

Price Rigidities and Credit Risk*

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Abstract

We develop a capital structure model in which firms feature differential flexibility in adjusting output prices to shocks. Inflexible-price firms have lower profits and higher cash-flow volatility, leading in equilibrium to lower financial leverage, shorter debt duration, higher cost of debt, more stringent debt covenants, and higher precautionary cash holdings. Moreover, a cash-flow volatility shock increases the cost of debt more for inflexible-price firms. We confirm these predictions empirically and exploit the 2008 Lehman Brothers bankruptcy to show that inflexible-price firms with higher pre-shock rollover risk exposure experience a significantly larger increase in credit spreads following the event than other firms.

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1 Introduction

The Covid-19 pandemic has again highlighted the central role of monetary policy as a key tool to stabilize the economy, to stimulate consumption, investment, and domestic production, but also to calm financial and credit markets. But monetary policy is also a key determinant of asset prices and risk premia (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, the fact that output prices do not immediately adjust 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 a major driver of cross-sectional differences in firm characteristics. Indeed, a recent literature using micro data underlying official price statistics documents a significant relation between the degree of price stickiness at the firm level, the cross section of stock returns, and firms' optimal leverage choices.¹ So far, little evidence exists 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.

In this paper, we develop a capital structure model to study the implications of price stickiness for firms' capital structure choices and their credit risk. In our model, firms produce goods using a linear technology and face shocks that increase cash-flow volatility. They finance their production using a mix of debt, equity, and cash. In particular, they choose their optimal leverage by weighing the tax benefits of debt against the costs arising from default. The issuance of equity is subject to equity flotation costs. Firms also have access to cash holdings that are subject to agency costs but help insulate firms against future adverse shocks. Importantly, firms differ in their ability to adjust output prices in response to shocks, which differentially affects their exposure to these shocks.

Our model offers a series of predictions. Specifically, in the model, firms with more flexible-output prices have higher leverage and more long-term debt, but lower precautionary cash

¹Gorodnichenko 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%; and D'Acunto, Liu, Pflueger, and Weber (2018) find sticky-price firms increase leverage more following a relaxation of borrowing constraints despite lower unconditional leverage.

holdings, lower costs of debt, and less stringent covenants associated with their debt contracts. In addition, following an exogenous shock to cash-flow volatility, the cost of debt increases more for sticky-price firms as compared to that for flexible-price firms, despite an identical shock size for both types of 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 at the granular level. We merge these measures with financial and balance sheet data from CRSP and Compustat. We also source information on 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 additional predictions about the differential debt characteristics between firms with high and low nominal output price rigidity. Specifically, we show that it is more expensive for sticky-price firms to issue debt, because these firms face greater issuance yield spreads. Related, 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.

Our framework generates additional testable predictions for the dynamics of credit spreads. Specifically, the model implies that the response of credit spreads to heightened uncertainty (e.g., volatility of firm cash flows or profitability) is amplified for firms that face higher nominal price rigidities. To support the model's prediction, we exploit the Lehman Brothers bankruptcy in September 2008 as an uncertainty shock (e.g., [Chodorow-Reich, 2014](#); [Ivashina and Scharfstein, 2010](#)), given the importance of realized uncertainty shocks for the macroeconomy ([Berger et al., 2020](#)). The Lehman Brothers decision to file for Chapter 11 bankruptcy rattled financial markets. At the time, the Dow Jones recorded the largest points drop since the terrorist attacks on September 11, 2001. It also represents the largest bankruptcy filing in U.S. history. Given previous bailouts of financial institutions, the regulator's decision to let the company fail was a major surprise to market participants.

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.

As a refinement of our analysis, we exploit additional cross-sectional variation at the firm level based on firms’ exposure to rollover risk (He and Xiong, 2012) and implement a triple difference-in-differences specification. Almeida et al. (2011) and Nagler (2020) document that rollover risk is a predetermined channel that may amplify credit risk. We build on their analysis and measure firms’ rollover risk based on the fraction of their debt maturing in 2009. Inflexible-price firms with high rollover risk exposure experience a significantly larger increase in credit spreads following the Lehman Brothers bankruptcy compared to other firms.

Taken together, our empirical results confirm the model’s prediction and show that central determinants of the real effects of nominal shocks are also important determinants of firms’ financial policies.

1.1 Related literature

We contribute to the literature that studies the role of nominal rigidities on financial outcomes. Gorodnichenko and Weber (2016) use the micro data underlying the PPI to test alternative theories of price stickiness in micro data. Performing high-frequency event studies around the press releases of the Federal Open Market Committee, they 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.

The key contribution of this paper is to show that output price stickiness also affects firms’ credit risk, their cash holdings, but also the properties of their debt such as maturity, pricing, and covenants. We document a persistent wedge in issuance and secondary market yield spreads between flexible- and sticky-price firms, and a greater yield spread sensitivity

of sticky-price firms to uncertainty shocks, which we show using cross-sectional differences in price reactions around the Lehman Brothers crash. The higher sensitivity of sticky-price firms to uncertainty shocks also 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.

While 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 has documented that across-industry heterogeneity in the degree of wage rigidity and labor shares results in return predictability, differences in credit risk, and helps resolve several long standing asset pricing puzzles (Favilukis and Lin, 2016a,b; Favilukis et al., 2020). We share with these papers the study of the role of nominal rigidities on financial markets. However, we extend it in that we study the role of frictions on the revenue rather than on the cost side. Moreover, we directly observe output prices that allow us to measure pricing frictions at the granular level.

Our paper also relates to the literature that studies the effect of sticky leverage on credit risk. Bhamra et al. (2011), Kang and Pflueger (2015) and Gomes et al. (2016) show that nominal debt contracts result in unexpected price level changes altering the real value of corporate debt and affect firms' credit risk. Corhay and Tong (2021) find that the sticky leverage effect can lead to a disruption in aggregate credit supply in the presence of constrained financial intermediaries and Bhamra et al. (2018) show the role of sticky leverage and cash-flow stickiness for credit risk and equity valuations.

In contrast to these papers, we focus on the effect of sticky-output prices on credit risk. In addition, and to the best of our knowledge, we are the first to document the effects of sticky prices on credit risk in the cross-section of firms and provide new results for both the pricing and characteristics of debt. In related work, Gu et al. (2018) and Gu et al. (2017) study how scale irreversibility affects firm risk and financial leverage. We share with these papers the fact that we document how a friction at the firm level modulates the exposure to aggregate risk and how it is priced in financial markets.

Given our focus on the relation between nominal price rigidities and credit risk, we also contribute to a vast literature on credit risk, which is too voluminous to review here. Regarding

the determinants of credit spreads, structural credit risk models advocate asset volatility and leverage, in addition to the riskless borrowing costs, as key factors that impact the level and time variation in spreads (Black and Scholes, 1973; Merton, 1974). Collin-Dufresne et al. (2001) find empirically that leverage and volatility have rather limited power in explaining credit spread changes of corporate bonds, while Ericsson et al. (2009) conclude that the same variables explain a much greater fraction in corporate CDS spread changes. More recently, Bharath and Shumway (2008) and Bai and Wu (2016) confirm that firm fundamentals and the Merton (1974) distance-to-default measure are important drivers of credit spreads.² We contribute to this literature in an important way, as we document 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, which have a greater sensitivity to cash-flow shocks, hold a greater proportion of liquid assets, i.e., cash. This finding relates directly to the literature that rationalizes precautionary savings due to higher current and future credit risk (e.g., Bolton et al., 2014). Subrahmanyam et al. (2017) show empirically that firms hold a greater amount of cash in response to the empty creditor problem, which arises due to the separation of cash-flow from ownership rights in the presence of credit default swaps. Harford et al. (2014) illustrate how firms may hold greater amounts of cash due to higher refinancing risk. This evidence is also consistent with the view that firms favor cash over lines of credit for liquidity management (Acharya et al., 2012, 2013).

In a recent paper, Lin et al. (2020) find that a higher production price risk leads to higher cash holdings, which relates to our results on cash holdings. However, our paper is different from theirs in four aspects. First, while they focus on production technology flexibility to measure price risk, we focus on output-price flexibility. Second, they focus on a sample of firms in the electricity-producing industry, whereas we measure frequency of price adjustments for a large sample of firms across different industries. Third, not only do we study

²Additional references point to the role of total and idiosyncratic volatility (Campbell and Taksler, 2003), option-implied and historical volatility (Cremers et al., 2008; Cao et al., 2010), industry competition (Corhay, 2017; Chen et al., 2020), high-frequency return-based volatility and jump risk measures (Zhang et al., 2009), accounting information (Blanco et al., 2005; Das et al., 2009), liquidity and liquidity risk (Longstaff et al., 2005; Tang and Yan, 2010; Bongaerts et al., 2011; Qiu and Yu, 2012; Acharya et al., 2013; Chen et al., 2007), counterparty risk (Arora et al., 2012), recovery risk (Pan and Singleton, 2008; Elkamhi et al., 2014), cheapest-to-deliver options (Jankowitsch et al., 2008; Ammer and Cai, 2011), restructuring risk (Berndt et al., 2007), counterparty and collateral risk (Giglio, 2014; Capponi et al., 2018). For a full literature review of the determinants of CDS spreads, see Augustin et al. (2014).

the relation between price stickiness and cash holdings, but we also examine its relation with debt maturity, cost of debt, and covenant tightness. And lastly, in addition to the empirical evidence, we develop a theoretical model to explain our findings.

Finally, we build on a large literature in macroeconomics on the determinants and role of output price stickiness. [Zbaracki et al. \(2004\)](#) document in detail the costs associated with changing prices for a large U.S. manufacturer, such as data collection, managerial costs, physical costs, or negotiation costs. The total cost of changing nominal prices is 1.22% of total revenue and 20.03% of the company's 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 and that substantial heterogeneity is present in price stickiness across industries. [Goldberg and Hellerstein \(2011\)](#) confirm these findings for producer prices. Other recent contributions to this literature are [Eichenbaum, Jaimovich, and Rebelo \(2011\)](#); [Anderson, Jaimovich, and Simester \(2015\)](#); and [Kehoe and Midrigan \(2015\)](#). [Pasten et al. \(2020\)](#), [Pasten et al. \(2017\)](#) 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 of 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 thereby its credit risk. Firms that face greater price rigidity have lower and more volatile cash flows, which increases default risk for creditors. 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. Debt covenants can help mitigate the agency problems between shareholders and creditors. Thus, all else equal, firms with stickier output prices have tighter covenants relative to firms with more flexible prices.³

³We develop an alternative, more micro-founded model in the appendix that allows price rigidity to jointly affect the firm's financing, default, and production decisions. The simpler reduced-form framework we develop here is sufficient to convey the economic intuition of how price rigidity affects financial outcomes.

2.1 Economic environment

We consider an economy populated by a continuum of firms that have access to a linear production technology. These firms are subject to shocks affecting their productivity, which is modulated by their degree of price stickiness.⁴ Figure 1 provides a timeline of events for firms. Specifically, firms live for three periods.

At $t = 0$, each firm finances the purchase of productive capital by issuing equity and two-period debt. Each firm also chooses the amount of cash to hold as a buffer against shocks, which are realized in subsequent periods.

At $t = 1$, the firm observes its productivity shock and decides on the optimal quantity to produce as well as the output price to charge for its product. The price setting is inflexible in the sense that a positive probability exists that the firm is unable to change its output price in response to the shock. We show that the degree of price rigidity affects the average level and volatility of firms' profits. Once profits are realized, each firm updates 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 the shareholders.

At $t = 2$, surviving firms experience a second productivity shock, choose their output price, realize profits, and decide on their default strategy. In the absence of default, the firm repays the face value of debt to creditors and distributes the residual cash flows to equity holders in the form of dividends. The firm then ceases its operations. All claims are held by risk-neutral agents with a unity subjective discount factor. We now describe in more detail the economic problem each firm in our economy faces to better understand how price rigidity affects firms' financing decisions.

⁴We model firm-specific productivity shocks for simplicity. Any shock (e.g., aggregate monetary policy shocks) that generates a differential response of firms' cash-flow volatility due to price stickiness would yield identical predictions.

2.1.1 Production

Each firm i has access to a linear production technology that produces a profit of R_{it} per unit of capital K_i . The return on capital, R_{it} , is composed of two components:

$$R_{it} = R Z_{it}(\theta), \tag{1}$$

where the first term, $R > 0$, is an aggregate productivity term common to all firms in the economy. The second term, $Z_{it}(\theta)$, is an i.i.d., firm-specific shock, realized in periods $t = 1$ and $t = 2$. Although the realizations of the firm-specific shocks are unknown in advance, as of time $t = 0$, their distribution is common knowledge. Note that firm-specific shocks depend on θ , which captures the degree of price stickiness, and it is therefore a key determinant of firms' profits.

