\frac{p_0}{P_1}\right)^{-\nu} \left(\frac{-\lambda}{1-\lambda} \int_0^{c^e_{\zeta_1=0}} \left(c^e_{\zeta_1=0} - \tilde{c}_1\right) d\Phi(\tilde{c}_1) + \frac{1}{1-\lambda} \int_0^{c^d_{\zeta_1=0}} \left(c^d_{\zeta_1=0} - \tilde{c}_1\right) d\Phi(\tilde{c}_1) \right) \\
&+(1-\theta) \left(\int_0^{c^e_{\zeta_1=1}} \left(\left(\frac{p^\star_1(\tilde{c}_1)}{P_1} - \tilde{c}_1 \right) \left(\frac{p^\star_1(\tilde{c}_1)}{P_1} \right)^{-\nu} + x_0 - f - b^S + \mathbb{E}_1 \left[M_2 \bar{V}_2(z_2(\tilde{c}_1), \Upsilon_2) \right] \right) d\Phi(\tilde{c}_1) \right. \\
&\left. + \int_{c^e_{\zeta_1=1}}^{c^d_{\zeta_1=1}} \left(\frac{\left(\frac{p^\star_1(\tilde{c}_1)}{P_1} - \tilde{c}_1 \right) \left(\frac{p^\star_1(\tilde{c}_1)}{P_1} \right)^{-\nu} + x_0 - f - b^S}{1-\lambda} + \mathbb{E}_1 \left[M_2 \bar{V}_2(z_2(\tilde{c}_1), \Upsilon_2) \right] \right) d\Phi(\tilde{c}_1) \right).
\end{aligned}$$

A.1.2.3 Optimal policies at $t = 0$

At $t = 0$, equity holders choose b^S, b^L, and x_0 to maximize the total firm value, which consists of future equity and debt claims. Shareholders recognize that increasing leverage today can influence future default and pricing decisions, and they cannot credibly pre-commit to a default policy unless it maximizes their own valuation. In other words, when maximizing firm value, shareholders acknowledge that debt is rationally priced by creditors. The optimization problem is:

$$\max_{b^S, b^L, x_0} \left\{ \mathbb{E}_0 \left[M_1 \bar{V}_1(z_1, \Upsilon_1) \right] - x_0 - \frac{\psi}{2} (x_0)^2 + (1+\chi^S) q^S_0 b^S + (1+\chi^L) q^L_0 b^L - f \right\}, \tag{A.26}$$

where creditors value the debt rationally:

$$\begin{aligned}
q^L_0 &= \mathbb{E}_0 \left[M_1 \left(\theta \int_0^{c^d_{\zeta_1=0}} q^S_1(\tilde{c}_1, \zeta_1 = 0) d\Phi(\tilde{c}_1) + (1-\theta) \int_0^{c^d_{\zeta_1=1}} q^S_1(\tilde{c}_1, \zeta_1 = 1) d\Phi(\tilde{c}_1) \right) \right] \\
q^S_1 &= \mathbb{E}_1 \left[M_2 \left(\theta \Phi(c^d_{\zeta_2=0}(\tilde{c}_1, \tilde{\zeta}_1)) + (1-\theta) \Phi(c^d_{\zeta_2=1}) \right) \right] \\
q^S_0 &= \mathbb{E}_0 \left[M_1 \left(\theta \Phi(c^d_{\zeta_1=0}) + (1-\theta) \Phi(c^d_{\zeta_1=1}) \right) \right].
\end{aligned} \tag{A.27}$$

The first order necessary condition with respect to b^L is given by:

$$\frac{\partial \mathbb{E}_0[M_1 \bar{V}_1]}{\partial b^L} + (1+\chi^L) \left(q^L_0 + \frac{\partial q^L_0}{\partial b^L} b^L \right) + (1+\chi^S) \frac{\partial q^S_0}{\partial b^L} b^S = 0, \tag{A.28}$$

where the partial derivatives are obtained using the Leibniz rule and the enveloppe condition:

