Predation or Self-Defense?
Endogenous Competition and Financial Distress

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Abstract

Firms tend to compete on prices more aggressively when they are in financial distress. More intense competition can in turn reduce firms' profit margins and push firms further into distress. To quantify the feedback effect between industry competition and financial distress and the predatory incentives, we incorporate supergames of price competition into a model of long-term debt and strategic default. We show that this feedback mechanism has important implications on asset prices and financial contagion. Depending on the heterogeneity in customer bases and financial conditions across firms in an industry as well as between incumbents and new entrants, firms can exhibit a rich variety of strategic interactions, including predation, self-defense, and collaboration. Finally, we provide empirical support for our model's predictions.

Keywords: Competition-Distress Feedback, Financial Contagion, Industrial Organization, Gross Profitability Premium, Financial Distress Premium

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1 Introduction

Product markets are often highly concentrated, and strategic competition among industry leaders plays a vital role in determining industry dynamics (e.g. Autor et al., 2017; Loecker and Eeckhout, 2017).[1] It is well established that firms' decisions in product markets affect their profit margins, financial conditions, and valuation.[2] Our paper focuses on the endogenous interactions between strategic competition and financial distress, which depend on the industry structure, firms' capital structure, as well as the macroeconomic conditions. We show that such interactions can generate adverse feedback and contagion effects within an industry, hence reducing financial stability.

In our model, a firm's incentive to collude with others in setting prices depends on its future perspective. Recessions are times with high discount rates and low persistent consumption growth, which shift firms attention from long-run to short-run cash flows. This induces firms to compete on prices more fiercely at such times. Higher competition intensity lowers firms' profit margins, which raises the default risk of levered firms, more so for those with higher leverage. The rising financial distress risk has the similar effect as higher discount rate or lower expected growth in demand. It makes firms in poor financial conditions compete more aggressively to generate more profits now, which induces other firms to narrow down profit margins as well, including those financially strong firms. Thus, the predation-like behavior and price war emerges endogenously. As competition becomes more intense, the financial distress risk in turn rises further among all firms, including those financially strong firms. This results in an adverse feedback loop between industry competition and financial distress, worsening firms' financial distress. Meanwhile, this also results in an adverse financial contagion among competitors within the same industry through the product market competition.

To study the quantitative effects of such competition-distress feedback and contagion, we incorporate dynamic games of price competition into an equilibrium framework with

[1] According to the U.S. Census data, the top four firms within each 4-digit SIC industry account for about 48% of the industry's total revenue, and the top eight firms own over 60% market shares (see Dou, Ji and Wu, 2019, Online Appendix C).

[2] For example, Corhay, Kung and Schmid (2017), Corhay (2017), and Dou, Ji and Wu (2019) analyze the implication of product market competition on equity returns and credit spreads.

time-varying macroeconomic conditions captured by the fluctuations in discount rates and expected growth rates of aggregate demand. There is a continuum of industries and each industry features dynamic Bertrand duopoly with differentiated products and tacit collusion (Tirole, 1988, Chapter 6). Consumers have relative deep habits (Ravn, Schmitt-Grohe and Uribe, 2006) over firms' products, which are embodied in customer base. Therefore, firms find it valuable to maintain their customer base. Firms' cash flows are endogenously determined by their product prices and customer base. Shareholders issue consols and promises a perpetual coupon payment to debtholders.

Duopolisits can implicitly collude with each other on setting high product prices and obtaining high profit margins.[3] Knowing that the competitor will honor the collusive profit-margin scheme, a firm can boost up its short-run revenue by undercutting prices to attract more customers; however, deviating from the collusive profit-margin scheme may reduce revenue in the long run if the profit-margin undercutting behavior is detected and punished by the competitor. Following the literature (e.g., Green and Porter, 1984; Brock and Scheinkman, 1985; Rotemberg and Saloner, 1986), we adopt the non-collusive Nash equilibrium as the incentive-compatible punishment for deviation. The implicit collusive profit margins depend on firms' deviation incentives: a higher collusive profit margin can only be sustained by a lower deviation incentive, which is further determined by firms' intertemporal trade-off between short- and long-run cash flows.

Our model yields several main implications. First, there exists a positive feedback loop between competition and financial distress. When firms become more financially distressed, default risk rises. The heightened default risk makes competition more fierce because firms find it more difficult to collude with each other. Intuitively, when default risk rises, the firm

[3]Collusion is pervasive among leading competitors in industries. John Connor's Private International Cartels Dataset (Connor, 2016) shows that during 1990-2016, 953 cartels were convicted of price fixing and 296 suspected cartels were under investigation. The estimated cartel overcharges since 1990 exceed $1.5 trillion. The majority of the corporate cartelists were from Europe or North America. More importantly, besides explicit collusion, firms also engage, even more pervasively, in tacit collusion. For example, Bourveau, She and Zaldokas (2019) show that firms can use corporate disclosure to facilitate tacit coordination. For another example, institutional cross-ownership can facilitate firms in tacitly colluding and better collaborating with each other in product markets (e.g., He and Huang, 2017). González, Schmid and Yermack (2019) show that managers have incentives to engage in price fixing as they enjoy greater job security and higher compensation. Managers also actively use concealment strategies to limit detection of cartel membership.

becomes more impatient and values its cash flows in the short run more than those in the long run. This renders the punishment for deviation less threatening, incentivizing the firm to undercut its competitor's profit margin and thus intensifying competition. The increased competition results in lower profit margins, further amplifying financial distress and default risk.

Second, predation-like behavior emerges endogenously as an equilibrium outcome of collusion. The model implies that the financially strong firm lowers its profit margin when the financially weak firm becomes more distressed. Such kind of pricing strategy echoes the idea of *defensive predation* termed by Fisher (2001). It is different from the usual (offensive) predation because the motivation of the financially strong firm to lower its profit margin is to protect its customer base from being stolen by its competitor, not to drive its competitor out of the market. In other words, the financially strong firm should be treated as a defender but not a predator. Intuitively, when the financially weak firm becomes more distressed, its deviation incentive increases, motivating it to undercut the financially strong firm's profit margin to gain customer base. Anticipating such increased deviation incentive, the financially strong firm lowers its profit margin to maintain collusion and prevent itself from being hurt by its financially weak competitor's aggressive undercutting behavior.

Importantly, our model does not only emphasize a mechanism of endogenous competition due to time-varying collusion incentives among firms in an industry, but also includes the mechanism of offensive predatory pricing strategy. This is a valuable feature of our framework because, in principle, firms do not necessarily have to collude with each other if they can drive their competitors out of the market and enjoy the monopoly rent. Intuitively, competitors may undercut each other's profit margins more aggressively in hopes of driving others out and monopolizing the industry, when the discount rate declines and/or the expected growth rises. However, such a mechanism can disappear or be substantially weakened once there is a new entry. Wiseman (2017) formalizes this intuition in a game-theoretic model and shows that with a sufficiently high entry barrier (infinitely high in his baseline model), sufficiently patient firms exhibit predation behavior, which contradicts the collusion behavior predicted by the folk theorems. In other words, such an anti-folk-theorem force can show up in our model when the entry barrier is very high and firms are extremely patient.

Third, our model generates financial contagion among competitors within an industry through the product market competition channel. More precisely, when one leading firm is disturbed by idiosyncratic adverse shocks and forced into the financial distress state, it will start to behave aggressively in the product market in hopes of gaining higher short-run cash flows to survive. However, the price-undercutting behavior of the financially distressed firm will push financially strong firm to undercut prices, narrow its profit margins, and even trigger price wars. As a result, the financial condition of the competitors in the same industry is also weakened.

Forth, in our model, higher gross profitability industries have higher equity returns but lower credit spreads. Dou, Ji and Wu (2019) build a model with endogenous market power risk like here, but focus on all-equity firms. They show that the gross profitability premium cross industries can be explained by the heterogeneous persistence of market leadership and the endogenous market power risk. This paper extends their framework by allowing the interaction between strategic competition and financial distress, which amplifies the effect of endogenous market power risk studied by Dou, Ji and Wu (2019); more importantly, it can explain the joint patterns of equity returns and credit spreads associated with gross profitability, which is generally viewed as a strengthened version of gross profitability premium puzzle.

While our contribution is mainly theoretical, we empirically test the main predictions of our model and find strong evidence that supports the theoretical implications

1.1 Related Literature

Our paper contributes to the large and growing literature on the structural model of corporate debt and default (see, e.g., Merton, 1974; Black and Cox, 1976; Fischer, Heinkel and Zechner, 1989; Leland, 1994; Leland and Toft, 1996; Anderson and Sundaresan, 1996; Goldstein, Ju and Leland, 2001; DeMarzo and Sannikov, 2006; Hackbarth, Miao and Morellec, 2006; Broadie, Chernov and Sundaresan, 2007; DeMarzo and Fishman, 2007; Chen, 2010; Anderson and Carverhill, 2012; He and Milbradt, 2014; Corhay, 2017). Sundaresan (2013) provides a comprehensive review. Theoretically, our paper pushes forward the literature by developing a structural model of default incorporated with dynamic supergames, in which product market competition endogenously varies with macroeconomic conditions. Chen (2010) and Hackbarth, Miao and Morellec (2006) focus on the impact of macroeconomic conditions on firms' financing policies and asset prices. In their models, cash flow dynamics exogenously vary with macroeconomic conditions. By contrast, we micro-found firms' cash flows through endogenous time-varying product market competition and emphasize the endogenous linkage between firms' cash flows and macroeconomic conditions. Like ours, Corhay (2017) also develops a model in which firms' cash flows are determined by strategic competition in the product market. The key difference is that our model incorporates a dynamic Bertrand duopoly playing a profit-margin-setting supergame. Therefore, our model predicts that the degree of product market competition endogenously varies with macroeconomic conditions, providing an amplification mechanism on credit risks through procyclical profit margins and cash flows.

Our paper is related to the literature on the connection between product markets and financial decision making (see, e.g., Brander and Lewis, 1986; Maksimovic, 1988; Dumas, 1989; Gertner, Gibbons and Scharfstein, 1988; Bolton and Scharfstein, 1990; Chevalier and Scharfstein, 1996; Dasgupta and Titman, 1998; MacKay and Phillips, 2005; Miao, 2005; Banerjee, Dasgupta and Kim, 2008; Fresard, 2010; Valta, 2012; Phillips and Sertsios, 2013; Belo, Lin and Vitorino, 2014; Gourio and Rudanko, 2014; Leary and Roberts, 2014; Vitorino, 2014; Gilchrist et al., 2017; D'Acunto et al., 2018; Dou and Ji, 2019; Belo et al., 2018). In particular, our paper is closely related to the literature that links product market competition to firm risks (see, e.g., Hou and Robinson, 2006; Aguerrevere, 2009; Loualiche, 2016; Bustamante and Donangelo, 2017; Corhay, 2017; Corhay, Kung and Schmid, 2017). We contribute to this literature by showing that there is a positive feedback loop between financial leverage and product market competition. This feedback loop amplifies default risks and is also empirically relevant. For example, Valta (2012) finds that the cost of bank debt is systematically higher for firms in competitive product markets. Fresard (2010) finds that large cash reserves allow firms to gain future market shares at the expense of their industry rivals. Phillips (1995) finds that following sharply increased financial leverage, the largest firms in the gypsum industry increased their market share at the expense of small firms and operating margins decrease.

2 The Baseline Model

Because predatory pricing and tacit collusion are inherently intertemporal phenomena, we develop a dynamic industry-equilibrium model of default with long-term bonds and time-varying market prices of risk. The industry has two market leaders indexed by $i \in \{1, 2\}$ and many followers with measure zero; so each industry is essentially a duopoly. We label a generic firm by i and its competitor by $\bar{i}$.

2.1 Product Market Structure

Industry Demand. Similar to the seminal works Hopenhayn (1992), Pindyck (1993), and Caballero and Pindyck (1996), we focus on the industry equilibrium by specifying an industry-level demand curve $C_t = \mathcal{D}(P_t)$. Specifically, we assume an isoelastic industry demand curve:

$$C_t = M_t P_t^{-\epsilon}, \tag{1}$$

where M_t is an endogenous stochastic process that captures the total customer base in the industry, which is affected by short-run demands of firms and subject to industry-and firm-level "taste" shocks. The coefficient ϵ captures the industry's price elasticity of demand.

Firm-level Demand. The demand for the industry good C_t is a basket of firm-level composites, determined by a Dixit-Stiglitz CES aggregation. More precisely, the industry demand C_t is determined through the aggregation of firm-level differentiated products,

$$C_t = \left[\sum_{i=1}^{2} \left(\frac{M_{i,t}}{M_t} \right)^{\frac{1}{\eta}} C_{i,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \text{ with } M_t = \sum_{i=1}^{2} M_{i,t}, \tag{2}$$

where $C_{i,t}$ is the demand for firm i's products, and the parameter $\eta > 1$ captures the elasticity of substitution among products produced by different firms in the same industry. The weight $M_{i,t}/M_t$ captures consumers' relative "taste" for purchasing firm i's products. The share $M_{i,t}/M_t$ can also be interpreted as the customer base share of firm i.

Given firm i's price $P_{i,t}$ and industry demand C_t, we obtain the firm-level demand $C_{i,t}$ by solving a standard expenditure minimization problem. The firm-level demand curves can be characterized as follows:

$$C_{i,t} = M_{i,t} \left(\frac{P_{i,t}}{P_t} \right)^{-\eta} P_t^{-\epsilon}, \quad \text{with } P_t = \left[\sum_{i=1}^{2} \left(\frac{M_{i,t}}{M_t} \right) P_{i,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}, \tag{3}$$

where P_t is the price index for the industry good.

In equation (3) that characterizes the equilibrium firm-level demand curve, the demand for firm i's goods $C_{i,t}$ is linear in $M_{i,t}$. From a firm's perspective, the consumer's taste determines its customer base (or customer capital) because it determines the demand for its products (e.g., Gourio and Rudanko, 2014; Dou et al., 2018). Such a connection has been made clear by deriving the firm's demand curve in (3).

Moreover, firm i will have more influence on the industry's price index P_t when the customer base share $M_{i,t}/M_t$ of firm i is greater. Each firm internalizes the effect of both its own and its competitor's price-setting behavior on the industry's price index, leading to strategic interaction. By contrast, in a standard monopolistic competition model with a continuum of firms, each firm is atomistic and has no influence on the industry's price index.

Endogenous Price Elasticity of Demand. The short-run price elasticity of demand for product i, taking into account the externality, is

$$-\frac{\partial \ln C_{i,t}}{\partial \ln P_{i,t}} = \underbrace{\mu_{i,t} \left[-\frac{\partial \ln C_t}{\partial \ln P_t} \right]}_{\text{cross-industry}} + \underbrace{(1 - \mu_{i,t}) \left[-\frac{\partial \ln(C_{i,t}/C_t)}{\partial \ln(P_{i,t}/P_t)} \right]}_{\text{within-industry}} = \mu_{i,t}\epsilon + (1 - \mu_{i,t})\eta,$$

where $\mu_{i,t}$ is the *(revenue) market share* of firm i and is defined as follows:

$$\mu_{i,t} = \frac{P_{i,t}C_{i,t}}{P_t C_t} = \left(\frac{P_{i,t}}{P_t}\right)^{1-\eta} \frac{M_{i,t}}{M_t}. \tag{4}$$

Equation (4) shows that the short-run price elasticity of demand is given by the average of within-industry elasticity η and cross-industry elasticity ϵ, weighted by the firm's revenue market share. That is, depending on firm i's revenue market share $\mu_{i,t}$, its short-run price elasticity of demand lies on the interval $[\epsilon, \eta]$. On the one hand, when firm i's revenue market share $\mu_{i,t}$ becomes smaller, within-industry competition becomes more relevant, so firm i's price elasticity of demand depends more heavily on the within-industry elasticity η. In the extreme case of $\mu_{i,t} = 0$, firm i becomes atomistic and takes the industry price index P_t as given. As a result, firm i's price elasticity of demand is exactly η. On the other hand, when $\mu_{i,t}$ becomes larger, cross-industry competition becomes more relevant and thus firm i's price elasticity of demand depends more strongly on the cross-industry elasticity ϵ. In the extreme case of $\mu_{i,t} = 1$, firm i monopolizes in the industry and its price elasticity of demand is exactly ϵ.

Evolution of Customer Base. Firms can attract consumers through undercutting profit margins, such as lowering prices, offering discounts, or increasing marketing expenses. Lowering profit margins can have a persistent positive effect on the firm's demand due to consumption inertia, information frictions, and switching costs. To capture this idea, following Phelps and Winter (1970) and Ravn, Schmitt-Grohe and Uribe (2006), we model the evolution of firm i's customer base as

$$\mathrm{d}M_{i,t}/M_{i,t} = \left[\alpha + \beta \left(C_{i,t}/M_{i,t}\right)^h\right] \mathrm{d}t + \varsigma \mathrm{d}Z_t + \sigma \mathrm{d}W_{i,t}. \tag{5}$$

In the above equation, the term $\beta \left(C_{i,t}/M_{i,t}\right)^h$ with $h \in [0,1]$ captures the endogenous accumulation of customer base. Intuitively, by setting a lower price $P_{i,t}$, firm i increases the contemporaneous demand flow rate $C_{i,t}$, thereby allowing the firm to accumulate more customer base over $[t, t + \mathrm{d}t]$. The parameter $\beta > 0$ captures the speed of customer base accumulation. A greater β indicates that customer base accumulation is more sensitive to contemporaneous demand $C_{i,t}$. The parameter h captures the relative importance of contemporaneous demand in accumulating customer base. Consistent with the empirical evidence, the slow-moving customer base $M_{i,t}$ implies that the long-run price elasticity of demand is higher than the short-run elasticity (e.g., Rotemberg and Woodford, 1991). The constant growth term α in equation (5) captures customer base accumulation and depreciation due to industry-level reasons such as the mortality of consumers. The standard Brownian motion Z_t captures the shocks to the industry's total customer base and $W_{i,t}$ captures idiosyncratic shocks to firm i's customer base. The Brownian motions Z_t, $W_{1,t}$, and $W_{2,t}$ can be interpreted as "taste shocks" and are mutually independent.

The preference towards differentiated goods, combining (2) and (5), is similar to the *relative habits* (e.g., Ravn, Schmitt-Grohe and Uribe, 2006; van Binsbergen, 2016). The specification of relative deep habits is inspired by the habit formation of Abel (1990), which features *catching up with the Joneses*. The defining feature of the relative deep habits is that agents form habits over individual varieties of goods as opposed to a composite consumption good. The coefficient α captures the strength of deep habits. When $h = 0$, the deep habit channel is shut down.

For β and h are small, suggested by the empirical results in Gilchrist et al. (2017), the firm-level customer base $M_{i,t}$ is persistent over time, which can be interpreted as customer inertia and brand loyalty to firm i's product (Klemperer, 1995).