2.1.2 Price stickiness

Firms face a rigidity in adjusting their output prices to shocks. Following [Calvo \(1983\)](#), we assume that, at the beginning of each period, and after observing the realization of the productivity shock, a firm can adjust its product prices with probability $(1 - \theta)$. We show in [Appendix A.1](#) that price inflexibility has two effects on profits. First, it reduces the firm's expected profitability. The intuition is that firms with more rigid prices are more likely to be in a situation in which they must sell their output at an inefficient price (either too high or too low), which lowers their expected profitability. Second, the inability to respond to exogenous productivity shocks increases the volatility of a firm's profits. [Gorodnichenko and Weber \(2016\)](#) provide supporting empirical evidence for such a relation between price flexibility and firm profits.

To capture the effect of price rigidity in a tractable way, we define the firm-specific shock, Z_{it} , as follows:

$$Z_{it}(\theta) = 1 - (1 + \theta)z_{it}R^{-1}, \tag{2}$$

where $z_{it} \sim N(\mu, \sigma)$, $\mu \geq 0$, and $\theta \in [0, 1]$. The cumulative probability distribution function of z_{it} is denoted by $\Phi(\cdot)$. The parameter θ captures the effect of price stickiness on the

firm's profits, that is, higher price stickiness (larger θ) leads to lower, more volatile profits. In this specification, the conditional volatility of profits of a perfectly flexible-price firm is equal to σ .

2.1.3 Financing

The entrepreneur finances the firm's operations using a combination of equity and long-term (two-period) debt, and it may choose to hold cash.

Debt: At $t = 0$, firms issue long-term, zero-coupon debt that matures at $t = 2$. Equity holders can choose to default on their debt obligations when the value of equity turns negative. Default, however, entails bankruptcy costs borne by creditors. We assume creditors' claims are wiped out in default such that they receive no payout. This assumption simplifies the tractability of the model, but our results are robust to assuming partial recovery in default. Bankruptcy costs make debt an unattractive source of financing.

To obtain an interior solution for the optimal debt/equity mix, we assume debt also provides benefits to shareholders. Such benefits may be microfounded, for instance, through a reduction of agency frictions or tax advantages. As in [Gourio \(2013\)](#), we capture these benefits by assuming the firm receives $(1 + \chi) > 1$ for each dollar of debt it issues. Thus, a higher value for χ increases the attractiveness of debt and leads to higher leverage. The total proceeds from debt financing at $t = 0$ are equal to:

$$(1 + \chi) q_{i0} B_i, \tag{3}$$

where B_i is the amount of two-period debt issued, and q_{i0} is the market price of debt at time $t = 0$.

Debt is issued in a competitive lending market in which creditors price debt rationally. Denoting the probability of default of the firm at time t by Φ_{it}^d , the value of a unit of newly issued debt is equal to the present value of the future cash flows, that is,

$$q_{i0} = (1 - \Phi_{i1}) \times (1 - \Phi_{i2}^d), \tag{4}$$

where the firm's probability of default, Φ_{it}^d , is endogenous and determined by the optimal decision of equity holders, as we discuss below.

Although we only allow the firm to finance through long-term debt, we allow the firm to hold cash, which is akin to negative one-period debt. Therefore, the firm jointly decides on the amount of short-term debt it issues and the amount of cash it holds (discussed below) and our model also has implications for the average debt maturity.⁵

Equity: The firm can also finance its operation using equity at $t = 0$. In addition, the firm has the option to obtain extra financing in subsequent periods at a cost. For every dollar of seasoned equity raised by the firm, it must pay a fee λ . The existence of flotation costs or agency frictions for equity issuance motivate this assumption (e.g., see [Hennessy and Whited, 2007](#)). Costly external finance gives an important role for holding cash. As we show below, when seasoned equity financing is costly, a wedge exists between the shadow value of \$1 of external vs. internal financing. This wedge makes the firm effectively risk averse and precautionary cash holdings become an important tool to avoid costly external financing.

Finally and in contrast to debt holders, equity holders have the right to the residual cash flows of the firm and possess a limited liability option. That is, equity holders can always choose to walk away with a cash flow of zero.

Cash: Each period, firms also choose whether to hold cash due to a precautionary savings motive to insulate against future productivity shocks. Cash is useful, because it saves the firm future financing costs. To avoid that the firm excessively uses cash to undo all financing frictions, we model an agency problem similar to [Nikolov and Whited \(2014\)](#), that is, the managers of the firm can divert free cash flows for private benefits. We model these agency costs in a reduced form, similar to the benefits of debt. In particular, we assume the firm pays a cost $\psi > 0$ for each dollar of new cash holdings. Denoting the previous period's cash

⁵One could further differentiate short-term debt from both cash (e.g., tax-deductibility, default risk) and long-term debt (e.g., rollover risk, differences in agency frictions across maturity). Such extended models would lead to identical conclusions for the average debt maturity.

balance by X_{it-1} , the net cash flow from cash balances is given by:

$$X_{it-1} - X_{it}(1 + \psi). \quad (5)$$

2.2 Objective function

The firm's objective is to maximize the value of equity by taking a series of financing and production decisions. As the firm's optimization problem is homogeneous in capital, we normalize all variables by K_i , implying that each variable should be interpreted as a fraction of total firm assets. We denote all normalized variables by lower case letters and drop the i -subscript, unless it is necessary to avoid confusion.

In period $t = 0$, the entrepreneur is unlevered, so the maximization problem boils down to choosing leverage b and cash-holdings x_0 to maximize the total proceeds from both debt and equity issuance, that is,⁶

$$\max_{b, x_0} \left\{ E_0[v_1] - x_0(1 + \psi) + (1 + \chi)q_0b \right\}, \quad (6)$$

where v_1 is the value of equity in period $t = 1$.

In periods $t > 0$, the firm chooses its optimal cash holdings x_t to maximize the equity value. The firm has the option to issue seasoned equity, subject to a flotation cost λ , or to declare bankruptcy. Seasoned equity issuance happens when the firm's dividend is negative and bankruptcy is declared when the firm's value is negative. Accordingly, the market value of equity satisfies the following recursive formulation for $t = 1, 2$:

$$v_t(z_t) = \max_{x_t} \left\{ \max \left(d_t(z_t) + E_t[v_{t+1}(z_{t+1})], 0 \right) \right\}, \quad (7)$$

⁶To improve readability, we abstract from directly modeling flotation costs for the initial equity issuance. Therefore, both the benefits of debt χ and the agency costs of cash ψ should be interpreted relative to the flotation cost λ .

where the dividends paid by the firm at $t = 1, 2$ are:

$$d_1(z_1) = \frac{R - (1 + \theta)z_1 + x_0 - x_1(1 + \psi)}{1 - \lambda \times \mathbb{1}_{\{d_1 < 0\}}}, \quad (8)$$

$$d_2(z_2) = \frac{R - (1 + \theta)z_2 + x_1 - x_2(1 + \psi) - b}{1 - \lambda \times \mathbb{1}_{\{d_2 < 0\}}}. \quad (9)$$

Given the finite nature of the firm optimization problem, we can solve the model recursively (see Appendix A.2 for details).

2.3 Optimal policies

We next describe the firm's optimal policies and provide intuition for the effect of price rigidity on the firms' optimal financing and default decisions, as well as on the equilibrium cost of debt. We provide details of the derivations in Appendix A.2. In period $t = 1$, the firm defaults when the shock z is large enough to generate a negative equity value. As long as z is below the default threshold z_1^d , the firm keeps operating. When the productivity shock causes a lack of liquidity, i.e., a negative dividend, the firm issues external equity. Taken together, we arrive at the following financing decision rules in period $t = 1$:

$$\begin{cases} \text{default} & \text{if } z_1 > z_1^d \\ \text{issue new equity} & \text{if } z_1^d \geq z_1 > z_1^e \\ \text{do nothing} & \text{if } z_1^e \geq z_1, \end{cases} \quad (10)$$

where the thresholds are determined such that $d_1(z_1^e) = 0$ and $v_1(z_1^d) = 0$, that is,

$$z_1^e = \frac{R + x_0}{(1 + \theta)} \quad (11)$$

$$z_1^d = \frac{R + x_0 + (1 - \lambda)E_1[v_2]}{(1 + \theta)}. \quad (12)$$

These endogenous thresholds determine the probability of default, $1 - \Phi(z_1^d)$, as well the probability of needing external financing, $1 - \Phi(z_1^e)$. Importantly, the degree of price inflexibility θ is a key determinant of these probabilities. All else equal, more inflexible firms face

higher risk and default more frequently. They are also more likely to face liquidity shortfalls. Hence, price stickiness affects the firm's optimal financing decisions such as leverage and cash holdings, and has, therefore, a first order impact on the equilibrium price of debt.

We now turn to the optimal leverage decision, which we obtain by taking the first order condition with respect to b at $t = 0$:

$$\chi q_0 = -\frac{\partial q_0}{\partial b} b. \quad (13)$$

Equation (13) indicates the optimal amount of leverage is pinned down at the level at which the marginal benefit of debt (left-hand side) equals its marginal cost (right-hand side). The marginal benefit comes from the extra inflow for each dollar raised, χ . The marginal cost of debt originates from the fact that an additional unit of debt increases the firm's incentive to default and, thus, decreases the value of debt to creditors, $\partial q_0 / \partial b < 0$. As we show in the next section, a higher degree of price stickiness, that is, a higher θ , increases firm risk and decreases the net benefits of debt, leading simultaneously to lower leverage, and both higher default risk and credit spreads.

Similarly, the optimal cash holding decision is determined so that the marginal benefits of an extra dollar in cash equal the marginal costs, that is,

$$\underbrace{\frac{\lambda}{1-\lambda} \times \mathbb{P}_1(\text{equity}) + (1+\chi) \frac{\partial q_0}{\partial x_0} b}_{\text{Marginal Benefits of Cash}} = \underbrace{\psi + \mathbb{P}_1(\text{default}) \times \frac{1}{1-\lambda}}_{\text{Marginal Costs of Cash}}, \quad (14)$$

where the probabilities of raising external financing and of defaulting are $\mathbb{P}_1(\text{equity}) = 1 - \Phi(z_1^e)$ and $\mathbb{P}_1(\text{default}) = 1 - \Phi(z_1^d)$, respectively.

To better understand the forces determining cash holdings, note that each additional unit of cash has two main benefits (left-hand side). First, it allows the firm to save on costly external equity finance in the subsequent period. Second, it allows the firm to increase the value of its debt by reducing the probability of default in the subsequent period, which raises the total debt proceeds. However, each additional unit of cash also bears a cost. First, greater cash cushions increase agency frictions (first term on the right-hand side). Second, the additional cash may be lost if the firm defaults in the following period.

Because more sticky-price firms are riskier, they are more likely to need costly external financing and to default. As a consequence, inflexible firms optimally accumulate more cash in equilibrium in order to relax their financing constraints.

2.4 Numerical exercise and empirical predictions

The model does not admit a closed form solution. Therefore, we solve and simulate the model numerically to generate testable predictions. We calibrate our model using estimates from the existing literature and to match key empirical moments from our data sample. We target a firm with an average degree of price rigidity of $\theta = 0.759$, which matches the average level of FPA in the data.⁷ The flotation cost λ is set to 0.10, which is within the range of the structural estimates in [Hennessy and Whited \(2005\)](#). The debt benefit parameter χ mainly drives the incentive to use leverage. We choose χ to generate an average book leverage equal to the average book leverage in our sample, 0.247. The agency cost of cash ψ affects the marginal cost of cash holdings. We pick ψ so that the average cash to assets ratio is 0.13, in line with the data. The firm's idiosyncratic volatility drives the amount of risk. We choose σ to generate an average credit spread equal to the average credit spread in our bond transaction sample (195bps). Finally, we set R to 1 and $\mu = 0$. The latter implies that we focus on the effect of price rigidity on the second moment of profits. This assumption is for simplicity, as choosing $\mu > 0$, which results in a negative impact of price rigidity on the first moment of profits, would lead to sharper predictions and strengthen our results.⁸

We consider various levels of θ to generate new predictions regarding the effect of price rigidity on the firm's optimal financing policies. In addition to the optimal policy functions, we generate predictions for credit spreads and average debt maturity. In our model, the bond yield is equivalent to the credit spread because we set the riskless borrowing rate to zero for simplicity. The credit spread is defined as the value of y that solves:

$$q = \frac{1}{(1+y)^2}. \tag{15}$$

⁷The probability of price stickiness is related to FPA in the following way: $\theta = 1 - FPA$.

⁸This assumption is consistent with a statistically insignificant relation between price flexibility and measures of profitability like return on equity or sales growth (the appendix). Return on assets, which we use in our empirical tests, is weakly negatively correlated with price flexibility.