$$
\begin{aligned}
\frac{\partial \mathbb{E}_0[M_1\bar{V}_1]}{\partial b^L} &= \theta\frac{\partial \mathbb{E}_0[M_1\bar{V}_1|\zeta_1=0]}{\partial b^L} + (1-\theta)\frac{\partial \mathbb{E}_0[M_1\bar{V}_1|\zeta_1=1]}{\partial b^L}\\
\frac{\partial \mathbb{E}_0[M_1\bar{V}_1|\zeta_1=0]}{\partial b^L} &= \mathbb{E}_0\left[M_1\int_0^{c^d_{\zeta_1=0}}\frac{\partial \mathbb{E}_1[M_2\bar{V}_2(\tilde{c}_1,\zeta_1=0)]}{\partial b^L}d\Phi(\tilde{c}_1)\right]\\
\frac{\partial \mathbb{E}_0[M_1\bar{V}_1|\zeta_1=1]}{\partial b^L} &= \mathbb{E}_0\left[M_1\int_0^{c^d_{\zeta_1=1}}\frac{\partial \mathbb{E}_1[M_2\bar{V}_2(\tilde{c}_1,\zeta_1=1)]}{\partial b^L}d\Phi(\tilde{c}_1)\right]\\
\frac{\partial q_0^L}{\partial b^L} &= \mathbb{E}_0 M_1\Bigg[\theta\phi(c^d_{\zeta_1=0})\frac{\partial c^d_{\zeta_1=0}}{\partial b^L}\times q_1^S(c^d_{\zeta_1=0},\zeta_1=0) + (1-\theta)\phi(c^d_{\zeta_1=1})\frac{\partial c^d_{\zeta_1=1}}{\partial b^L}\times q_1^S(c^d_{\zeta_1=1},\zeta_1=1)\\
&\qquad +\theta\int_0^{c^d_{\zeta_1=0}}\frac{\partial q_1^S(\tilde{c}_1,\tilde{\zeta}_1=0)}{\partial b^L}d\Phi(\tilde{c}_1) + (1-\theta)\int_0^{c^d_{\zeta_1=0}}\frac{\partial q_1^S(\tilde{c}_1,\tilde{\zeta}_1=1)}{\partial b^L}d\Phi(\tilde{c}_1)\Bigg]\\
\frac{\partial q_0^S}{\partial b^L} &= \mathbb{E}_0 M_1\left[\theta\phi(c^d_{\zeta_1=0})\frac{\partial c^d_{\zeta_1=0}}{\partial b^L} + (1-\theta)\phi(c^d_{\zeta_1=1})\frac{\partial c^d_{\zeta_1=1}}{\partial b^L}\right]\\
\frac{\partial q_1^S(\tilde{c}_1,\tilde{\zeta}_1)}{\partial b^L} &= \mathbb{E}_1 M_2\left[\theta\phi(c^d_{\zeta_2=0}(\tilde{c}_1,\tilde{\zeta}_1))\frac{\partial c^d_{\zeta_2=0}(\tilde{c}_1,\tilde{\zeta}_1)}{\partial b^L} + (1-\theta)\phi(c^d_{\zeta_2=1})\frac{\partial c^d_{\zeta_2=1}}{\partial b^L}\right]\\
\frac{\partial c^d_{\zeta_1=0}}{\partial b^L} &= (1-\lambda)\frac{\partial \mathbb{E}_1[M_2\bar{V}_2(\tilde{c}_1,\zeta_1=0)]}{\partial b^L}\times\left(\frac{p_0}{P_1}\right)^{\nu}\\
\frac{\partial c^d_{\zeta_1=1}}{\partial b^L} &= (1-\lambda)\frac{\partial \mathbb{E}_1[M_2\bar{V}_2(\tilde{c}_1,\zeta_1=1)]}{\partial b^L}\times\left(\frac{p^d_{\zeta_1=1}}{P_1}\right)^{\nu}\\
\frac{\partial c^d_{\zeta_2=0}}{\partial b^L} &= -\left(\frac{p_1}{P_2}\right)^{\nu}\\
\frac{\partial c^d_{\zeta_2=1}}{\partial b^L} &= -\left(\frac{p^d_{\zeta_2=1}}{P_2}\right)^{\nu} = -\left(c^d_{\zeta_2=1}\frac{\nu}{\nu-1}\right)^{\nu}\\
\frac{\partial \mathbb{E}_1[M_2\bar{V}_2(\tilde{c}_1,\tilde{\zeta}_1)]}{\partial b^L} &= -\mathbb{E}_1\left[M_2\left(\theta\Phi(c^d_{\zeta_2=0}(\tilde{c}_1,\tilde{\zeta}_1)) + (1-\theta)\Phi(c^d_{\zeta_2=1})\right)\right] = -q_1^S(\tilde{c}_1,\tilde{\zeta}_1),
\end{aligned}
$$

where $\phi(x)\equiv\Phi'(x)$. Combining these equations, we obtain:

$$
\chi^L q_0^L = -(1+\chi^L)\frac{\partial q_0^L}{\partial b^L}b^L - (1+\chi^S)\frac{\partial q_0^S}{\partial b^L}b^S. \tag{A.29}
$$

In other words, the firm decides to increase leverage up to the point where the marginal benefit of issuing an additional unit of debt today (left-hand side) equals its marginal cost (right-hand side).