Persistence of Market Leadership. The market leaders' position is sticky. Market followers in an industry are constantly challenging and trying to replace the existing market leaders, and they typically do so through distinctive innovation or rapid business expansion. The change of market leaders does not occur gradually over an extended period of time; instead, market leaders are replaced rapidly and disruptively (e.g., Christensen, 1997). For example, Apple and Samsung replaced Nokia and Motorola and became the leaders in the mobile phone industry over a very short period of time.

We assume that the change of market leaders in the industry, as a disruption to the market structure, occurs with intensity $\lambda \geq 0$.[4] Upon the disruption to the market structure, the incumbent market leaders are replaced by new entrant market leaders who used to be followers, and the replaced firms' asset value is destroyed. Each of the new leaders has a positive initial customer base M_0 and debt level b_0. The initial customer base M_0 is normalized to be one, without loss of any generality.

2.2 Firms' Decisions

Firms' shareholders choose profit margins and exit decisions strategically to maximize their market equity value.

Profit Margin Decision. The marginal cost for a firm to produce a flow of goods is ω with $\omega > 0$. That is, when firm i produce goods at rate $Y_{i,t}$, its total costs of production will be $\omega Y_{i,t} \mathrm{d}t$ over $[t, t + \mathrm{d}t]$. In equilibrium, the firm finds it optimal to choose $P_{i,t} > \omega$ and the market clears for each differentiated good: $Y_{i,t} = C_{i,t}$. Denote by $\theta_{i,t}$ and θ_t the firm-level and industry-level profit margins. They are defined as follows:

$$\theta_{i,t} \equiv \frac{P_{i,t} - \omega}{P_{i,t}} \quad \text{and} \quad \theta_t \equiv \frac{P_t - \omega}{P_t}. \tag{6}$$

It directly follows from equation (3) that the relation between $\theta_{i,t}$ and θ_t is

$$1 - \theta_t = \left[\sum_{j=1}^{2} \left(\frac{M_{i,t}}{M_t} \right) (1 - \theta_{i,t})^{\eta - 1} \right]^{\frac{1}{\eta - 1}}. \tag{7}$$

Firm i's operating profit depends on both its own and its competitor's profit margin decisions:

$$\Pi_i(\theta_{i,t}, \theta_{\bar{i},t}) \equiv (\theta_{i,t} - 1)\, \omega C_{i,t} = \omega^{1-\epsilon} \theta_{i,t} \,(1 - \theta_{i,t})^{\eta - 1} \,(1 - \theta_t)^{\epsilon - \eta} M_{i,t}. \tag{8}$$

Equation (8) shows that the (local) profit rate of firm i depends on its competitor $\bar{i}$'s profit margin $\theta_{\bar{i},t}$ through the industry's profit margin θ_t. This reflects the externality of firm $\bar{i}$'s

[4] Significant heterogeneity exists in the persistence of market leaders' position across industries. See, for example, Baldwin (1995), Geroski and Toker (1996), Caves (1998), Matraves and Rondi (2007), Sutton (2007), Bronnenberg, Dhar and Dubé (2009), and Ino and Matsumura (2012) for empirical evidence.

decisions. For example, holding firm i's profit margin fixed, if firm $\bar{i}$ cuts its profit margin $\theta_{\bar{i},t}$, the industry's profit margin θ_t will drop, which will reduce the demand for firm i's goods $C_{i,t}$ (see equation (3)), and in turn firm i's profit $\Pi_i(\theta_{i,t}, \theta_{\bar{i},t})$. The potential decrease in profits will motivate firm i to lower its own profit margin $\theta_{i,t}$ in order to maintain the demand for its goods. As a result, the two firms' profit-margin setting decisions exhibit strategic complementarity in equilibrium.

Default and Exit Decision of Incumbent Firm. Firms are financed by debt and equity, and they issue long-term debt to take advantage of the tax shield. The corporate tax rate is τ. We assume that firms do not hold cash reserves. A levered firm first uses its cash flow to make interest payments, then pays taxes, and distributes the rest to equity-holders as dividend. Shareholders have limited liability and have the option to default. When internally generated cash cannot cover the interest expenses, the firm may be able to costlessly issue equity to cover the shortfalls.[5] If equity-holders are no longer willing to inject more capital, the firm defaults and exits. Thus, if the equity value falls to zero, shareholders will default and exit. Upon shareholders' defaulting on the debt, the firm is liquidated and its debtholders would obtain a fraction ν of the abandonment value (unlevered asset value).

Debt is modeled as a consol bond, which promises perpetual coupon payments at rate b_i. This is a standard assumption in the literature (Leland, 1994; Duffie and Lando, 2001), which helps maintain a time-homogeneous setting. Thus, firm i's flow of earnings after interest expenses and taxes over $[t, t + \mathrm{d}t]$ is $(1 - \tau) \left[\Pi_i(\theta_{i,t}, \theta_{\bar{i},t}) - b_i\right] \mathrm{d}t$.

To maintain the tractability, we assume that a new market leader would enter only after an incumbent market leader defaults and exits. This is a standard assumption in the literature of industrial organization on predatory pricing (e.g., Besanko, Doraszelski and Kryukov, 2014). Intuitively, the competition we focus on is always between the top leader in the industry and the next one. More precisely, upon an incumbent firm's exiting, a new entrant firm with initial customer base $M_{new} > 0$ and coupon rate b_{new} will enter the market, where b_{new} is

[5]The costless issuance of equity is a simplification assumption widely adopted in credit risk models (e.g., Leland, 1994; Hackbarth, Miao and Morellec, 2006; Chen, 2010). Incorporating the costly equity issuance and endogenous cashholding, as in Bolton, Chen and Wang (2011, 2013), and Dou et al. (2019), is interesting for future research.

chosen so that the initial debt-asset ratio, market value of debt divided by market value of assets, is set to be ℓ_{new}.

2.3 Stochastic Discount Factor

Given the focus on the feedback effect between the industry competition and the financial distress, we directly specify the stochastic discount factor (SDF), denoted by Λ_t. The SDF evolves as follows:

$$\frac{\mathrm{d}\Lambda_t}{\Lambda_t} = -r_f \mathrm{d}t - \gamma_t \mathrm{d}Z_t - \zeta \mathrm{d}Z_{\gamma,t}, \tag{9}$$

where Z_t and $Z_{\gamma,t}$ are independent standard Brown motions, the equilibrium risk-free rate is r_f, and the time-varying market prices of risk γ_t evolves as follows:

$$\mathrm{d}\gamma_t = -\varphi(\gamma_t - \overline{\gamma})\mathrm{d}t - \pi \mathrm{d}Z_{\gamma,t} \quad \text{with} \quad \varphi, \overline{\gamma}, \pi > 0. \tag{10}$$

Following the literature on cross-sectional return predictability (e.g., Lettau and Wachter, 2007; Belo and Lin, 2012; Dou, Ji and Wu, 2019), we directly specify the time-varying discount rate γ_t. We assume $\zeta > 0$ to capture the well-documented countercyclical price of risk. The primitive economic mechanism driving the countercyclical price of risk can be, for example, time-varying risk aversion, as in Campbell and Cochrane (1999). Therefore, our model is similar to Chen, Collin-Dufresne and Goldstein (2008), who show that the strongly countercyclical risk prices generated by the habit formation model (Campbell and Cochrane, 1999), combined with exogenously imposed countercyclical asset value default boundaries, can generate high credit spreads. However, by contrast, default boundaries are highly endogenous in our model due to the endogenous time-varying competition intensity.

It worth to point that the industry's market structure disruption shock is not priced in the SDF. This is because the economy comprises a continuum of industries, and thus the industry-specific change of market leaders is an idiosyncratic event to the fully diversified representative investor.

2.4 Nash Equilibrium: Collusion and Equity Value

We now solve the dynamic games with strategic profit margin and default decisions based on the SDF specified in (9) and (10). The discount rate γ_t is the only aggregate state. Economic downturns in our model are characterized by those states with a high γ_t.

Subgame Perfect Nash Equilibrium. The two firms in an industry play a supergame (Friedman, 1971), in which the stage games of setting profit margins are played continuously and repeated infinitely with exogenous and endogenous state variables varying over time. Formally, a subgame perfect Nash equilibrium for the dynamic game consists of a collection of profit-margin strategies that constitute a Nash equilibrium for every history of the game. We do not consider all such equilibria; instead, we only focus on those which allow for collusive arrangements enforced by punishment schemes. All strategies are allowed to depend upon both "payoff-relevant" states $x_t = \{M_{1,t}, M_{2,t}, \gamma_t\}$ in state space $\mathcal{X}$, as in Maskin and Tirole (1988*a*,*b*), and a set of indicator functions that track whether any firm has previously deviated from a collusive profit-margin agreement, as in Fershtman and Pakes (2000, Page 212).[6] Thus, the industry's state is the vector of firms' payoff-relevant states $x_t = \{M_{1,t}, M_{2,t}, \gamma_t\}$.

In particular, there exists a non-collusive equilibrium, which is the repetition of the one-shot Nash equilibrium and thus is Markov perfect. Meanwhile, multiple subgame perfect collusive equilibria also exist in which profit-margin strategies are sustained by conditional punishment strategies.[7]

Non-Collusive Equilibrium with Endogenous Default Boundaries. The non-collusive equilibrium is characterized by profit-margin scheme $\Theta^N(\cdot) = (\theta_1^N(\cdot), \theta_2^N(\cdot))$, which is a pair of functions defined in state space $\mathcal{X}$, such that each firm i chooses profit margin $\theta_{i,t} \equiv \theta_i(x_t)$ to maximize shareholder value $V_{i,t}^N \equiv V_i^N(x_t)$, under the assumption that its competitor $\bar{i}$ will set the one-shot Nash-equilibrium profit margin $\theta_{\bar{i},t}^N \equiv \theta_{\bar{i}}^N(x_t)$. Following the recursive

[6]For notational simplicity, we omit the indicator states of historical deviations.

[7]In the industrial organization and macroeconomics literature, this equilibrium is called the collusive equilibrium or collusion (see, e.g., Green and Porter, 1984; Rotemberg and Saloner, 1986). Game theorists generally call it the equilibrium of repeated game (see Fudenberg and Tirole, 1991) in order to distinguish it from the one-shot Nash equilibrium (i.e., our non-collusive equilibrium).

formulation in dynamic games for characterizing the Nash equilibrium (e.g., Pakes and McGuire, 1994; Ericson and Pakes, 1995; Maskin and Tirole, 2001), optimization problems can be formulated recursively by Hamilton-Jacobi-Bellman (HJB) equations:

$$0 = \max_{\theta_{i,t}} \Lambda_t \left[(1-\tau)[\Pi_i(\theta_{i,t}, \theta_{\bar{i},t}^N) - b_i] - \lambda V_{i,t}^N \right] \mathrm{d}t + \underbrace{\mathbb{E}_t \left[\mathrm{d}(\Lambda_t V_{i,t}^N) \right]}_{\text{if not disrupted}}, \quad \text{for } i = 1, 2. \tag{11}$$

The solutions to the coupled HJB equations give the non-collusive-equilibrium profit margin $\theta_{i,t}^N \equiv \theta^N(x_{i,t})$ with $i = 1, 2$.

Firm i's endogenous default boundary in the non-collusive equilibrium, which is in terms of the customer base, is denoted by $\underline{M}_{i,t}^N \equiv \underline{M}_i^N(M_{\bar{i},t}, \gamma_t)$. At the optimal default boundary, equity value of firm i is equal to zero (the value matching condition) and the boundary is optimal in terms of maximizing the equity value (the smooth pasting condition):

$$V_i^N(x_t)\big|_{M_{i,t}=\underline{M}_{i,t}^N} = 0 \quad \text{and} \quad \frac{\partial}{\partial M_{i,t}} V_i^N(x_t)\bigg|_{M_{i,t}=\underline{M}_{i,t}^N} = 0, \quad \text{respectively.} \tag{12}$$

The boundary condition at $M_{i,t} = +\infty$ is given by Appendix A.1.

Collusive Equilibrium with Endogenous Default Boundaries. In the collusive equilibrium, firms (tacitly) collude in setting higher profit margins, with any deviation triggering a switch to the non-collusive Nash equilibrium. The collusion is "tacit" in the sense that it can be enforced without relying on legal contracts. Each firm is deterred from breaking the collusion agreement because doing so could provoke fierce non-collusive competition.

Consider a generic collusive equilibrium in which the two firms follow a collusive profit-margin scheme. Both firms can costlessly observe the other's profit margin, so that deviation can be detected and punished. The assumption of perfect information follows the literature.[8] In particular, if one firm deviates from the collusive profit-margin scheme, then with probability $\xi \mathrm{d}t$ over $[t, t + \mathrm{d}t]$ the other firm will implement a punishment strategy in which it will forever set the non-collusive profit margin. Entering the non-collusive equilibrium is considered as

[8] A few examples include Rotemberg and Saloner (1986), Haltiwanger and Harrington (1991), Staiger and Wolak (1992), and Bagwell and Staiger (1997).

the punishment for the deviating firm, because the industry will switch from the collusive to the non-collusive equilibrium featuring the lowest profit margin.[9] We use the idiosyncratic Poisson process $N_{i,t}$ to characterize whether a firm can successfully implement a punishment strategy. One interpretation of $N_{i,t}$ is that, with $1 - \xi \mathrm{d}t$ probability over $[t, t + \mathrm{d}t]$, the deviator can persuade its competitor not to enter the non-collusive Nash equilibrium over the period $[t, t + \mathrm{d}t]$.[10] Thus, the punishment intensity ξ can be viewed as a parameter governing the credibility of the punishment for deviating behavior. A higher ξ leads to a lower deviation incentive.

Formally, the set of incentive-compatible collusion agreements, denoted by $\mathcal{C}$, consists of all continuous profit-margin schemes $\Theta^C(\cdot) \equiv (\theta_1^C(\cdot), \theta_2^C(\cdot))$, such that the following participation constraints (PC) and incentive compatibility (IC) constraints are satisfied:

$$V_i^N(x) \leq V_i^C(x), \quad \text{for all } x \in \mathcal{X} \text{ and } i = 1, 2; \qquad \text{(PC constraints)} \tag{13}$$

$$V_i^D(x) \leq V_i^C(x), \quad \text{for all } x \in \mathcal{X} \text{ and } i = 1, 2. \qquad \text{(IC constraints)} \tag{14}$$

Here, $V_i^N(x)$ is the firm i's shareholder value in the non-collusive equilibrium, $V_i^D(x)$ is firm i's shareholder value if it chooses to deviate from the collusion, and $V_i^C(x)$ is firm i's shareholder value in the collusive equilibrium, pinned down recursively according to

$$0 = \Lambda_t \left\{ (1 - \tau)[\Pi_i(\theta_{i,t}^C, \theta_{\bar{i},t}^C) - b_i] - \lambda V_{i,t}^C \right\} \mathrm{d}t + \mathbb{E}_t \left[\mathrm{d}(\Lambda_t V_{i,t}^C) \right], \tag{15}$$

subject to the PC and IC constraints in (13) and (14), where $\theta_{i,t}^C \equiv \theta_i^C(x_t)$ with $i = 1, 2$ are the collusive profit margins. Obviously, the equilibrium recursive relation in (15) only holds true within the non-default region, characterized by $M_{i,t} > \underline{M}_{i,t}^C \equiv \underline{M}_i^C(M_{\bar{i},t}, \gamma_t)$ where $\underline{M}_{i,t}^C$

[9] We adopt the non-collusive equilibrium as the incentive-compatible punishment for deviation, which follows the literature (see, e.g., Green and Porter, 1984; Rotemberg and Saloner, 1986). We can extend the setup to allow for finite-period punishment. The quantitative implications are not altered significantly provided that the punishment lasts long enough.

[10] Ex-post renegotiations can occur because the non-collusive equilibrium is not renegotiation-proof or "immune to collective rethinking" (see Farrell and Maskin, 1989). The strategy we consider is essentially a probabilistic punishment strategy. This "inertia assumption" also solves the technical issue of continuous-time dynamic games about indeterminacy of outcomes (see, e.g., Simon and Stinchcombe, 1989; Bergin and MacLeod, 1993).

is firm i's default boundary in the collusive equilibrium. The value matching and smooth pasting conditions for the optimal default boundary are

$$V_i^C(x_t)\big|_{M_{i,t}=\underline{M}_{i,t}^C} = 0 \quad \text{and} \quad \frac{\partial}{\partial M_{i,t}} V_i^C(x_t)\Big|_{M_{i,t}=\underline{M}_{i,t}^C} = 0, \text{ respectively.} \tag{16}$$

The boundary condition at $M_{i,t} = +\infty$ is identical to that in the non-collusive equilibrium, because when $M_{i,t} = +\infty$, firm i is essentially an industry monopoly and there is no benefit from colluding with firm $\bar{i}$ with zero customer base share.

Equilibrium Deviation Values. Let $V_{i,t}^D \equiv V_i^D(x_{i,t})$ be firm j's highest shareholder value if it deviates from the implicit collusion. The highest deviation value evolves as follows:

$$0 = \max_{\theta_{i,t}} \Lambda_t \left\{(1-\tau)[\Pi_i(\theta_{i,t}, \theta_{\bar{i},t}^C) - b_i] - \xi\left(V_{i,t}^D - V_{i,t}^N\right) - \lambda V_{i,t}^D\right\} \mathrm{d}t + \underbrace{\mathbb{E}_t\left[\mathrm{d}(\Lambda_t V_{i,t}^D)\right]}_{\text{if not disrupted}}, \tag{17}$$

for $i = 1, 2$. The equilibrium recursive relation above in equation (17) only holds true within the non-default region, characterized by $M_{i,t} > \underline{M}_{i,t}^D \equiv \underline{M}_i^D(M_{\bar{i},t}, \gamma_t)$ where $\underline{M}_{i,t}^D$ is firm i's default boundary if it chooses to deviate from the collusion. The value matching and smooth pasting conditions for the optimal default boundary are

$$V_i^D(x_t)\big|_{M_{i,t}=\underline{M}_{i,t}^D} = 0 \quad \text{and} \quad \frac{\partial}{\partial M_{i,t}} V_i^D(x_t)\Big|_{M_{i,t}=\underline{M}_{i,t}^D} = 0, \quad \text{respectively.} \tag{18}$$

More Discussion. Several points are worth mentioning. First, the shareholder value in the collusive equilibrium may be equal to that in the non-collusive equilibrium, i.e., the PC constraints (13) are binding. When one firm's PC constraint starts to bind, the two firms switch to the non collusive equilibrium. The endogenous switch to the non-collusive equilibrium captures predation-like behavior, which we illustrate in Section 3.2. We assume that once the two firms switch to the non-collusive equilibrium, they will stay there forever.[11] The endogenous equilibrium switching is a key difference of our model from that of Dou, Ji

[11] The firm that proposes to switch to the non-collusive equilibrium is essentially deviating, and thus we assume they will not return to the collusive equilibrium to be consistent with our specification of punishment strategies.

and Wu (2019), in which firms finance only by issuing equity and never suffer from financial distress, and the PC constraints for profit-margin collusion are always not binding since higher profit margin always leads to higher shareholder value without default or exit.