We obtain the average maturity of debt by noting that x is akin to cash, net of one-period debt.⁹

In Figure 2, we provide comparative statics to show the impact of price rigidity (as proxied by θ) on firm policies and asset prices. Our model delivers several testable predictions which we aim to validate empirically. First, our theory predicts that firms with greater nominal price rigidities exhibit lower leverage. That prediction is consistent with the empirical evidence documented in [D'Acunto, Liu, Pflueger, and Weber \(2018\)](#). One might expect that the lower leverage for sticky-price firms coincides with lower cash holdings as in [Bolton et al. \(2014\)](#), yet we illustrate that, in equilibrium, sticky-price firms hold more precautionary savings in response to their greater sensitivity to credit risk. This prediction is the subject of the first hypothesis we test.

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

Because inflexible-price firms have less discretion in adjusting their product prices in response to shocks, they are more likely to be in situations in which they are forced to sell their output at inefficient prices. This mechanism increases the cash-flow volatility and, therefore, makes inflexible-price firms more vulnerable to default risk. As a result, debt financing will be costlier for inflexible-price firms. This conjecture is the second hypothesis we aim to empirically verify.

H₂: Sticky-price firms have higher credit spreads than flexible-price firms.

The combination of greater credit risk and greater sensitivity to cash-flow shocks make it more difficult for firms to borrow using longer-term debt. Hence, we expect firms with lower flexibility in adjusting their product prices to have a greater amount of short-term debt. This is the third hypothesis that we plan to validate.

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

In addition, debt should be associated with a greater number of covenants, in order to mitigate shareholders' incentives to default, which are larger for inflexible firms. More specifically, [Demerjian \(2017\)](#) shows that creditors optimally impose tight financial covenants on

⁹We scale debt by total assets instead of total debt to avoid scaling by a potentially negative denominator.

firms that face uncertainty regarding their future prospects. This way, tight covenants trigger renegotiation if the company performs poorly in the future. In our model, sticky-price firms exhibit higher cash-flow uncertainty and credit risk. Thus, we predict that sticky-price firms benefit more from tighter covenants to mitigate credit risk than flexible firms. We, therefore, test a fourth hypothesis related to tightness of firms' covenants.

H₄: Sticky-price firms have tighter covenants tied to their external debt holdings.

To further corroborate the importance of price rigidity for credit risk, we generate an additional prediction that exploits an exogenous change in the level of uncertainty.¹⁰ To that end, we augment the model to allow for time-varying volatility of profits σ_t :

$$\sigma_t = \rho\sigma_{t-1} + \sigma_\sigma\varepsilon_{\sigma,t}$$

where $\varepsilon_{\sigma,t}$ is an uncertainty shock known at the end of period $t = 0$, after the firm has made its financing decision, ρ determines the persistence of the shock, and σ_σ defines the sensitivity.

The effect of an uncertainty shock on credit spreads is likely to depend on the level of price rigidity. The intuition is as follows. First, sticky-price firms have a higher likelihood of default, making their debt value more sensitive to changes in volatility.¹¹ Second, higher uncertainty implies a higher chance of being stuck at an inefficient price-level. This effect further increases the risk of a sticky-price firm relative to that of a flexible-price firm. In Figure 3, we compare the impulse response of credit spreads to an increase in uncertainty for a flexible- vs. a sticky-price firm. In response to the higher uncertainty, credit spreads increase for all firms, but the increase is comparatively higher for sticky-price firms. Thus, we posit the following final hypothesis:

H₅: The increase in credit spreads in response to an uncertainty shock is higher for sticky-price firms than for flexible-price firms.

¹⁰For empirical evidence on the importance of time-varying uncertainty for asset prices and macro quantities, see Bloom (2009), Christiano et al. (2014), and Coibion et al. (2021).

¹¹As an analogy, consider the Merton (1974) model, in which corporate debt is a default-free bond minus a put option on the firm 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.

2.5 Discussion and Model Extension

In our baseline model, we propose a reduced-form specification whereby price rigidity is exogenously specified and affects the firm’s profits via the probability of no price adjustment (θ), which multiplies the profit shock. This specification implies the model predictions for price rigidity, as modulated by θ and presented in Figures 2 and 3, would be similar to predictions obtained from a shock to cash-flow uncertainty, modulated by the profit shock volatility parameter σ . Our modeling choice is motivated by parsimony, because the baseline model is sufficient to convey the economic channel of price rigidities in affecting firm decisions and asset prices.

To more clearly distinguish the independent impact of price rigidity from that of cash-flow volatility, we develop a more general model in Appendix Section B, allowing price rigidities to jointly affect the firm’s financing, default, and production decisions. This extended framework explicitly distinguishes the price rigidity from the cash-flow uncertainty channel, at the expense of greater complexity. Nonetheless, the extended framework generates identical testable predictions to those implied by our baseline model, as we show in Figures B.1 and B.2. The economic intuition for these results is similar to that in our benchmark model. Sticky price firms have lower operational flexibility. As a result, they suffer more when hit by an adverse shock and are less able to take advantage of positive shocks. Sticky price firms are thus endogenously more exposed to shocks and riskier, all else being equal.

Moreover, we also show empirically the independent effect of price rigidity and contrast it with the inconsistent effect of generic cash-flow uncertainty on financial outcomes.

3 Data

To test whether sticky-price firms have higher cash holdings, greater credit spreads, and more short-term debt that is more likely to be restricted by covenants, we merge a number of data sources.

As a key input to our analysis, we obtain confidential micro pricing data underlying the PPI from the BLS. We combine granular measures of price flexibility with balance sheet

information on cash holdings and debt maturity from Compustat. We source bond and loan characteristics, such as issuance cost and covenants, from Mergent FISD and Thomson-Reuters LPC DealScan. We complement that information with a battery of financial ratios. We provide a detailed description of all variables in Appendix Table [A.1](#).

We consider all firms that have been part of the S&P 500 Index during the sample period for which we observe pricing data as in [Gorodnichenko and Weber \(2016\)](#) and [D’Acunto et al. \(2018\)](#). However, we exclude financial and utility firms with SIC codes between 6000–6999 and 4900–4999, respectively, since financial (utility) firms can hold cash and debt due to regulatory requirements that are unrelated to price stickiness (see, e.g. [Bates et al. \(2009\)](#), [Badoer and James \(2016\)](#), and [Han and Zhou \(2014\)](#)).

3.1 Micro pricing data

Our analysis uses measures of nominal price rigidities from the BLS measured at the granular six-digit NAICS industry level from [Pasten et al. \(2017, 2020\)](#). These measures are based on monthly price information for individual goods 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, and gas and electricity, as well as the service sector.¹²

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

¹²The BLS started sampling prices for the service sector in 2005. The PPI covers about 75% of the service sector output.

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.¹³

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 an 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

¹³Market power and industry concentration are unlikely drivers of nominal price rigidities because if they were, monetary policy would be neutral.

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 the frequency of price adjustment. First, we examine the cost of debt in the primary bond market using bond issuance data. Second, we examine the cost of debt in the secondary bond 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 a 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. Then, we remove canceled records and adjust corrected or reversed transactions following [Dick-Nielsen \(2009\)](#) and [Dick-Nielsen \(2014\)](#).

To construct a monthly sample of bond credit spreads, we first aggregate the transactions data for each bond on each day by calculating 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.¹⁴ 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).¹⁵ 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 debt/EBITDA, current ratio, quick ratio, net worth, tangible net worth, EBITDA and capital expenditures. We provide more detailed definitions of these variables in Panel C of the Appendix Table A.1.

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

¹⁴The 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.

¹⁵The 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.

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:

$$\text{Tightness} = 1 - \Phi_N(\mathbf{r} - \underline{\mathbf{r}}), \quad (16)$$

where Φ_N is the cumulative distribution function of a multivariate normal distribution with mean zero and covariance matrix Σ , and $\mathbf{r} = [r_1, \dots, r_n]'$ and $\underline{\mathbf{r}} = [\underline{r}_1, \dots, \underline{r}_n]'$ 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 quarterly data among firms in the same 1-digit SIC industry over the past 10 years. If there are insufficient observations (less than 20) to estimate Σ , we use the covariance matrix estimated over the entire sample period 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 1 summary statistics for our baseline sample from 1982 to 2018. Our matched sample of annual fundamental data consists of 1,045 unique firms with 21,291 firm-year observations. Among all observations, 21,273 have information on cash ratios and we have available long-term debt ratio data 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. Our loan issuance sample consists of 2,968 loans from 621 borrowers with available tightness measure. Detailed definitions of all the variables are available in Appendix Table A.1.

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 the frequency of price adjustment across firms.

The average firm in our sample 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 2, we show the pairwise correlation coefficients for all variables. The frequency of price adjustment 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 hold indeed 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. \(2018\)](#). While we measure a weakly negative correlation between FPA and return on assets in our sample (6%), we show in Appendix Table A.2 that the correlation with other measures of profitability (return on equity, sales growth) is statistically indistinguishable from zero. This low correlation supports our emphasis on the effect of price rigidity on the second moment of profits in the model.

In Panel B of Table 1, we show the summary statistics for the variables related to the cost of debt. The average yield spread at issuance is 1.54%, with a standard deviation of 1.43%. We also observe a wide dispersion in issuance spreads that range from less than 40 basis points (bps) to more than 430 bps. The average offering amount of a bond in our sample is \$546 million and has an ordinal credit rating of 7.68, which corresponds 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.

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 spread. 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 1 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:

$$Characteristic_{i,t} = \alpha + \beta FPA_{j,t} + \gamma \cdot X_{i,t} + \eta_t + \nu_k + \varepsilon_{i,t}, \quad (17)$$

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, M/B ratio, ROA, equity volatility, intangibility, firm age, not-rated dummy, interest coverage, loss dummy, and z-score dummy.¹⁶ 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. The definitions of all firm-level variables are listed in Panel A of the Appendix Table [A.1](#).

For our bond (loan) issue sample, control variables include both bond (loan) characteristics and the 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.1](#).

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.

¹⁶See, for instance, [Opler et al. \(1999\)](#); [Harford et al. \(2008\)](#); [Bates et al. \(2009\)](#); [Duchin \(2010\)](#); [Harford et al. \(2014\)](#); [Azar et al. \(2016\)](#); [Lyandres and Palazzo \(2016\)](#) for determinants of cash holdings, [Barclay and Smith \(1995\)](#); [Guedes and Opler \(1996\)](#); [Stohs and Mauer \(1996\)](#); [Johnson \(2003\)](#); [Datta et al. \(2005\)](#); [Brockman et al. \(2010\)](#); [Saretto and Tookes \(2013\)](#) for determinants of debt maturity, [Datta et al. \(1999\)](#); [Bhojraj and Sengupta \(2003\)](#); [Ortiz-Molina \(2006\)](#); [Qi et al. \(2010\)](#); [Huang et al. \(2016\)](#); [Pan et al. \(2018\)](#); [Jiang et al. \(2018\)](#) for determinants of cost of debt, and [Murfin \(2012\)](#); [Prilmeier \(2017\)](#) for determinants of loan covenant tightness.

4.1 Nominal rigidities and cash holdings

In Table 3, 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 3, 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 2.

In columns (2) to (5) of Table 3, we successively add year fixed effects, 1-digit SIC industry fixed effects, both year and industry fixed effects, and their interaction. We find FPA is consistently significant across these different specifications, and the coefficient changes little in magnitude. Accounting for common variation across firms using year fixed effects in column (2) has no impact on the coefficient. Adding 1-digit SIC 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, these findings provide supportive evidence for the model prediction that more flexible-price firms hold less cash. Our results complement the findings of [Lin et al. \(2020\)](#), who find a similar effect in the electricity industry. We show that the precautionary savings motives created by price inflexibility is a pervasive effect that holds across and within industries.

4.2 Nominal rigidities and debt maturity

In Table 4, we report the results for the long-term debt ratio. The long-term debt ratio is measured 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.¹⁷

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 is consistent with the model prediction 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 5 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 5, we successively include control variables, year fixed effects, and 1-digit SIC 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 ranging between approximately \$327,600 and \$436,800. In column (4), we obtain similar results when we control for fixed effects both at the industry and time dimensions.

¹⁷For brevity, we refrain from reporting estimates on control variables in this and subsequent tables.

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 5).

In Panels C and D of Table 5, 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 magnitude of the coefficients across Panels C and D is remarkably similar, while the statistical significance is stronger for the results reported in Panel D. The higher significance is indicative of noisy 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 5 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 6, we examine the relation between price flexibility and covenant tightness. In column (1) of Table 6, 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 coefficients 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 volatility of a firm’s profits. This modeling choice is motivated by [Gorodnichenko and Weber \(2016\)](#), who show that firms with sticky-output prices have a higher conditional volatility of stock market returns. We nonetheless provide an extended version of our model in Appendix Section B, allowing nominal price rigidity and profit volatility to independently impact firm decisions and credit spreads. In this extended model, price rigidity affects the firm by reducing its operational flexibility, endogenously increasing the exposure to shocks.

