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FEEDBACK AND CONTAGION THROUGH DISTRESSED COMPETITION

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ABSTRACT

Firms tend to compete more aggressively in financial distress; the intensified competition in turn reduces profit margins, pushing themselves further into distress and adversely affecting other firms. To study such feedback and contagion effects, we incorporate strategic competition into a dynamic model with long-term defaultable debt, which generates various peer interactions like predation and self-defense. The feedback effect imposes an additional source of financial distress costs incurred for raising leverage, which helps explain the negative profitability-leverage relation across industries. Owing to the contagion effect, in a decentralized equilibrium, leverage is excessively high from an industry perspective, compromising industry's financial stability.

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A data appendix is available at <http://www.nber.org/data-appendix/w30841>
SSRN link is available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3513296

1 Introduction

Product market concentration has risen substantially over the past three decades (e.g., Gutiérrez and Philippon, 2017; Autor et al., 2020; Loecker and Eeckhout, 2019). Industries are increasingly characterized by a “winner takes most” feature, with a small number of firms controlling a large share of the market.¹ Moreover, the positions of market leaders are often highly persistent (e.g., Sutton, 2007; Bronnenberg, Dhar and Dubé, 2009), which allows them to compete strategically and sustain high profit margins through tacit collusion.² The increasingly ubiquitous adoption of pricing algorithms aided by artificial intelligence has further facilitated such tacit collusion.³ Since these market leaders contribute significantly to aggregate earnings and output (Gabaix, 2011), a better understanding of the nature of the strategic competition among them is not only important for studying industry dynamics but also aggregate fluctuations.

In this paper, we study the dynamic strategic competition among firms that face threats of financial distress, which demonstrates important financial implications of rising industry concentration. We show that the interplay between tactical competition and the threat of financial distress generates a distressed competition mechanism, which implies a competition-distress feedback loop and a new form of financial contagion. The feedback and contagion effects have rich implications for the determinants of firm’s credit risk and industry’s financial stability. They also enrich the tradeoff theory of capital structure and help explain the long-standing “profitability-leverage puzzle.”

Figure 1 illustrates the intuition behind the competition-distress feedback loop. An increase in financial distress raises firms’ default risks, which in turn makes firms more impatient, in the sense of being more focused on the present or short term. Under tacit collusion in a repeated game, firms retaliate rivals’ deviation from collusion by reverting to non-collusive competition. Thus, as firms become more impatient, they value less the future profits from cooperation and care less about future retaliation, thereby tightening the no-deviation incentive compatibility (IC) constraints. As a result, collusion capacity is reduced and competition intensifies, leading to lower profit margins. Lower profit margins then push the firms further into financial distress, closing the feedback loop. This is essentially

¹According to the U.S. Census data, on average, the top four firms within each four-digit SIC industry account for about 48% of each industry’s total revenue (see Dou, Ji and Wu, 2021a).

²See, e.g., Gutiérrez, Jones and Philippon (2019), Grullon, Larkin and Michaely (2019), and Corhay, Kung and Schmid (2020b) for evidence of high markups and profit margins, and Anderson, Rebelo and Wong (2018) and Dou, Ji and Wu (2021a,b) for evidence of strongly pro-cyclical net profit margins. There is extensive granular and direct evidence showing that tacit collusion, as a form of strategic competition, is prevalent (see Online Appendix 2).

³See, e.g., Calvano et al. (2020), Asker, Fershtman and Pakes (2022), Brown and MacKay (2022), and Sanchez-Cartas and Katsamakos (2022).

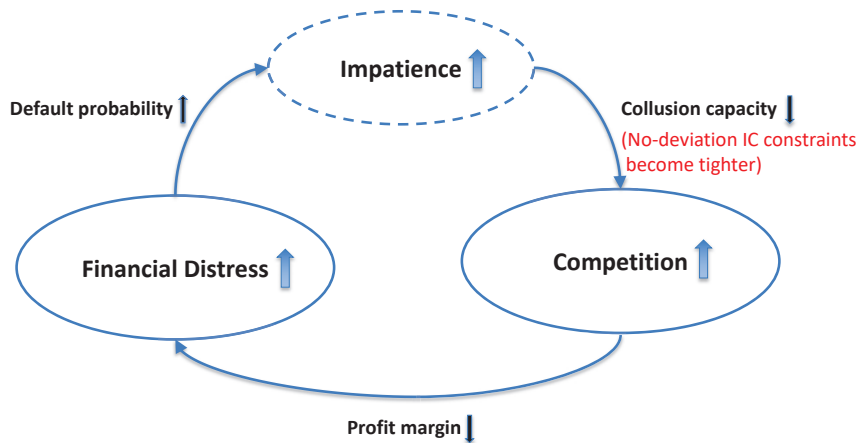


Figure 1. Interplay between financial distress and product-market competition.

Fudenberg and Maskin (1986)’s version of folk theorem; our model endogenizes firms’ discount rates through the impact of product market competition on default probability. Importantly, it is not the firms that optimally choose to compete more aggressively; rather, it is the tightened no-deviation IC constraints that force the firms to reduce their profit margins.

The competition-distress feedback loop has two financial implications. First, it reduces firms’ incentive to raise leverage, because higher leverage reduces firms’ collusion capacity and profitability, thereby reducing the level of firms’ cash flows. This is a new source of financial distress costs that is unique to the setting of tacit collusion. Second, the feedback loop can help explain the profitability-leverage puzzle at industry level. Specifically, profitability is negatively associated with leverage across both firms and industries, which is at odds with the traditional tradeoff theory of capital structure (e.g., Myers, 1993; Rajan and Zingales, 1995; Fama and French, 2002). Our model shows that industries with a higher capacity for tacit collusion tend to have higher profitability due to weaker price competition, but the firms tend to have lower leverage because they are subject to a stronger competition-distress feedback effect.⁴

Strategic competition can also generate financial contagion within industry in the short run. When a leading firm is hit by an idiosyncratic shock and becomes more financially distressed, the no-deviation IC constraints are further tightened, and thus competition intensifies within the industry, resulting in lower profits for all firms. Consequently, the financial conditions of the firm’s competitors within the same industry will also weaken in the short run. With multi-industry firms, financial contagion can also spread across

⁴The same idea can also shed light on the financial distress anomaly (see Online Appendix 4), adding to recent studies (e.g., Garlappi and Yan, 2011; Boualam, Gomes and Ward, 2020; Chen, Hackbarth and Strebulaev, 2022).

industries.⁵

This contagion effect has several implications. First, it expands the channels through which idiosyncratic shocks are transmitted across firms and industries. An adverse idiosyncratic shock to one market leader has ripple effects: the profit margins of the firm's competitors will also be negatively affected due to the endogenous competition responses. Such ripple effects imply that firms' cash flow risks and thus their financial distress levels are interdependent. They also justify a key primitive assumption bolstering the information-based theories of credit market freezes (e.g., [Bebchuk and Goldstein, 2011](#)). Second, the strength of the contagion effect will depend on the industry structure. It is stronger in those industries with higher concentration, higher leverage, or a lower entry threat. It implies that the industry structure and the financial conditions of the major competitors should be taken into account when analyzing firm-level credit risk. This prediction is in sharp contrast to standard credit risk models that explain firm-level credit risk through firm-specific and systematic (industry- or market-wide) economic conditions. A third implication of the contagion effect is that the leverage ratios that firms optimally choose in a decentralized equilibrium will be overly high from the industry's perspective.

To formalize the above intuitions concerning the feedback and contagion effects arising from tacit collusion among firms that face threats of financial distress, and study their theoretical implications, we present three models with increasing level of complexity.