Second, there exist infinitely many elements in $\mathcal{C}$ and hence infinitely many collusive equilibria. We focus on a subset of $\mathcal{C}$, denoted by $\overline{\mathcal{C}}$, consisting of all profit-margin schemes $\Theta_i^C(\cdot)$ such that the IC constraints (14) are binding state by state, i.e., $V_i^D(x_t) = V_i^C(x_t)$ for all $x_t \in \mathcal{X}$ and $i = 1, 2$.[12] It is obvious that the subset $\overline{\mathcal{C}}$ is nonempty since it contains the profit-margin scheme in the non-collusive Nash equilibrium. We further narrow our focus to the "Pareto-efficient frontier" of $\overline{\mathcal{C}}$, denoted by $\overline{\mathcal{C}}_p$, consisting of all pairs of $\Theta_i^C(\cdot)$ such that there does not exist another pair $\widetilde{\Theta}^C(\cdot) \in \overline{\mathcal{C}}$ with $\widetilde{\theta}_i(x_t) \geq \theta_i^C(x_t)$ for all $x_t \in \mathcal{X}$ and $i = 1, 2$, and with strict inequality holding for some x_t and i.[13] Our numerical algorithm follows a method similar to that of Abreu, Pearce and Stacchetti (1990*a*).[14] Deviation never occurs on the equilibrium path. Using the one-shot deviation principle (Fudenberg and Tirole, 1991), it is clear that the collusive equilibrium characterized above is a subgame perfect Nash equilibrium.

2.5 Debt Value

We start by determining the value of corporate debt. Debt value equals the sum of the present value of the cash flows that accrue to debtholders until the default time or the replaced time, whichever is earlier, and the change in this present value that arises in default or disruption. Since the latter component depends on the firm's recovery of its abandonment value, we start by deriving this value.

We follow the literature on dynamic debt models (e.g., Mello and Parsons, 1992; Leland,

[12]Such equilibrium refinement in a general equilibrium framework is similar in spirit to Abreu (1988), Alvarez and Jermann (2000, 2001), and Opp, Parlour and Walden (2014).

[13]It can be shown that the "Pareto-efficient frontier" is nonempty based on the fundamental theorem of the existence of Pareto-efficient allocations (see, e.g., Mas-Colell, Whinston and Green, 1995), as $\overline{\mathcal{C}}$ is nonempty and compact, and the order we are considering is complete, transitive, and continuous.

[14]Alternative methods include Cronshaw and Luenberger (1994), Pakes and McGuire (1994), and Judd, Yeltekin and Conklin (2003), which contain similar ingredients to those of our solution method. Proving the uniqueness of the equilibrium under our selection criterion is beyond the scope of the paper. We use different initial points in our numerical algorithm and find robust convergence to the same equilibrium.

1994; Hackbarth, Miao and Morellec, 2006) by presuming that the abandonment value of the firm equals the value of unlevered assets. The disruption-driven exit is due to economic distress, and thus, the abandonment value is set to be zero. By contrast, the default-driven exit is due to financial distress, and thus, the abandonment value is set to be a fraction of the unleveled asset value $A_i^C(x_t)$. The asset value $A_i^C(x_t)$ is the value of an all-equity firm. In the collusive equilibrium, the unlevered asset value $A_i^C(x_t)$ is determined similarly by equations (11) – (18) except for setting $b_i = 0$ and removing the default boundary conditions (12), (16), and (18).

The value of debt in collusive equilibrium, denoted by $D_{i,t}^C = D_i^C(x_t)$, can be characterized as follows. In the non-default region (i.e., $M_{i,t} > \underline{M}_{i,t}^C$), the debt value is given by the following HJB equation:

$$0 = \Lambda_t \left(b_i - \lambda D_{i,t}^C\right) \mathrm{d}t + \mathbb{E}_t \left[\mathrm{d}(\Lambda_t D_{i,t}^C)\right], \quad \text{for } i = 1, 2. \tag{19}$$

The HJB equations above lead to a set of coupled partial differential equations with boundary conditions:

$$D_i^C(x_t)\big|_{M_{i,t}=\underline{M}_{i,t}^C} = \nu A_i^C(x_t)\big|_{M_{i,t}=\underline{M}_{i,t}^C} \quad \text{and} \quad \lim_{M_{i,t}\to+\infty} D_i^C(x_t) = b_i/r_f, \quad \text{for } i = 1, 2. \tag{20}$$

The first condition in (20) is the liquidation payoff to the debtholders at the default boundary, and the second condition in (20) captures the asymptotic behavior of debt value when customer base $M_{i,t}$ approach to infinity.

3 Predation-Like Behavior

In this section, we calibrate the model and use our calibrated model to address the following three interrelated questions. First, when does predation-like behavior arise? We show that there is a positive feedback loop between competition and financial distress as increased competition leads to more financial distress, which in turn motivates firms to compete more fiercely. The endogenous time-varying competition risk interacts with financial distress, which further amplifies firms' risk exposure. We show that the quantitative effect of such feedback mechanism is significant. Further, the feedback channel can be supported by the cross-sectional patterns along heterogenous degrees of financial distress. More precisely, the model implies that debt returns of more financially distressed firms are more exposed to aggregate discount rate shocks and thus the endogenous competition risk; however, after controlling for the leverage effect, equity returns of more financially distressed firms are less exposed to aggregate discount rate shocks, consistent with so-called financial distress premium of equity returns.

Second, how much of predation-like behavior is attributed to real predatory incentives? Our model generates real predatory incentives, especially in industries with a high level of entry barrier for market leaders. Specifically, the model implies that financially strong firm may significantly cut its profit margin in order to drive the financially weak firm out of the market. Using our calibrated model, we can isolate a firms predatory incentives by analytically decomposing and quantifying the equilibrium product-market pricing condition.

Third, what is the impact of predation-like behavior caused by endogenous competition-distress feedback? One the one hand, we show financial contagion through endogenous competition intensity in product markets. On the other hand, we shed light on the asset pricing implications of the interaction between the competition-distress feedback and the market structure disruption rate. The model implies that in the industries where market leaders have higher turnover rates, firms' profit margins are lower and less sensitive to discount rate shocks. As a result, in such industries, shareholders of financially distressed firms are more exposed to aggregate discount rate shocks whereas shareholders of financially strong firms are less exposed to aggregate discount rate shocks. However, debtholders are always more exposed to aggregate discount rate shocks due to higher default risk.

Calibration. The risk-free rate is $r_f = 2\%$. We set the persistence of the market price of risk to be $\varphi = 0.13$ as in Campbell and Cochrane (1999) and $\pi = 0.12$ as in Lettau and Wachter (2007). The within-industry elasticity of substitution is set at $\eta = 15$ and the industry's price elasticity of demand at $\epsilon = 2$, which are broadly consistent with the values of Atkeson and Burstein (2008). We set the corporate tax rate $\tau = 27\%$ and the drift term

Table 1: Calibration and parameter choice.

Panel A: Externally Determined Parameters					
Parameter	Symbol	Value	Parameter	Symbol	Value
Risk-free rate	r_f	2%	Persistence of market price of risk	φ	0.13
Volatility of market price of risk	π	0.12	Within-industry elasticity	η	15
Industry's price elasticity	ϵ	2	Corporate tax rate	τ	0.27
Mean growth rate of customer base	α	1.89%	Bond recovery rate	ν	0.41
Debt-asset ratio of new entrant	l_{new}	0.4	Customer base of new entrant	M_{new}	1
Market disruption rate	λ	0	Initial customer base	M_0	1
Customer base accumulation rate	β	0.05	Customer base adjustment friction	h	0.44
Panel B: Internally Calibrated Parameters					
Parameter	Symbol	Value	Moments	Data	Model
Initial coupon rate	b_0	10	Average debt-asset ratio	0.34	0.35
Volatility of idiosyncratic shocks	σ	25%	10-year default rate (Baa rated)	4.9%	5.0%
Marginal cost of production	ω	2	Average net profitability	3.9%	3.6%
Punishment rate	ξ	0.09	Average gross profit margin	31.4%	26.5%
Market price of risk for Z_t	$\overline{\gamma}$	0.15	Average risk premium ($\mathbb{E}(r - r_f)$)	6.7%	6.7%
Volatility of aggregate shocks	ς	0.04	Sharpe ratio ($\mathbb{E}(r - r_f)/\sigma(r - r_f)$)	0.40	0.42
Market price of risk for $Z_{\gamma,t}$	ζ	0.45	Credit spread for Baa-rated bonds	138 bps	143 bps

under physical measure $\alpha = 1.8\%$ as in He and Milbradt (2014). We set the bond recovery rate at $\nu = 0.41$ based on the mean recovery rate of Baa-rated bonds estimated by Chen (2010). The initial debt-asset ratio of new entrant is set at $l_{new} = 0.4$. We set the initial customer base of new entrant to be $M_{new} = 1$ and the market disruption rate is set to be $\lambda = 0$ in our baseline calibration, we study the comparative statics of M_{new} and λ below.

The parameters β and h determine the stickiness of customer base with respect to short-run demand. We choose β and h to match two moments based on profit margins. The parameter β determines the overall incentive to invest in customer base. A higher β implies that firms have more incentive to set lower markups to accumulate customer base. Thus, we set $\beta = 0.05$ to capture the stickiness of the customer base, emphasized by Gilchrist et al. (2017). The parameter h determines the extent to which firms' profit margin respond to their financial distress and customer bases. We thus set $h = 0.44$ following Dou and Ji (2019).

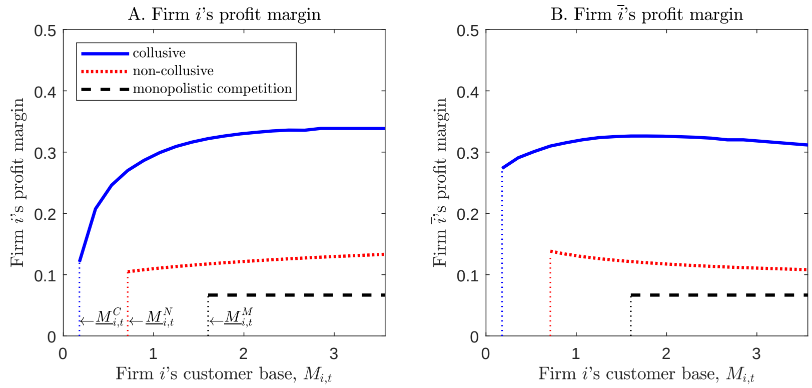
The remaining parameters are calibrated by matching relevant moments in Panel B of Table 1. We assume that the two firms in the industry initially have the same coupon rate b_0 and customer base M_0. The initial customer base M_0 is normalized to be 1 and we set $b_0 = 10$ to generate an average debt-asset ratio of 0.35. The volatility of idiosyncratic shocks is $\sigma = 25\%$ which generates a 10-year default rate of 5%. The marginal cost of production $\omega = 2$ is determined to match the average net profitability. We set the punishment rate $\xi = 0.09$ so that the average gross profit margin is consistent with the data. Duffee (1998) reports that the average credit spread between a Baa-rated 10-year bond in the industrial sector and the Treasury is 138 bps. We set $\zeta = 0.45$, $\overline{\gamma} = 0.15$, and $\varsigma = 4\%$ so that the average equity premium is 6.7%, the Sharpe ratio is 0.42, and the credit spread is 143 bps.

3.1 Feedback Effect: Competition and Distress

In this subsection, we illustrate the interaction between endogenous product market competition and financial distress. We show that there is a positive feedback loop between competition and financial distress as heightened competition leads to increased financial distress, which in turn incentivizes firms to compete more fiercely.

Figure 1 plots the equilibrium profit margins of firm i (panel A) and firm $\bar{i}$ (panel B) as a function of firm i's customer base $M_{i,t}$ given firm $\bar{i}$'s customer base fixed. Both firms have higher profit margins in the collusive equilibrium (the blue solid line) than in the non-collusive equilibrium (the red dotted line) for any $M_{i,t}$. Moreover, compared to the competitive industry with a continuum of firms (the black dashed line), firms in the duopoly industry have higher profit margins. Intuitively, firms' profit margins in the product market reflect the competition they face. More competition effectively means a higher price elasticity of demand, which results in lower equilibrium profit margins. The lower profit margins in turn increase the probability of default. As shown by the vertical lines in the figure, both firms' default boundaries are higher in the non-collusive equilibrium of the duopoly industry; and firms' default boundaries are highest in the monopolistically competitive industry (i.e., $\underline{M}_{i,t}^{M} > \underline{M}_{i,t}^{N} > \underline{M}_{i,t}^{C}$). Thus, financial distress is more likely to occur with increased competition because competition erodes firms' profit margins and cash flows.

Figure 1 also shows that both firms in the collusive equilibrium endogenously have lower profit margins when either firm's customer base decreases. This indicates that a higher likelihood of financial distress leads to more competition and lower equilibrium profit margins. Intuitively, the incentive to collude on higher profit margins depends on how much firms value

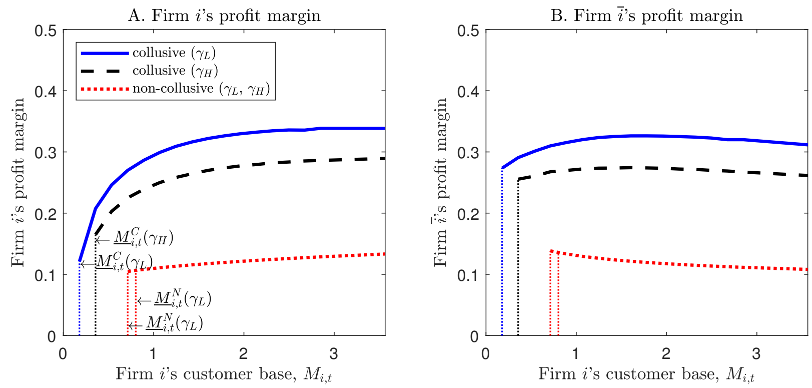


Note: Panel A plots firm i's profit margin as a function of its own customer base $M_{i,t}$; and panel B plots firm $\bar{i}$'s profit margin as a function of firm i's customer base $M_{i,t}$. The blue solid and red dotted lines represent the collusive equilibrium and the non-collusive equilibrium in a duopoly industry. The black dashed line plots an atomistic firm's profit margin in a competitive industry with a continuum of firms. The vertical dotted lines represent default boundaries of firm i in respective cases. In both panels, we use $\gamma_t = \overline{\gamma}$ and $M_{\bar{i},t} = 2$.

Figure 1: Positive feedback loop between competition and financial distress.

future cash flows relative to their contemporaneous cash flows. By deviating from collusive profit-margin-setting schemes, firms can obtain higher contemporaneous cash flows; however, firms run into the risk of losing future cash flows because once the deviation is punished by the other firm, the non-collusive equilibrium will be implemented. When firm i is closer to the default boundary, the probability of default increases and the firm is more likely to exit the market in the near future. As a result, firm i becomes effectively more impatient and values its cash flows in the short run more than those in the long run. This motivates firm i to undercut its competitor $\bar{i}$'s profit margin. Knowing that firm i would set a lower profit margin, firm $\bar{i}$ would also cut its profit margin. In other words, if the two firms were to maintain the collusive equilibrium, the mutually agreed profit margins must fall when either firm is more distressed to ensure that deviation does not occur in equilibrium (i.e., the IC constraints are satisfied). Thus, increased financial distress of either firm would generate lower profit margins and intensify competition.

Our idea echoes and formalizes the important generic insight of Maskin and Tirole (1988*a*) and Fershtman and Pakes (2000): the tacit collusion among oligopolists arises in industries where each firm expects others to remain in the market for a long time; but if firms are more likely to exit the market in the future, the incentive for collusive behavior becomes weaker. Taken together, Figure 1 implies a positive feedback loop between competition and financial



Note: Panel A plots firm i's profit margin as a function of its own customer base $M_{i,t}$; and panel B plots firm $\bar{i}$'s profit margin as a function of firm i's customer base $M_{i,t}$. The blue solid and black dashed lines represent the aggregate state with a low $\gamma_t \equiv \gamma_L$ and a high $\gamma_t \equiv \gamma_H$ in the collusive equilibrium. The red dotted line represents the non-collusive equilibrium with γ_L or γ_H. The vertical dotted lines represent default boundaries of firm i in respective cases. In both panels, we use $\gamma_L = \overline{\gamma}$, $\gamma_H = \overline{\gamma} + 2\text{std}(\gamma_t)$, and $M_{\bar{i},t} = 2$.

Figure 2: Firms' pricing decisions in different aggregate states (γ_t).

distress. Such a feedback loop amplifies default risks because firms would find their profit margins lower exactly when they are more distressed.

Amplification Mechanism of Endogenous Competition The degree of competition in the product market also endogenously varies with the economy's aggregate condition, captured by the market price of risk γ_t.

Figure 2 plots the two firms' profit margins in the collusive equilibrium and non-collusive equilibrium. It is shown that, in the collusive equilibrium, when the discount rate γ_t increases from γ_L to $\gamma_H > \gamma_L$, both firms also compete more fiercely and obtain lower profit margins in equilibrium. The default boundary also increases.

Intuitively, higher profit margins are more difficult to sustain when firms become effectively more impatient due to a high discount rate γ_t, as future punishment becomes less threatening. As recessions are usually associated with a higher risk premium, our model implies that firms compete more fiercely during recessions. The endogenously intensified competition during economic downturns is further amplified by the feedback loop between competition and financial distress, generating much larger amplification effects for the aggregate risk exposure of both shareholders and debtholders. In particular, the intensified competition during economic downturns lowers firms' cash flows, which raises the default risk of levered firms. The rising risk of financial distress makes firms in poor financial conditions compete more aggressively, which further reduces profit margins and increases the risks of financial distress across firms. By contrast, in the non-collusive equilibrium, profit margins do not vary with the discount rate γ_t and default boundaries only increase slightly. Thus in the non-collusive equilibrium, the degree of competition remains the same in different aggregate states.