Differences in cash-flow volatility can of course arise for a variety of reasons, both related and unrelated to differences in price stickiness across firms. Price stickiness is in fact a likely fundamental driver of firm policies because it itself is rather sticky and varies little within firm over time ([Nakamura et al., 2018](#)). Other, more short-term drivers of cash-flow volatility are less likely to determine corporate policies because firms are unlikely to adjust corporate policies to short-term time-varying changes in cash-flow volatility.

To isolate the effect of price inflexibility from other drivers of cash-flow risks, we control in all regressions for firms' equity return volatility. This, however, does not impact the statistical significance of the coefficients that relate price flexibility to the outcome variables predicted by our model (see, e.g., Table 3).

We directly show how other raw measures of cash-flow and sales-growth volatility impact the key outcome variables, using our baseline regression specifications. Specifically, we use the volatility of a firm's cash flows, 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. In addition, we use sales-growth volatility, defined as the standard deviation of annual sales growth over the past 10 years.

The findings in Table A.3 show price rigidity is consistently significant with the expected sign according to economic intuition. That is, FPA has a negative relation with precautionary cash holdings, debt maturity, credit spreads and covenant tightness and a positive relation with leverage. In contrast, the coefficients associated with the alternative volatility predictors are mostly insignificant or have a sign that runs opposite to our economic intuition.

Overall, these results support the view that price flexibility is the fundamental source of risk for firm policies and credit risk rather than other determinants of cash-flow volatility.

5 Evidence from the Lehman Brothers' Bankruptcy

In this section, we propose a difference-in-differences identification strategy to provide additional evidence on the causal impact of output price rigidity on credit risk. To do so, we rely on the last prediction of our model, which states 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 (see Figure 3). In order to obtain an exogenous shock to uncertainty in the data, we exploit the bankruptcy of Lehman Brothers as in Chodorow-Reich (2014). The price impact around the shock is measured 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 in September 2008. We consider two different specifications. We first expand Equation (17) with an indicator variable $Post_t$ that equals 1 after September 2008 and 0 before September 2008, resulting in the following regression model for credit spreads measured for bond ℓ of firm i in month t :

$$\begin{aligned} CreditSpread_{\ell,i,t} = & \alpha + \beta \times Post_t \times FPA_{j,t} + \delta_1 \times FPA_{j,t} \\ & + \delta_2 \times Post_t + \gamma \cdot X_{\ell,i,t} + \eta_t + \nu_k + \varepsilon_{\ell,i,t}, \end{aligned} \quad (18)$$

where $X_{\ell,i,t}$ is a vector of control variables, η_t captures the 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 Brothers bankruptcy should be higher for sticky-price firms than for flexible-price firms.

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

$$\Delta CreditSpread_{\ell,i} = \alpha + \beta \times FPA_j + \gamma \cdot X_{\ell,i} + \nu_k + \varepsilon_{\ell,i}, \quad (19)$$

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

5.2 Results

In Table 7, 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. Consistent with Figure 3, we find in untabulated results that the higher

uncertainty due to the Lehman Brothers' bankruptcy caused a large increase in credit spreads for all firms.

More importantly, the coefficient on the interaction term is negative and significant, which corroborates the model predictions 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 *67bps* 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 fixed effects. Similar to our difference-in-differences specification, the coefficient on FPA is negative and highly statistically significant. These findings further support the model prediction that flexible-price firms are more resilient than sticky-price firms in response to uncertainty shocks and highlight that price flexibility is an important driver of credit risk.

We graphically illustrate our results in Figure 4. 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:

$$CS_{i,t} = \beta_0 + \sum_{\substack{\tau=-8 \\ \tau \neq 0}}^8 \beta_{1,\tau} \times Quarter_{\tau} \times FPA_{j,t} + \beta_2 \times FPA_{j,t} + \gamma \cdot X_{i,t} + \eta_t + \nu_k + \varepsilon_{i,t}. \quad (20)$$

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

Before the Lehman Brothers' bankruptcy, all coefficients are statistically indistinguishable from zero, confirming no differential trend in credit spreads for sticky- and flexible-price

firms before the event. After the crash, however, the coefficients become negative and are statistically different from zero. These results are consistent 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 we illustrate in Figure 3.

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 is financially constrained. For example, firms that need to refinance their debt shortly after an uncertainty shock are more likely to be impacted by this shock. In fact, Almeida et al. (2011) show 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 companies with high debt rollover exposure face larger increases in yield spreads around the Lehman Brothers' bankruptcy.

To bring further support to our analysis, 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. We follow Nagler (2020) and 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 bond amounts outstanding by merging the data from Compustat 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 8. Focusing on the panel regressions in columns (1) to (4), we find 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 supports the idea that price stickiness amplifies credit risk. In column (5),

we add interactions of industry \times time fixed effects and the coefficient estimate remains economically significant.¹⁸

Columns (6) and (7) in Panel A of Table 8 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 that are observed within one year prior to Lehman Brothers' bankruptcy using the Mahalanobis distance measure.¹⁹ 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 8 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 firms with inflexible-output prices are more exposed to shocks to cash-flow volatility. The increased cash-flow volatility creates a precautionary savings motive for inflexible firms, resulting in higher cash holdings. At the same time, inflexible firms face higher credit risk that makes debt less attractive to creditors. As a result, inflexible firms use less financial leverage and issue debt at higher costs. They also tend to borrow using shorter-term debt. Given that the incentive to mitigate default is

¹⁸One caveat to keep in mind is that our model predicts that inflexible-price firms endogenously have lower debt maturities and hence, we measure the total effect of price stickiness on credit spreads following an uncertainty shock in the presence of rollover risk.

¹⁹Firm characteristics include size, leverage, M/B ratio, ROA, credit rating, and equity return volatility.

higher for inflexible firms, we should expect these firms to be more likely to accept tighter debt covenants.

We test these new predictions empirically using a panel of publicly traded companies and find consistent empirical evidence. Our framework also suggests the reaction in credit spreads to uncertainty shocks are amplified for firms with higher output price rigidity. Thus, to bring further empirical support to our predictions, we use the 2008 Lehman Brothers bankruptcy as a shock to cash-flow volatility. We indeed find 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.

Monetary policy is a central driver of asset prices in financial markets, and nominal price rigidity is the leading explanation for real effects of monetary policy. We show price rigidity is also central for understanding many corporate policies such as optimal leverage, cash holdings, and the credit risk of firms. Thus, our framework contributes to providing a unified view on the drivers of real and financial quantities and prices.

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Figure 1: Timeline of Firm Decisions.

This figure illustrates the timeline of events in the firm's decision process. At $t = 0$, firms choose their optimal capital structure in terms of the optimal amount of equity and 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 decide on their production capacity. Firms decide whether to adapt their precautionary cash holdings, whether to use external equity, or whether they should default. Residual cash flows are paid to shareholders in the form of dividends. At $t = 2$, a second i.i.d. profit shock is realized. Firms revise their output prices with probability $(1 - \theta)$ and decide on their production capacity. Firms decide whether to adapt their precautionary cash holdings, whether to use external equity, or whether they should default. In the absence of default, debt is repaid and residual cash flows are paid to shareholders in the form of dividends.

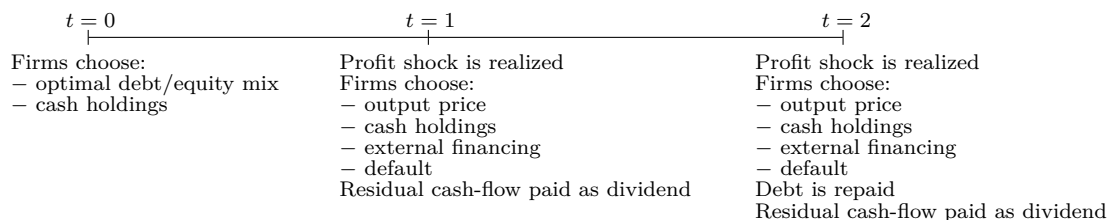


Figure 2: Model Predictions.

This figure shows the model-implied effects of price rigidity on several key firm variables: leverage, cash over assets, the credit spread at issuance, and the average maturity of debt. Price rigidity is modulated through the value of the parameter θ . The plots are obtained after solving for the firm's optimal decisions under different values for θ , ranging from 0.5 to 0.9.

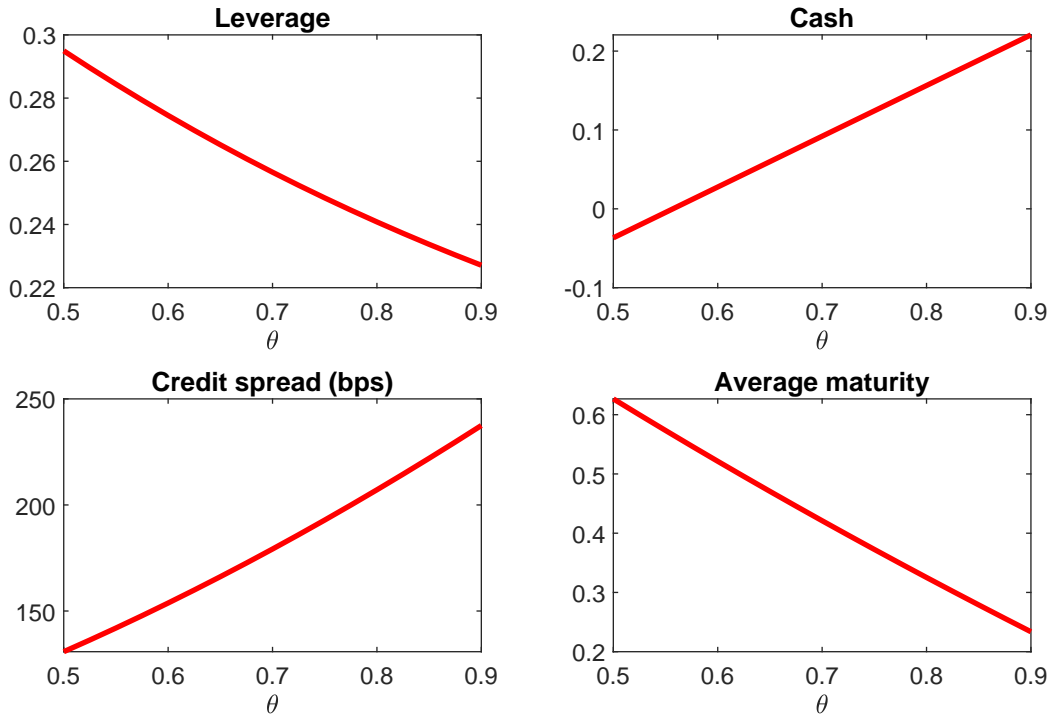


Figure 3: The Impact of Uncertainty Shocks on Credit Spreads.

This figure illustrates model-implied credit spreads (y-axis) for sticky and flexible price firms (x-axis) in response to an uncertainty shock. Flexible price firms are identified by the solid black line, while sticky price firms are identified by the dashed red line. The starting point of the graph (time 0) represents the equilibrium credit spread of each firm, net of their steady state value. This makes both firms directly comparable. The subsequent evolution of the credit spreads characterizes the response to a one period shock in the volatility of each firm's profits. The higher increase in credit spreads for sticky price firms to the same volatility shock characterizes a greater sensitivity of sticky price firms to shocks in the uncertainty of its profits. The profit volatility process is calibrated using the following values: $\rho_\sigma = 0.8$, and $\sigma_\sigma = 1.5\%$. Flexible (sticky) price firms are characterized by decreasing (increasing) θ by two times the empirical standard deviation of FPA.

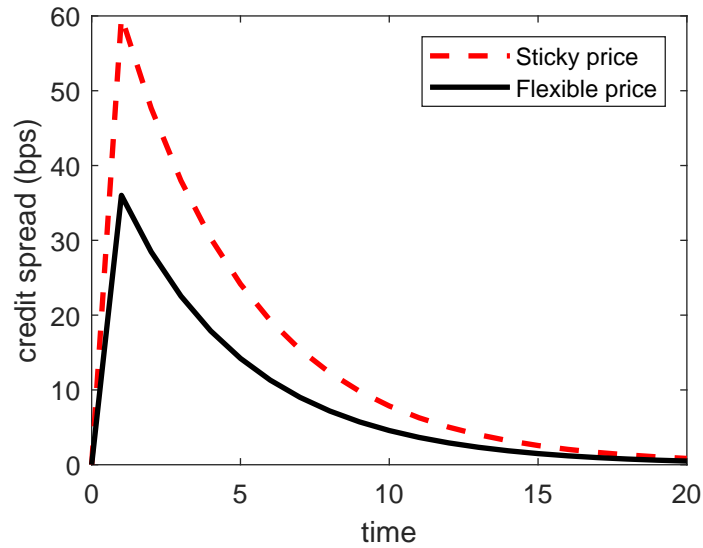


Figure 4: Differential Credit Spread Reactions to Lehman Brothers Bankruptcy

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.