As the first step, we start with a simple model in Section 2, which is a minimum departure from a hybrid of the Merton model of credit risk ([Merton, 1974](#)) and the repeated-game model of Bertrand competition with potential tacit collusion (e.g., [Fudenberg and Maskin, 1986](#); [Rotemberg and Saloner, 1986](#)). This simple model is illustrative and transparent. It has all the ingredients to capture the feedback and contagion effects while ensuring closed-form solutions. Specifically, in the simple model, we consider the strategic interactions between two firms, regarded as the market leaders of a duopoly industry. Time is discrete, and the risk-free rate is set to be zero. Firms generate revenues by the sales of homogeneous goods to consumers and pay corporate taxes. Firms are financed by external equity and long-term consol debt, and default on debt once their operating cash flows fall below an exogenous threshold, upon which they exit the industry. To ensure stationarity and maintain the duopoly market structure, a new firm immediately enters the industry to replace the defaulting firm, and the game of industry competition is "reset" to a new game between the surviving incumbent firm and the new entrant.

We now describe, in the simple model, how product prices and demands are determined under product market competition. Because goods are perishable and their prices are chosen

⁵See [Dou, Johnson and Wu \(2022\)](#) for causal evidence of the cross-industry financial contagion effects.

above the costs, firms produce goods to exactly meet the demand in equilibrium. Demand for a firm's goods depends on three components: (i) the customer base, (ii) the expected demand per unit of customer base, and (iii) the exogenous i.i.d. idiosyncratic demand shock. Customer bases are set to unity, whereas the expected demand per unit of customer base is endogenously determined according to a demand system of homogeneous goods, following the literature (e.g., Rotemberg and Saloner, 1986; Asker, Fershtman and Pakes, 2022). If the two firms set the same product price, each firm obtains unity demand per unit of customer base in expectation. If their prices are different, the firm with a higher price will lose all demand, whereas the firm with a lower price will capture a higher expected demand, with the magnitude increasing with the rival's price. This demand system implies that, in the absence of collusion, firms would undercut each other until they reach the unique non-collusive equilibrium which features zero profits for both firms. However, as firms interact in a repeated game, they have the incentives to tacitly collude with each other to achieve positive profits. We focus on the collusive equilibrium sustained by grim trigger strategies. Given that the rival firm will honor the collusive price, a firm may be tempted to boost its current revenue by undercutting the price; however, deviating from the collusive price reduces future revenue because it will be retaliated by the rival firm in the next period. Following the literature,⁶ we adopt the non-collusive equilibrium as the incentive compatible punishment for deviation. Using the closed-form solutions, we rigorously prove the existence of the competition-distress feedback loop and the financial contagion effect arising from the distressed competition mechanism.

The simple model above focuses on demonstrating the feedback and contagion effects, while taking firm debt levels as given. To explore the implications for firms' capital structure decisions, we need to allow firms to optimally choose their debt levels. However, owing to its parsimony, the simple model cannot provide a meaningful analysis of how strategic competition affects firms' capital structure decisions because the equilibrium leverage ratios are indeterminate. In the second step, we extend the simple model in Section 3 by allowing firms to attain different profitability levels in equilibrium, and thus solves the indeterminacy issue of equilibrium leverage ratios. Specifically, in addition to allowing firms to choose their debt levels at the beginning, the extended simple model's main departure from the simple model is to allow firms to strategically choose their customer bases in the first stage before strategically setting product prices in the second stage within each period, following the two-stage game framework of Kreps and Scheinkman (1983). This simple extension allows firms to attain different profitability levels in equilibrium, even though they sell homogeneous goods and must set the same price in equilibrium, thus allowing us to provide a meaningful analysis for optimal capital structure while still maintaining analytical

⁶See, e.g., Green and Porter (1984), Brock and Scheinkman (1985), and Rotemberg and Saloner (1986).

tractability. The optimal capital structure is determined by the fixed point of each firm's best response function of debt level to its competitor's debt level in the collusive equilibrium, in which firms tacitly collude on their profitability levels as in the simple model.

Like the traditional tradeoff theories of capital structure, a firm chooses its optimal leverage considering the tradeoff of tax-shield benefits against financial distress costs in the extended simple model. A novelty of our theory is that a new source of financial distress costs endogenously emerges due to the competition-distress feedback loop because a higher leverage further tightens the no-deviation IC constraints in the collusive equilibrium, and thus intensifies industry competition, reducing profitability and cash flows. The feedback loop motivates firms to choose lower financial leverage, *ex ante*, even in the absence of bankruptcy costs, and it helps rationalize the negative correlation between profitability and leverage at industry level. The financial contagion effect implies that the optimal leverage of firms is excessively high from an industry perspective. This suggests that firms in industries with higher common ownership tend to have lower leverage ratios because they are likely to better coordinate on joint leverage decisions.

Finally, in the third step, we further develop a full-fledged quantitative model to evaluate the quantitative importance of the distressed competition mechanism and its implications for capital structure in Section 4. The full-fledged quantitative model adopts more realistic assumptions and functional form specifications, further generalizing the extended simple model in the following four dimensions. First, it allows the firm-specific demand dynamics to follow a sequentially dependent process, similar to [Leland \(1994\)](#), rather than an i.i.d. process as in the simple models, and thus the distance-to-default of firms becomes a persistent state variable. Second, it allows firms to produce differentiated goods, and thus unlike the simple models, firms can set different prices in equilibrium. Third, it allows firms to make default decisions optimally according to endogenous default boundaries as in [Leland \(1994\)](#), rather than following exogenously specified default boundaries. Fourth, it allows partial recoveries of debt and industry structure changes when default occurs. Specifically, by varying the size of entrant firms, we analyze industries with different levels of entry barriers to elucidate how entry threats affect rivals' predatory pricing behaviors.

The main contributions of this paper are theoretical. In a companion paper, [Dou, Johnson and Wu \(2022\)](#) provide extensive causal evidence of the contagion effects based on granular data. Despite this, we provide three sets of empirical results to support the main theoretical implications in this paper. First, we provide evidence of the feedback effect. In the data, we find that industry-level profit margins load negatively on the discount rate and more so in industries where firms are closer to their default boundaries. This finding is consistent with our model's prediction that the competition-distress feedback effect is stronger when firms'

distances to default are lower. Second, we provide evidence of the financial contagion effect. By sorting the top six firms (ranked by sales) within each industry into three groups based on their distances to default, we find that adverse idiosyncratic shocks to the financially distressed group diminish the profit margins of the financially healthy group. Furthermore, we find that the within-industry spillover effect is more pronounced in the industries facing lower entry threats (i.e., higher entry barriers) as predicted by our quantitative model. Third, we provide evidence of the model's implications for the profitability-leverage relationship. Specifically, using the data, we show that industries with lower profit margins or higher idiosyncratic left-tail risk are associated with higher leverage ratios. Moreover, the negative profitability-leverage relationship across industries becomes insignificant after controlling for idiosyncratic left-tail risk. Thus, consistent with our model's prediction, the data suggest that heterogeneous idiosyncratic left-tail risks across industries can explain a major part of the industry-level profitability-leverage anomaly.

Related Literature. Our paper contributes to the large and growing literature on the structural model of corporate debt, default, and equity returns (for the seminal benchmark framework, see Merton, 1974; Leland, 1994). Several papers, specifically Hackbarth, Miao and Morellec (2006), Chen, Collin-Dufresne and Goldstein (2008), Bhamra, Kuehn and Strebulaev (2010a,b), Chen (2010), and Chen et al. (2018), focus on how macroeconomic conditions affect firms' financing policies, credit risk, and asset prices. Kuehn and Schmid (2014) and Gomes, Jermann and Schmid (2016), among others, study the interaction between long-term debt financing and corporate investments. He and Xiong (2012a,b) study the interaction between the rollover risk of debt, credit risk, and fluctuations in firm fundamentals. He and Milbradt (2014) and Chen et al. (2018) study the interaction between default decisions and secondary market liquidity for defaultable corporate bonds. Typically, dynamic models of capital structure and credit risk assume that the product market offers exogenous cash flows that are unrelated to firms' financial distress levels. One way to build the endogenous connection between firms' cash flows and financial distress in a dynamic debt model is to incorporate investment decisions and adjustment costs (e.g., Philippon, 2009). Our model differs from the existing literature by explicitly considering an oligopoly industry in which firms' strategic competition generates endogenous cash flows. This focus allows us to jointly study firms' financial decisions in the financial market and firms' decisions in the product market, as well as their interactions. Brander and Lewis (1986) and Corhay (2017) also develop models in which firms' cash flows are determined by strategic competition in the product market; however, unlike our paper, they do not consider supergames or long-term debts to investigate the competition-distress feedback and contagion effects.