The first order condition with respect to b^S is given by:

$$\frac{\partial \mathbb{E}_0[M_1\bar{V}_1]}{\partial b^S} + (1+\chi^L)\frac{\partial q_0^L}{\partial b^S}b^L + (1+\chi^S)\left(q_0^S + \frac{\partial q_0^S}{\partial b^S}b^S\right) = 0, \tag{A.30}$$

where the partial derivatives are obtained using the Leibniz rule:

$$\begin{aligned}
\frac{\partial \mathbb{E}_0[M_1\bar{V}_1]}{\partial b^S} &= \theta\frac{\partial \mathbb{E}_0[M_1\bar{V}_1|\zeta_1=0]}{\partial b^S} + (1-\theta)\frac{\partial \mathbb{E}_0[M_1\bar{V}_1|\zeta_1=1]}{\partial b^S} \\
\frac{\partial \mathbb{E}_0[M_1\bar{V}_1|\zeta_1=0]}{\partial b^S} &= -\mathbb{E}_0 M_1\left[\frac{\Phi(c^d_{\zeta_1=0}) - \lambda\Phi(c^e_{\zeta_1=0})}{1-\lambda}\right] \\
\frac{\partial \mathbb{E}_0[M_1\bar{V}_1|\zeta_1=1]}{\partial b^S} &= -\mathbb{E}_0 M_1\left[\frac{\Phi(c^d_{\zeta_1=1}) - \lambda\Phi(c^e_{\zeta_1=1})}{1-\lambda}\right] \\
\frac{\partial q_0^S}{\partial b^S} &= \mathbb{E}_0 M_1\left[\theta\times\phi(c^d_{\zeta_1=0})\frac{\partial c^d_{\zeta_1=0}}{\partial b^S} + (1-\theta)\times\phi(c^d_{\zeta_1=1})\frac{\partial c^d_{\zeta_1=1}}{\partial b^S}\right] \\
\frac{\partial q_0^L}{\partial b^S} &= \mathbb{E}_0 M_1\Bigg[\theta\phi(c^d_{\zeta_1=0})\frac{\partial c^d_{\zeta_1=0}}{\partial b^S}\times q_1^S(c^d_{\zeta_1=0},\zeta_1=0) \\
&\quad + (1-\theta)\left(\phi(c^d_{\zeta_1=1})\frac{\partial c^d_{\zeta_1=1}}{\partial b^S}\times q_1^S(c^d_{\zeta_1=1},\zeta_1=1)\right)\Bigg] \\
\frac{\partial c^d_{\zeta_1=0}}{\partial b^S} &= -\left(\frac{p_0}{P_1}\right)^\nu \\
\frac{\partial c^d_{\zeta_1=1}}{\partial b^S} &= -\left(\frac{p^d_{\zeta_1=1}}{P_1}\right)^\nu.
\end{aligned}$$

Combining these equations, we obtain:

$$q_0^S\chi^S = -(1+\chi^L)\frac{\partial q_0^L}{\partial b^S}b^L - (1+\chi^S)\frac{\partial q_0^S}{\partial b^S}b^S + \frac{\lambda}{1-\lambda}\left(\mathbb{P}_1(\text{financing}) - \mathbb{P}_1(\text{default})\right), \tag{A.31}$$

where $\mathbb{P}_1(\text{financing}) = 1 - \left(\theta\Phi(c^e_{\zeta_1=0}) + (1-\theta)\Phi(c^e_{\zeta_1=1})\right)$, and $\mathbb{P}_1(\text{default}) = 1 - (\theta\Phi(c^d_{\zeta_1=0}) + (1-\theta)\Phi(c^d_{\zeta_1=1}))$.