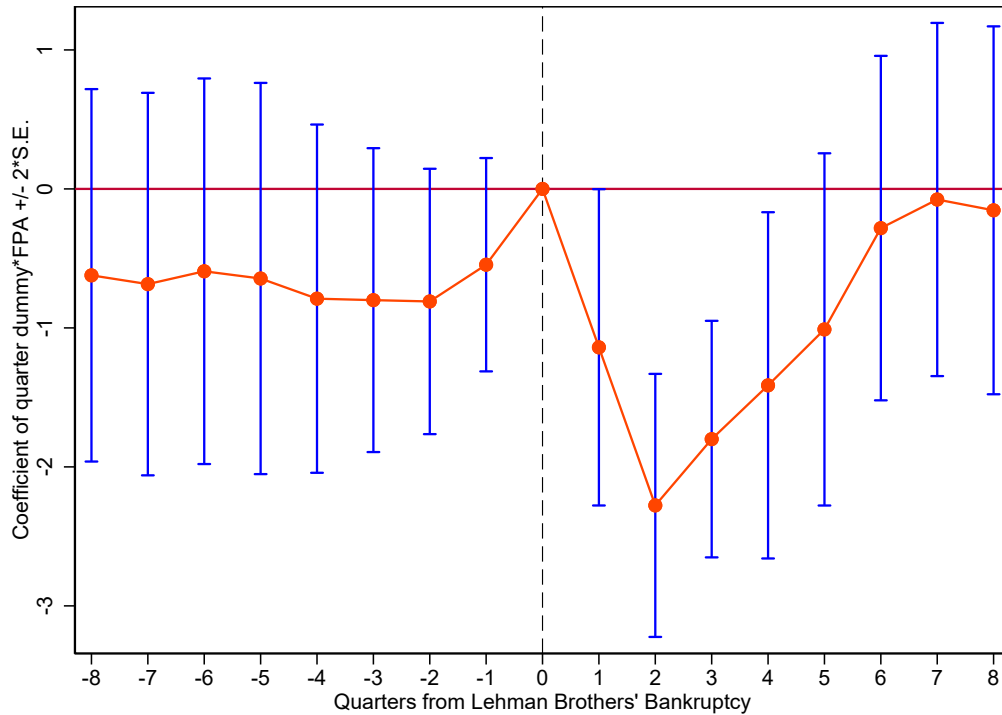


Table 1: Descriptive Statistics

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.1.

| | 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 2: 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.1.

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

Table 4: 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 3. 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*** (3.34) | 0.11*** (3.36) | 0.10** (2.66) | 0.10** (2.70) | 0.10** (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 5: 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.1. The control variables include the same firm characteristics that we use in Table 3 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** (-2.70) | -0.47*** (-3.48) | -0.40*** (-2.91) | -0.48*** (-3.64) | -0.40*** (-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*** (-3.26) | -0.53*** (-4.81) | -0.45*** (-3.40) | -0.56*** (-4.64) | -0.46*** (-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*** (-3.32) | -0.56*** (-2.83) | -0.61*** (-2.85) | -0.35** (-2.05) | -0.36** (-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*** (-3.43) | -0.50*** (-3.42) | -0.45*** (-3.21) | -0.44*** (-3.13) | -0.43*** (-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 \times Time FE | | | | | X |

Table 6: 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 3](#), 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*** (-4.90) | -0.11*** (-5.37) | -0.06** (-2.61) | -0.06*** (-3.09) | -0.07*** (-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 7: 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.1. The control variables are the same as those in Table 5. 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 \times <i>FPA</i> | -0.67*** (-2.79) | -0.86** (-2.50) | -0.64** (-2.52) | -0.88** (-2.53) | -1.08*** (-3.71) | | |
| <i>FPA</i> | | | | | | -1.72*** (-3.14) | -2.43*** (-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 \times Month FE | | | | | X | | |

Table 8: 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 5. 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 \times Treated \times FPA | -0.74** (-2.34) | -1.21*** (-2.97) | -0.76** (-2.57) | -1.24*** (-3.05) | -1.12** (-2.50) | | |
| Treated \times FPA | | | | | | -2.78*** (-2.96) | -2.02** (-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 \times Treated \times FPA | -1.54*** (-6.70) | -2.15*** (-4.21) | -1.49*** (-5.77) | -2.17*** (-4.09) | -1.80*** (-3.35) | | |
| Treated \times FPA | | | | | | -1.48** (-2.48) | -1.40** (-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 \times Month FE | | | | | X | | |

A Model Appendix

In this appendix section, we develop in Section (A.1) a simple model to motivate our reduced-form specification for the effect of price stickiness on firm profits presented in Section 2. In particular, we show that price inflexibility leads to lower and more volatile expected profits. We next provide in Section (A.2) a detailed derivation of the firm's optimal decisions.

A.1 Price stickiness and profits

Economic environment. We consider a firm that enjoys monopolistic power over the sale of its production. The demand for the firm's product, Y_t , depends on the price charged by the firm, P_t , in the following way:

$$Y_t = P_t^{-\nu}, \tag{A.1}$$

where $\nu > 1$ captures the firm's product demand elasticity.

The firm produces output using a stock of capital $K_0 = 1$, which is pre-determined and normalized to one for simplicity and a variable production input, L_t (e.g., labor). The production technology is:

$$Y_t = \tilde{X} K_0 L_t, \tag{A.2}$$

where \tilde{X} is an i.i.d. log-normal productivity shock with distribution $\log(\tilde{X}) \sim \mathcal{N}(0, \sigma_x^2)$.

The firm's profit in each period, Π_t , is determined by its revenues minus its operating costs, that is,

$$\Pi_t = P_t Y_t - W_t L_t, \tag{A.3}$$

where W_t is the cost of the variable production input (e.g., wages).

Firm's problem. Following Calvo (1983), the firm faces rigidities in adjusting its output price. At the beginning of each period, and after observing the realization of the productivity shock \tilde{X} , the firm can choose a new optimal output price, P^* , with probability $(1 - \theta)$. With probability θ , the firm cannot re-optimize, and continues to sell at the previous sales price, \bar{P} .

Optimizing firm. The objective of the optimizing firm is to choose the output quantity and price in order to maximize the period profit, subject to the inverse demand for the firm's product. Using Equation (B.2) to substitute for Y_t , and given that $K_0 = 1$, the profit maximization problem is:

$$\max_P P^{1-\nu} - \frac{W}{\tilde{X}} P^{-\nu}. \tag{A.4}$$

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

$$P^*(\tilde{X}) = \frac{\nu}{\nu-1} \frac{W}{\tilde{X}}. \quad (\text{A.5})$$

Equation (A.5) shows that the optimizing firm chooses a price that reflects a constant markup over the marginal cost of its production. The resulting optimizing firm's profit is:

$$\Pi^*(\tilde{X}) = \frac{1}{\nu-1} P^{*\nu} \frac{W}{\tilde{X}} \quad (\text{A.6})$$

$$= \frac{1}{\nu} P^{*1-\nu}. \quad (\text{A.7})$$

Non-optimizing firm. The non-optimizing firm charges a price of \bar{P} (which we normalize to one, without loss of generality), and receives a demand $\bar{Y} = \bar{P}^{-\nu} = 1$. Its profit is given by:

$$\bar{\Pi} = \bar{P}^{1-\nu} - \frac{W}{\tilde{X}} \bar{P}^{-\nu}. \quad (\text{A.8})$$

Observe that, in the preceding period, we assume the firm to be at its optimum with $\tilde{X} = 1$. This implies that $W = \frac{\nu-1}{\nu}$.

Price stickiness and profits. We illustrate the effect of price stickiness on firm profits using the ratio of profits generated by the non-optimizing firm to those generated by the optimizing firm:

$$\frac{\bar{\Pi}}{\Pi^*} = \nu \left(\frac{\bar{P}}{P^*} \right)^{1-\nu} - (\nu-1) \left(\frac{\bar{P}}{P^*} \right)^{-\nu} \quad (\text{A.9})$$

$$= \nu \tilde{P}^{1-\nu} - (\nu-1) \tilde{P}^{-\nu}, \quad (\text{A.10})$$

where $\tilde{P} = \bar{P}/P^* = P^{*-1}$ captures the wedge between the suboptimal price and the optimal price.

Denoting log-variables with lower case letters, we take a second order log-approximation around the non-optimizing firm's profit:

$$\bar{\pi} - \pi^* \approx -\frac{1}{2} \nu (\nu-1) \tilde{p}^2. \quad (\text{A.11})$$

Note that because $\nu > 1$, we have $\bar{\pi} \leq \pi^*$, that is, non-optimizing firms generate lower profits.

We next compute the firm's expected profit conditional on \tilde{X} and prior to the firm knowing if it can update its output price. Given that the firm is stuck at its prior output price with probability θ , the log-expected profit before the price setting decision is:

$$\pi_\theta \approx \theta \pi + (1-\theta) \pi^* \quad (\text{A.12})$$

$$= \pi^* - \theta \frac{1}{2} \nu (\nu-1) \tilde{p}^2, \quad (\text{A.13})$$

where the last equality is obtained by substituting using the expression for Π^* in Equation (B.6). Using the approximation that $e^y - 1 \approx y$, we can rewrite $\log(\Pi_\theta)$ as:

$$\pi_\theta \approx -\log(\nu) + (\nu - 1)\tilde{p} - \theta \frac{1}{2}\nu(\nu - 1)\tilde{p}^2 \quad (\text{A.14})$$

$$= \pi^* - \theta \frac{1}{2}\nu(\nu - 1)\tilde{x}^2, \quad (\text{A.15})$$

where we have used Equation (A.5) to substitute for \tilde{p} .

The first two moments of log-profits prior to the realization of firm-specific shocks x are given by:

$$E[\pi] = E[\pi^*] - \theta \frac{\nu(\nu - 1)}{2}\sigma_x^2 \quad (\text{A.16})$$

$$\sigma^2[\pi] = \sigma^2[\pi^*] + \theta^2 \frac{\nu^2(\nu - 1)^2}{2}\sigma_x^4. \quad (\text{A.17})$$

Taking the first derivative of the first two moments with respect to the price inflexibility parameter θ , we show that an increase in the level of price stickiness leads to lower and more volatile profits:

$$\frac{\partial E[\pi]}{\partial \theta} = -\frac{\nu(\nu - 1)}{2}\sigma_x^2 < 0 \quad (\text{A.18})$$

$$\frac{\partial \sigma^2[\pi]}{\partial \theta} = \theta \nu^2(\nu - 1)^2 \sigma_x^4 > 0. \quad (\text{A.19})$$

We can, therefore, model the effect of price rigidity on conditional profits using the following reduced-form specification:

$$R_{it} = R - (1 + \theta)z_i, \quad (\text{A.20})$$

where $z_i \sim \mathcal{N}(\mu, \sigma^2)$, and $\mu \geq 0$.

Therefore the conditional volatility of profits for a perfectly flexible price firm (i.e., $\theta = 0$) is normalized to σ .

A.2 Derivations of the firm's optimal policies

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 financing and default policies.

A.2.1 Firm's optimization problem

Following the intuition provided in Appendix A.1, the firm's operating profit is defined as

$$R(z_t) = R - (1 + \theta)z_t, \quad (\text{A.21})$$

where $z_t \sim \mathcal{N}(\mu, \sigma^2)$ is an i.i.d., firm-specific shock and θ captures the degree of price inflexibility, i.e., higher θ is associated with more inflexible firms. We denote the associated probability density and distribution function of z_t by $\phi(\cdot)$ and $\Phi(\cdot)$, respectively.

The firm's objective is to take a series of decisions in order to maximize the value of equity. As the firm's optimization problem is homogenous in capital, we normalize by K_i , implying that all variables should be interpreted as a fraction of total firm assets. We denote all normalized variables by lower case letters and drop the i -subscript, unless it is necessary to avoid confusion. We summarize the notation for the main variables of interest below:

- v : market value of equity
- b : outstanding face value of corporate debt
- q : market price of \$1 of corporate debt
- x : cash holdings
- d : dividend
- z : firm-specific shock

At $t = 0$, the firm is unlevered and chooses its leverage b , and cash-holdings x_0 , to maximize the total proceeds from both debt and equity issuance:

$$\max_{b, x_0} \left\{ E_0[v_1] - x_0(1 + \psi) + (1 + \chi)q_0b \right\}, \quad (\text{A.22})$$

where ψ is the agency cost of holding cash and χ characterizes the net benefits of debt.