Our paper also contributes to the growing literature on the feedback effects between the

capital market and the real economy. Feedback effects can be grouped into two major classes of channels: fundamental- and information-based channels. Seminal examples of studies on the fundamental-based channel include [Bernanke and Gertler \(1989\)](#) and [Kiyotaki and Moore \(1997\)](#), who show that the price-dependent financing constraints can spur an adverse feedback loop. [Dou et al. \(2020\)](#) survey this class of macro-finance models. In an influential work, [He and Milbradt \(2014\)](#) show the existence of a fundamental-liquidity feedback loop in the context of corporate bond markets. [Bond, Edmans and Goldstein \(2012\)](#) emphasize that the fundamental-based channel mainly concerns primary financial markets, whereas the equally crucial feedback effect between secondary financial markets and the real economy is mainly transmitted through the information-based channel (e.g., [Chen, Goldstein and Jiang, 2006](#); [Bakke and Whited, 2010](#); [Edmans, Goldstein and Jiang, 2012](#); [Cespa and Foucault, 2014](#)). This paper introduces a novel fundamental-based feedback effect between imperfect primary capital and product markets that arises from strategic dynamic competition.

Similar to the feedback effect, financial contagion also takes place through two major classes of channels: the fundamental- and information-based channels ([Goldstein, 2013](#)). The fundamental-based channel operates through real linkages among economic entities, such as common (levered) investors (e.g., [Kyle and Xiong, 2001](#); [Kodres and Pritsker, 2002](#); [Kaminsky, Reinhart and Végh, 2003](#); [Martin, 2013](#); [Gârleanu, Panageas and Yu, 2015](#)) and financial-network linkages (e.g., [Allen and Gale, 2000](#); [Acemoglu, Ozdaglar and Tahbaz-Salehi, 2015](#)). Contagion can also operate through information-based channels (e.g., [Goldstein and Pauzner, 2004](#); [Cespa and Foucault, 2014](#)). This paper proposes a novel strategic dynamic competition channel through which financial distress propagates among product-market peers.

Our paper also contributes to the literature exploring how industry competition and customer markets affect firms' financial decisions. [Titman \(1984\)](#), [Maksimovic \(1988\)](#), and [Titman and Wessels \(1988\)](#) provide the foundations for subsequent work in this line of the literature. [Banerjee, Dasgupta and Kim \(2008\)](#), [Hoberg, Phillips and Prabhala \(2014\)](#), and [D'Acunto et al. \(2018\)](#) empirically investigate the effects of industry competition and customer base on firms' leverage decisions. [Dumas \(1989\)](#), [Kovenock and Phillips \(1997\)](#), [Grenadier \(2002\)](#), [Aguerrevere \(2009\)](#), [Back and Paulsen \(2009\)](#), [Hoberg and Phillips \(2010\)](#), [Hackbarth and Miao \(2012\)](#), [Gourio and Rudanko \(2014\)](#), [Hackbarth, Mathews and Robinson \(2014\)](#), [Opp, Parlour and Walden \(2014\)](#), [Bustamante \(2015\)](#), [Bova and Yang \(2017\)](#), [Dou and Ji \(2021\)](#), [Dou et al. \(2021b\)](#), and [Loualiche \(2021\)](#) investigate how industry competition and the customer base affect various corporate policies, such as investment, cash holdings, mergers and acquisitions, employee compensation, labor hiring, and entries and exits. Although most studies focus on one-shot strategic interactions (e.g., [Corhay, Kung and Schmid, 2020a](#)), an exception is [Dou, Ji and Wu \(2021a,b\)](#), who study dynamic strategic interactions of all-equity firms. Crucially, we also study firms' dynamic strategic interactions

by allowing collusive behavior as opposed to imposing a one-shot strategic (non-collusive) setting, because of the extensive empirical evidence showing that tacit collusion is prevalent across industries. Our model highlights the dynamic interaction of endogenous competition and financial distress, generating competition-distress feedback and financial contagion effects; it provides an explanation for the profitability-leverage puzzle across industries. Very relatedly, [Spiegel and Tookes \(2013, 2020\)](#) develop an analytically tractable oligopoly model with multiple firms strategically competing for market shares by spending funds to acquire each other's customers. They estimate the model to quantify and decompose the direct and spillover effects of mergers and acquisitions (M&A) and initial public offerings on firms' valuations and marketing policies. We propose a different strategic competition mechanism through which firm-level profitability per unit of market share is endogenously determined in equilibrium rather than exogenously specified as in [Spiegel and Tookes \(2013, 2020\)](#). Thus, the competition-distress feedback and financial contagion effects through endogenous profitability are unique predictions of our theory. Moreover, our theory complements the model of [Spiegel and Tookes \(2013\)](#). Specifically, in their model, rival firms may incur losses after M&A even though the number of competitors is reduced; this is because the combined firm could be a much stronger competitor. Our model implies that the reduced number of competitors itself may generate losses to rival firms because it strengthens the competition-distress feedback effect, compromising rival firms' financial stability.

Finally, our paper is related to the burgeoning literature probing how financial characteristics influence firms' performance and decisions in the product market. In early seminal works, [Titman \(1984\)](#) and [Maksimovic and Titman \(1991\)](#) study how capital structure affects a firm's choice of product quality and the viability of the firm's product warranties. [Brander and Lewis \(1986\)](#) focus on the "limited liability" effect of short-term debt financing on product competition behavior. [Bolton and Scharfstein \(1990\)](#) show that financial constraints induce rational predation behavior. [Allen \(2000\)](#) shows that firms with higher debt levels face a higher probability of bankruptcy and liquidation, which is costly, and thus, their higher leverage results in less aggressive product market behavior. [Phillips \(1995\)](#), [Chevalier and Scharfstein \(1996\)](#), [Hortaçsu et al. \(2013\)](#), [Kojien and Yogo \(2015\)](#), [Hoberg and Phillips \(2016\)](#), [Cookson \(2017\)](#), [Gilchrist et al. \(2017\)](#), [Hackbarth and Taub \(2018\)](#), [Banerjee et al. \(2019\)](#), and [Grieser and Liu \(2019\)](#), among others, advance the empirical study of the product-market implications of financial frictions. Unlike these works, our paper combines a structural model of default with dynamic strategic competition featuring collusive behavior.

2 A Simple Model

In this section, we present a simple model that is a minimum departure from a hybrid of the Merton model of credit risk (Merton, 1974) and the repeated-game model that allows tacit collusion to occur (e.g., Fudenberg and Maskin, 1986; Rotemberg and Saloner, 1986). This simple tractable model captures the main insights about the competition-distress feedback loop and financial contagion effects. In Section 3, we extend the model to analyze the implications of strategic competition for firms' capital structure decisions. In Section 4, we show that the key insights are robust and quantitatively important under more realistic assumptions and functional form specifications.

2.1 Model Formulation

We consider an infinite-horizon economy with discrete time $t = 0, 1, 2, \dots$. The risk-free rate is constant and zero, that is, $r_f = 0$. We assume that the industry has two dominant risk-neutral firms ($n = 2$), referred to as market leaders. We denote the generic market leader by i and its competitor by j , that is, $i = 1, 2$ and $j \neq i$. At $t = 0$, firm i is financed by external equity and long-term consol debt with coupon payment of e^{b_i} each period. Firms repeatedly engage in price competition each period, subject to a demand-based capacity constraint for production. Due to the i.i.d. setting, we suppress the subscript t .