The first order condition with respect to x_0 is given by:

$$\frac{\partial \mathbb{E}_0[M_1\bar{V}_1]}{\partial x_0} - 1 - \psi x_0 + (1+\chi^L)\frac{\partial q_0^L}{\partial x_0}b^L + (1+\chi^S)\frac{\partial q_0^S}{\partial x_0}b^S = 0, \tag{A.32}$$

where the partial derivatives are given by:

$$\begin{aligned}
\frac{\partial q_0^L}{\partial x_0} &= \mathbb{E}_0 M_1 \left[\theta \phi(c^d_{\zeta_1=0}) \frac{\partial c^d_{\zeta_1=0}}{\partial x_0} \times q_1^S(c^d_{\zeta_1=0}, \zeta_1 = 0) \right. \\
& \qquad \left. +(1-\theta) \left(\phi(c^d_{\zeta_1=1}) \frac{\partial c^d_{\zeta_1=1}}{\partial x_0} \times q_1^S(c^d_{\zeta_1=1}, \zeta_1 = 1) \right) \right] \\
\frac{\partial q_0^S}{\partial x_0} &= \mathbb{E}_0 M_1 \left[\theta \times \phi(c^d_{\zeta_1=0}) \frac{\partial c^d_{\zeta_1=0}}{\partial x_0} + (1-\theta) \times \phi(c^d_{\zeta_1=1}) \frac{\partial c^d_{\zeta_1=1}}{\partial x_0} \right] \\
\frac{\partial \mathbb{E}_0[M_1 \bar{V}_1]}{\partial x_0} &= \mathbb{E}_0 M_1 \left[\theta \times \frac{\Phi(c^d_{\zeta_1=0}) - \lambda \Phi(c^e_{\zeta_1=0})}{1-\lambda} + (1-\theta) \times \frac{\Phi(c^d_{\zeta_1=1}) - \lambda \Phi(c^e_{\zeta_1=1})}{1-\lambda} \right],
\end{aligned}$$

and where we used the fact that:

$$\begin{aligned}
\frac{\partial c^d_{\zeta_1=0}}{\partial x_0} &= \left(\frac{p_0}{P_1} \right)^{\nu} \\
\frac{\partial c^d_{\zeta_1=1}}{\partial x_0} &= \left(\frac{p^d_{\zeta_1=1}}{P_1} \right)^{\nu}.
\end{aligned}$$

Putting it all together, the FOC can be rewritten as:

$$\frac{\lambda}{1-\lambda} \times \mathbb{P}_1(\text{financing}) + (1+\chi^L) \frac{\partial q_0^L}{\partial x_0} b^L + (1+\chi^S) \frac{\partial q_0^S}{\partial x_0} b^S = \psi x_0 + \mathbb{P}_1(\text{default}) \times \frac{1}{1-\lambda}. \quad \text{(A.33)}$$

A.2 Numerical Appendix

Solution method: The model is solved using a second-order approximation around the steady state. Solving for the optimal firm policies first requires integrating over the firm-specific marginal cost shock, $\tilde{c}$. In the case of a sticky price firm, these integrals can be computed exactly using properties of the log-normal distribution. Specifically, assuming $\ln(x) \sim N(\mu, \sigma)$ and denoting the cdf of the standard normal distribution by $\Phi(\cdot)$, we have:

$$
\begin{aligned}
\int_0^{\bar{x}} x^a d\Phi(x) &= \int_0^{\bar{x}} e^{a\ln(x)} \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\ln(x)-\mu)^2}{2\sigma^2}} dx = \int_0^{\bar{x}} \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{\ln(x)^2+\mu^2-2\ln(x)(\mu+a\sigma^2)}{2\sigma^2}} dx \\
&= \int_0^{\bar{x}} \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{\ln(x)^2+(\mu+a\sigma^2)^2-2\ln(x)(\mu+a\sigma^2)+\mu^2-(\mu+a\sigma^2)^2}{2\sigma^2}} dx \\
&= \int_0^{\bar{x}} \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{\left(\ln(x)-(\mu+a\sigma^2)\right)^2}{2\sigma^2}} dx \times e^{-\frac{\mu^2-(\mu+a\sigma^2)^2}{2\sigma^2}} \\
&= e^{\mu a+a^2\frac{\sigma^2}{2}} \Phi\left(\frac{\ln(\bar{x})-(\mu+a\sigma^2)}{\sigma}\right).
\end{aligned}
$$

The pdf of the log-normal distribution is given by: $\phi(x) = g\left(\frac{\ln(x)-\mu}{\sigma}\right)\frac{1}{x\sigma}$.

For a flexible-price firm at $t = 1$, the integration is complicated by the forward-looking nature of the pricing decision, which causes the firm's future value to depend on $\tilde{c}_1$. To address this challenge, whenever we need to integrate over the firm-specific productivity shock, we first take a first-order approximation of the integrand around the conditional mean of $\tilde{c}_1$ over the relevant interval, and then integrate with respect to $\tilde{c}_1$.