In periods $t > 0$, the firm chooses its optimal cash holdings x_t to maximize equity value. In addition, the firm can issue seasoned equity offerings subject to a flotation cost λ . New equity issuance is triggered when the firm's dividend is negative. Thus, the dividend paid by the firm at time $t = 1, 2$ is:

$$d_1(z_1) = \frac{R - (1 + \theta)z_1 + x_0 - x_1(1 + \psi)}{1 - \lambda \times \mathbb{1}_{\{d_1 < 0\}}} \quad (\text{A.23})$$

$$d_2(z_2) = \frac{R - (1 + \theta)z_2 + x_1 - x_2(1 + \psi) - b}{1 - \lambda \times \mathbb{1}_{\{d_2 < 0\}}}. \quad (\text{A.24})$$

Equity holders have limited liability and declare bankruptcy when the firm value is negative. Accordingly, the market value of equity satisfies the following recursive formulation:

$$v_t(z_t) = \max_{x_t} \left\{ \max \left(d_t(z_t) + E_t[v_{t+1}(z_{t+1})], 0 \right) \right\}. \quad (\text{A.25})$$

A.2.2 Optimal policies

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

At $t = 2$: After the final period (i.e., after $t = 2$), the firm ceases its operations, so there are no benefits to holding cash. Therefore, the optimal cash policy is to have $x_2 = 0$. In addition, the firm will not be able to issue new equity since it has zero continuation value. The firm only faces the decision whether to default. Given that there is no continuation value, the value of equity is equal to the dividend, i.e., $v_2 = d_2$.

The optimal default decision consists of a threshold rule where the firm declares default whenever $z_2 > z_2^d$. In other words, the firm declares bankruptcy when the idiosyncratic shock is high enough to make the firm value negative. In the event of bankruptcy, shareholders leave with a zero payoff. The default threshold is determined such that the $v_2(z_2^d) = d_2(z_2^d) = 0$,

$$z_2^d = \frac{R - b + x_1}{(1 + \theta)}. \quad (\text{A.26})$$

Note that the probability of default is $1 - \Phi(z_2^d)$.

Given $x_2 = 0$, and $d_2 \geq 0$, the value of equity at $t = 2$, before the idiosyncratic shock is realized, is equal to:

$$\begin{aligned} E_1[v_2] &= \int_{-\infty}^{z_2^d} d_2(z) d\Phi(z) + 0 \\ &= (1 + \theta) \int_{-\infty}^{z_2^d} (z_2^d - z) d\Phi(z). \end{aligned} \quad (\text{A.27})$$

At $t = 1$: In period $t = 1$, the firm decides whether to (i) issue new equity, (ii) accumulate cash for the period $t = 2$, or (iii) default. Since the firm never issues (costly) external equity in period $t = 2$, it is not optimal for the firm to accumulate precautionary cash holdings. Therefore, the optimal cash holding decision is $x_1 = 0$. The decision to issue external equity or to default is triggered by two different thresholds for z . In particular, the firm defaults when $z > z_1^d$ and issues new equity when $z_1^d \geq z > z_1^e$. When $z \leq z_1^e$, the firm pays out a dividend to shareholders. The equity financing threshold is such that $d_1(z_1^e) = 0$:

$$z_1^e = \frac{R + x_0}{(1 + \theta)}. \quad (\text{A.28})$$

The default threshold, z_1^d , is such that $v_1(z_1^d) = 0$:

$$z_1^d = \frac{R + x_0 + (1 - \lambda)E_1[v_2]}{(1 + \theta)}. \quad (\text{A.29})$$

Thus the value of equity is:

$$v(z_1) = \begin{cases} 0 & \text{if } z_1 > z_1^d \\ \frac{(1+\theta)(z_1^e - z_1)}{1-\lambda} + E_1[v_2] & \text{if } z_1^d > z_1 > z_1^e \\ (1 + \theta)(z_1^e - z_1) + E_1[v_2] & \text{if } z_1^e > z_1. \end{cases}$$

The value of the firm prior to the realization of z_1 is:

$$E_0[v_1] = \int_{-\infty}^{z_1^e} ((1 + \theta)(z_1^e - z_1) + E_1[v_2])d\Phi(z) + \int_{z_1^e}^{z_1^d} \left(\frac{(1 + \theta)(z_1^e - z_1)}{1 - \lambda} + E_1[v_2] \right) d\Phi(z) \quad (\text{A.30})$$

$$= (1 + \theta) \int_{-\infty}^{z_1^d} (z_1^d - z)d\Phi(z) + \frac{\lambda}{1 - \lambda}(1 + \theta) \int_{z_1^e}^{z_1^d} (z_1^d - z)d\Phi(z) + \lambda\Phi(z_1^e)E_1[v_2]. \quad (\text{A.31})$$

We have derived the optimal financing and default decisions for $t > 0$. We can now solve for the optimal cash holdings x_0 and leverage decisions at time $t = 0$.

At $t = 0$: A $t = 0$, equity holders choose b and x_0 to maximize the total value of the firm, composed of future equity and debt claims. Shareholders understand that increasing leverage today may affect future default decisions, and that they cannot credibly pre-commit to a default policy, unless it maximizes their own valuation. In other words, when maximizing firm value, shareholders understand that debt is rationally priced by creditors. The optimization problem is defined as:

$$\max_{b, x_0} \left\{ E_0[v_1] - x_0(1 + \psi) + (1 + \chi)q_0b \right\}, \quad (\text{A.32})$$

where creditors value the debt rationally:

$$q_0 = \Phi(z_1^d) \times \Phi(z_2^d). \quad (\text{A.33})$$

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

$$\frac{\partial E_0[v_1]}{\partial b} + (1 + \chi) \left(q_0 + \frac{\partial q_0}{\partial b} b \right) = 0, \quad (\text{A.34})$$

where the partial derivatives are obtained using the Leibniz rule:

$$\frac{\partial q_0}{\partial b} = -\frac{1}{(1 + \theta)} \left(\phi(z_1^d)(1 - \lambda)\Phi^2(z_2^d) + \phi(z_2^d)\Phi(z_1^d) \right) \quad (\text{A.35})$$

$$\frac{\partial E_0[v_1]}{\partial b} = -\Phi(z_1^d)\Phi(z_2^d). \quad (\text{A.36})$$

Combining these equations, we get that:

$$\left(1 - \frac{1}{1 + \chi} \right) q_0 \approx \chi q_0 = -\frac{\partial q_0}{\partial b} b. \quad (\text{A.37})$$

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

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

$$\frac{\partial E_0[v_1]}{\partial x_0} - (1 + \psi) + (1 + \chi) \frac{\partial q_0}{\partial x_0} b = 0, \quad (\text{A.38})$$

where the partial derivatives are given by:

$$\frac{\partial q_0}{\partial x_0} = \frac{1}{(1 + \theta)} \phi(z_1^d) \Phi(z_2^d) \quad (\text{A.39})$$

$$\frac{\partial E_0[v_1]}{\partial x_0} = \frac{\Phi(z_1^d) - \lambda \Phi(z_1^e)}{1 - \lambda}. \quad (\text{A.40})$$

Combing these equations, we get that:

$$\frac{\Phi(z_1^d) - \lambda \Phi(z_1^e)}{1 - \lambda} - (1 + \psi) + (1 + \chi) \frac{\partial q_0}{\partial x_0} b = 0, \quad (\text{A.41})$$

which can be rewritten as:

$$\frac{\lambda}{1 - \lambda} \times \mathbb{P}_1(\text{equity}) + (1 + \chi) \frac{\partial q_0}{\partial x_0} b = \psi + \mathbb{P}_1(\text{default}) \times \frac{1}{1 - \lambda}, \quad (\text{A.42})$$

where the probabilities of external financing and default are $\mathbb{P}_1(\text{equity}) = 1 - \Phi(z_1^e)$ and $\mathbb{P}_1(\text{default}) = 1 - \Phi(z_1^d)$, respectively.

B Alternative Model

In our benchmark model, price rigidity affects the firm's profits through its interaction with the firm-specific productivity shock. This reduced-form specification is sufficient to convey the main economic intuition of the price rigidity channel. To further emphasize the importance of price rigidity independently from that of cash flow volatility, we consider a more general model in which price rigidities jointly affect a firm's financing, default, and production decisions.

B.1 Economic environment

The main economic environment is similar to our baseline model in that there exists a continuum of firms with access to a linear production technology that live for three periods and are subject to productivity shocks. Figure 1 provides the timeline of all events and firm decisions. The financing decisions and the modeling of debt, equity, and cash are identical to the baseline model and are described in Section 2.1.3.

B.1.1 Production

Each firm i has access to a linear production technology that produces a quantity of output Y_{it} using a predetermined stock of capital K_0 (normalized to 1 for simplicity) and a variable production input (e.g., labor) purchased in a competitive market at a unit cost W_t :

$$Y_{it} = \tilde{X} K_0 L_{it} \tag{B.1}$$

where \tilde{X} is an i.i.d. log-normal shock, i.e., $\log(\tilde{X}) \sim \mathcal{N}(0, \sigma^2)$.

The demand for the firm's product depends non-linearly on its price, P_{it} :

$$Y_{it} = P_{it}^{-\nu} \tag{B.2}$$

where $\nu > 1$ is the elasticity of product demand.

The firm's period per profit corresponds to revenues net of operating costs (labor, capital):

$$\pi_{it} = P_{it} Y_{it} - W_t L_{it} - f K_0 \times \mathbb{1}_{t < 2}, \tag{B.3}$$

where f is a fixed production cost, which corresponds to the costs associated with the capital reinvestment that is needed for the firm to operate in the next period. A firm only lives for two periods, implying that the the fixed cost is only paid in periods 0 and 1.

B.1.2 Price stickiness

Following Calvo (1983), the firm faces rigidity in adjusting its output price. At the beginning of the period and after observing the productivity shock realization \tilde{X} , the firm can choose a new optimal price, P , with probability $(1 - \theta)$. With probability θ , the firm cannot re-optimize, and must sell at the steady state sale price, \bar{P} . In the following, we use an indicator variable ζ to capture if a firm can re-optimize its product price. In particular, we identify an optimizing firm by setting $\zeta = 1$ and an inflexible firm by setting $\zeta = 0$.

B.2 Derivations of the firm's optimal policies

The firm's optimization with respect to output and price is static, allowing us to solve the model in two steps. First, we consider the profit maximization problem whereby the firm chooses the optimal price and quantity given the productivity shock \tilde{X} . Next, we solve for the optimal financing and default decisions.

B.2.1 Profit maximization

Each period, after observing the shock \tilde{X} , the firm can be in two states, depending on its ability to adjust output prices in response to the aggregate shock. Accordingly, we solve for the optimal profit of both a fully flexible firm ($\zeta = 1$) and an inflexible firm ($\zeta = 0$).

Flexible firm. The optimizing firm chooses labor and the output price to maximize per period profits, subject to the inverse demand for the firm's product. Plugging Equation (B.2) into Equation (B.3), the profit maximization problem is:

$$\max_P P^{1-\nu} - \frac{W}{\tilde{X}} P^{-\nu} - f \quad (\text{B.4})$$

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

$$P(\tilde{X}) = \frac{\nu}{\nu-1} \frac{W}{\tilde{X}} \quad (\text{B.5})$$

Equation (B.5) shows that the optimizing firm chooses a price that reflects a constant markup over its marginal cost of production. The resulting optimizing firm's profit at time t is:

$$\pi_{t,\zeta=1}(\tilde{X}) = \frac{1}{\nu-1} P^{-\nu} \frac{W}{\tilde{X}} - f \times \mathbb{1}_{t < 2} \quad (\text{B.6})$$

Inflexible firm. The non-optimizing firm charges a price of \bar{P} (normalized to 1)¹ and faces a demand $\bar{Y} = \bar{P}^{-\nu} = 1$. Its profit is given by:

$$\pi_{t,\zeta=0}(\tilde{X}) = \bar{P}^{1-\nu} - \frac{W}{\tilde{X}} \bar{P}^{-\nu} - f \times \mathbb{1}_{t < 2}. \quad (\text{B.7})$$

Profit functions. The optimal price setting condition in Equation (B.5) shows that there exists a one-to-one mapping between P and \tilde{X} . We, therefore, can replace for \tilde{X} and express the firm's profits as a function of P :

$$\pi_1(P) = \begin{cases} 1 - \frac{\nu-1}{\nu} P - f & \text{if } \zeta = 0 \\ \frac{1}{\nu} P^{1-\nu} - f & \text{if } \zeta = 1 \end{cases} \quad (\text{B.8})$$

$$\pi_2(P) = \begin{cases} 1 - \frac{\nu-1}{\nu} P & \text{if } \zeta = 0 \\ \frac{1}{\nu} P^{1-\nu} & \text{if } \zeta = 1 \end{cases} \quad (\text{B.9})$$

¹This is without loss of generality.