Cash Flows. A firm's demand-based capacity constraint for production is determined by its customer base, denoted by M_i . Given M_i , the total demand for firm i 's goods is $\tilde{C}_i = e^{z_i} C_i M_i$, where $e^{z_i} C_i$ is the demand per unit of customer base. The component C_i is the expected demand per unit of customer base, which is endogenously determined in the Nash equilibrium of the competition games; z_i captures the i.i.d. idiosyncratic demand shock that satisfies $\mathbb{E}[e^{z_i}] \equiv 1$. For simplicity, we normalize both firms' customer bases to unity, i.e., $M_i = 1$ for $i \in \{1, 2\}$. We endogenize firms' customer bases in the extended simple model in Section 3.

The marginal cost of production is zero, and thus each firm i would always choose its product price $P_i \geq 0$. The timeline of firms' decisions and actions within each period can be summarized as follows. First, both firms simultaneously name their product prices (P_1, P_2) , which determine the expected demand for their goods per unit of customer base (C_1, C_2) according to the demand system (2) introduced below. Then, each firm i receives an idiosyncratic demand shock z_i , after which it produces goods to exactly meet its total demand $\tilde{C}_i = e^{z_i} C_i M_i$ because goods are perishable.⁷ Next, firm i derives revenue $P_i \tilde{C}_i$ from

⁷This demand-based capacity constraint for production is intuitive and is widely adopted in the literature

selling its products, and then uses its revenue to pay interest and taxes, and distribute the remainder to shareholders as dividends. Finally, each firm makes decisions on whether to default or not. Specifically, firm i 's earnings after interest expenses and taxes are $(1 - \tau)\varepsilon_i$, where $\tau \in (0, 1)$ is the corporate tax rate, and ε_i is firm i 's earnings after interest expenses:

$$\varepsilon_i = P_i \tilde{C}_i - e^{b_i}. \quad (1)$$

Prices P_i for $i \in \{1, 2\}$ are determined before the idiosyncratic demand shocks are realized in the same period. Thus, they are not responsive to these shocks, which reflects price rigidity.

Financial Distress. Firm i defaults when its operating cash flow $P_i \tilde{C}_i$ is lower than an exogenous default boundary $e^{\varphi(b_i)}$, as in the standard Merton model.⁸ For tractability, we postulate a functional form, $\varphi(b) \equiv \frac{1}{2} \bar{\varphi} b^2$, with $\bar{\varphi} > 0$. This assumption captures the idea that when a firm is sufficiently underwater, it will not be able to raise sufficient capital to survive the debt. Moreover, the higher the debt level the more likely default becomes.

To ensure stationarity and maintain tractability, we assume that a new firm enters the industry when an incumbent firm defaults and exits.⁹ In particular, when incumbent firm i exits, a new firm enters immediately, with coupon payment e^{b_i} . The game of industry competition is then “reset” to a new one between the surviving incumbent firm and the new entrant. Upon default and exit, the firm is liquidated and its debt holders obtain a fraction δ of the debt value. We assume that δ equals zero for simplicity.¹⁰

Product Market Competition. Now, we explain the demand system that lies at the heart of the determination of (C_1, C_2) . The two market leaders simultaneously name prices $P_1, P_2 \in [0, \bar{P}]$, knowing that the expected demand per unit of customer base faced by firm i is

$$C_i = \begin{cases} 1 + \rho P_j^\eta, & \text{if } P_i < P_j \\ 1, & \text{if } P_i = P_j \\ 0, & \text{if } P_i > P_j \end{cases}, \quad \text{with } i \neq j \in \{1, 2\}, \quad (2)$$

(e.g., Gourio and Rudanko, 2014; Corhay, Kung and Schmid, 2020a; Dou et al., 2021b; Dou, Ji and Wu, 2021a,b).

⁸We consider endogenous default boundaries in the full-fledged quantitative model in Section 4. As shown in the literature (e.g., Longstaff and Schwartz, 1995; Chen, Collin-Dufresne and Goldstein, 2008; Cremers, Driessen and Maenhout, 2008; Huang and Huang, 2012; Leland, 2012), models with exogenous and endogenous default boundaries can generate quantitatively similar predictions for default probabilities and credit spreads.

⁹This assumption is similar in spirit to the “return process” of Luttmer (2007) and the “exit and reinjection” assumption in the industry dynamics models of Miao (2005) and Gabaix et al. (2016). The same assumption is commonly adopted in the industrial organization (IO) literature on oligopolistic competition and predation (e.g., Besanko, Doraszelski and Kryukov, 2014) and can be interpreted as the reorganization of the exiting firm.

¹⁰In the full-fledged quantitative model in Section 4, we calibrate the recovery rate of debt to match the data, and provide a detailed discussion of the exit and entry effects under various specifications of entry threats.

where $\eta > 1$, $\rho > 0$, and $\bar{P} > 1$ satisfy $\rho \bar{P}^\eta \leq 1$.

Several points are worth further discussion. First, the expected demand per unit of customer base is normalized to unity (i.e., $C_1 = C_2 = 1$) if firms do not undercut each other (i.e., $P_1 = P_2$). Second, following the literature (e.g., Rotemberg and Saloner, 1986; Asker, Fershtman and Pakes, 2022), if firm i 's price is lower than that of rival firm j (i.e., $P_i < P_j$), firm j will lose all demand, whereas firm i will gain additional demand in expectation, the size of which is equal to a proportion ρP_j^η of its customer base. The coefficient ρ captures the flexibility of demand relative to the customer base: when ρ is larger, firm i would gain more demand by setting a lower price than its rival. The parameter η captures a notion similar in spirit to within-industry price elasticity of demand. When η is larger, setting a higher price P_j increases the fragility of firm j 's demand by giving firm i more incentives to undercut firm j . Third, as in Asker, Fershtman and Pakes (2022), there is an upper bound \bar{P} on the price. We assume that $\rho \bar{P}^\eta \leq 1$ to ensure that the expected demand gain for the firm that undercuts its rival never exceeds the expected demand loss experienced by its rival. In other words, the condition $\rho \bar{P}^\eta \leq 1$ ensures that the expected total demand $C_1 M_1 + C_2 M_2$, which equals $C_1 + C_2$, never goes beyond the total customer base $M_1 + M_2$, which equals 2. In the rest of this section, we consider a sufficiently large η and a sufficiently small ρ to ensure the existence of the collusive equilibrium.

2.2 Nash Equilibrium

The two market leaders play a supergame, in which the stage games of setting prices are infinitely repeated over time. A non-collusive equilibrium, which is the repetition of the one-shot Nash equilibrium, exists and is Markov perfect. Multiple subgame-perfect collusive equilibria can also exist, in which competition strategies are sustained by grim trigger strategies.

Unique Non-Collusive Equilibrium. In the following proposition, we characterize the non-collusive equilibrium. The proof is in Online Appendix 1.1.