Calibration: We calibrate the parameters to values from the literature or to match key empirical moments. Specifically, we target a firm with an average degree of price rigidity of $\theta = 0.759$, which matches the average frequency of price adjustment (FPA) observed in the data.[1] The average flotation cost $\bar{\lambda}$ is set to 0.075, consistent with the range of structural estimates reported in Hennessy and Whited (2005). We normalize the steady-state flexible price to $\bar{p}_0 = 1$ by setting the wage rate to $W = (\nu - 1)/\nu$. We also set $\bar{\mu} = 0$, implying a steady-state productivity level of 1, without loss of generality. The demand elasticity is set to $\nu = 3$, corresponding to a price markup of 50%, which aligns with recent empirical evidence in De Loecker et al. (2020). We fix the fixed cost of production at $f = 0.15$, consistent with a 15% capital depreciation rate, a value commonly used in the macroeconomics literature. The target inflation rate is set at 2%, and the monetary policy response parameter is set to $\phi_\pi = 2$.

The debt benefit parameters, χ^S and χ^L, govern the incentives to use short- and long-term debt.

[1]The probability of price stickiness is related to the frequency of price adjustment via $\theta = 1 - \text{FPA}$.

We calibrate them jointly to match the average book leverage (0.247) and the average debt maturity (0.40) observed in our sample. The agency cost of cash, ψ, is chosen so that the model replicates the average cash-to-assets ratio of 0.13. Idiosyncratic productivity volatility determines firm-level risk. We calibrate $\bar{\sigma}$ to match the average credit spread on long-term debt (195 basis points), consistent with our bond transaction data.[2]

We set the steady-state risk-free rate $\bar{r}$ and the price of risk γ to target a real annual risk-free rate of 3% and a Sharpe ratio of 0.40. We fix the conditional volatility of all exogenous shocks at 1.5% and set their persistence to 0.90, ensuring that differences in persistence do not drive our results. Finally, we set the countercyclical volatility parameter to $\rho_{\mu\sigma} = -0.20$. This generates a credit risk premium of 48 basis points, which lies on the lower end of the range documented in the literature, but remains sizable given the simplicity of the model and the fact that firms only live for two periods.

Table A.1 provides a comprehensive overview of the model parameters, while Table A.2 reports the simulated model moments alongside their empirical counterparts. Overall, the model closely matches all targeted moments.

[2]More formally, the corporate yield on long-term debt is defined as $y := q^L = 1/(1+y)^2$. The credit spread is given by $cs \equiv y - r_f$, where r_f is the real risk-free rate.

Table A.1: Benchmark calibration

Panel A. Firm-level									
$\bar{p}_0$	1.000	$\bar{\lambda}$	0.075	θ	0.759	ν	3.000	f	0.200
$\bar{\sigma}$	0.082	χ^L	0.098	χ^S	0.001	ψ	0.005		
Panel B. Macroeconomic									
$\bar{r}$	0.141	γ	-31.430	$\bar{\Pi}$	1.020	ϕ_π	2.000		
Panel C. Stochastic processes									
ρ_i	0.900	ρ_μ	0.900	ρ_σ	0.900	ρ_λ	0.900	$\rho_{\sigma,\mu}$	0.200
σ_i	0.015	σ_μ	0.015	σ_σ	0.015	σ_λ	0.015		

Table A.2: Simulated and target moments

This table reports the target moments obtained from the model-simulated data alongside their empirical target counterparts. Total debt-to-assets is defined as $b^S + b^L$, net cash holdings-to-assets as $b^S - x_0$, the average credit spread as the spread on long-term debt, and the average maturity as $b^S \times 1 + b^L \times 2$. Moments are computed over 10,000 simulation periods, following a burn-in period of 2,000 periods.

Moment	Model	Target
Total debt-to-assets	0.25	0.25
Net cash-holdings to assets	0.12	0.13
Average credit spread	$202bps$	$195bps$
Average debt maturity	0.40	0.40
Risk-free rate	3.00%	3.00%
Sharpe ratio	0.40	0.40