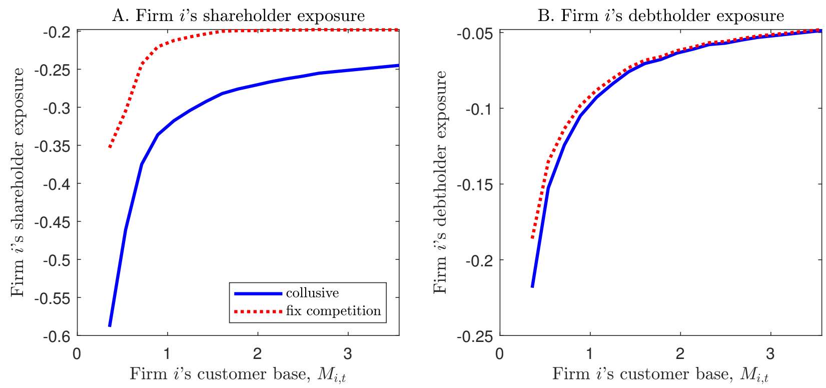
We illustrate the exposure to aggregate risks by computing βs for debtholders and debtholders in the collusive equilibrium, defined by

$$\beta^C_{i,\text{equity}}(M_{i,t}) = V^C_i(M_{i,t}, \gamma_H)/V^C_i(M_{i,t}, \gamma_L) - 1, \tag{21}$$

$$\beta^C_{i,\text{debt}}(M_{i,t}) = D^C_i(M_{i,t}, \gamma_H)/D^C_i(M_{i,t}, \gamma_L) - 1. \tag{22}$$

The blue solid lines in Panels A and B show that both shareholders and debtholders are more exposed variations in the discount rate γ_t when the firm is closer to the default boundary, due to a standard leverage effect. Thus our model implies that credit spread is higher and more volatile when firms are more financially distressed. To illustrate the amplification effect of time-varying competition, the red dotted lines plot the exposure in a counterfactual economy where both firms' profit margins are kept unchanged when the discount rate γ_t changes. It is shown that without endogenous time-varying competition, both shareholders and debtholders are less exposed to aggregate risks. The difference in aggregate-risk exposure is larger when the firm is closer to the default boundary (i.e., lower $M_{i,t}$). Thus, our model provides a new mechanism to amplify aggregate risks through endogenous competition and its interaction with financial distress.

Implications on Financial Distress Premium In the rest of this section, we focus on the collusive equilibrium to analyze the more interesting case with endogenous competition. Panel A of Figure 4 plots the firm i's shareholder as a function of its customer base $M_{i,t}$, similar to the blue solid line in panel A of Figure 3. The firm's shareholders are more exposed to aggregate risks when it is financially distressed. This results from two counterveiling effects. On the one hand, the debt-asset ratio increases when the firm becomes more financially



Note: Panel A plots firm i's shareholder exposure (defined in equation 21) as a function of its customer base $M_{i,t}$; and panel B plots firm i's debtholder exposure (defined in equation 22) as a function of its customer base $M_{i,t}$. The blue solid line represents the collusive equilibrium. The red dotted line represents the equilibrium where profit margins are fixed when γ_t increases from γ_L to γ_H. In both panels, we use $\gamma_L = \overline{\gamma}$, $\gamma_H = \overline{\gamma} + 2\text{std}(\gamma_t)$, and $M_{\bar{i},t} = 2$.

Figure 3: Financial distress, exposure to aggregate risks, and amplification.

distressed, as shown in panel B of Figure 4, and this generates a leverage effect that increases shareholder exposure to aggregate risks. On the other hand, as we show in Figure 2, firms' profit margins become less sensitive to the discount rate γ_t when they become more financially distressed due to the lack of collusion. This implies that the risk premium attributed to endogenous competition is smaller when the firm is more financially distressed.

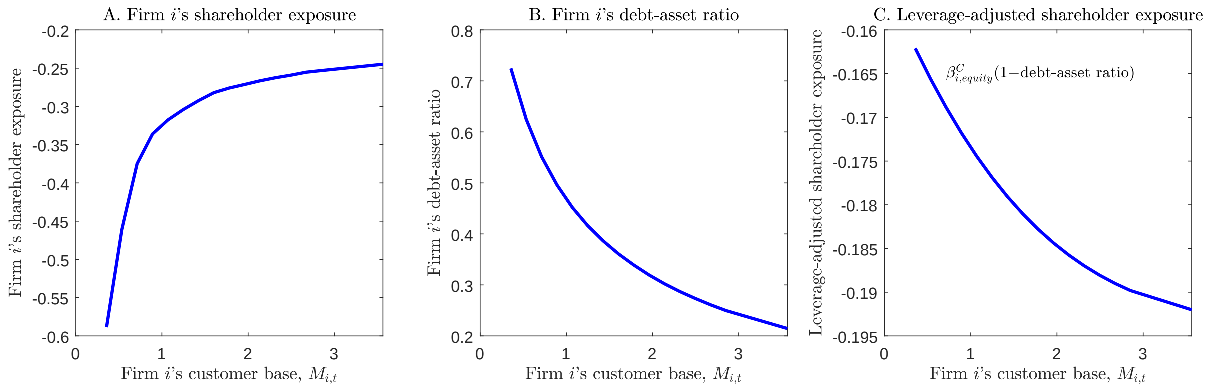
To isolate the endogenous competition premium, we compute leverage-adjusted shareholder exposure according to

$$\beta^{C,\text{adj}}_{i,\text{equity}}(M_{i,t}) = \beta^{C}_{i,\text{equity}}(M_{i,t})(1 - \text{debt-asset ratio}^{C}_{i}(M_{i,t}, \gamma_L)), \tag{23}$$

where

$$\text{debt-asset ratio}^{C}_{i}(M_{i,t}, \gamma_L) = D^{C}_{i}(M_{i,t}, \gamma_L)/(V^{C}_{i}(M_{i,t}, \gamma_L) + D^{C}_{i}(M_{i,t}, \gamma_L)). \tag{24}$$

The leverage-adjusted shareholder exposure, $\beta^{C,\text{adj}}_{i,\text{equity}}(M_{i,t})$, captures the shareholder exposure of an otherwise identical all-equity firm incorporating the bankruptcy risk. Panel C of Figure 4 plots firm i's leverage-adjusted shareholder exposure. It is shown that, after adjusting for financial leverage, firm i's shareholders are less exposed to aggregate risks when



Note: Panel A plots firm i's shareholder exposure (defined in equation 21) as a function of its customer base $M_{i,t}$ in the collusive equilibrium. Panel B plots firm i's debt-asset ratio (defined in equation 24) as a function of its customer base $M_{i,t}$ in the collusive equilibrium. Panel C plots firm i's shareholder exposure adjusted for leverage (defined in equation 23). In all panels, we use $\gamma_L = \overline{\gamma}$, $\gamma_H = \overline{\gamma} + 2\text{std}(\gamma_t)$, and $M_{\bar{i},t} = 2$.

Figure 4: Implications on financial distress premium.

the firm is more financially distressed (i.e., lower $M_{i,t}$). This implies that the channel of endogenous competition generates a lower risk premium for financially distressed firms, which can potentially help explain the financial distress premium.

3.2 Predation vs. Self-defense

In our model, when one firm defaults, a new entrant with initial customer base M_e will immediately enter the market. A smaller value of M_e implies that the industry has a lower level of entry barrier. In this subsection, we illustrate how the level of entry barrier can affect the dynamics of pricing of the two firms.

3.2.1 Strategic Profit-Margin Setting

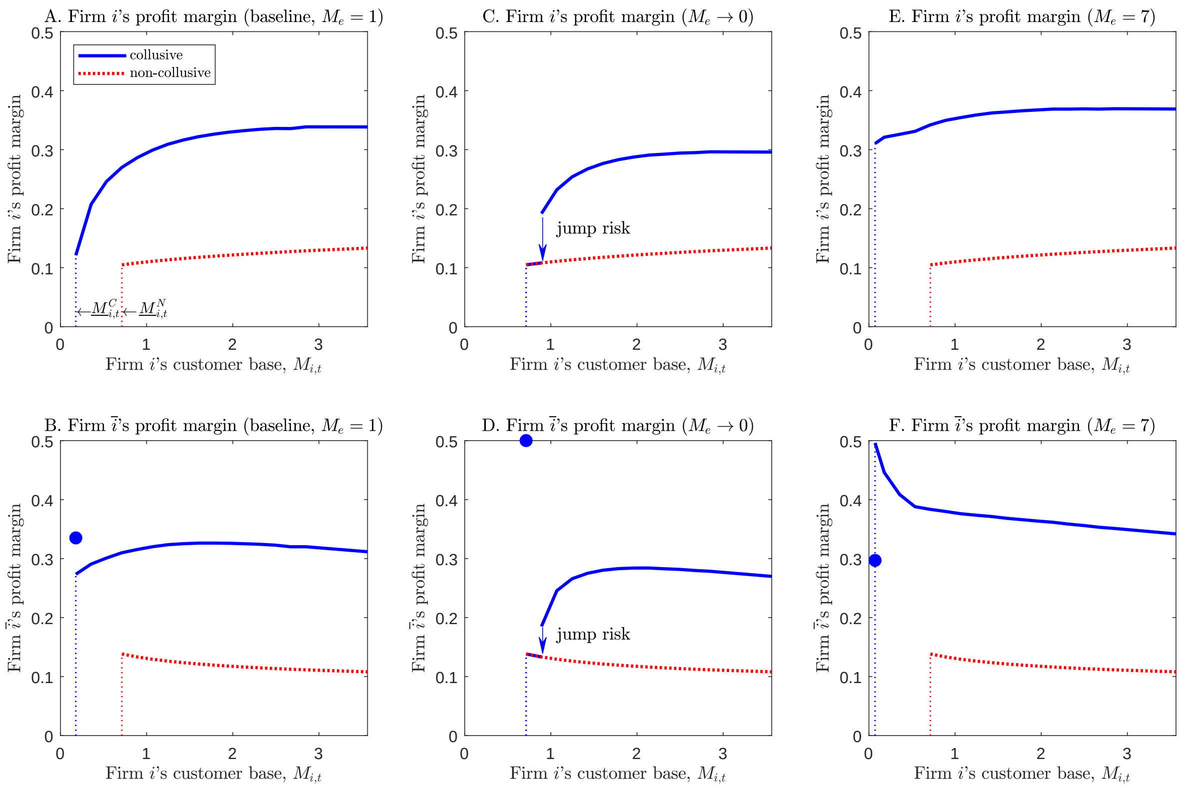
Self-defense. Panels A and B of Figure 5 plot the two firms' prices in our baseline calibration when firm i's customer base $M_{i,t}$ decreases from 3.5 to $\underline{M}_{i,t}$, given firm $\bar{i}$'s profit margin fixed. It is shown that when firm i moves closer to the default boundary and becomes more financially distressed, its competitor $\bar{j}$ also lowers its profit margin (see the blue solid line in panel B). As we discuss above, intuitively, firm $\bar{j}$ is conducting a self-defense profit-margin strategy because it knows that firm j will cut its profit margin to steal contemporaneous demand when it becomes more financially distressed. Such profit-margin undercutting behavior of firm $\bar{j}$ is defensive because the intention of setting a lower profit margin is to prevent the financially weak firm j from stealing demand.[15]

The blue dot in panel B represents the profit margin that firm $\bar{i}$ would set immediately after firm i defaults and exits the market. At the calibrated value of the size of new entrant $M_e = 1$, firm $\bar{i}$'s profit margin immediately jumps up upon the exit of firm i. In fact, we can think of M_e as capturing the barrier to entry. A lower M_e means new entrants have smaller customer base, implying a higher entry barrier to the industry.

Predation. To study how entry barriers affect incumbent firms' profit-margin strategy, we plot the two firms' profit-margin strategies when $M_e \to 0$ in panels C and D, which reflect an industry with an extremely high entry barrier. Compared to our baseline in panels A and B, both firms set much lower profit margins when $M_e \to 0$, for any $M_{i,t}$ in the collusive equilibrium (see the blue solid lines). Intuitively, both firms have less incentive to collude with each other because they know that by driving other firms out of the market, they can almost monopolize the industry and enjoy much higher profit margins in the future. Even more dramatically, panels C and D show that the two firms will not collude with each other at all when firm i's customer base $M_{i,t}$ drops below 0.9 and becomes financially distressed. The collusive profit margins suddenly jump downward at $M_{i,t} = 0.9$ and are equal to the non-collusive prices for $M_{i,t} < 0.9$.

In Figure 6, we compare each firm's shareholder value in the collusive and non-collusive equilibria. Panel B shows that firm $\bar{i}$'s equity value in the collusive equilibrium (the blue solid line) intersects with that in the non-collusive equilibrium (the red-dotted line) at $M_{i,t} = 0.9$. This is the critical point when firm $\bar{i}$'s PC constraint (13) becomes binding. For $M_{i,t} > 0.9$, both firms' PC constraints are always satisfied and not binding for the collusive profit margin schemes that satisfy the IC constraints (14), and thus they want to collude with each other. For $M_{i,t} < 0.9$, the PC constraint (13) becomes binding for firm $\bar{i}$. In other words, if the two firms would be colluding on profit margins that are higher than the non-collusive ones. Even

[15]This profit-margin strategy is similar in spirit to the concept of "defensive predation" termed by Franklin Fisher in his testimony for Microsoft (see Fisher, 2001). Defensive predation refers to the profit-margin undercutting strategy whose intention is to protect existing businesses from being snatched by competitors.

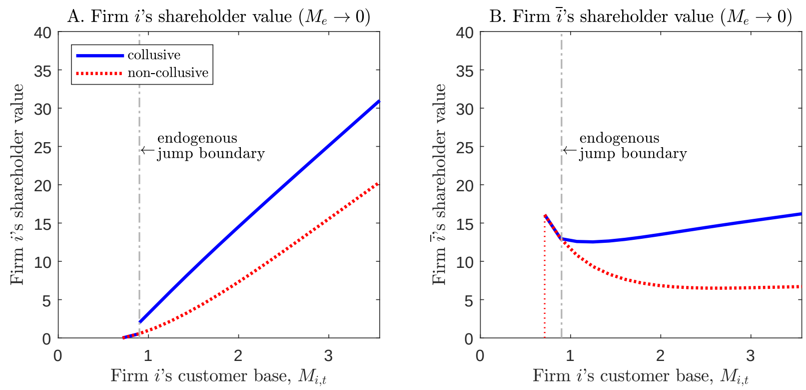


Note: Panels A, C, and E plot firm i's profit margin as a function of its own customer base $M_{i,t}$; and panels B, D, and F plot firm $\bar{i}$'s profit margin as a function of firm i's customer base $M_{i,t}$. The blue solid and red dash-dotted lines represent the collusive equilibrium and the non-collusive equilibrium. The blue dots in panels B, D, and F represent the profit margin that firm $\bar{i}$ would set immediately after firm i defaults and exits the market. The vertical dotted lines represent default boundaries of firm i in respective cases. Panels A and B plot the baseline calibration with $M_e = 1$; panels C and D plot the industry with $M_e \to 0$; and panels E and F plot the industry with $M_e = 7$. In all panels, we use $\gamma_t = \overline{\gamma}$ and $M_{\bar{i},t} = 2$.

Figure 5: Illustration of different profit-margin strategies in the collusive equilibrium.

though the collusive profit-margin scheme may honor the IC constraints (14), it will violate the PC constraint of firm $\bar{i}$.

On the other hand, panel A of Figure 6 shows that firm i's shareholder value in the collusive equilibrium is strictly higher than that in the non-collusive equilibrium when $M_{i,t} \geq 0.9$, indicating that firm i would always want to collude with firm $\bar{i}$. Only when $M_{i,t} < 0.9$, firm i's shareholder value in the collusive equilibrium is equal to that in the non-collusive equilibrium because firm $\bar{i}$ chooses not to collude. At $M_{i,t} = 0.9$, there is an endogenous jump in firm i's shareholder value. Therefore, our model implies that it is the firm with a stronger financial

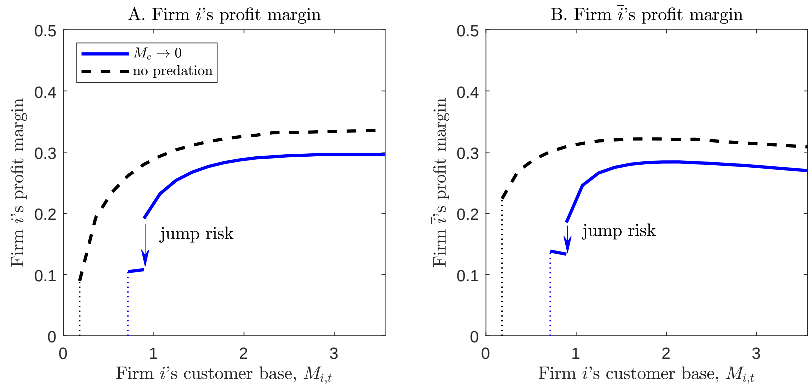


Note: Panels A plots firm i's shareholder value as a function of its own customer base $M_{i,t}$; and panel B plots firm $\bar{i}$'s shareholder value as a function of firm i's customer base $M_{i,t}$. The blue solid and red dash-dotted lines represent the collusive equilibrium and the non-collusive equilibrium in a duopoly industry. The vertical red dotted line represents default boundaries of firm i. The vertical dash-dotted line represents the endogenous jump (i.e., switching between collusion and non-collusion) boundary. In all panels, we use $\gamma_t = \overline{\gamma}$, $M_{\bar{i},t} = 2$, and $M_e \to 0$. In all panels, we use $\gamma_t = \overline{\gamma}$ and $M_{\bar{i},t} = 2$.

Figure 6: Firms' shareholder values when $M_e \to 0$.

condition (or larger customer base when the two firms pay the same coupon rates) that wants to abandon collusion and set lower profit margins. Such profit-margin strategy adopted by firm $\bar{i}$ is predatory because the intention to undercut profit margins is to drive the other firm out of the market to enjoy the monopoly rent. As shown by the blue dot in panel D, when the size of the new entrant $M_e \to 0$, firm $\bar{i}$ can set a profit margin equal to the monopoly profit margin $\frac{1}{\epsilon} = 0.5$. Our result is related to the insight of Kawakami and Yoshihiro (1997) and Wiseman (2017), who show that with no entry to market, the folk theorem fails and firms may not collude with each other at all in an infinitely repeated dynamic game. Instead, they enter into a price war until only one firm in the industry is alive.

Collaboration. What would happen in the size of entrants is larger than the incumbent firm? As shown in panels E and F of Figure 5, if we consider an industry with a lower entry barrier as represented by a large size of new entrants, $M_e = 7$. In this industry, the two firms set much higher profit margins in the collusive equilibrium compared to the baseline industry with $M_e = 1$ (see panels A and B). This is because both firms worry about losing market power to the large new entrants, and they thus collaborate with each other on maintaining higher profit margins in order to reduce the default risk. In particular, panel F shows that



Note: Panel A plots firm i's profit margin as a function of its own customer base $M_{i,t}$; and panel B plots firm $\bar{i}$'s profit margin as a function of firm i's customer base $M_{i,t}$. The blue solid represents the industry with predation (i.e, $M_e \to 0$). The black dashed line represents the industry where the new entrant has exactly the same level of customer base as the exiting firm. The vertical dotted lines represent default boundaries of firm i in respective cases. In both panels, we use $\gamma_t = \overline{\gamma}$ and $M_{\bar{i},t} = 2$.

Figure 7: Isolating the incentive of predation.