Proposition 2.1 (Non-Collusive Equilibrium). *There exists a unique non-collusive equilibrium, in which firms set $P_1^N = P_2^N = 0$ and obtain $C_1^N = C_2^N = 1$ in each period. Thus, both firms have zero profits and zero equity values ($E_1^N = E_2^N = 0$).*

Competition Under Tacit Collusion. We consider the collusive equilibrium with grim trigger strategies in which deviations from the tacit collusion scheme are punished in subsequent periods by termination of coordination and reversion to the non-collusive

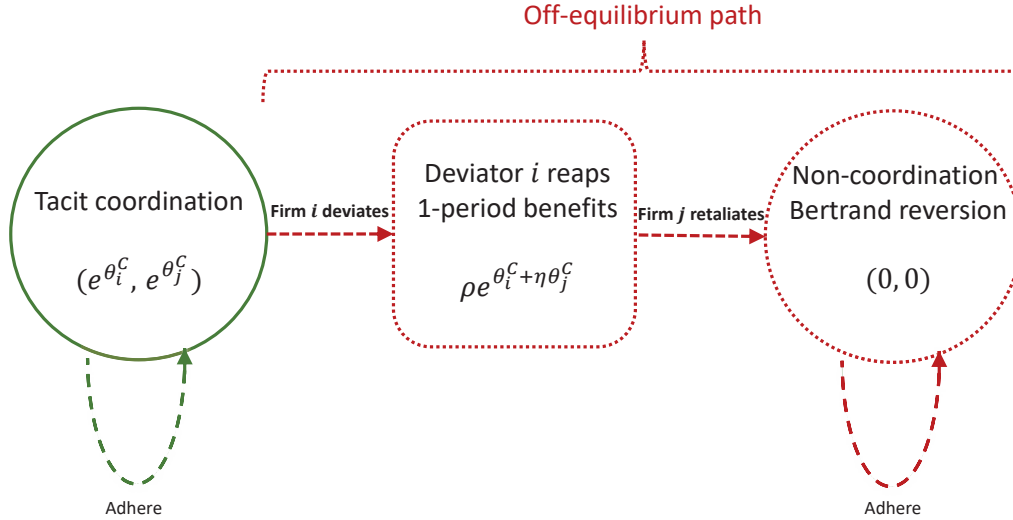


Figure 2. Graphic illustration of the classes of equilibria and the off-equilibrium-path threats. The two circled nodes represent the two phases of different forms of competition, and the squared node represents the transition based on the deviant behavior of the game players i or j with $i \neq j \in \{1, 2\}$. The two firms have profits $(e^{\theta_i^C}, e^{\theta_j^C})$ under tacit coordination and $(0, 0)$ under non-coordination Bertrand reversion.

equilibrium. This form of collusive equilibrium sustained by Bertrand reversion is widely adopted in the literature. Both firms can costlessly observe their rival's price, such that deviant behavior can be detected and punished.¹¹

In the collusive equilibrium, the two firms' prices must be the same: $P_1^C = P_2^C = P^C$, where P^C can be viewed as the industry price index; indeed, no firm would ever agree to set a higher price than the other firm, knowing that it would lead to zero profits according to (2).¹² As a result, both firms face equal demand per unit of customer base: $C_1^C = C_2^C = 1$. Let $\theta_i^C \equiv \ln(P_i^C C_i^C M_i)$ denote the log profitability of firm i in the collusive equilibrium. As graphically illustrated in Figure 2, the punishment for deviation is a shift from tacit coordination to non-coordination Bertrand reversion, under which firms' profits and equity values become zero. Similar to many studies (e.g., Rotemberg and Saloner, 1986; Hatfield et al., 2020), retaliation by terminating coordination and reverting to the non-collusive equilibrium is the harshest (i.e., the retaliation leads to zero profits), which is useful to ensure closed-form solutions while retaining the main idea.¹³

Below, we describe the phase of implicit coordination in which firms tacitly collude to reach possibly higher profit levels. Because $C_1^C = C_2^C = 1$ and $M_1 = M_2 = 1$, it holds that

¹¹The assumption of perfect information follows the literature (e.g., Rotemberg and Saloner, 1986; Haltiwanger and Harrington, 1991; Staiger and Wolak, 1992; Bagwell and Staiger, 1997).

¹²In the full-fledged quantitative model in Section 4, firms can set different prices because they sell differentiated goods.

¹³In the full-fledged quantitative model in Section 4, profits are positive in the non-collusive equilibrium, which increases the practical relevance of the same retaliation scheme.

$\theta_i^C \equiv \ln(P_i^C)$ for $i \in \{1, 2\}$ in the collusive equilibrium. Generally, we use θ to denote the log profitability of a firm. We assume that for firm i , the idiosyncratic demand shock z_i follows a logistic distribution, Logistic($\mu(\nu), \nu$), with $\nu \in (0, 1/2)$ and¹⁴

$$\mu(\nu) \equiv \ln(\sin(\nu\pi)) - \ln(\nu\pi) < 0. \quad (3)$$

It holds that $\mathbb{E}[z_i] = \mu(\nu)$, $\text{var}[z_i] = \nu^2\pi^2/3$, and $\mathbb{E}[e^{z_i}] \equiv 1$ for $i \in \{1, 2\}$. The model has no closed-form solution if z_i is Gaussian. The analytical expression for the default probability is presented in the following proposition. The proof is in Online Appendix 1.2.

Proposition 2.2 (Default Probability). *In a collusive equilibrium, the default probability of firm i over one period, denoted by λ_i^C , is equal to*

$$\lambda_i^C = \lambda^C(\theta_i^C, b_i), \quad \text{with } \lambda^C(\theta, b) \equiv \frac{1}{1 + e^{[\mu(\nu) + \theta - \varphi(b)]/\nu}}. \quad (4)$$

We now explain the IC constraints that prevent the occurrence of deviation on the equilibrium path. The price-setting scheme at P^C can be sustained as an equilibrium outcome only if neither firm has incentive to deviate by setting a price lower than P^C , or equivalently, a log profitability lower than θ^C . For example, if firm i deviates by reducing θ_i^C by an infinitesimal margin, its expected demand will increase by an amount $\rho e^{\eta\theta_j^C}$ according to (2). In response to the deviation, the rival firm will retaliate in the next period by entering the non-collusive equilibrium, which results in zero profits and equity value for firm i . Therefore, the gain from deviation, due to reaping more profits in the current period, and the subsequent associated loss, due to losing the value of future cooperation, are as follows:

$$\text{Expected benefits of deviation for firm } i = P_i^C \Delta C_i = \rho e^{\theta_i^C + \eta\theta_j^C}, \quad (5)$$

$$\text{Expected costs of deviation for firm } i = \left[1 - \lambda^C(\theta_i^C, b_i)\right] E_i^C(b_i, b_j), \quad (6)$$

where $E_i^C(b_i, b_j)$ is the equity value of firm i in the collusive equilibrium.

To ensure that firm i has no incentive to deviate from tacit coordination, it must hold that

$$\underbrace{\rho e^{\theta_i^C + \eta\theta_j^C}}_{\text{Benefits of deviation}} \leq \underbrace{\left[1 - \lambda^C(\theta_i^C, b_i)\right] E_i^C(b_i, b_j)}_{\text{Costs of deviation}}, \quad \text{with } i \neq j \in \{1, 2\}. \quad (7)$$

¹⁴The operating cash flow shock e^{z_i} follows the log-logistic distribution, also known as the *Fisk distribution*, which is widely applied in economic research (e.g., in modeling the distribution of wealth or income). This distribution has a heavy tail close to the Pareto tail, which is more realistic compared with the log-normal distribution. The parameter restriction $\nu \in (0, 1/2)$ ensures that the moments of z_i are well defined. Specifically, $\mathbb{E}[z_i] / \sqrt{\text{var}[z_i]}$ is a monotonically decreasing and strictly concave function of ν over $(0, 1/2)$.

The IC constraints in (7) lead to our second result, which characterizes the collusive equilibrium of the repeated game (Proposition 2.3). The proof is in Online Appendix 1.3.

Proposition 2.3 (Collusive Equilibrium). *The equity and debt value of firm i in the collusive equilibrium are*

$$E_i^C(b_i, b_j) = (1 - \tau) \left(e^{\theta^C} - e^{b_i} \right) \lambda^C(\theta^C, b_i)^{-1}, \quad (8)$$

$$D_i^C(b_i, b_j) = e^{b_i} \lambda^C(\theta^C, b_i)^{-1}, \quad (9)$$

where θ^C is the log profitability for both firms in the collusive equilibrium, and (θ^C, θ^C) is the unique Pareto efficient point of the following incentive compatible region (IC region) in the log-profitability space:

$$\mathcal{C} \equiv \{(\theta_1, \theta_2) : \theta_i \leq \Psi(\theta_j, b_j)/\eta \text{ and } \theta_i = \theta_j, \text{ with } i \neq j \in \{1, 2\}\}, \quad (10)$$

for b_1 and b_2 such that \mathcal{C} is not empty. The function $\Psi(\theta, b)$ in (10) has the expression:

$$\Psi(\theta, b) \equiv \ln[(1 - \tau)/\rho] + [\mu(\nu) + \theta - \varphi(b)]/\nu + \ln \left[1 - e^{-(\theta-b)} \right]. \quad (11)$$

Consequently, the log profitability in the collusive equilibrium is characterized by:

$$\theta^C = \Psi(\theta^C, b_1 \vee b_2)/\eta, \quad (12)$$

where $b_1 \vee b_2$ denotes the maximum of b_1 and b_2 , and θ^C is a function of $b_1 \vee b_2$.