Table A.3: Variable definitions

Variable	Definitions [Compustat codes in brackets]
A. Fundamental data	
Cash/assets	Cash and marketable securities [che] divided by total assets [at].
Cash/net assets	Cash and marketable securities [che] divided by net assets, defined as the difference between total assets [at] and cash [che].
Long-term debt ratio	The amount of debt maturing in more than 3 years divided by total debts [dltt+dlc].
Size	Logarithm of total assets in 2010 dollars (adjusted using CPI All Urban).
Leverage	Long-term debt [dltt] plus debt in current liabilities [dlc], scaled by total assets.
M/B	Total assets−book value of equity [ceq]+stock price at fiscal-year-end [prcc_f]×shares outstanding [csho], scaled by total assets.
ROA	Net income [ni] divided by total assets [at].
Equity volatility	Annualized standard deviation of daily stock returns over the previous 12 months (at least 21 observations).
Intangibility	Total assets [at] minus the sum of net property, plant and equipment [ppent], cash and marketable securities [che], total receivables [rect], and total inventory [invt], scaled by total assets.
Firm age	The natural logarithm of the number of years since the firm first appeared in CRSP/Compustat.
Rating	The S&P long-term issuer rating from Compustat. If it is unavailable, we use the average S&P ratings of all bonds of the firm weighted by their principal amounts, retrieved from Mergent FISD. If it is still unavailable, we set it to 0. The ratings are coded as AAA=1, ..., D=22.
Not-rated dummy	Equal to 1 if Rating is greater than 0 and 0 otherwise.
Interest coverage	EBITDA divided by interest expense [xint]. If EBITDA is negative, we set it to 0. If the interest coverage ratio is greater than 100 or the interest expense is missing or non-positive, we set it to 100. Then, we define 4 spline variables (k1–k4) according to Blume et al. (1998).
Loss dummy	Equal to 1 if net income [ni] is negative and 0 otherwise.
Z-score dummy	Equal to 1 if the Z-score is greater than 1.81 and 0 otherwise. The Z-score is defined as 3.3×EBIT/assets + 1.0×sales/assets +1.4×retained earnings/assets + 1.2×working capital/assets + 0.6×market value equity/total debt.
Price-to-cost margin	Net sales [sale] minus the cost of goods sold [cogs], divided by total assets [at].
HHI	The Herfindahl-Hirschman index (HHI) of sales [sale] at the Fama-French 48 industry level.
B. Bond issuance data	
Bond rating	Average ordinal rating from Moody's and S&P coded from Aaa=1 to C=21 for Moody's and from AAA=1 to D=22 for S&P.
Bond size	The natural logarithm of the offering amount of a bond.
Bond maturity	The natural logarithm of the years to maturity.
Callable dummy	Equal to 1 if the bond is callable and 0 otherwise.

Senior dummy	Equal to 1 if the bond is senior and 0 otherwise.
Putable dummy	Equal to 1 if the bond is putable and 0 otherwise.
Private dummy	Equal to 1 if the bond is issued through a private placement and 0 otherwise.
C. Loan issuance data and related variables	
Maturity	The natural logarithm of average maturity of all facilities in a deal weighted by the facility amount.
Deal amount	The natural logarithm of the amount of the deal (package).
No. of participants	The natural logarithm of the number of lenders identified as "Participant" in a deal plus 1 (We add 1 to avoid having missing values if the number of participants is 1.).
Secured dummy	Equal to 1 if none of the facilities in a deal is secured and 0 otherwise.
Loan type	Indicator variables for the following loan types: term loan, revolver, 364-day facility, bridge loan, delay draw term loan, and others.
Loan purpose	Indicator variables for the following loan purposes: Takeover/acquisition, corporate purposes, debt repayment, working capital, CP backup, and others.
Leverage	Sum of long-term debt and debt in current liabilities divided by total assets.
Senior leverage	Sum of long-term debt and debt in current liabilities, less subordinated debt, divided by total assets.
Debt/equity	Sum of long-term debt and debt in current liabilities divided by shareholders' equity.
Debt/tangible net worth	Sum of long-term debt and debt in current liabilities, divided by tangible net worth.
Interest coverage	Sum of rolling four-quarter operating income before depreciation divided by the sum of rolling four-quarter interest expenses.
Fixed coverage	Sum of rolling four-quarter operating income before depreciation divided by the sum of rolling four-quarter interest expenses plus the debt in current liabilities 1 year ago.
Cash interest coverage	Sum of rolling four-quarter operating income before depreciation divided by the sum of rolling four-quarter net interest paid.
Debt/EBITDA	Sum of long-term debt and debt in current liabilities divided by the sum of rolling four-quarter operating income before depreciation.
Senior debt/EBITDA	Sum of long-term debt and debt in current liabilities, less subordinated debt, divided by the sum of rolling four-quarter operating income before depreciation.
Current ratio	Total current assets divided by total current liabilities.
Quick ratio	Total current assets minus inventories, divided by total current liabilities.
Net worth	Total assets minus total liabilities.
Tangible net worth	Total net worth minus intangible assets.
EBITDA	Sum of rolling four-quarter operating income before depreciation.
Capital expenditure	Sum of rolling four-quarter capital expenditures.