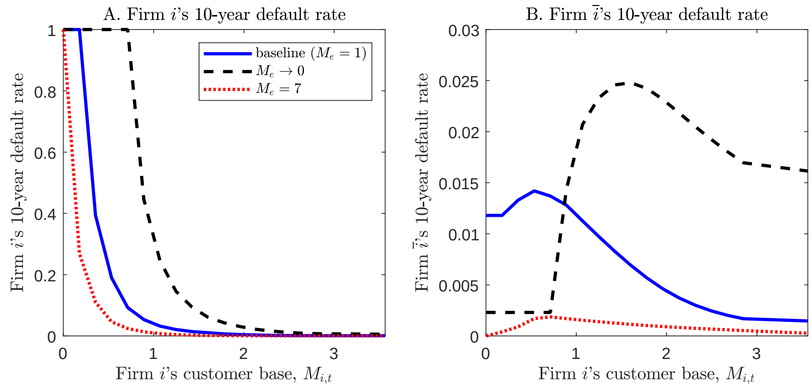
when firm i's customer base decreases, firm $\bar{i}$ is willing to sacrifice its demand by significantly increasing its profit margin, with the intention to help increase firm i's cash flows.

3.2.2 Isolating the Incentive of Predation

In the industry with $M_e \to 0$, the financially strong firm has the incentive to conduct predation precisely because the new entrant has a negligible level of customer base. By driving its current competitor into default, the financially strong firm can enjoy monopoly rents in the future. Suppose the new entrant has the same level of customer base as the exiting firm, then the financially strong firm would have no predation incentive and the profit margins set in the industry would purely reflect the impact of financial distress on competition.

Therefore, we can isolate the predation incentive by comparing the profit margins set by firms in the industry with $M_e \to 0$ with those set by firms in the industry where the new entrant has the same level of customer base as the defaulting firm.[16] Figure 7 plots the profit margins set by the two firms in each case. Comparing the black dashed and blue solid lines in panel B, we see that the financially strong competitor (i.e., firm $\bar{i}$) is willing to forgo 10%

[16]Of course, the new entrant will choose a lower coupon rate b_e to keep the initial debt ratio at l_e. This ensures that the new entrant does not default immediately even though it has the same level of customer base as the defaulting firm.



Note: Panels A plots firm i's 10-year default rate in the collusive equilibrium as a function of its own customer base $M_{i,t}$; and panel B plots firm $\bar{i}$'s 10-year default rate in the collusive equilibrium as a function of firm i's customer base $M_{i,t}$. The blue solid line, black dashed line, and red dotted line represent the baseline calibration with $M_e = 1$, the industry with $M_e \to 0$, and the industry with $M_e = 7$, respectively. In all panels, we use $\gamma_t = \overline{\gamma}$ and $M_{\bar{i},t} = 2$.

Figure 8: Comparing the default rates in industries of different levels of entry barrier.

of its profit margin when its competitor is near the default boundary. Even when both firms are far away from the default boundary, the existence of predation incentive significantly restricts the degree of tacit collusion, lowering both firms' profit margins by as large as 3.5%.

3.2.3 Asset Pricing Implications

The strategic predatory behavior in setting profit margins increases financial fragility and risk exposure for industries with a high level of entry barrier (i.e., small values of M_e). Intuitively, when firm i becomes more financially distressed, the lower profit margin set by $\bar{i}$ will attract consumer demand from firm i, which further reduces firm i's cash flows and increases its default risk. Figure 8 compares firm i' 10-year default rate in the collusive equilibrium in industries with different levels of entry barrier. Panel A shows that the default rate of firm i is uniformly higher in the industry with a high level of entry barrier (i.e., $M_e \to 0$, see the black dashed line) due to the low profit margins (see panel C of Figure 5) caused by predation. By contrast, the default rate of firm i is uniformly lower in the industry with a low level of entry barrier (i.e., $M_e = 7$), where the two firms have more incentive to collaborate with each other on setting higher profit margins.

Panel B illustrates firm $\bar{i}$'s 10-year default rate when firm i's customer base $M_{i,t}$ varies. It is shown that in the industry with a low level of entry barrier (i.e., $M_{i,t} = 7$), firm $\bar{i}$'s default rate is also uniformly lower than the baseline industry with $M_e = 1$. However, in the industry with $M_e \to 0$, firm $\bar{i}$'s default rate displays a strong inverted U-shape as we vary the customer base $M_{i,t}$ of firm i (the black dashed line). In particular, firm $\bar{i}$ has the lowest default rate when $M_{i,t} < \underline{M}_{i,t}^C = 0.5$, where firm i immediately defaults and the new entrant that replaces firm i is tiny so that firm $\bar{i}$ can obtain high monopoly profit margins in the near future. When $M_{i,t}$ increases from 0.7 to 1.5, firm $\bar{i}$'s default rate increases. This is the region where firm $\bar{i}$ conducts predatory pricing with the intention to drive firm i into default, and this in turn hurts firm $\bar{i}$ itself because of the low profit margins. When $M_{i,t}$ further increases, the default rate of firm $\bar{i}$ goes down because both firms become financially healthy and so they collude on higher profit margins. These results suggest that the rich interactions between the two firms in setting profit margins significantly influence their default risk. The predation behavior in the industry with a high entry barrier (i.e., $M_e \to 0$) largely amplifies the default risk and results in financial fragility for the industry.

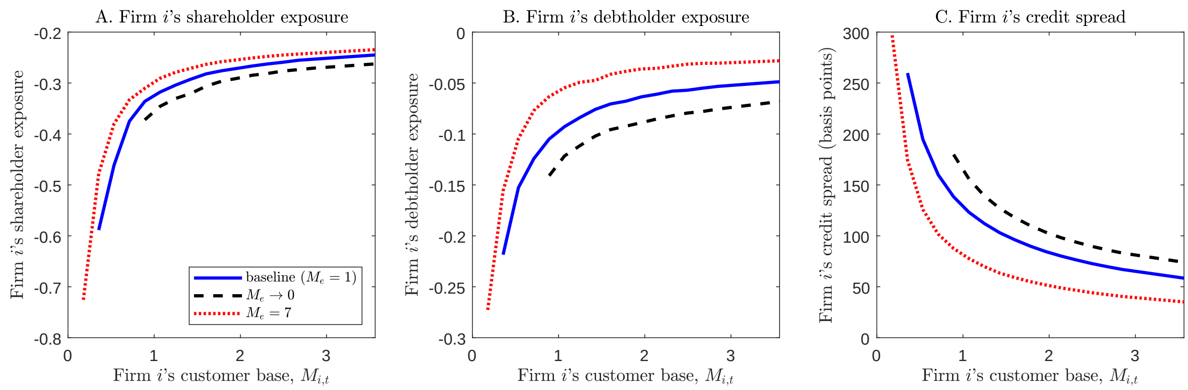
We now turn to the asset pricing implications of market entry barrier. Panels A of Figure 9 shows that in the industry with a high entry barrier (i.e., $M_e \to 0$, see the blue solid line), the shareholders of firm i are more exposed to aggregate risks due to low profit margins and high default risk for any customer base $M_{i,t}$.

Panel B shows that the debtholders of firm i are also more exposed to aggregate risks in the industry with a high entry barrier (i.e., $M_e \to 0$, see the blue solid line). Thus, in such industries, the value of debt is more sensitive to changes in γ_t and the default rate of corporate bonds is higher (see panel A of Figure 8). This results in a higher credit spread for any customer base (see panel C of Figure 9) and a higher volatility of credit spread.

3.3 Implications of Market Structure Disruption

In our baseline calibration, the likelihood of market structure disruption is set at $\lambda = 0$, which indicates that the two leaders in the industry cannot be displaced by other firms unless they default. In this subsection, we shed light on the implications of market structure disruption by studying the comparative statics of the parameter λ.

Panels A and B of Figure 10 plots firm i and $\bar{i}$'s profit margin in the our baseline industry



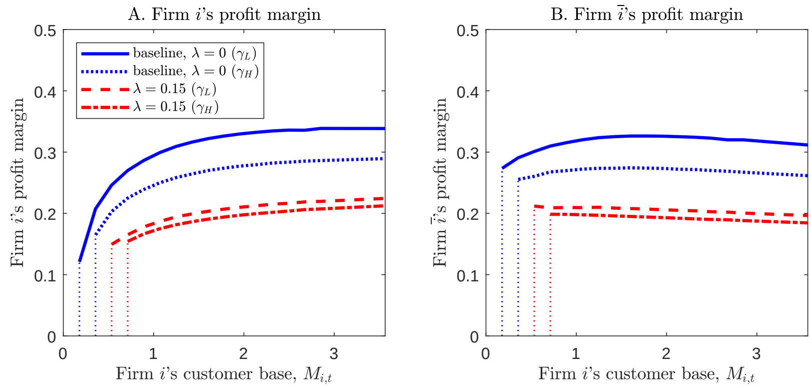
Note: Panels A plots firm i's shareholder exposure (defined in equation 21) as a function of its customer base $M_{i,t}$; panel B plots firm i's debtholder exposure (defined in equation 22) as a function of its customer base $M_{i,t}$; and panel C plots firm i's credit spread as a function of its customer base $M_{i,t}$. The blue solid line, black dashed line, and red dotted line represent the baseline calibration with $M_e = 1$, the industry with $M_e \to 0$, and the industry with $M_e = 7$, respectively. In all panels, we use $\gamma_L = \overline{\gamma}$, $\gamma_H = \overline{\gamma} + 2\text{std}(\gamma_t)$, and $M_{\bar{i},t} = 2$.

Figure 9: Implications of market entry barrier on risk exposure and credit spread.

with $\lambda = 0$ and the industry with $\lambda = 0.15$, where market leaders are displaced by followers every $6 - 7$ years on average. Profit margins are much lower in the industry with $\lambda = 0.15$ for any customer base $M_{i,t}$ of firm i. More importantly, profit margins drop more substantially in the baseline industry with $\lambda = 0$ in response to an increase in γ_t from γ_L to γ_H. In other words, the cash flows of firms in such industries are more exposed to discount rate shocks.

Intuitively, a higher rate of market structure disruption has a similar effect to that of a higher discount rate. It motivates firms to compete more aggressively to generate more profits now rather than in the future, which dampens the collusion incentive, resulting in both lower levels and lower sensitivity of profit margins to aggregate shocks. Our idea echoes the important generic insight of Maskin and Tirole (1988a) and Fershtman and Pakes (2000): oligopolists tacitly collude in industries where all firms expect all other firms to remain in the market for a long time.

In panel A of Figure 11, we compare firm i's shareholder exposure to aggregate risk in our baseline industry with $\lambda = 0$ (the blue solid line) and the industry with $\lambda = 0.15$ (the black dashed line). It is shown that compared to those in the baseline industry, shareholders in the industry with $\lambda = 0.15$ are less exposed to aggregate risks. Intuitively, the cash flows of firms in the industry with $\lambda = 0.15$ are less exposed to aggregate shocks as shown in Figure 10,



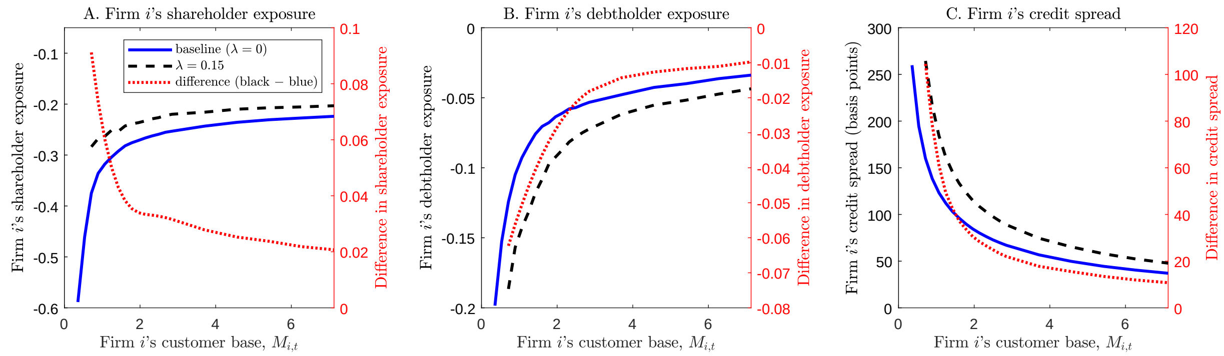
Note: Panel A plots firm i's profit margin as a function of its own customer base $M_{i,t}$; and panel B plots firm $\bar{i}$'s profit margin as a function of firm i's customer base $M_{i,t}$. The blue solid and blue dotted lines represent the baseline calibration with $\lambda = 0$. The red dashed and red dash-dotted lines represent the industry with $\lambda = 0.15$. The vertical dotted lines represent default boundaries of firm i in respective cases. In both panels, we use $\gamma_L = \overline{\gamma}$, $\gamma_H = \overline{\gamma} + 2\text{std}(\gamma_t)$, and $M_{\bar{i},t} = 2$.

Figure 10: Implications of market structure disruption on profit margins.

and this directly implies that shareholders are less exposed to aggregate risks due to the less significant movement in endogenous competition. Based on this mechanism, Dou, Ji and Wu (2019) provides one explanation for the gross profitability premium across industries.

Different from Dou, Ji and Wu (2019), who focus on all-equity firms, our model also sheds light on the interaction between financial distress and gross profitability. The red-dotted line in panel A of Figure 11 shows that the difference in firm i's shareholder exposure between the baseline industry with $\lambda = 0$ and the industry with $\lambda = 0.15$ is larger when the firm is more financially distressed (i.e., lower $M_{i,t}$). This is because financially distressed firms are coupled with a high financial leverage, which amplifies the shareholder exposure to aggregate risks in both industries. In other words, even though the endogenous competition channel itself becomes weaker due to the lack of collusion (see the black dashed line in panel A of Figure 4), the high financial leverage provides an additional amplification effect which increases the difference in shareholder exposure between the two industries. Thus, our model implies that the gross profitability premium is more pronounced among financially distressed firms.

In panel B, we compare the exposure of firm i's debt holders to aggregate risks in the two industries. It shows that although shareholders in the industry with $\lambda = 0.15$ are less exposed to aggregate risks, debtholders of such industries are actually more exposed to aggregate risks. Intuitively, because profit margins are lower in the industry with $\lambda = 0.15$, firm i's



Note: The blue solid line in panel A plots firm i's shareholder exposure (defined in equation 21) in the baseline industry with $\lambda = 0$ as a function of its customer base $M_{i,t}$. The black-dashed line in panel A plots firm i's leverage-adjusted shareholder exposure in the industry with $\lambda = 0.15$ as a function of its customer base $M_{i,t}$. The leverage-adjusted shareholder exposure is defined as $\beta^{C,\text{adj}}_{i,\text{equity}}(M_{i,t}; \lambda = 0.15) = \beta^{C}_{i,\text{equity}}(M_{i,t}; \lambda = 0.15)\frac{(1-\text{debt-asset ratio}^C_i(M_{i,t},\gamma_L;\lambda=0.15))}{(1-\text{debt-asset ratio}^C_i(M_{i,t},\gamma_L;\lambda=0))}$, where $\beta^{C}_{i,\text{equity}}(M_{i,t}; \lambda = 0.15)$ is given by equation (21) and the debt-asset ratio is given by equation (24). Intuitively, the leverage-adjusted shareholder exposure adjusts for the fact that the two firms in the two industries may have different debt-asset ratios due to the difference in profit margins for any $M_{i,t}$. The red-dotted line plots the difference in shareholder exposure in the two industries, i.e., $\beta^{C,\text{adj}}_{i,\text{equity}}(M_{i,t}; \lambda = 0.15) - \beta^{C}_{i,\text{equity}}(M_{i,t}; \lambda = 0)$, and its magnitude is displayed on the right y-axis. Panel B plots firm i's debtholder exposure (defined in equation 22) as a function of its customer base $M_{i,t}$; and panel C plots firm i's credit spread as a function of its customer base $M_{i,t}$. In all panels, we use $\gamma_L = \overline{\gamma}$, $\gamma_H = \overline{\gamma} + 2\text{std}(\gamma_t)$, and $M_{\bar{i},t} = 2$.

Figure 11: Implications of market structure disruption on risk exposure and credit spread.

default boundary is higher in such industries (see panel A of Figure 10). The higher default risk increases debtholders' exposure to aggregate risks due to a leverage effect, which in turn increases the credit spread (see panel C of Figure 10) and the volatility of credit spread. Moreover, the red-dotted lines in panels B and C of Figure 11 indicate that the difference in debtholder exposure and credit spread is larger among financially distressed firms.

3.4 Summary of Model Predictions

We summarize the model's predictions as follows.

First, an increase in market leaders' financial distress will lead to more competition and lower profit margins in the product market. Conversely, more competition among market leaders as reflected by lower profit margins will lead to more financial distress (see Figure 1).

Second, market leaders' profit margins decrease when the discount rate rises (see Figure 2). When leading firms in an industry are more financially distressed, their shareholders and debtholders are more exposed to discount rate shocks (see Figure 3). Thus, more financially distressed leading firms are associated with higher expected stock returns, higher credit spreads, and higher volatilities of credit spreads.

Third, shareholders of financially distressed firms are less exposed to discount rate shocks after adjusting for financial leverage (see Figure 4).

Fourth, the leading firms with strong financial conditions tend to lower their profit margins when the leading firms with weak financial conditions become more financially distressed. The decrease in profit margins is stronger in industries with a higher level of entry barrier (see Figure 5). Moreover, in such industries, the leading firms' default rates are higher; their shareholders and debtholders are more exposed to discount rate shocks; and the leading firms are associated with higher expected stock returns, higher credit spreads, and higher volatilities of credit spreads (Figure 9).

Fifth, in industries with a higher turnover rates of market leaders, the leading firms' profit margins are lower and less sensitive to discount rate shocks (Figure 10). In such industries, shareholders of leading firms are less exposed to discount rate shocks, especially for those of financially distressed firms. However, in such industries, the debtholders of leading firms are more exposed to discount rate shocks and their credit spread is higher and more volatile, especially for those of financially distressed firms.

4 Empirical Analyses

4.1 Data

In the empirical section, we take firm level accounting data from Compustat, stock return data from CRSP, credit spread data, consumption growth data, and the fluidity data from Hoberg, Phillips and Prabhala (2014). Finance and utility firms are excluded from the analysis, as some of the analyses involves leverage. Unless otherwise noted, at least 10 firms are required in each industry-year to ensure that the aggregate variables, such as industry-year level profit margin, are well-behaved. The finance distress measure is as in Campbell, Hilscher and Szilagyi (2008). For the analyses below we will look at the "top firms" within an industry-year, as some of theory applies better to that context. Those top firms are firms with the highest sales. Most industry-year aggregate variables—profit margin, distress, operating leverage, idiosyncratic shocks, fluidity—are weighted by sales. The only exception is the stock return forecasting results in Table 8 and Table 9, where both industry level returns and profitability are weighted by stock market cap. Across industries, weighting is always equal whether it is aggregation to the bin level or in regression, again with the only exception of stock returns. Variables involving bonds are always weighted by the bonds' par value. When organizing the cross section of accounting data, we first map fiscal year to calendar year and when applicable, map to market data starting from the June of the next year. This follows the practice of Fama and French (1993).