The characterizations of the equilibrium equity and debt values in (8) and (9) are intuitive. The debt value in (9) is the discounted coupon until the time of default. The equity value in (8) is the asset value minus the debt value, plus the value of tax shield:

$$E_i^C(b_i, b_j) = \underbrace{(1 - \tau)e^{\theta^C} \lambda^C(\theta^C, b_i)^{-1}}_{\text{Asset value}} - \underbrace{D_i^C(b_i, b_j)}_{\text{Debt value}} + \underbrace{\tau D_i^C(b_i, b_j)}_{\text{Value of tax shield}}, \text{ with } i \neq j \in \{1, 2\}. \quad (13)$$

The total value of firm i in the collusive equilibrium is $V_i^C(b_i, b_j) \equiv E_i^C(b_i, b_j) + D_i^C(b_i, b_j)$. The market leverage of firm i , denoted by $lev_i^C(b_i, b_j) \equiv D_i^C(b_i, b_j)/V_i^C(b_i, b_j)$, is equal to

$$lev_i^C(b_i, b_j) = \frac{1}{(1 - \tau)e^{\theta^C - b_i} + \tau}, \text{ with } i \neq j \in \{1, 2\}. \quad (14)$$

Figure 3 illustrates the central idea of Proposition 2.3. First, as discussed above, the firms must agree on the collusive price and log profitability each period. As a result, the equilibrium pair of log profitabilities must lie on the 45-degree dotted lines in panels A and B, the feasible set for any collusive equilibrium. In panel A, we consider the symmetric case

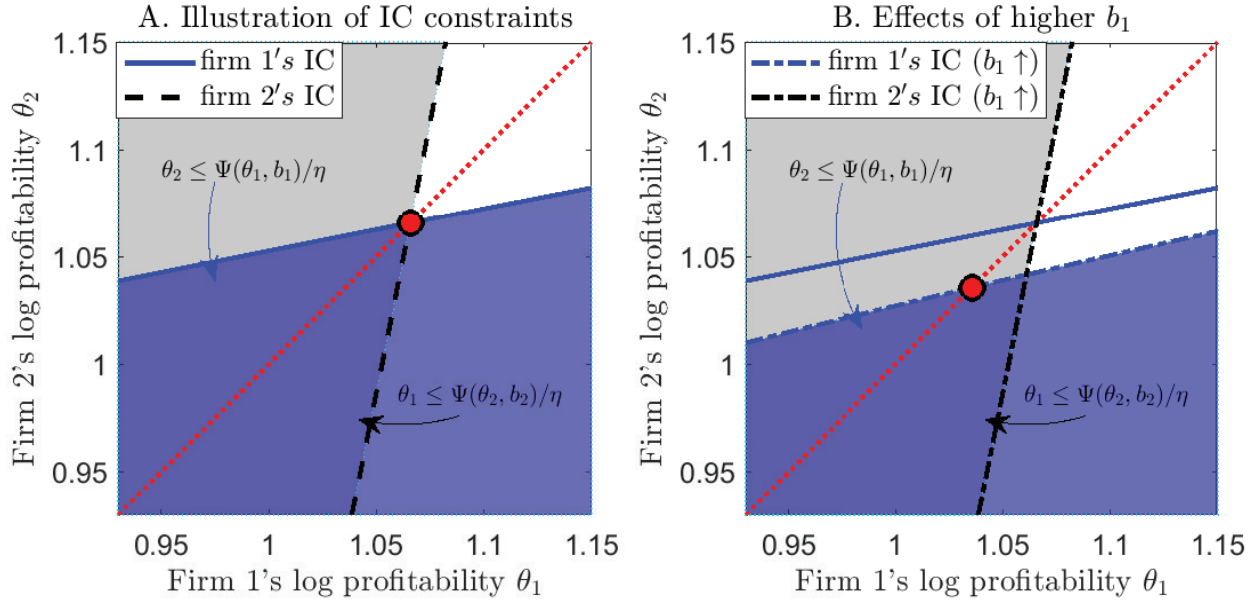


Figure 3. Illustration of the characterization of collusive equilibria and IC constraints. In panel A, we consider the symmetric case with $b_1 = b_2 = \ln(1.5)$. In panel B, we set $b_1 = \ln(2)$ and $b_2 = \ln(1.5)$. Other parameter values are set at $\tau = 0.35$, $\bar{\varphi} = 0.2$, $\rho = \exp(-20.5)$, $\eta = 21$, $\nu = 0.3$, and $\bar{P} = 3.5$.

with $b_1 = b_2$. Firm 1's IC constraint is satisfied in the region below the solid line, whereas firm 2's IC constraint is satisfied in the region to the left of the dashed line.¹⁵ Therefore, the segment of the 45-degree dotted line that lies within the overlapping area of the two firms' IC regions consists of all collusive equilibria sustained by grim trigger strategies. The large dot at the intersection of the three lines represents the unique Pareto efficient collusive equilibrium, denoted by (θ^C, θ^C) in Proposition 2.3.

In panel B, we examine the case when firm 1's leverage is increased (i.e., $b_1 > b_2$ while b_2 is fixed). The dash-dotted lines characterize the new IC constraints faced by the two firms. Firm 1's IC constraint shifts downward, whereas firm 2's IC constraint remains unchanged. It follows immediately from equation (11) that $\Psi(\theta, b)$ becomes smaller for all θ when b increases. Intuitively, when b_1 is higher, firm 1's default probability $\lambda^C(\theta^C, b_1)$ becomes higher, and thus firm 1 has stronger incentives to deviate from collusion because the cost of deviation in (7) is lower. As a consequence, firm 2 cannot set the profitability level as high as before. By contrast, firm 2's IC constraint remains unchanged as it depends only on b_2 . Taken together, the segment of the 45-degree dotted line that lies within the overlapping area of the two firms' IC regions, consisting of all collusive equilibria sustained by grim trigger strategies, shrinks relative to that in panel A. The large dot at the intersection of firm 1's new IC constraint and the 45-degree dotted line represents the new unique Pareto efficient collusive equilibrium with a lower log profitability. At this point, the IC constraint of firm

¹⁵Recall that, for any given θ_i , the higher the price charged by firm j , the stronger firm i 's incentive to deviate.

2 is not binding. The example in Figure 3 shows that higher leverage can intensify price competition.

2.3 Financial Contagion Through Endogenous Competition

The following proposition formally shows how a firm's financial leverage affects its own and its peer's profitability through endogenous changes in the intensity of competition. The proof is in Online Appendix 1.4.

Proposition 2.4 (Effects of Financial Leverage on Product Pricing Behaviors). *For $i \neq j \in \{1, 2\}$, the partial derivative of θ^C with respect to b_i is*

$$\frac{\partial \theta^C}{\partial b_i} = \begin{cases} 0, & \text{if } b_i < b_j \\ -\frac{\dot{\varphi}(b_i)/\nu + d_i}{\eta - (1/\nu + d_i)}, & \text{if } b_i \geq b_j, \end{cases}$$

where $d_i \equiv 1/(e^{\theta^C - b_i} - 1)$ and $\dot{\varphi}(b)$ is the derivative of $\varphi(b)$. Therefore, the log profitability θ^C is decreasing in both b_1 and b_2 in the collusive equilibrium.