Table A.4: FPA vs. Volatility Measures.

We re-estimate our baseline regression models using volatility measures in place of FPA (Panel A) or adding both FPA and volatility measures (Panel B). We use two measures of volatility. The first one is volatility of cash flows, defined as the standard deviation of cash flow-to-assets ratio over the past 10 years, where cash flow is defined as earnings after interest, dividends, and taxes but before depreciation. The second one is volatility of sales growth, defined as the standard deviation of annual sales growth over the past 10 years. In columns (1), (4), (7), (10), and (13), we repeat baseline regressions for comparison. In the other columns, we use the volatility measure in place of FPA in Panel A and add both FPA and the volatility measure in Panel B. In columns (1)-(3), the dependent variable is the logarithm of the net cash ratio. In columns (4)-(6), the dependent variable is the long-term debt ratio. In columns (7)-(9), we use the primary bond issuance credit spread as the dependent variable, while in columns (10)-(12), we use the secondary market credit spread data instead. In columns (13)-(15), the dependent variable is loan covenant tightness. In all specifications, we add the same control variables as in our baseline models and the interaction between time and 1-digit SIC industry fixed effects. Standard errors are clustered at the firm and time level.

	Cash ratio			LT debt ratio			Credit spread (issue)			Credit spread (transaction)			Covenant tightness		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A. Replace FPA with volatility measures.															
FPA	−1.02***			0.10**			−0.40***			−0.36**			−0.07***		
	(−3.81)			(2.59)			(−3.05)			(−2.21)			(−2.93)		
Vol. of cash flow		5.35***			0.25**			2.04*			2.03			−0.21*	
		(7.91)			(2.19)			(1.95)			(0.74)			(−1.83)	
Vol. of sales growth			0.49***			0.02			−0.35**			−0.24			0.01
			(5.52)			(0.69)			(−2.67)			(−0.72)			(0.49)
N	19,252	18,400	18,560	16,644	16,049	16,141	5,065	4,996	4,978	525,216	529,765	530,455	2,503	2,385	2,408
Adj. R^2	0.380	0.363	0.367	0.183	0.156	0.167	0.715	0.716	0.715	0.700	0.700	0.700	0.415	0.405	0.405
Controls	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SIC1 × Time FE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Panel B. Control for volatility measures.															
FPA	−1.02***	−1.07***	−1.08***	0.10**	0.09**	0.10**	−0.40***	−0.40***	−0.36***	−0.36**	−0.38**	−0.35**	−0.07***	−0.06**	−0.07***
	(−3.81)	(−3.95)	(−3.86)	(2.59)	(2.49)	(2.70)	(−3.05)	(−3.16)	(−2.97)	(−2.21)	(−2.35)	(−2.04)	(−2.93)	(−2.77)	(−3.18)
Vol. of cash flow		5.66***			0.22*			2.08*			2.07			−0.17	
		(8.34)			(1.92)			(1.99)			(0.76)			(−1.46)	
Vol. of sales growth			0.53***			0.01			−0.32**			−0.19			0.02
			(6.04)			(0.45)			(−2.46)			(−0.59)			(0.81)
N	19,252	18,120	18,283	16,644	15,799	15,894	5,065	4,968	4,950	525,216	522,401	523,091	2,503	2,366	2,389
Adj. R^2	0.380	0.375	0.380	0.183	0.158	0.170	0.715	0.717	0.716	0.700	0.700	0.700	0.415	0.409	0.409
Controls	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SIC1 × Time FE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table A.5: Natural Logarithm of FPA

We re-estimate our baseline regression models using the natural logarithm of FPA instead of FPA. In column (1), the dependent variable is the logarithm of the net cash ratio. In column (2), the dependent variable is the long-term debt ratio. In column (3), we use the primary bond issuance credit spread as the dependent variable. In columns (4), we use the secondary market credit spread data instead. In columns (5), the dependent variable is loan covenant tightness. In all specifications, we add the same control variables as in our baseline models and the interaction between time and 1-digit SIC industry fixed effects. Standard errors are clustered at the firm and time level.

	Cash ratio	LT debt ratio	Credit spread (issue)	Credit spread (transaction)	Covenant tightness
	(1)	(2)	(3)	(4)	(5)
log(FPA)	−0.29***	0.03**	−0.11***	−0.12**	−0.02**
	(−4.03)	(2.52)	(−2.82)	(−2.44)	(−2.75)
N	19,252	16,644	5,065	525,216	2,503
Adj. R^2	0.379	0.183	0.715	0.700	0.415
Controls	X	X	X	X	X
SIC1 × Time FE	X	X	X	X	X

Table A.6: FPA vs. Other Types of Nominal Rigidity.