4.2 Empirical Results

Sensitivity to Consumption Growth Rates We test our model's prediction on industries' loadings on the low frequency component of consumption growth, measured using the eight-quarter moving average of consumption growth rates. Table 2 reports the loadings of the change in industry profit margin on the shock to the consumption growth measure. The cross section of industries are sorted into five bins based on each industry's aggregate distress level. Average profit margin and its change are then computed for each bin. The loading is then estimated for each bin using time series regressions. The table shows that industries with low distress level have higher loadings than those with high distress level. While this relationship is not monotonic with respect to the bin number, the downward trend from left to the right is clear. The difference in loadings between bin 5 and bin 1 is only marginally statistically significant. However, the economic scale of the difference is large. Both profit margin and the consumption growth rate are in fractional unit, and the consumption growth rate is annualized. The coefficient of 0.421 in column 1 means when 1% increase in annualized consumption growth rate shock corresponds to 0.421% increases in change of profit margin, for the most financially sound industries of the cross section.

Table 3 reports the loadings of firms' credit spread on the consumption growth rate. Here, the cross section of firms are sorted into five bins based on the aggregate distress level of

Table 2: Industry Distress and Profit Margin Loadings on Consumption Growth

	1(Low Distress)	2	3	4	5 (High Distress)	5 - 1
β	0.421**	0.284**	0.335*	0.219	−0.650	−1.071*
	[2.34]	[2.12]	[1.96]	[0.98]	[−1.20]	[−1.92]
N	46	46	46	46	46	46
R^2	0.098	0.020	0.017	0.007	0.015	0.039

Note: This table reports results from the following annual time-series regressions: $\Delta PM_{i,t} = \alpha_i + \beta_i x_t + \epsilon_{i,t}$. Here, the cross section of industries are sorted into 5 bins based on industry level distress. $\Delta PM_{i,t} = PM_{i,t} - PM_{i,t-1}$, where $PM_{i,t}$ is the average profit margin among industries in bin i. x_t is the shock to the 8 quarter average consumption growth rate, computed as the AR1 residuals. Each bin's profit margin loadings on consumption growth shock, β_i, are reported in the table. Both profit margin and the consumption growth rate are in fractional unit, and the consumption growth rate is annualized. T-statistics robust to heteroskedasticity and autocorrelation are reported in square brackets.

their industries. Average credit spread is then computed for each bin, and each bin's loading on the consumption growth rate is estimated using a time series regression. Overall, the table shows that credit spread have negative loadings on the consumption growth rate, which means that bond prices are on average pro-cyclical. This credit spread loadings then become more negative as the distress level increases. The difference in loadings for bin 1 and 5 is statistically significant. Credit spread and consumption growth are both in annualized fractional unit. The coefficient of -0.181 means that 1% increase in annualized consumption growth rate corresponds to 0.181% decrease in credit spread for firms in the most financially sound industries.

Spillover effect among top firms Table 4 tests our model's prediction on the spillover effect among the industry leaders. The model predicts that idiosyncratic shocks to the distressed firms within an industry will spillover to the financially healthy firms. Additionally, the model predicts that this spillover effect to be larger on industries where the distressed and healthy firms are of comparable sizes. To see the spillover effect, in each year we split the top firms of each industries into 3 bins based on the firms' distress level, where bin 1 contains the financially healthy firms and bin 3 contains the distressed. We then compute the contemporaneous idiosyncratic shock to each bin. Three methods of computing the idiosyncratic shocks are tried, and the details of their construction are described in Appendix

Table 3: Industry Distress and Credit Spread Loadings on Consumption Growth

	1(Low Distress)	2	3	4	5 (High Distress)	5 - 1
			Panel A: All firms			
β	−0.181**	−0.165**	−0.312**	−0.278*	−0.387**	−0.206**
	[−2.10]	[−2.20]	[−2.32]	[−1.79]	[−2.22]	[−2.00]
			Panel B: Top 6 firms within industry			
β	−0.137*	−0.160	−0.166	−0.351*	−0.408**	−0.271**
	[−1.96]	[−1.60]	[−1.61]	[−1.93]	[−2.42]	[−2.25]
N	181	181	181	181	181	181

Note: This table reports results from the following quarterly time-series regressions: $Spread_{i,t} = \alpha_i + \beta_i x_t + \gamma_i OL_{i,t} + \epsilon_{i,t}$. Here, the cross section of industries are sorted into 5 bins based on industry level distress. $Spread_{i,t}$ is the par value weighted average credit spread among firms within bin i. x_t is the 8 quarter average consumption growth rate ending in quarter t. $OL_{i,t}$ is the par-value weighted operating leverage within bin i, where operating leverage is operating cost divided by total asset, as in (Novy-Marx 2011). Top 6 firms are determined by sales. Annual accounting data of year t are mapped to credit spread data from Q2 of year t+1 to Q1 of year t+2, as in (Fama and French (1993)). Each bin's credit spread loadings on consumption growth, β_i, are reported in the table. Credit spread and consumption growth are both in annualized fractional unit. T-statistics robust to heteroskedasticity and autocorrelation are reported in square brackets.

C.2. We then run the following industry-annual level panel regression:

$$PM^1_{i,t} = \alpha + \beta_3 Shock^3_{i,t} + \beta_1 Shock^1_{i,t} + \sum_{j=1}^{5} \gamma_j PM^1_{i,t-j} + \sum_t \delta_t FE_t + \sum_i \rho_i FE_i + \epsilon_{i,t} \quad (25)$$

The coefficient β_3 capture effect of bin 3 shock on the profit margin of bin 1, hence measures the spillover effect. Notice group 1's own idiosyncratic shock, group 1's past profit margins, the time fixed effects, and the industry fixed effects are controlled for in this regression.

The first column, titled "All", of Table 4 shows that the spillover effect is strong and robust to the choice of the specific idiosyncratic risk measure. Both idiosyncratic the shocks and the profit margins are in fractional units. A coefficient of 0.035 means a 100% increase in idiosyncratic shock to the distressed firms' sales (note all idiosyncratic shocks are sales-based) corresponds to a 3.5% increase in profit margins of the financially sound firms in the same industry-year. In addition to this unconditional spillover effect, the model makes an unique prediction that such spillover effect should be larger when the size of distressed and the healthy are the more comparable, and smaller when the sizes are more unbalanced. To test this prediction, we split the aforementioned panel regression into 3 subsamples based on the absolute value of the log size ratio of bin 1 over bin 3. When bin 1 and bin 3 are of equal

Table 4: Spillover Effect among Top Firms and Heterogeneity across Industries

	All	1 (Comparable)	2	3 (Different)	3-1
Method 1	0.035***	0.061***	0.029*	0.022**	0.039**
	[3.61]	[4.02]	[1.96]	[2.03]	[2.35]
Method 2	0.037***	0.064***	0.032*	0.021	0.043**
	[3.45]	[5.02]	[1.94]	[1.19]	[2.05]
Method 3	0.035***	0.061***	0.034**	0.014	0.047***
	[3.48]	[4.61]	[2.12]	[0.89]	[2.08]

Note: This table reports results from the following industry-annual level panel regressions: $PM^1_{i,t} = \alpha + \beta_3 Shock^3_{i,t} + \beta_1 Shock^1_{i,t} + \sum_{j=1}^{5} \gamma_j PM^1_{i,t-j} + \sum_t \delta_t FE_t + \sum_i \rho_i FE_i + \epsilon_{i,t}$. Here, each industry-year is sorted into 3 groups according to the firm's distress level, where group 1 is the least distressed, and group 3 is the most distressed. $PM^1_{i,t}$ is the profit margin of group 1 of industry i in year t. $Shock^3_{i,t}$ and $Shock^1_{i,t}$ are the aggregated idiosyncratic shocks to group 3 and group 1 of industry i in year t, where the idiosyncratic shocks are computed using 3 methods: 1) firm's sales growth subtracting the cross sectional average sales growth, 2) time series regression residual of firm's sales growth on the cross sectional average sales growth, and 3) time series regression residual of firm's sales growth on the first PC extracted from a panel of industry level sales growth. FE_t and FE_i are time and industry fixed effect. Each bin's spillover coefficient, β_3, are reported in the first column (All). The rest of the columns are the coefficients on the subsamples of the panel split according to the relative size of group 1 and group 3: the first subsample includes industries where group 1 and 3 are of the most comparable sizes, while subsample 3 contains those where they are the most unbalanced. Results in this table use only the top 6 firms. Idiosyncratic shocks and profit margin are both in fractional unit. T-statistics computed with Driscoll-Kraay standard errors with 5 lags are reported in square brackets.

size, the absolute value will achieve the theoretical minimum of zero. When bin 1 contains much larger or smaller firms than those in bin 3, this absolute value will be larger.

Column 2-4 of table 4 report the spillover coefficients for the 3 subsamples. As we can see, the spillover effect is the largest in subsample 1 where the firm sizes are the most comparable, and the smallest when the firm sizes are least comparable. The difference between the coefficient in subsample 1 and 3 are statistically significant. This is consistent with the model's prediction.

Volatilty and Industry Concentration In this section we test the model's prediction that more concentrated industries should see lower volatility in credit spread and profit margin in the future. We measure each industry's concentration level with the Herfindahl-Hirschman Index (HHI). As a crude way to make sure that this measure behaves well, we require at least 6 firms in each industry-year. To measure a firm's credit spread volatility, we take its monthly credit spread and compute its volatility within the next 12-month. Table 5 regresses each firm's forward one year credit spread volatility on the firm's industry's HHI, while controlling for the industry's distress, operating leverage, the firm's past credit spread

Table 5: Credit Spread Volatility and Heterogeneity across Industries

	All Firms	Top 6
	$Vol_{i,t+1}$	$Vol_{i,t+1}$
$HHI_{i,t}$	−0.133**	−0.176***
	[−2.40]	[−3.13]
$Vol_{i,t}$	0.364***	0.409***
	[14.89]	[16.84]
$Distress_{i,t}$	6.074	4.736
	[1.62]	[0.65]
$OL_{i,t}$	−0.004	−0.032
	[−0.28]	[−1.53]
N	6621	9153
R^2	0.439	0.427

Note: This table reports results from the following firm-annual level panel regressions: $Vol_{i,t+1} = \alpha + \beta_1 HHI_{i,t} + \beta_2 Vol_{i,t} + \beta_3 Distress_{i,t} + \beta_4 OL_{i,t} + \sum_t \delta_t FE_t + \sum_i \rho_i FE_i + \epsilon_{i,t}$. Here, $Vol_{i,t+1}$ the volatility of the monthly credit spread for firm i over year $t+1$. $HHI_{i,t}$, $Distress_{i,t}$, and $OL_{i,t}$ are the Herfindahl-Hirschman Index (HHI), the average distress level, and the average operating leverage of the industry of firm i in year t. FE_t and FE_i are time and industry fixed effect. The computation of the HHI requires at least 6 firms in each industry-year. Average within an industry is weighted by sales. The regression is weighted by the bond's par value. The spread on which we compute the volatility are in annualized, percentage unit. All other variables are in fractional unit. T-statistics computed with Driscoll-Kraay standard errors with 5 lags are reported in square brackets.

volatility, in addition the time and industry fixed effect. The first row of the table shows that firms in more concentrated industries, measured using higher HHI value, sees higher credit spread volatility in the next 12 months. Here both credit spread volatility and HHI are in fractional units. A coefficient of -0.133 means a 0.15 (about the standard deviation of the HHI measure) increase in HHI corresponds to a 2.00% decrease in credit spread volatility.

Table 6 tests a similar prediction on profit margin volatility. For each firm, we compute its quarterly profit margin, and then winsorize at the 5th and 95th percentile values on the panel. This winsorization step is necessary as firm level profit margin can attain very extreme values. We then compute each firm's profit margin volatility over the next four quarters, and regress it on the industry's HHI. Controls are similar to those found in table 5. Here, we find that more concentrated industries see lower volatility in profit margin over the next four quarters, consistent with the model's prediction. Here both profit margin volatility and HHI are in fractional units. A coefficient of -0.030 means a 0.15 (about the standard deviation of

Table 6: Profit Margin Volatility and Heterogeneity across Industries

	All Firms	Top 6
	$PMVol_{i,t+1}$	$PMVol_{i,t+1}$
$HHI_{i,t}$	-0.030***	-0.018**
	[-3.50]	[-2.61]
$PMVol_{i,t}$	0.259***	0.186***
	[7.73]	[4.41]
$Distress_{i,t}$	4.300***	3.671***
	[3.92]	[3.44]
$OL_{i,t}$	-0.006	-0.011***
	[-1.55]	[-4.23]
N	173,015	46,202
R^2	0.168	0.167

Note: This table reports results from the following firm-annual level panel regressions: $PMVol_{i,t+1} = \alpha + \beta_1 HHI_{i,t} + \beta_2 PMVol_{i,t} + \beta_3 Distress_{i,t} + \beta_4 OL_{i,t} + \sum_t \delta_t FE_t + \sum_i \rho_i FE_i + \epsilon_{i,t}$. Here, $Vol_{i,t+1}$ the volatility of the quarterly winsorized profit margin for firm i over year $t+1$. $HHI_{i,t}$, $Distress_{i,t}$, and $OL_{i,t}$ are the Herfindahl-Hirschman Index (HHI), the average distress level, and the average operating leverage of the industry of firm i in year t. FE_t and FE_i are time and industry fixed effect. The computation of the HHI requires at least 6 firms in each industry-year. Average within an industry is weighted by sales. The regression is weighted by the firm's sale in year t. The spread on which we compute the volatility are in annualized, percentage unit. All other variables are in fractional unit. T-statistics computed with Driscoll-Kraay standard errors with 5 lags are reported in square brackets.

the HHI measure) increase in HHI corresponds to a 0.45% decrease in profit margin volatility.

Predictive Relationship among Industry Profit Margin, Distress, and Fluidity Table 7 shows the predictive relationship among profit margin, distress, and competition, as measured by fluidity. The first two columns show that when the industry is distressed this year, it is likely to have lower profit margin in the next year. The next two columns show that when the profit margin of the industry is low, it is likely to have high level distress in the next year. The last two columns show that when the current competition level in the industry is high, the industry is likely to be more distressed in the next year. These results confirm the basic channels of the model. Here, profit margin and distress are in fractional unit, while fluidity are in the original unit as in Hoberg, Phillips and Prabhala (2014). The coefficient of -4.274 in the first column means that a 1% increase in distress this year corresponds to a 4.274% decrease in the profit margin of the industry in the next

Table 7: Predictive Relationship among Industry Profit Margin, Distress, and Fluidity

	All Firms	Top 6	All Firms	Top 6	All Firms	Top 6
	$PM_{i,t+1}$	$PM_{i,t+1}$	$Distress_{i,t+1}$	$Distress_{i,t+1}$	$Distress_{i,t+1}$	$Distress_{i,t+1}$
$Distress_{i,t}$	-4.274**	-2.569*				
	[-2.13]	[-1.97]				
$PM_{i,t}$			-0.003***	-0003***		
			[-3.31]	[-2.99]		
$Fluidity_{i,t}$					0.0004***	0.0003***
					[3.72]	[4.28]
N	4,754	4,754	4,754	4,754	3,486	3,486
R^2	0.208	0.246	0.167	0.137	0.460	0.495

Note: This table reports results from the following industry-annual level panel regressions: $PM_{i,t+1} = \alpha + \beta_1 Distress_{i,t} + \sum_t \delta_t FE_t + \sum_i \rho_i FE_i + \epsilon_{i,t}$, $Distress_{i,t+1} = \alpha + \beta_1 PM_{i,t} + \sum_t \delta_t FE_t + \sum_i \rho_i FE_i + \epsilon_{i,t}$, and $Distress_{i,t+1} = \alpha + \beta_1 Fluidity_{i,t} + \sum_t \delta_t FE_t + \sum_i \rho_i FE_i + \epsilon_{i,t}$. $PM_{i,t}$, $Distress_{i,t}$, and $Fluidity_{i,t}$ are the average profit margin, the average distress, and the average fluidity of the industry of firm i in year t. FE_t and FE_i are time and industry fixed effect. Average within an industry is weighted by sales. All variables are in fractional unit, except for the fluidity, which is taken from Hoberg, Phillips and Prabhala (2014). Instead of 10 firms, 5 are required for an industry-year to be included in the regressions involving fluidity. This is because the fluidity measure has coverage for only a fraction of the sample and the cutoff of 10 will greatly cut our sample size. All other variables are in fractional unit. T-statistics computed with Driscoll-Kraay standard errors with 5 lags are reported in square brackets.

year. The standard deviation of the fluidity measure is about 0.65 and that for the aggregate distress measure is about 0.00044. Hence, a coefficient of 0.0004 in the 5th column means a 1 standard deviation increase fluidity corresponds to 0.65 standard deviation increase in distress level the next year.

Average Returns and Credit Spread by Gross Profitability Table 8 shows the relationship between profitability, defined in Novy-Marx (2013), and stock returns and credit spreads. Panel A shows that when an industry has high profitability, firms in it have higher stock returns relative to those in the low profitability industries. This confirms the profitability puzzle in Novy-Marx (2013) at the industry level. Panel B shows that when an industry has high profitability, firms in it have lower credit spread relative to those in the low profitability industries.

The Profitability Puzzle by Industry Distress Table 9 shows the average returns of 9 double-sorted portfolios. The cross section of industry level stock returns are first sorted into 3 bins based on their respective distress level, and then each bin is sorted into 3 bins

Table 8: Average Returns and Credit Spread by Profitability

	1(Low)	2	3	4	5 (High)	5 - 1
			Panel A: Stock Return			
α	0.007***	0.010***	0.010***	0.009***	0.011***	0.003**
	[3.79]	[5.22]	[4.32]	[4.12]	[6.02]	[2.36]
N	671	671	671	671	671	671
			Panel B: Credit Spread			
α	0.005***	0.004***	0.004***	0.003***	0.003***	-0.002***
	[7.60]	[7.01]	[7.93]	[8.09]	[10.92]	[-4.47]
N	545	545	545	545	545	545

Note: This table reports results from the following monthly time-series regressions: $Spread_{i,t} = \alpha_i + \epsilon_{i,t}$ and $Ret_{i,t} = \alpha_i + \epsilon_{i,t}$. Here, the cross section of industries are sorted into 5 bins based on industry level gross profitability, defined as in Novy-Marx (2013). $Ret_{i,t}$ is the market value weighted returns among the stocks in the bin i. $Spread_{i,t}$ is the par value weighted average credit spread among firms within bin i. Annual accounting data of year t are mapped to credit spread and return data from Q2 of year t+1 to Q1 of year t+2, as in Fama and French (1993) and Novy-Marx (2013). The coefficient α equals the time series mean of the bin's return and credit spread. Returns are in fractional unit, and credit spreads are in annualized fractional unit. For the credit spread regression, t-statistics robust to autocorrelation are reported in square brackets.

based on their profitability. The positive numbers in column "3-1" shows that a strategy that longs high profitability stocks and short low profitability industries earns positive returns on average. This repeats the message in Panel A of Table 8. The new point of Table 9 is that this return increases with the industries' distress level. Among the high distress industries, a portfolio that long high profitability and short low profitability earns 68 basis points per month. In contrast, among the low distress industries, the return is only 3 basis points. The difference of 66 basis points is statistically significant at the 5% level.