Proposition 2.4 shows that if firm i increases its financial leverage by increasing b_i , both firm i and its rival firm j will have lower profitability (i.e., θ^C decreases) in the collusive equilibrium. As summarized in the following corollary, this reduced profitability will raise firm j 's default probability, leading to a spillover effect of financial distress. The proof is in Online Appendix 1.5.

Corollary 2.1 (Financial Distress Spillovers Through Endogenous Competition). *An increase in leverage for firm i , with b_j kept unchanged, increases the default probability of rival firm j in the collusive equilibrium. That is,*

$$\frac{\partial \lambda_j^C}{\partial b_i} \geq 0, \text{ with } i \neq j \in \{1, 2\}. \quad (15)$$

2.4 Competition-Distress Feedback Loop

The following proposition shows that, when firm i increases its financial leverage by increasing b_i , the default probability of firm i increases not only due to the direct effect of higher leverage but also due to a positive feedback effect through the endogenously intensified product market competition. This feedback between the financial and product markets is intuitive. An increase in b_i raises the default probability of firm i as a direct effect, which

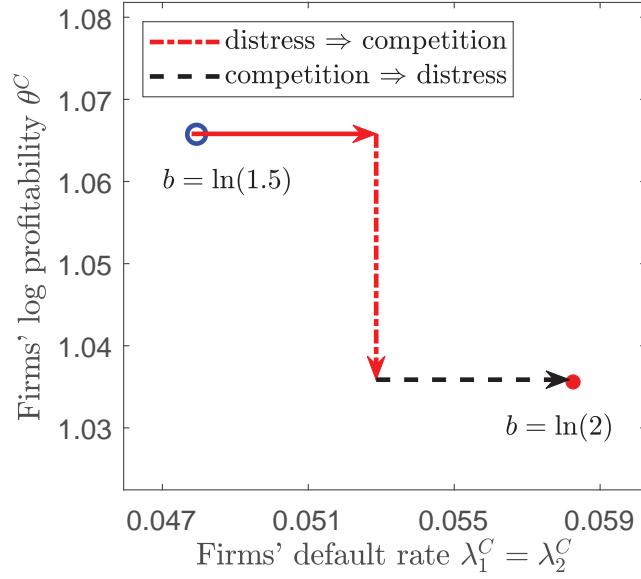


Figure 4. Illustration of the competition-distress feedback loop. Consider the symmetric case with $b_1 = b_2 = b$. The open circle represents the initial collusive equilibrium with $b = \ln(1.5)$. The dot represents the collusive equilibrium with $b = \ln(2)$, which is reached after the shock to financial distress (i.e., after b_1 and b_2 both increase from $\ln(1.5)$ to $\ln(2)$). The arrows represent the process of the firms' responses regarding θ^C and λ^C . The horizontal solid line represents the initial direct effect of an increase in b from $\ln(1.5)$ to $\ln(2)$ on the default probability, while holding firms' log profitability θ^C unchanged. The vertical dash-dotted line represents the decrease in firms' log profitability caused by the increase in their default probability via the endogenously decreased collusion capacity. Finally, the horizontal dashed line represents the further increase in firms' default probability due to the decrease in their profitability. Other parameters are set at $\tau = 0.35$, $\bar{\varphi} = 0.2$, $\rho = \exp(-20.5)$, $\nu = 0.3$, $\eta = 21$, and $\bar{P} = 3.5$.

in turn reduces the profitability level of both firms because of the endogenous decrease in coordination capacity, as discussed in Section 2.3. Then, the reduced profitability further increases the default probability of firm i . The proof is in Online Appendix 1.6.

Proposition 2.5 (Feedback Loop Between Financial and Product Markets). *With firm j 's coupon b_j remaining unchanged, an increase in firm i 's financial leverage via an increase in b_i triggers a feedback loop between the financial and product markets, amplifying the impact of b_i on the default probability λ_i^C :*

$$\begin{bmatrix} d\lambda_i^C \\ d\theta^C \end{bmatrix} = \underbrace{\begin{bmatrix} \partial\lambda^C(\theta, b_i)/\partial b_i|_{\theta=\theta^C} \\ 0 \end{bmatrix}}_{\text{Initial direct effect} \geq 0} db_i + \underbrace{\begin{bmatrix} 0 & \partial\lambda^C(\theta, b_i)/\partial\theta|_{\theta=\theta^C} \\ \partial\theta^C/\partial\lambda_i^C|_{b_j} & 0 \end{bmatrix}}_{\text{Higher-order feedback effect} \leq 0} \begin{bmatrix} d\lambda_i^C \\ d\theta^C \end{bmatrix},$$

where $\partial\theta^C/\partial\lambda_i^C|_{b_j}$ is the sensitivity of log profitability θ^C to firm i 's default probability λ_i^C , with b_j kept unchanged, in the collusive equilibrium. Importantly, the system is stable because the eigenvalues of the matrix that captures the higher-order feedback effect lie on $(-1, 1)$.

As shown in Proposition 2.5, an increase in b_i drives up the default probability λ_i^C not only through the initial direct effect, captured by the first term with $\partial\lambda^C(\theta, b_i)/\partial b_i|_{\theta=\theta^C} > 0$, but also through the feedback effect, captured by the second term with $\partial\lambda^C(\theta, b_i)/\partial\theta|_{\theta=\theta^C} < 0$ and $\partial\theta^C/\partial\lambda_i^C|_{b_i} < 0$. Specifically, an increase in b_i directly leads to an increase in the default probability λ_i^C , which will in turn lead to a decline in the log profitability of both firms, θ^C , because a higher default probability suppresses the coordination capacity of rivals (see the IC constraints in (7) and Proposition 2.4). Furthermore, to close the feedback loop, the decline in log profitability θ^C further increases the default probability λ_i^C (see equation (4)). Figure 4 visually illustrates the competition-distress feedback loop.

Naturally, the competition-distress feedback loop amplifies the effect of changes in firms' coupon on their default probability to a greater extent if firms are more financially distressed. This is formalized in the following corollary. The proof is in Online Appendix 1.7.

Corollary 2.2 (Amplification Due to Feedback Effects). *Suppose firms are symmetric with $b_1 = b_2 = b$. The sensitivity $\partial\theta^C/\partial b$ becomes more negative as b increases.*

3 Extended Simple Model of Capital Structure

With a minimum set of model ingredients, the simple model in Section 2 demonstrates two key insights: (i) a feedback loop between the product and financial markets, and (ii) a financial contagion effect through endogenous competition. However, owing to its parsimony, the simple model cannot provide a meaningful analysis of how strategic competition affects firms' capital structure decisions because the equilibrium leverage ratios are indeterminate. In this section, we extend the simple model by allowing firms to attain different profitability levels in equilibrium, and thus solves the indeterminacy issue of equilibrium leverage ratios.

Profitability-Leverage Puzzle. Based on the extended simple model, we show that the competition-distress feedback effect can reconcile the tradeoff theory of capital structure and the observed negative profitability-leverage relation. The strong inverse relation between profitability and financial leverage in the data is widely regarded as a serious defect of the tradeoff theory of capital structure (e.g., Myers, 1993; Rajan and Zingales, 1995; Fama and French, 2002), because this theory predicts that more profitable firms borrow more and have higher leverage than less profitable firms. This is often referred to as the profitability-leverage puzzle in the literature.¹⁶ Our model highlights the novel insight that the

¹⁶A partial list of papers documenting an inverse relation between leverage and profitability include Titman and Wessels (1988), Fischer, Heinkel and Zechner (1989), Booth et al. (2001), Graham and Tucker (2006), Frank and Goyal (2014), Chen, Harford and Kamara (2019), and Eckbo and Kissner (2021).

negative profitability-leverage relation appears puzzling because profitability is viewed as a predetermined, or even exogenous, firm characteristic for the choice of financial leverage in traditional tradeoff theory. We show that the negative profitability-leverage relation can be rationalized by the tradeoff theory once we recognize that product-market competition (and thus profitability) can be endogenously affected by financial leverage decisions.