The price P is the only source of risk in the model and inherits the log-normal property of \tilde{X} . In particular, P is an i.i.d. log-normal shock such that $p = \log(P) \sim \mathcal{N}(0, \sigma^2)$. Because there is an inverse relation between the price and productivity, states of high productivity will be characterized by low P and vice-versa for states of low productivity.

B.2.2 Equity maximization

The firm's objective is to maximize the value of equity by taking a series of financing and production decisions. As the firm's optimization problem is homogeneous in capital, we normalize by K_i , implying that all variables should be interpreted as a fraction of total firm assets. We denote all normalized variables by lower case letters and drop the i -subscript, unless it is necessary to avoid confusion. We summarize the notation for the main variables of interest below:

- v : market value of equity
- b : outstanding face value of corporate debt
- q : market price of \$1 of corporate debt
- x : cash holdings
- d : dividend
- P : output price and source of firm-specific risk

At $t = 0$, the firm is unlevered and chooses its leverage, b , and cash-holdings, x_0 , to maximize the total proceeds from both debt and equity issuance, that is:

$$\max_{b, x_0} \left\{ E_0[v_1] - x_0(1 + \psi) + (1 + \chi)q_0b - f \right\}, \quad (\text{B.10})$$

where ψ is the agency cost of holding cash and χ characterizes the net benefits of debt.

In periods $t > 0$, the firm chooses its optimal cash holdings x_t to maximize equity value. In addition, the firm has the option to issue seasoned equity, subject to a flotation cost λ . Seasoned equity issuance is triggered when the firm's dividend is negative. Thus, the dividends paid by the firm at time $t = 1, 2$ are:

$$d_{1,\zeta}(P_1) = \frac{\pi_{1,\zeta}(P_1) + x_0 - x_1(1 + \psi)}{1 - \lambda \times \mathbb{1}_{\{d_1 < 0\}}} \quad (\text{B.11})$$

$$d_{2,\zeta}(P_2) = \frac{\pi_{2,\zeta}(P_2) + x_1 - x_2(1 + \psi) - b}{1 - \lambda \times \mathbb{1}_{\{d_2 < 0\}}}. \quad (\text{B.12})$$

Equity holders have limited liability and declare bankruptcy when the firm value is negative. Accordingly, the market value of equity satisfies the following recursive formulation:

$$v_{t,\zeta}(P_t) = \max_{x_t} \left\{ \max \left(d_{t,\zeta}(P_t) + E_t[v_{t+1}(z_{t+1})], 0 \right) \right\}. \quad (\text{B.13})$$

B.3 Optimal policies

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

At $t = 2$: After the final period (i.e., after $t = 2$), the firm ceases its operations, so there are no benefits to holding cash. Therefore, the optimal cash policy is to have $x_{2,\zeta} = 0$, for $\zeta = 0, 1$. In addition, the firm will not be able to issue new equity since it has zero continuation value. The firm only faces the decision whether to default. Given that there is no continuation value, the value of equity is equal to the dividend, i.e., $v_{2,\zeta}(P) = d_{2,\zeta}(P)$.

The optimal default decision consists of a threshold rule where the firm declares default when $P_{2,\zeta} > P_{2,\zeta}^d$. The default threshold is determined such that $d_{2,\zeta}(P_{2,\zeta}^d) = 0$:

$$P_{2,\zeta}^d := \pi_{2,\zeta}(P_{2,\zeta}^d) - b + x_1 = 0. \quad (\text{B.14})$$

Replacing for the profit function, we can solve for the default threshold:

$$P_{2,\zeta}^d = \begin{cases} P_{2,\zeta=0}^d = (1 - b + x_1) \frac{\nu}{\nu-1} & \text{if } \zeta = 0 \\ P_{2,\zeta=1}^d = (\nu(b - x_1))^{1-\nu} & \text{if } \zeta = 1. \end{cases}$$

The probability of default conditional on ζ is $1 - \Phi(P_{2,\zeta}^d)$, where $\Phi(\cdot)$ is the cumulative density function of the log normal distribution, i.e., $\log(P) \sim \mathcal{N}(0, \sigma^2)$. This default probability is endogenous and depends on both the firm's financing decision and the degree of price rigidity.

Given the optimal default decision, the value of equity at $t = 2$, before the idiosyncratic shock is realized, is

$$\begin{aligned} E_1[v_2] &= \theta \int_0^{P_{2,\zeta=0}^d} \frac{\nu-1}{\nu} (P_{2,\zeta=0}^d - P) d\Phi(P) \\ &+ (1-\theta) \int_0^{P_{2,\zeta=1}^d} \frac{1}{\nu} (P^{1-\nu} - (P_{2,\zeta=1}^d)^{1-\nu}) d\Phi(P), \end{aligned} \quad (\text{B.15})$$

where θ captures the probability of being an inflexible firm in the next period.

At $t = 1$: In period $t = 1$, the firm decides whether to (i) issue new equity, (ii) accumulate cash for the period $t = 2$, or (iii) default. Since the firm never issues (costly) external equity in period $t = 2$, it is not optimal for the firm to accumulate precautionary cash holdings. Therefore, the optimal cash holding decision is $x_{1,\zeta} = 0$, for $\zeta = 0, 1$. The decision to issue external equity or to default is triggered by two different thresholds for P , in each state $\zeta = 0, 1$. In particular, the firm defaults when $P > P_{1,\zeta}^d$ and issues

new equity when $P_{1,\zeta}^d \geq P > P_{1,\zeta}^e$. When $P \leq P_{1,\zeta}^e$, the firm pays out a dividend to shareholders. The equity financing threshold is such that $d_{1,\zeta}(P_{1,\zeta}^e) = 0$:

$$P_{1,\zeta}^e := \pi_{1,\zeta}(P_{1,\zeta}^e) + x_0 = 0. \quad (\text{B.16})$$

Replacing for the firm's profit, we can derive the equity financing thresholds:

$$P_{1,\zeta}^e = \begin{cases} P_{1,\zeta=0}^e = (1 + x_0 - f) \frac{\nu}{\nu-1} & \text{if } \zeta = 0 \\ P_{1,\zeta=1}^e = (\nu(f - x_0))^{\frac{1}{1-\nu}} & \text{if } \zeta = 1. \end{cases}$$

The default threshold, $P_{1,\zeta}^d$, is such that $v_{1,\zeta}(P_{1,\zeta}^d) = 0$, that is:

$$P_{1,\zeta}^d := \frac{\pi_{1,\zeta}(P_{1,\zeta}^d) + x_0}{1 - \lambda} + E_1[v_2] = 0.$$

Replacing for the firm's profit, we can derive the optimal default thresholds:

$$P_{1,\zeta}^d = \begin{cases} P_{1,\zeta=0}^d = (1 + x_0 - f + (1 - \lambda)E_1[v_2]) \frac{\nu}{\nu-1} & \text{if } \zeta = 0 \\ P_{1,\zeta=1}^d = (\nu(f - x_0 - (1 - \lambda)E_1[v_2]))^{\frac{1}{1-\nu}} & \text{if } \zeta = 1. \end{cases}$$

Thus the value of equity is :

$$v_{1,\zeta}(P_{1,\zeta}) = \begin{cases} 0 & \text{if } P_{1,\zeta} > P_{1,\zeta}^d \\ \frac{\pi_{1,\zeta}(P_{1,\zeta}) + x_0}{1 - \lambda} + E_1[v_2] & \text{if } P_{1,\zeta}^d > P_{1,\zeta} > P_{1,\zeta}^e \\ \pi_{1,\zeta}(P_{1,\zeta}) + x_0 + E_1[v_2] & \text{if } P_{1,\zeta} > P_{1,\zeta}^e. \end{cases}$$

The value of the firm, prior to the realization of P_1 is:

$$E_0[v_1] = \theta \left[\int_0^{P_{1,\zeta=0}^e} (\pi_{1,\zeta=0}(P) + x_0 + E_1[v_2]) d\Phi(P) + \int_{P_{1,\zeta=0}^e}^{P_{1,\zeta=0}^d} \left(\frac{\pi_{1,\zeta=0}(P) + x_0}{1 - \lambda} + E_1[v_2] \right) d\Phi(P) \right] \\ + (1 - \theta) \left[\int_0^{P_{1,\zeta=1}^e} (\pi_{1,\zeta=1}(P) + x_0 + E_1[v_2]) d\Phi(P) + \int_{P_{1,\zeta=1}^e}^{P_{1,\zeta=1}^d} \left(\frac{\pi_{1,\zeta=1}(P) + x_0}{1 - \lambda} + E_1[v_2] \right) d\Phi(P) \right].$$

We have derived the optimal financing and default decisions for $t > 0$. We can now solve for the optimal cash holdings x_0 and leverage decisions at time $t = 0$.

At $t = 0$: A $t = 0$, equity holders choose b and x_0 to maximize total firm value composed of future equity and debt claims. Shareholders understand that increasing leverage today may affect future default decisions,

and that they cannot credibly pre-commit to a default policy, unless it maximizes their own valuation. In other words, when maximizing firm value, shareholders understand that debt is rationally priced by creditors. The optimization problem is defined as:

$$\max_{b, x_0} \left\{ E_0[v_1] - x_0(1 + \psi) + (1 + \chi)q_0b - f \right\}, \quad (\text{B.17})$$

where creditors value the debt rationally:

$$q_0 = (\theta \times \Phi(P_{1,\zeta=0}^d) + (1 - \theta) \times \Phi(P_{1,\zeta=1}^d)) \times (\theta \times \Phi(P_{2,\zeta=0}^d) + (1 - \theta) \times \Phi(P_{2,\zeta=1}^d)). \quad (\text{B.18})$$

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

$$\frac{\partial E_0[v_1]}{\partial b} + (1 + \chi) \left(q_0 + \frac{\partial q_0}{\partial b} b \right) = 0, \quad (\text{B.19})$$

where the partial derivatives are obtained using the Leibniz rule:

$$\frac{\partial E_0[v_1]}{\partial b} = \theta \frac{\partial E_0[v_1|\zeta=0]}{\partial b} + (1 - \theta) \frac{\partial E_0[v_1|\zeta=1]}{\partial b} \quad (\text{B.20})$$

$$\frac{\partial E_0[v_1|\zeta=0]}{\partial b} = \Phi(P_{1,\zeta=0}^d) \frac{\partial E_1[v_2]}{\partial b} \quad (\text{B.21})$$

$$\frac{\partial E_0[v_1|\zeta=1]}{\partial b} = \Phi(P_{1,\zeta=1}^d) \frac{\partial E_1[v_2]}{\partial b} \quad (\text{B.22})$$

$$\frac{\partial q_0}{\partial b} = \left(\theta \phi(P_{1,\zeta=0}^d) \frac{\partial P_{1,\zeta=0}^d}{\partial b} + (1 - \theta) \phi(P_{1,\zeta=1}^d) \frac{\partial P_{1,\zeta=1}^d}{\partial b} \right) (\theta \Phi(P_{2,\zeta=0}^d) + (1 - \theta) \Phi(P_{2,\zeta=1}^d)) \quad (\text{B.23})$$

$$+ (\theta \Phi(P_{1,\zeta=0}^d) + (1 - \theta) \Phi(P_{1,\zeta=1}^d)) \left(\theta \phi(P_{2,\zeta=0}^d) \frac{\partial P_{2,\zeta=0}^d}{\partial b} + (1 - \theta) \phi(P_{2,\zeta=1}^d) \frac{\partial P_{2,\zeta=1}^d}{\partial b} \right) \quad (\text{B.24})$$

$$\frac{\partial P_{1,\zeta=0}^e}{\partial b} = 0 \quad (\text{B.25})$$

$$\frac{\partial P_{1,\zeta=1}^e}{\partial b} = 0 \quad (\text{B.26})$$

$$\frac{\partial P_{1,\zeta=0}^d}{\partial b} = (1 - \lambda) \frac{\nu}{\nu - 1} \frac{\partial E_1[v_2]}{\partial b} \quad (\text{B.27})$$

$$\frac{\partial P_{1,\zeta=1}^d}{\partial b} = (1 - \lambda) \frac{\nu}{\nu - 1} \frac{\partial E_1[v_2]}{\partial b} \times (P_{1,\zeta=1}^d)^\nu \quad (\text{B.28})$$

$$\frac{\partial P_{2,\zeta=0}^d}{\partial b} = -\frac{\nu}{\nu - 1} \quad (\text{B.29})$$

$$\frac{\partial P_{2,\zeta=1}^d}{\partial b} = -\frac{\nu}{\nu - 1} \times (P_{2,\zeta=1}^d)^\nu \quad (\text{B.30})$$

$$\frac{\partial E_1[v_2]}{\partial b} = -\theta \Phi(P_{2,\zeta=0}^d) - (1 - \theta) \Phi(P_{2,\zeta=1}^d) \quad (\text{B.31})$$