5 Conclusion

In this paper, we explore the implication of endogenous competition on credit risks. We develop a general-equilibrium asset pricing model incorporating dynamic supergames of profit-margin competition among firms. In our model, firms compete more fiercely in recessions through profit-margin undercutting, resulting in low cash flows and high credit risks. The high credit risks induce more intense competition in product markets, further reducing profit margins and cash flows. This feedback mechanism between product market competition and financial leverage increases credit risks and generates high credit spreads.

Table 9: The Profitability Puzzle by Industry Distress

	1 (Low Profitability)	2	3 (High Profitability)	3-1
1 (Low Distress)	0.0107***	0.0132***	0.0110***	0.0003
	[4.81]	[6.25]	[5.44]	[0.14]
2	0.0078***	0.0111***	0.0127***	0.0049**
	[3.18]	[4.00]	[4.98]	[2.42]
3 (High Distress)	0.0067**	0.0079**	0.0135***	0.0068***
	[2.05]	[2.43]	[4.54]	[2.60]
3-1	-0.0040	-0.0053**	0.0026	0.0066**
	[-1.57]	[-2.01]	[1.16]	[2.38]

Note: This table reports average monthly returns of 9 portfolios consisting of industries, sequentially sorted on the industry's distress and then profitability. Annual accounting data, used in the construction of the profitability measure, of year t are mapped to credit spread and return data from Q2 of year t+1 to Q1 of year t+2, as in Fama and French (1993) and Novy-Marx (2013). Quarterly accounting data used in the construction of the distress measure is mapped to return data with a two-month lag, as in Campbell, Hilscher and Szilagyi (2008). Sample starts in 1975m8, as before that month the data coverage is too unstable to performance double sorting. T-statistics are reported in square brackets.

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Appendix

A Model Solutions

A.1 Boundary Condition at $M_{i,t} = +\infty$

When $M_{i,t} = +\infty$, firm i is essentially a monopoly in the industry with negligible default rate because its competitor $\bar{i}$ is negligible for any given $M_{\bar{i},t}$. Thus, the boundary condition of firm i's shareholder value at $M_{i,t} = +\infty$ should satisfy:

$$\lim_{M_{i,t}\to\infty} \frac{\partial}{\partial M_{i,t}} V_i^N(x_t) = \lim_{M_{i,t}\to\infty} \frac{\partial}{\partial M_{i,t}} V_i^C(x_t) = \lim_{M_t\to\infty} \frac{\partial}{\partial M_t} U(M_t, \gamma_t), \tag{26}$$

where $U(M_t, \gamma_t)$ is the shareholder value of an unlevered monopoly industry with customer base M_t. In this monopoly industry, the demand curve facing the monopoly firm is given by equation (1)

$$C_t = M_t P_t^{-\epsilon}, \tag{27}$$

and the evolution of the single firm's customer base M_t is

$$\frac{\mathrm{d}M_t}{M_t} = g\mathrm{d}t + \sigma_m \mathrm{d}Z_{m,t} + \sigma_\iota \mathrm{d}W_t, \tag{28}$$

where W_t and $Z_{m,t}$ are independent standard Brownian motions. Thus, the HJB equation that determines $U(M_t, \gamma_t)$ can be written as

$$0 = \max_{\theta_t} \Lambda_t \left[(1-\tau)[\omega^{1-\epsilon}\theta_t(1-\theta_t)^{\epsilon-1}M_{i,t} - b_i] - \lambda U(M_t, \gamma_t)\right] \mathrm{d}t + \mathbb{E}_t \left[\mathrm{d}(\Lambda_t U(M_t, \gamma_t))\right]. \tag{29}$$

The boundary condition of firm i's debt value at $M_{i,t} = +\infty$ is the value of a default-free consol bond with constant coupon rate b_i and value b_i/r_f.

A.2 Monopolistic and Competitive Industries

Although our model focuses on duopoly industries with two firms competing for customer base, we can also analyze the implications in monopolistic and competitive industries using a similar framework.

Monopolistic Industry. Consider a monopolistic industry with a single firm i. The demand for firm i's good is given by equation (1)

$$C_t = M_t P_t^{-\epsilon}, \tag{30}$$

The firm's operating profit rate is given by

$$\Pi(\theta_t, \gamma_t) \equiv (\theta_t - 1)\,\omega C_t = \omega^{1-\epsilon}\theta_t\,(1-\theta_t)^{\epsilon-1}\,M_t. \tag{31}$$

The optimal profit margin chosen by the firm is $\theta^* = \frac{1}{\epsilon}$, which implies that the equilibrium operating profit rate is

$$\Pi(\theta_t^*, \gamma_t) = \omega^{1-\epsilon} \left(\frac{1}{\epsilon}\right) \left(\frac{\epsilon - 1}{\epsilon}\right)^{\epsilon - 1} M_t. \tag{32}$$

Competitive Industry. Consider a competitive industry with a continuum of firms. The demand for each firm's good is determined by

$$C_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\eta} P_t^{-\epsilon} M_{i,t}, \tag{33}$$

where P_t is

$$P_t = \left[\int_{j\in\mathcal{F}} \left(\frac{M_{i,t}}{M_t}\right) P_{i,t}^{1-\eta} \mathrm{d}j\right]^{\frac{1}{1-\eta}}. \tag{34}$$

The key difference between the price index (3) of a duopoly industry and the price index (34) of a competitive industry is that for the latter, each firm is atomistic and takes the price index P_t as exogenously given when choosing $P_{i,t}$.

The optimal profit margin chosen by any firm i is $\theta_{i,t} = \frac{1}{\eta}$. Thus, the competitive industry's profit margin index is $\theta_t = \frac{1}{\eta}$. In equilibrium, firm i's operating profit rate is

$$\Pi(\theta_{i,t}^*, \gamma_t) = \omega^{1-\epsilon} \left(\frac{1}{\eta}\right) \left(\frac{\eta - 1}{\eta}\right)^{\epsilon - 1} M_{i,t}. \tag{35}$$

B Numerical Algorithm

In this section, we detail the numerical algorithm that solves the model. To give an overview, our algorithm proceeds in the following steps:

(1). We solve the non-collusive equilibrium. This requires us to solve the subgame perfect equilibrium of the dynamic game played by two firms. The simultaneous-move dynamic game requires us to solve the intersection of the two firms' best response (i.e., optimal decisions on profit margins and default) functions, which themselves are optimal solutions to coupled PDEs.

(2). We solve the collusive equilibrium using the value functions in the non-collusive equilibrium as punishment values. Because we are interested in the highest collusive profit margins with binding incentive-compatibility constraints, this requires us to solve a high-dimensional fixed-points problem. We thus use an iteration method inspired by Abreu, Pearce and Stacchetti (1986, 1990*b*), Ericson and Pakes (1995), and Fershtman and Pakes (2000) to solve the problem.

Note that standard methods for solving PDEs with free boundaries (e.g. finite difference or finite element) can easily lead to non-convergence of value functions. To mitigate such problems and obtain accurate solutions, we solve the continuous-time game using a discrete-time dynamic programming method, as in Dou, Ji and Wu (2019). In Appendix B.1, we present the discretized recursive formulation for the model, including firms' problems in non-collusive equilibrium, collusive equilibrium, and deviation. In Appendix B.2, we discuss how we discretize the stochastic processes, time grids, and state variables in the model. Finally, in Appendix B.3, we discuss the details on implementing our numerical algorithms, including finding the equilibrium prices in the non-collusive equilibrium and solving the optimal collusive profit margins and default boundaries.

B.1 Discretized Dynamic Programming Problem

We solve the model in risk-neutral measure, where we have

$$\mathrm{d}Z_{m,t} = -\gamma_t \mathrm{d}t + \mathrm{d}\tilde{Z}_{m,t}, \tag{36}$$

$$\mathrm{d}Z_{g,t} = -\zeta \mathrm{d}t + \mathrm{d}\tilde{Z}_{g,t}. \tag{37}$$

Because firm 1 and firm 2 are symmetric, one firm's equity value and policy functions are obtained directly given the other firm's equity value and policy functions. We first illustrate the non-collusive equilibrium and then we illustrate the collusive equilibrium.

B.1.1 Non-Collusive Equilibrium

Below, we first present the recursive formulation for the firm's equity value in the non-collusive equilibrium. Next, we present the conditions that determine the non-collusive (Nash) equilibrium.

Recursive Formulation for The Value of Equity in Non-Collusive Equilibrium Firm i's state is characterized by three state variables, including firm i's customer base $M_{i,t}$, firm $\bar{i}$'s customer base $M_{\bar{i},t}$, and the aggregate state γ_t. Denote the equity value functions in the non-collusive equilibrium as $V_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ for $i = 1, 2$, where b_i and $b_{\bar{i}}$ are the two firms' coupon rates. In our baseline calibration, we set $b_i = b_{\bar{i}} = b_0$. We make coupon rate explicitly as state variables because upon defaults of any incumbent firms, the coupon rate of new entrants is b_e, which may be different from b_0.

To characterize the equilibrium value functions, it is more convenient to introduce two off-equilibrium value functions. Let $\widehat{V}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i},t}, d_{\bar{i},t}; b_i, b_{\bar{i}})$ be firm $i(=1,2)$'s value when its competitor $\bar{i}$'s profit margin is any (off-equilibrium) value $\theta_{\bar{i},t}$ and default status is any (off-equilibrium) value $d_{\bar{i},t} = 0, 1$.

Firm $i = 1, 2$ solves the following problem:

$$\widehat{V}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i},t}, d_{\bar{i},t}; b_i, b_{\bar{i}}) = \max_{\theta_{i,t}, d_{i,t}} (1 - d_{i,t}) \Big\{ (1-\tau) \left[\omega^{1-\epsilon} \theta_{i,t} (1-\theta_{i,t})^{\eta-1} (1-\theta_t)^{\epsilon-\eta} M_{i,t} - b_i \right] \Delta t$$
$$+ e^{-(r_f+\lambda)\Delta t} \mathbb{E}_t \left[(1 - d_{\bar{i},t}) V_i^N(M_{i,t+\Delta t}, M_{\bar{i},t+\Delta t}, \gamma_{t+\Delta t}; b_i, b_{\bar{i}}) + d_{\bar{i},t} V_i^N(M_{i,t+\Delta t}, M_e, \gamma_{t+\Delta t}; b_i, b_e) \right] \Big\}, \tag{38}$$

subject to the following constraints. (1) The industry's profit margin is given by

$$1 - \theta_t = \left[\frac{M_{i,t}(1-\theta_{\bar{i},t})^{\eta-1} + M_{\bar{i},t}(1-\theta_{\bar{i},t})^{\eta-1}}{M_t} \right]^{\frac{1}{\eta-1}} \quad \text{with} \quad M_t = M_{i,t} + M_{\bar{i},t}. \tag{39}$$

(2) The customer base evolves according to

$$M_{i,t+\Delta t} = M_{i,t} + g M_{i,t} \Delta t + \sigma_m M_{i,t}(-\gamma_t \Delta t + \Delta \tilde{Z}_{m,t}) + \sigma_\iota M_{i,t} \Delta W_{i,t}, \tag{40}$$

$$M_{\bar{i},t+\Delta t} = M_{\bar{i},t} + g M_{\bar{i},t} \Delta t + \sigma_m M_{\bar{i},t}(-\gamma_t \Delta t + \Delta \tilde{Z}_{m,t}) + \sigma_\iota M_{\bar{i},t} \Delta W_{\bar{i},t}. \tag{41}$$

(3). The aggregate state γ_t evolves according to

$$\gamma_{t+\Delta t} = \gamma_t - \varphi(\gamma_t - \overline{\gamma})\Delta t - \nu_m(-\zeta \Delta t + \Delta \tilde{Z}_{g,t}). \tag{42}$$

Non-Collusive (Nash) Equilibrium Denote the equilibrium profit margin and default functions as $\theta_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ and $d_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$. Denote the off-equilibrium profit margin and default functions as $\widehat{\theta}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i},t}, d_{\bar{i},t}; b_i, b_{\bar{i}})$ and $\widehat{d}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i},t}, d_{\bar{i},t}; b_i, b_{\bar{i}})$.

Given firm $\bar{i}$'s profit margin $\theta_{\bar{i},t}$ and default decision $d_{\bar{i},t}$, firm i optimally sets the profit margin $\theta_{i,t}$ and makes default decision $d_{i,t}$. The non-collusive (Nash) equilibrium is derived from the fixed point—each firm's profit margin and default are optimal given the other firm's optimal profit margin and default:

$$\theta_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) = \widehat{\theta}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i}}^N(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i), d_{\bar{i}}^N(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i); b_i, b_{\bar{i}}), \tag{43}$$

$$d_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) = \widehat{d}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i}}^N(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i), d_{\bar{i}}^N(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i); b_i, b_{\bar{i}}). \tag{44}$$

The equilibrium value functions are given by

$$V_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) = \widehat{V}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i}}^N(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i), d_{\bar{i}}^N(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i); b_i, b_{\bar{i}}). \tag{45}$$

B.1.2 Collusive Equilibrium

Below, we present the recursive formulation for the firm's value in the collusive equilibrium. Then we present the recursive formulation for the firm's value when it deviates from the collusive equilibrium.

Finally, we present the incentive compatibility constraints to determine the equilibrium collusive profit margins. After finding the equilibrium collusive profit margin scheme, we check whether the participation constraints are satisfied. There are two cases, if the participation constraints are satisfied, the two firms will collude on the equilibrium profit margin scheme. If the participation constraints are not satisfied, the two firms will set profit margins according to their non-collusive ones.

Recursive Formulation for The Value of Equity in The Collusive Equilibrium Denote $\overline{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot))$ as firm $j(=1,2)$'s value in the collusive equilibrium with collusive profit margin scheme $\overline{\Theta}^C(\cdot)$. Denote $\widehat{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; d_{\bar{i},t}; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot))$ be firm $i(=1,2)$'s value in the collusive equilibrium with collusive profit margin scheme $\overline{\Theta}^C(\cdot)$ when its competitor $\bar{i}$'s default status is any (off-equilibrium) value $d_{\bar{i},t} = 0, 1$.

Firm i solves the following problem:

$$\begin{aligned}
&\widehat{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; d_{\bar{i},t}; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)) = \max_{d_{i,t}}(1-d_{i,t}) \Big\{(1-\tau)\left[\omega^{1-\epsilon}\overline{\theta}_{i,t}^C(1-\overline{\theta}_{i,t}^C)^{\eta-1}(1-\overline{\theta}_t^C)^{\epsilon-\eta}M_{i,t} - b_i\right]\Delta t \\
&+e^{-(r_f+\lambda)\Delta t}\mathbb{E}_t\left[(1-d_{\bar{i},t})\overline{V}_i^C(M_{i,t+\Delta t}, M_{\bar{i},t+\Delta t}, \gamma_{t+\Delta t}; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)) + d_{\bar{i},t}\overline{V}_i^C(M_{i,t+\Delta t}, M_e, \gamma_{t+\Delta t}; b_i, b_e; \overline{\Theta}^C(\cdot))\right]\Big\},
\end{aligned} \tag{46}$$

subject to the following constraints. (1) The industry's profit margin is given by

$$1 - \overline{\theta}_t^C = \left[\frac{M_{i,t}(1-\overline{\theta}_{i,t}^C)^{\eta-1} + M_{\bar{i},t}(1-\overline{\theta}_{\bar{i},t}^C)^{\eta-1}}{M_t}\right]^{\frac{1}{\eta-1}} \quad \text{with} \quad M_t = M_{i,t} + M_{\bar{i},t}. \tag{47}$$

(2) The customer base evolves according to

$$M_{i,t+\Delta t} = M_{i,t} + gM_{i,t}\Delta t + \sigma_m M_{i,t}(-\gamma_t \Delta t + \Delta\tilde{Z}_{m,t}) + \sigma_\iota M_{i,t}\Delta W_{i,t}, \tag{48}$$

$$M_{\bar{i},t+\Delta t} = M_{\bar{i},t} + gM_{\bar{i},t}\Delta t + \sigma_m M_{\bar{i},t}(-\gamma_t \Delta t + \Delta\tilde{Z}_{m,t}) + \sigma_\iota M_{\bar{i},t}\Delta W_{\bar{i},t}. \tag{49}$$

(3). The aggregate state γ_t evolves according to

$$\gamma_{t+\Delta t} = \gamma_t - \varphi(\gamma_t - \overline{\gamma})\Delta t - \nu_m(-\zeta\Delta t + \Delta\tilde{Z}_{g,t}). \tag{50}$$

Denote the equilibrium default function as $\overline{d}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot))$. Denote the off-equilibrium default function as $\widehat{d}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; d_{\bar{i},t}; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot))$. The default decisions are determined in Nash equilibrium. In particular, given firm $\bar{i}$'s default decision $d_{\bar{i},t}$, firm i optimally makes default decision $d_{i,t}$. The Nash equilibrium is derived from the fixed point—each firm's default is optimal given the other firm's optimal default:

$$\overline{d}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)) = \widehat{d}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; \overline{d}_{\bar{i}}^C(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i; \overline{\Theta}^C(\cdot)); b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)). \tag{51}$$

The equilibrium value functions are given by

$$\overline{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)) = \widehat{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; \overline{d}_{\bar{i}}^C(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i; \overline{\Theta}^C(\cdot)); b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)). \tag{52}$$

Recursive Formulation for The Value of Equity upon Deviation The deviation value is obtained by assuming that firm i optimally sets its profit margin conditional on firm $\bar{i}$ setting the profit margin according to the collusive profit margin scheme, i.e., $\overline{\theta}_{\bar{i}}^C(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i; \overline{\Theta}^C(\cdot))$ and default decision $\overline{d}_{\bar{i}}^C(M_{\bar{i},t}, M_{i,t}, \gamma_t; b_{\bar{i}}, b_i; \overline{\Theta}^C(\cdot))$. Denote $\overline{V}_i^D(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot))$ as firm i's deviation value.