We re-estimate our baseline regression models adding wage rigidity measures (Panel A) or leverage rigidity measures (Panel B). In Panel A, we use two measures of wage rigidity following Favilukis and Lin (2016a): the standard deviation and the first-order autocorrelation (AC1) of annual wage growth at the 2-/3-digit NAICS industry level from National Income and Product Accounts (NIPA) between 1998 and 2019. We use data starting from 1998 since NIPA switched to NAICS industry definitions after that. The second one is the five-year rolling-window AC1 of annual wage growth for each industry, requiring a minimum of 5 observations for the calculation. Both measures are merged with our sample using the NAICS code in a similar way as FPA. In Panel B, we use two measures to proxy for leverage rigidity. The first one is the five-year rolling-window standard deviation of debt growth and the second one is the five-year rolling-window AC1 of debt growth, where debt growth is defined as the first difference of the natural logarithm of total debt (dltt+dlc) (Lyandres et al., 2008), requiring a minimum of 5 observations for the calculation. In columns (1), (4), (7), (10), and (13), we repeat baseline regressions for comparison. In the other columns, we add measures of wage rigidity in Panel A and measures of leverage rigidity in Panel B. In columns (1)-(3), the dependent variable is the logarithm of the net cash ratio. In columns (4)-(6), the dependent variable is the long-term debt ratio. In columns (7)-(9), we use the primary bond issuance credit spread as the dependent variable, while in columns (10)-(12), we use the secondary market credit spread data instead. In columns (13)-(15), the dependent variable is loan covenant tightness. In all specifications, we add the same control variables as in our baseline models and the interaction between time and 1-digit SIC industry fixed effects. Standard errors are clustered at the firm and time level.

	Cash ratio			LT debt ratio			Credit spread (issue)			Credit spread (transaction)			Covenant tightness		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A. Control for wage rigidity measures.															
FPA	−1.02***	−1.13***	−1.09***	0.10**	0.10**	0.11***	−0.40***	−0.34**	−0.31**	−0.36**	−0.40**	−0.35*	−0.07***	−0.09***	−0.09***
	(−3.81)	(−4.07)	(−4.04)	(2.59)	(2.68)	(2.83)	(−3.05)	(−2.52)	(−2.44)	(−2.21)	(−2.23)	(−1.87)	(−2.93)	(−3.76)	(−3.86)
Std. wage growth		4.17			0.93**			−1.83			−2.86			0.25	
		(1.64)			(2.28)			(−0.77)			(−1.01)			(0.86)	
AC1 wage growth			0.16			−0.01			0.41***			0.61***			−0.02
			(0.88)			(−0.51)			(3.62)			(3.81)			(−1.12)
N	19,252	16,713	16,713	16,644	14,441	14,441	5,065	4,291	4,291	525,216	474,181	474,181	2,503	2,108	2,108
Adj. R^2	0.380	0.393	0.393	0.183	0.195	0.194	0.715	0.710	0.713	0.700	0.703	0.705	0.415	0.418	0.418
Panel B. Control for leverage rigidity measures.															
FPA	−1.02***	−0.98***	−0.98***	0.10**	0.11***	0.11***	−0.40***	−0.38***	−0.38***	−0.36**	−0.37**	−0.38**	−0.07***	−0.07***	−0.07***
	(−3.81)	(−3.51)	(−3.47)	(2.59)	(2.92)	(2.94)	(−3.05)	(−2.94)	(−2.98)	(−2.21)	(−2.21)	(−2.20)	(−2.93)	(−3.11)	(−3.15)
Std. debt growth		0.16***			0.00			0.02			0.12			0.01	
		(4.06)			(0.29)			(0.53)			(1.44)			(0.89)	
AC1 debt growth			0.01			0.01			−0.02			−0.02			0.01
			(0.16)			(0.84)			(−0.40)			(−0.20)			(0.71)
N	19,252	16,646	16,638	16,644	14,676	14,668	5,065	4,699	4,698	525,216	513,800	513,796	2,503	2,224	2,222
Adj. R^2	0.380	0.348	0.346	0.183	0.156	0.158	0.715	0.712	0.712	0.700	0.701	0.701	0.415	0.420	0.420
Controls	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SIC1 × Time FE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X