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

$$\left(1 - \frac{1}{1 + \chi} \right) q_0 \approx \chi q_0 = -\frac{\partial q_0}{\partial b} b. \quad (\text{B.32})$$

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

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

$$\frac{\partial E_0[v_1]}{\partial x_0} - (1 + \psi) + (1 + \chi) \frac{\partial q_0}{\partial x_0} b = 0, \quad (\text{B.33})$$

where the partial derivatives are given by:

$$\begin{aligned} \frac{\partial q_0}{\partial x_0} &= \left(\theta \times \phi(P_{1,\zeta=0}^d) \frac{\partial P_{1,\zeta=0}^d}{\partial x_0} + (1 - \theta) \times \phi(P_{1,\zeta=1}^d) \frac{\partial P_{1,\zeta=1}^d}{\partial x_0} \right) \times (\theta \times \Phi(P_{2,\zeta=0}^d) + (1 - \theta) \times \Phi(P_{2,\zeta=1}^d)) \\ \frac{\partial E_0[v_1]}{\partial x_0} &= \theta \frac{\Phi(P_{1,\zeta=0}^d) - \lambda \Phi(P_{1,\zeta=0}^e)}{1 - \lambda} + (1 - \theta) \frac{\Phi(P_{1,\zeta=1}^d) - \lambda \Phi(P_{1,\zeta=1}^e)}{1 - \lambda}, \end{aligned}$$

and where we used the fact that

$$\begin{aligned} \frac{\partial E_0[v_1|\zeta=0]}{\partial x_0} &= \frac{\Phi(P_{1,\zeta=0}^d) - \lambda \Phi(P_{1,\zeta=0}^e)}{1 - \lambda} \\ \frac{\partial E_0[v_1|\zeta=1]}{\partial x_0} &= \frac{\Phi(P_{1,\zeta=1}^d) - \lambda \Phi(P_{1,\zeta=1}^e)}{1 - \lambda} \\ \frac{\partial P_{1,\zeta=0}^e}{\partial x_0} &= \frac{\nu}{\nu - 1} \\ \frac{\partial P_{1,\zeta=1}^e}{\partial x_0} &= \frac{\nu}{\nu - 1} (P_{1,\zeta=1}^e)^\nu \\ \frac{\partial P_{1,\zeta=0}^d}{\partial x_0} &= \frac{\nu}{\nu - 1} \\ \frac{\partial P_{1,\zeta=1}^d}{\partial x_0} &= \frac{\nu}{\nu - 1} (P_{1,\zeta=1}^d)^\nu \\ \frac{\partial P_{2,\zeta=0}^d}{\partial x_0} &= 0 \\ \frac{\partial P_{2,\zeta=1}^d}{\partial x_0} &= 0 \\ \frac{\partial E_1[v_2]}{\partial x_0} &= 0 \end{aligned}$$

Putting it all together, the FOC can be rewritten as

$$\frac{\lambda}{1 - \lambda} \times P_1(\text{equity}) + (1 + \chi) \frac{\partial q_0}{\partial x_0} b = \psi + P_1(\text{default}) \times \frac{1}{1 - \lambda}, \quad (\text{B.34})$$

where

$$P_1(\text{equity}) = 1 - (\theta \Phi(P_{1,\zeta=0}^e) + (1 - \theta) \Phi(P_{1,\zeta=1}^e))$$

and

$$P_1(\text{default}) = 1 - (\theta \Phi(P_{1,\zeta=0}^d) + (1 - \theta) \Phi(P_{1,\zeta=1}^d))$$

B.4 Technical note for solving the integrals

Assuming that $\ln(x) \sim N(\mu, \sigma)$, and denoting the pdf of the standard normal variable by $G(\cdot)$, we have that:

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

Using this expression for $a = 0, 1, (1 - \nu)$, we can solve for all integrals, that is, $\Phi(x)$, $\int_0^{\bar{P}} P d\Phi(P)$, and $\int_0^{\bar{P}} P^{1-\nu} d\Phi(P)$. Note that the pdf of the log-normal distribution is given by:

$$\phi(x) = g\left(\frac{\ln(x) - \mu}{\sigma}\right) \frac{1}{x\sigma}.$$

B.5 Calibration

We calibrate the model using values from the existing literature and to match key empirical moments as for the benchmark model. In particular, we calibrate the model for a firm that has a level of price stickiness $\theta = 1 - FPA = 0.759$. We choose χ to match the average debt to asset ratio in our sample (0.247), and set the volatility σ to match the average observed credit spread in our transaction data sample (195 bps). We calibrate $\lambda = 0.10$ following [Hennessy and Whited \(2005\)](#), and we choose ψ to generate an average cash to assets ratio of 0.130 as in our sample. Our value for the demand elasticity ν implies a price markup consistent with the recent evidence in [De Loecker et al. \(2020\)](#). Finally, we set $f = 0.1$, which is consistent with a capital depreciation rate of 10% often used in the literature.

B.6 Model Implications

As for our baseline model, we provide in [Figure B.1](#) comparative statics to show the impact of price rigidity (as proxied by the probability θ) on firm policies and asset prices. The testable predictions in both models are identical. Specifically, our theory predicts that firms with greater nominal price rigidities exhibit lower leverage, hold more precautionary savings, face more costly debt financing, and are more likely to issue

short-term debt. The economic intuition for these results is similar to that in our benchmark model. Sticky price firms have lower operational flexibility. As a result, they suffer more when hit by an adverse shock and are less able to take advantage of positive shocks. Sticky price firms are thus endogenously more exposed to shocks and riskier, all else being equal.

In Figure B.2, we show that the generalized model also predicts that credit spreads increase comparatively more for sticky-price firms than for flexible price firms in response to an uncertainty shock, echoing the results presented in figure 3 of the benchmark model.

Table A.1: Variable definitions

| Variable | Definitions [Compustat codes in brackets] |
|----------------------------|--|
| <i>A. Fundamental data</i> | |
| 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+d1c]. |
| Size | Logarithm of total assets in 2010 dollars (adjusted using CPI All Urban). |
| Leverage | Long-term debt [dltt] plus debt in current liabilities [d1c], 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 [<i>ni</i>] 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 $3.3 \times \text{EBIT}/\text{assets} + 1.0 \times \text{sales}/\text{assets} + 1.4 \times \text{retained earnings}/\text{assets} + 1.2 \times \text{working capital}/\text{assets} + 0.6 \times \text{market value equity}/\text{total debt}$. |
| Price-to-cost margin | Net sales [<i>sale</i>] minus the cost of goods sold [<i>cogs</i>], divided by total assets [<i>at</i>]. |
| HHI | The Herfindahl-Hirschman index (HHI) of sales [<i>sale</i>] 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 puttable 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.2: Correlation between FPA and profitability measures

In this table, we provide estimates of pairwise correlation coefficients between FPA, our measure of price flexibility, and different measures of profitability in our firm-year sample: net income scaled by total equity, net income scaled by shareholder equity, net income scaled by common equity, sales growth over the previous year, and sales growth over the past year. The definitions of all variables are provided in the Appendix Table A.1. We report p -values in parentheses.

| | FPA |
|---------------------------------|----------------------|
| Net income/total equity | -0.0147 (0.17) |
| Net income/Shareholders' equity | -0.00393 (0.57) |
| Net income/Common equity | -0.00306 (0.65) |
| Sales growth over previous year | -0.00469 (0.50) |
| Sales growth over next year | -0.00472 (0.50) |
| Net income/assets | -0.0643*** (0.00) |

Table A.3: FPA vs. volatility measures.

We re-estimate our baseline regression models using volatility measures in place of FPA. 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 columns (1) and (2), the dependent variable is the logarithm of the net cash ratio. In columns (3) and (4), the dependent variable is the long-term debt ratio. In columns (5) and (6), we use the primary bond issuance credit spread as the dependent variable, while in columns (7) and (8), we use the secondary market credit spread data instead. In columns (9) and (10), the dependent variable is loan tightness. In all specifications, we add the same control variables as in our baseline model 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) |
| FPA | -1.02*** (-3.81) | | | 0.10** (2.59) | | | -0.40*** (-3.05) | | | -0.36** (-2.21) | | | -0.07*** (-2.93) | | |
| Vol. of cash flow | | 5.35*** (7.91) | | | 0.25** (2.19) | | | 2.04* (1.95) | | | 2.03 (0.74) | | | -0.21* (-1.83) | |
| Vol. of sales growth | | | 0.49*** (5.52) | | | 0.02 (0.69) | | | -0.35** (-2.67) | | | -0.24 (-0.72) | | | 0.01 (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 \times Time FE | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

Figure B.1: Model Predictions – Extended Model.

This figure shows the model-implied effects of price rigidity on several key firm variables (leverage, cash over assets, the credit spread at issuance, and the average maturity of debt) for the extended model described in Section B. Price rigidity is modulated through the value of the parameter θ . The plots are obtained after solving for the firm's optimal decisions under different values for degree of price stickiness (θ), ranging from 0 to 1.

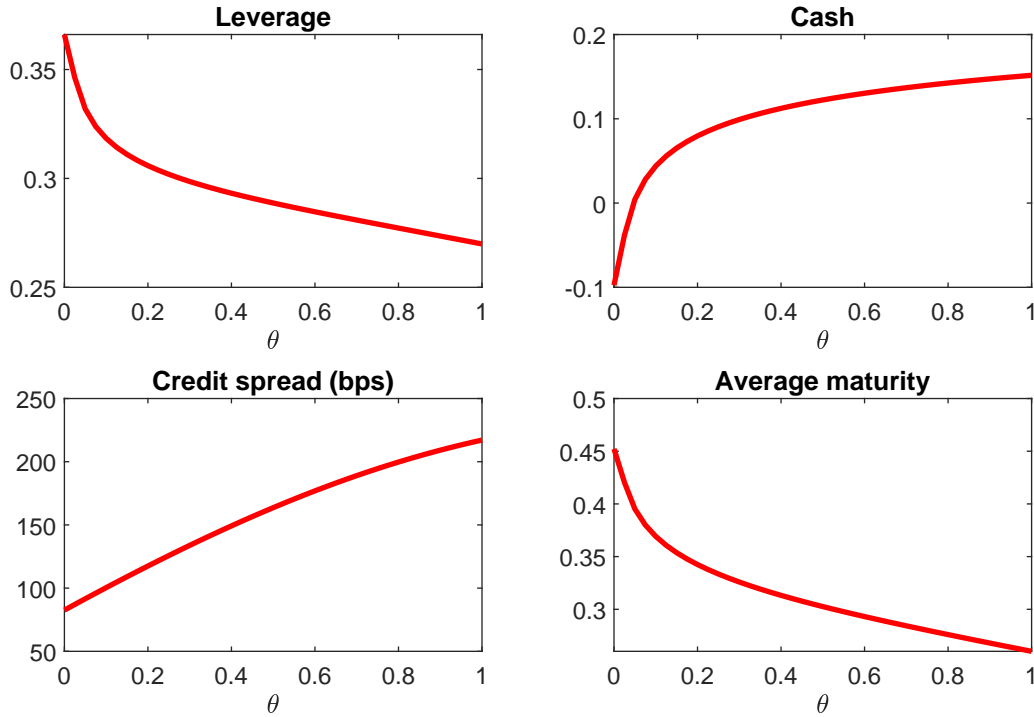


Figure B.2: The Impact of Uncertainty Shocks on Credit Spreads – Extended Model.

This figure illustrates model-implied credit spreads (y-axis) for sticky and flexible price firms (x -axis) in response to an uncertainty shock based on the extended model described in Section B. Flexible price firms are identified by the solid black line, while sticky price firms are identified by the dashed red line. The starting point of the graph (time 0) represents the equilibrium credit spread of each firm, net of their steady state value. This makes both firms directly comparable. The subsequent evolution of the credit spreads characterizes the response to a one period shock in the volatility of each firm's profits. The higher increase in credit spreads for sticky price firms to the same volatility shock characterizes a greater sensitivity of sticky price firms to shocks in the uncertainty of its profits. The profit volatility process is calibrated using the following values: $\rho_\sigma = 0.8$, and $\sigma_\sigma = 1.5\%$. Flexible (sticky) price firms are characterized by decreasing (increasing) θ by two times the empirical standard deviation of FPA.