Firm i solves the following problem:

$$\begin{aligned}
\overline{V}_i^D(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)) = &\max_{\theta_{i,t}, d_{i,t}} (1 - d_{i,t}) \Big\{ (1-\tau) \Big[\omega^{1-\epsilon}\theta_{i,t}(1-\theta_{i,t})^{\eta-1}(1-\overline{\theta}_t^D)^{\epsilon-\eta} M_{i,t} - b_i \Big] \Delta t \\
&+ e^{-(r_f+\lambda)\Delta t}\mathbb{E}_t \Big[d_{\bar{i},t} \Big((1-\xi\Delta t)\overline{V}_i^D(M_{i,t+\Delta t}, M_e, \gamma_{t+\Delta t}; b_i, b_e; \overline{\Theta}^C(\cdot)) + \xi\Delta t V_i^N(M_{i,t+\Delta t}, M_e, \gamma_{t+\Delta t}; b_i, b_e) \Big) \\
&(1 - d_{\bar{i},t}) \Big((1-\xi\Delta t)\overline{V}_i^D(M_{i,t+\Delta t}, M_{\bar{i},t+\Delta t}, \gamma_{t+\Delta t}; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)) + \xi\Delta t V_i^N(M_{i,t+\Delta t}, M_{\bar{i},t+\Delta t}, \gamma_{t+\Delta t}; b_i, b_{\bar{i}}) \Big) \Big] \Big\}
\end{aligned} \tag{53}$$

subject to the following constraints. (1) The industry's profit margin is given by

$$1 - \overline{\theta}_t^D = \left[\frac{M_{i,t}(1-\theta_{i,t})^{\eta-1} + M_{\bar{i},t}(1-\overline{\theta}_{\bar{i},t}^C)^{\eta-1}}{M_t} \right]^{\frac{1}{\eta-1}} \quad \text{with} \quad M_t = M_{i,t} + M_{\bar{i},t}. \tag{54}$$

(2) The customer base evolves according to

$$M_{i,t+\Delta t} = M_{i,t} + gM_{i,t}\Delta t + \sigma_m M_{i,t}(-\gamma_t \Delta t + \Delta\tilde{Z}_{m,t}) + \sigma_\iota M_{i,t}\Delta W_{i,t}, \tag{55}$$

$$M_{\bar{i},t+\Delta t} = M_{\bar{i},t} + gM_{\bar{i},t}\Delta t + \sigma_m M_{\bar{i},t}(-\gamma_t \Delta t + \Delta\tilde{Z}_{m,t}) + \sigma_\iota M_{\bar{i},t}\Delta W_{\bar{i},t}. \tag{56}$$

(3). The aggregate state γ_t evolves according to

$$\gamma_{t+\Delta t} = \gamma_t - \varphi(\gamma_t - \overline{\gamma})\Delta t - \nu_m(-\zeta\Delta t + \Delta \tilde{Z}_{g,t}). \tag{57}$$

Solving For Equilibrium Profit Margins The collusive equilibrium is a subgame perfect Nash equilibrium if and only if the collusive profit margin scheme $\overline{\Theta}^C(\cdot)$ satisfies the following PC and IC constraints:

$$\begin{aligned}\overline{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)) \geq& V_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}), &(58)\\ \overline{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)) \geq& \overline{V}_i^D(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \overline{\Theta}^C(\cdot)), &(59)\end{aligned}$$

for all $M_{i,t} \in [0, +\infty)$, $\gamma_t \in \mathbb{R}$, and $i = 1, 2$.

There exist infinitely many subgame perfect Nash equilibria. We focus on the collusive equilibrium with the collusive profit margins lie on the "Pareto efficient frontier" (denoted by $\Theta^C(\cdot)$), which are obtained when all incentive compatibility constraints are binding, i.e.

$$\overline{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \Theta^C(\cdot)) = \overline{V}_i^D(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \Theta^C(\cdot)), \tag{60}$$

for all $M_{i,t} \in [0, +\infty)$, $\gamma_t \in \mathbb{R}$, and $i = 1, 2$. The collusive equilibrium is solved by finding profit margin scheme $\Theta^C(\cdot)$ such that the PC constraint (58) and the IC constraint (60) are satisfied simultaneously.

We denote $V_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ as firm i's value in the collusive equilibrium with collusive profit margin scheme $\Theta_i^C(\cdot)$. In solving the equilibrium, we first ignore the PC constraint (58) and solve for $\Theta^C(\cdot)$ that satisfies the IC constraint (60). Then given $\Theta^C(\cdot)$, we check whether the PC constraint (58) is satisfied for each value of $M_{i,t}$, $M_{\bar{i},t}$, and γ_t. If it is satisfied, we have

$$\begin{aligned}V_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) =& \overline{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \Theta^C(\cdot)), &(61)\\ \theta_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) =& \overline{\theta}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \Theta^C(\cdot)) &(62)\end{aligned}$$

If it is not satisfied, we guess the endogenous collusion boundary $\zeta(M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ (through iterations) at which one of the firm's participation constraint is just binding. For $M_{i,t} \leq \zeta(M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$, we set

$$\begin{aligned}V_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) =& V_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}), &(63)\\ \theta_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) =& \theta_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}). &(64)\end{aligned}$$

For $M_{i,t} > \zeta(M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$, we have

$$\begin{aligned}V_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) =& \overline{V}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \Theta^C(\cdot)), &(65)\\ \theta_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) =& \overline{\theta}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}; \Theta^C(\cdot)) &(66)\end{aligned}$$

Value of Debt Firm i's value of debt in the collusive equilibrium is given by

$$\begin{aligned}D_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) =& (1 - d_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})) \left\{ b_i\Delta t + e^{-r_f\Delta t}\mathbb{E}_t \left[D_i^C(M_{i,t+\Delta t}, M_{\bar{i},t+\Delta t}, \gamma_{t+\Delta t}; b_i, b_{\bar{i}}) \right] \right\}\\ &+ d_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})\nu A_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; 0, b_{\bar{i}}), \qquad (67)\end{aligned}$$

where $d_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ and $A_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; 0, b_{\bar{i}})$ are the optimal default decision and the unlevered asset value in the collusive equilibrium under the collusive profit margin scheme $\Theta^C(\cdot)$.

Firm i's value of debt in the non-collusive equilibrium is determined similarly using the optimal default decision and the unlevered asset value in the non-collusive equilibrium.

B.2 Discretization

We discretize the aggregate state γ_t based on n_γ grids using the method of Tauchen (1986). We approximate the persistent AR(1) process of long-run growth rates θ_t using n_θ discrete states based on the method of Rouwenhorst (1995). The time line is discretized into intervals with length Δt. We choose a large n_γ to ensure the continuous process is accurately approximated.

We use collocation methods to solve each firm's problem. Let $S_M \times S_M \times S_\gamma \times S_b \times S_b$ be the grid of collocation nodes for a firm's equilibrium value, $S_M \times S_M \times S_\gamma \times S_\theta \times S_d \times S_b \times S_b$ be the grid of collocation nodes for a firm's off-equilibrium value in the non-collusive equilibrium, and $S_M \times S_M \times S_\gamma \times S_d \times S_b \times S_b$ be the grid of collocation nodes for a firm's off-equilibrium value in the collusive equilibrium. We have $S_M = \{M_1, M_2, ..., M_{n_M}\}$, $S_\gamma = \{\gamma_1, \gamma_2, ..., \gamma_{n_\gamma}\}$ $S_\theta = \{\theta_1, \theta_2, ..., \theta_{n_\theta}\}$, $S_d = \{0, 1\}$, and $S_b = \{b_1, b_2, ..., b_{n_b}\}$.

We approximate the firm's value function $V(\cdot)$ and $D(\cdot)$ on the grid of collocation notes using a linear spline with coefficients corresponding to each grid point. We first form a guess for the spline's coefficients, then we iterate to obtain a vector that solves the system of Bellman equations.

B.3 Implementation

The numerical algorithms are implemented using C++. The program is run on the server of MIT Economics Department, supply.mit.edu and demand.mit.edu, which are built on Dell PowerEdge R910 (64 cores, Intel(R) Xeon(R) CPU E7-4870, 2.4GHz) and Dell PowerEdge R920 (48 cores, Intel(R) 4 Xeon E7-8857 v2 CPUs). We use OpenMP for parallelization when iterating value functions and simulating the model.

Selection of Grids We set $n_\gamma = 51$, $n_M = 22$, $n_\theta = 11$ $n_b = 3$, $\Delta t = 1/24$. The grid of customer base S_M is discretized into 22 nodes from $M_1 = 0$ to $M_{n_M} = 8$. We use 17 grids with equal spaces to discretize the region $[0, 1.5]$ to capture the large nonlinearity around the default boundary and use 5 grids with equal spaces to discretize the region $[1.5, 8]$. The upper bound $M_{n_M} = 8$ is determined so that the marginal value of $M_{i,t}$ becomes a constant. This ensures that the boundary condition at infinity is accurately solved and satisfied. The time interval Δt is set to be 1/24 (i.e., half month). A higher Δt implies faster convergence for the same number of iterations but lower accuracy. We checked that the solution is accurate enough for $\Delta t = 1/24$, further reducing Δt would not improve the accuracy much. With $\Delta = 1/24$, 5000 times iterations allow us to achieve convergence in value functions. The profit margin grid is discretized into 11 nodes from 0 to $1/\epsilon$ with equal spaces. The lowest coupon rate is set to be zero to consider unlevered firms. The highest coupon rate is set to be our calibrated value $b_0 = 10$.

Solving the Non-Collusive Equilibrium Given the value functions from the previous iteration, we use the golden section search method to find the optimal profit margins. The computational complexity of this algorithm is at the order of $\log(n)$, much faster and more accurate than a simple grid search. The optimal default decisions can be trivially solved by checking two cases with $d_{i,t}^N = 0$ and $d_{i,t}^N = 1$.

Searching for the equilibrium profit margin is challenging because we have to solve a fixed-point problem that involves both firms' simultaneous prices decisions. Our solution technique is to iteratively solve the following three steps.

First, given $V_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$, we solve the off-equilibrium value $\widehat{V}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i}}, d_{\bar{i},t}; b_i, b_{\bar{i}})$ and the off-equilibrium policy functions $\widehat{\theta}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i},t}, d_{\bar{i},t}; b_i, b_{\bar{i}})$ and $\widehat{d}_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; \theta_{\bar{i},t}, d_{\bar{i},t}; b_i, b_{\bar{i}})$. Second, for each $(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) \in S_M \times S_M \times S_\gamma \times S_b \times S_b$, we solve equations (43 – 44) and obtain the equilibrium profit margins $\theta_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ and defaults $d_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$. Third, we solve equations (45) and obtain equilibrium value functions $V_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$.

Solving the Collusive Equilibrium To solve the collusive equilibrium, we have to simultaneously solve the endogenous default boundaries and the endogenous collusive prices within the collusion boundaries. We implement a nested iteration method. First, we guess the default boundaries. Second, we solve for the highest collusive profit margins within the boundary using the iteration algorithm below. The profit margins associated with the states below the default boundaries are indeterminate because firms are in default. For these states, we set firms' profit margins at the non-collusive profit margins $\theta_i^N(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$. Third, we check whether the implied default boundaries are consistent with our guessed boundaries. If not, we update our guess and resolve the highest collusive profit margins.

We modify the golden section search method to find the highest collusive profit margins $\theta^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ within the default boundaries by iterations. For each iteration, we guess collusive profit margins $\overline{\theta}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$, and given the guessed profit margins, we solve firms' collusion value and deviation value using standard recursive methods. We update the guessed collusive profit margins until the incentive compatibility constraints (60) are binding for all states.

There are two key differences between our method and a standard golden section search method. First, to increase efficiency, we guess and update the collusive profit-margin scheme $\overline{\theta}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ simultaneously for all $(M_{i,t}, M_{\bar{i},t}, \gamma_t) \in S_M \times S_M \times S_\gamma$, instead of doing it one by one for each state. A natural problem introduced by the simultaneous updating is that there might be overshooting. For example, if for some particular state $(M_{i,t}^*, M_{\bar{i},t}^*, \gamma_t^*)$, we updated a collusive profit margin $\overline{\theta}_i^C(M_{i,t}^*, M_{\bar{i},t}^*, \gamma_t^*; b_i, b_{\bar{i}})$ too high in the previous iteration, the collusive profit margin for some other states $(M_{i,t}, M_{\bar{i},t}, \gamma_t) \neq (M_{i,t}^*, M_{\bar{i},t}^*, \gamma_t^*)$ might be affected in this iteration and never achieve a binding incentive compatibility constraint. Eventually, this may lead to non-convergence.

We solve this problem by gradually updating the collusive profit margins. In particular, in each round of iteration, we first compute the updated collusive profit-margin schme $\overline{\theta}_i^{C'}(M_{i,t}, M_{\bar{i},t}, \gamma_t)$ implied by the golden section search method. Then, instead of changing the upper search bound or lower search bound to $\overline{\theta}_i^{C'}(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ directly, we change it to $(1 - adj) \times \overline{\theta}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}}) + adj \times \overline{\theta}_i^{C'}(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$, i.e., a weighted average of the current iteration's collusive profit margin $\overline{\theta}_i^C(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$ and the updated collusive profit margin $\overline{\theta}_i^{C'}(M_{i,t}, M_{\bar{i},t}, \gamma_t; b_i, b_{\bar{i}})$. If $adj = 0.5$, our algorithm is essentially the same as bisection search algorithm. A lower adj is more suitable to solve the problem in which different states have a higher degree of interdependence. We set a relatively low $adj = 0.05$ to ensure convergence.

C Data Appendix

C.1 Variable Description

Table 2

- $PM_{i,t}$ is the profit margin among industries in bin i at time t. Firm level profit margin is computed as net income divided by sales. It is aggregated to the industry level weighting by sales. Equal weight are taken across industries within a bin.
- x_t is the shock to the 8 quarter average consumption growth rate. The consumption is seasonally adjusted non-durable plus service. The shock is computed as an AR1 residual.
- The sorting variable in this table is industry level distress, which is aggregated from firm level distress, weighting by sales. Firm level distress is computed as in Campbell, Hilscher and Szilagyi (2008).

Table 3

- $Spread_{i,t}$ is the par value weighted average credit spread among firms within bin i.
- x_t is the 8 quarter average consumption growth rate. The consumption is seasonally adjusted non-durable plus service.
- $OL_{i,t}$ is the par value weighted operating leverage within bin i. The firm level operating leverage is computed as the sum of selling, general and administrative expense and cost of goods sold divided by total asset. Before aggregation, firm level operating leverage is winsorized on the panel at the 1st and 99th percentiles.
- The sorting variable in this table is industry level distress, which is aggregated from firm level distress, weighting by sales.

Table 4

- $PM^j_{i,t}$ is the profit margin of group j of industry i in year t. Firm level profit margin is computed as net income divided by sales. It is aggregated to the industry-group level weighting by sales.
- $Shock^j_{i,t}$ are idiosyncratic shocks to group j of industry i in year t. Construction details of shocks are in the next subsection.

Table 5

- $Vol_{i,t+1}$ the volatility of the monthly credit spread for firm i over year $t+1$.
- $HHI_{i,t}$ is the Herfindahl-Hirschman Index of the industry of firm i in year t. First compute the sales of each individual firm within an industry, take the square of the shares, and sum across the firms in the industry.
- $Distress_{i,t}$ is the average distress level of the industry of firm i in year t. Firm level distress level is aggregated to the industry level, weighting by sales.
- $OL_{i,t}$ is the sales weighted average operating leverage of the industry of firm i in year t. The firm level operating leverage is computed as the sum of selling, general and administrative expense and cost of goods sold divided by total asset. Before aggregation, firm level operating leverage is winsorized on the panel at the 1st and 99th percentiles.

Table 6

- $Vol_{i,t+1}$ the volatility of the quarterly winsorized profit margin for firm i over year $t+1$. The winsorization is done on the full panel at the 5th and 95th percentiles.
- $HHI_{i,t}$ is the Herfindahl-Hirschman Index of the industry of firm i in year t. First compute the sales of each individual firm within an industry, take the square of the shares, and sum across the firms in the industry.
- $Distress_{i,t}$ is the average distress level of the industry of firm i in year t. Firm level distress level is aggregated to the industry level, weighting by sales.
- $OL_{i,t}$ is the sales weighted average operating leverage of the industry of firm i in year t. The firm level operating leverage is computed as the sum of selling, general and administrative expense and cost of goods sold divided by total asset. Before aggregation, firm level operating leverage is winsorized on the panel at the 1st and 99th percentiles.

Table 7

- $PM_{i,t}$ is the profit margin of industry i at time t. Firm level profit margin is computed as net income divided by sales. It is aggregated to the industry level weighting by sales.
- $Distress_{i,t}$ is the average distress level of the industry of firm i in year t. Firm level distress level is aggregated to the industry level, weighting by sales.
- $Fluidity_{i,t}$ is the fluidity of the industry of firm i in year t. It is taken from Hoberg, Phillips and Prabhala (2014).

Table 8

- $Ret_{i,t}$ is the market value weighted returns among the stocks in the bin i.
- $Spread_{i,t}$ is the par value weighted average credit spread among firms within bin i.
- The sorting variable in this table is industry level profitability. Firm level profitability is computed as gross profit divided by total assets. It is then winsorized on the panel at th 1st and the 99th percentiles. The winsorized profitability measure is then aggregated to the industry level. In panel A, the weighting is by the firm's stock market cap. In panel B, the weighting is by the firm's sales.

C.2 Construction of Industry-Level Shocks

Method 1:

(i) Compute the annual sales growth of individual firms, censoring the rare instances where the sales of the last year is negative.

(ii) Compute the panel means of the sales growth on top 100 firms of each cross section.

(iii) Winsorize the sales growth at the panel means plus and minus 30%.

(iv) Compute the aggregate sales growth as the average of the winsorized sales growth on the top 100 firms.

(v) Compute firm level idiosyncratic shock as winsorized sales growth subtracting the average sales growth.

(vi) Aggregate idiosyncratic shock to the industry-year level, weighting by last year's sale.

This methodology closely aligns with the method used in (Gabaix 2011) with the exception of the winsorization bounds. The bounds were 20% in (Gabaix 2011), which we relax to 30%.
Method 2:

(i) Compute the aggregate sales growth as in Method 1.

(ii) Conduct firm level time series regression of sales growth on aggregate sales growth and a constant. Take the residual as the idiosyncratic shock.

(iii) Aggregate idiosyncratic shock to the industry-year level, weighting by last year's sale.

Method 3:

(i) Aggregate the winsorized firm-year level sales growth to industry-year level.

(ii) Over the 50 year of 1968 to 2017, drop those industries with less than 45 non-missing sales growth measures.

(iii) For the remaining industry-year, replace missing sales growth with the cross sectional average sales growth among the available industry-year sales growths.

(iv) Extract the first principal component from the panel of industry-year level sales growth.

(v) Conduct firm level time series regression of sales growth on the PC and a constant. Take the residual as the idiosyncratic shock.

(vi) Aggregate idiosyncratic shock to the industry-year level, weighting by last year's sale.