Extension: Kreps-Scheinkman Framework. The extension is motivated by the seminal work of [Kreps and Scheinkman \(1983\)](#), who develop a two-stage game-theoretic framework that nests both Cournot and Bertrand models as reduced-form special cases. Many studies develop variants of this Kreps-Scheinkman model to investigate the effect of pre-committed capacity investments (or customer-base investments) on duopoly behavior in price competition.¹⁷

In the extended simple model, there are two stages within each period t . In the first stage, unlike the simple model where customer bases are normalized to unity, firms simultaneously choose their customer bases. In the second stage, similar to the simple model, firms engage in Bertrand-like price competition, subject to a demand-based capacity constraint for production, which is determined by their respective customer-base limits. The extended simple model incorporates the simple model in Section 2 as a special case, as the second stage is the same as the simple model.

We adopt the two-stage framework of [Kreps and Scheinkman \(1983\)](#) for three reasons. First, the literature suggests that Cournot and Bertrand models can be viewed as a reduced-form simplification of more complex, structural, and realistic multi-stage games (e.g., [Kreps and Scheinkman, 1983](#); [Friedman, 1988](#)). Second, as [Vives \(1989\)](#) emphasizes, it is usually more difficult to adjust customer base than the price, and the two-stage model captures this important feature as firms set prices individually once the customer base of each firm is determined. Thus, the two-stage model with demand-based capacity constraints offers a more complete and plausible description of duopolistic competition than parsimonious Cournot and Bertrand models. Third, the two-stage model enables us to obtain closed-form solutions for collusive equilibria, which cannot be achieved by seemingly more tractable Cournot or Bertrand models.

3.1 Model Formulation

Because this model is an extension of the simple model in Section 2, we focus on describing the newly added model ingredients to avoid repetition.

¹⁷Examples include [Benoit and Krishna \(1987\)](#), [Friedman \(1988\)](#), [Deneckere and Kovenock \(1992\)](#), [Herk \(1993\)](#), [Boot and Thakor \(1997\)](#), and [Van Mieghem and Dada \(1999\)](#).

We first explain the demand system that determines (M_1, M_2) in the first stage and (P_1, P_2) and (C_1, C_2) in the second stage. In contrast to the simple model, firms 1 and 2 can choose their customer bases M_1 and M_2 , respectively, knowing that they face a downward-sloping industry-level (inverse) demand function in the first stage:

$$\bar{P} = a - \varepsilon(M_1 + M_2), \quad \text{with } a > 0 \text{ and } \varepsilon > 0, \quad (16)$$

where \bar{P} is the highest price that the firms can charge, and a lower ε reflects a higher cross-industry elasticity of substitution.

In the second stage, conditioning on M_1 and M_2 , firms simultaneously name their prices $P_1, P_2 \in [0, \bar{P}]$, knowing that each firm i will face the following expected demand per unit of customer base:

$$C_i = \begin{cases} 1 + \rho_i P_j^\eta, & \text{if } P_i < P_j \\ 1, & \text{if } P_i = P_j \\ 0, & \text{if } P_i > P_j \end{cases}, \quad \text{with } \rho_i \equiv \rho M_j^\eta \text{ and } i \neq j \in \{1, 2\}, \quad (17)$$

where $\eta > 1$ and $\rho > 0$ satisfy $\rho^{1/\eta} a^2 \leq 4\varepsilon$.

Several points are worth further discussion. First, the demand system of the simple model, specified in (2), is a special case of the general specification in (17). If $M_1 \equiv M_2 \equiv 1$, the demand system (17) is simplified into (2). Second, according to the specification of the two-stage model, the choices of customer bases in the first stage are relatively inflexible ex post in the second stage. This setup captures the stickiness of customer base. Intuitively, within each period, the first stage is a proxy for medium-run competition between firms in developing their customer bases, whereas the second stage describes the subsequent short-run price competition subject to the demand-based capacity constraints imposed by the firms' customer bases. Third, similar to the simple model, the condition $\rho^{1/\eta} a^2 \leq 4\varepsilon$ ensures that the expected total demand $C_1 M_1 + C_2 M_2$ will never go beyond the total customer base $M_1 + M_2$.

Next, we describe the operating profits, idiosyncratic left-tail risk, and default. As in the simple model, firm i 's earnings after interest expenses are specified as $\mathcal{E}_i = P_i \tilde{C}_i - e^{b_i}$, with $\tilde{C}_i = e^{z_i} C_i M_i$, and firm i defaults when $P_i \tilde{C}_i < e^{\varphi(b_i)}$. Similarly, z_i denotes the i.i.d. idiosyncratic demand shock. We define that a left-tail event occurs if $z_i \leq \underline{z}$ for a given threshold $\underline{z} < 0$. The following proposition shows that the probability of the left-tail event increases with ν . The proof is in Online Appendix 1.8.

Proposition 3.1 (Probability of a Left-Tail Event). *Suppose that $z \sim \text{Logistic}(\mu(\nu), \nu)$ where $\mu(\nu)$ is defined in (3). The probability of a left-tail event, $\mathbb{P}\{z \leq \underline{z}\}$, is monotonically increasing in ν .*

We treat industry-level idiosyncratic left-tail risk ν as a crucial and fundamental industry characteristic in our model. In Section 6.4, we provide evidence that the heterogeneity in ν is a crucial determinant of the cross-industry dispersion of financial leverage and profitability, as well as their cross-sectional correlation. Intuitively, ν can be interpreted as the displacement risk caused by drastic innovation;¹⁸ industries in which firms face higher idiosyncratic left-tail risk are those in which firms are more radically innovative.

3.2 Nash Equilibrium

Non-Collusive Equilibrium. The following proposition characterizes non-collusive equilibria. The proof is in Online Appendix 1.9.

Proposition 3.2 (Non-Collusive Equilibrium). *There exists infinitely many non-collusive equilibria, in which firms set $P_1^N = P_2^N = 0$ and $M_1^N + M_2^N \leq a/\varepsilon$. Thus, all non-collusive equilibria feature zero profits and zero equity values ($E_1^N = E_2^N = 0$) for both firms.*

Competition Under Tacit Collusion. Let $\theta_i^C \equiv \ln(P_i^C C_i^C M_i^C)$ denote the log profitability of firm i in the collusive equilibrium. Similar to the simple model in Section 2, we focus on the log profitability levels, (θ_1^C, θ_2^C) , as the strategic variables in characterizing the collusive equilibrium, because firms' equity and debt values are independent of (M_1^C, M_2^C) and (P_1^C, P_2^C) conditioning on (θ_1^C, θ_2^C) . Although the strategic variables that matter for equity and debt values are (θ_1^C, θ_2^C) , firms have to coordinate on both customer bases (M_1^C, M_2^C) in the first stage and prices (P_1^C, P_2^C) in the second stage.

Below, we describe the phase of implicit coordination in which firms tacitly collude to achieve possibly higher profitability levels. Similar to the simple model in Section 2, the two firms' prices must be the same in the collusive equilibrium: $P_1^C = P_2^C = P^C$, because a firm with a higher price than its rival, even if the difference is slight, will have zero profits. As a consequence, the two firms have identical demand per unit of customer base, i.e., $C_1^C = C_2^C = 1$. However, in contrast to the simple model, firms can obtain different levels of profitability (i.e., $\theta_1^C \neq \theta_2^C$) in the second stage because they can choose different levels of customer base M_1^C and M_2^C in the first stage.

We now present firms' potential benefits from deviation and the grim trigger strategy, which ensures that deviant behavior never occurs on the equilibrium path. Firms can deviate

¹⁸Small market followers in an industry are constantly challenging and trying to displace market leaders, and they typically do so through distinctive innovation or rapid business expansion. A change in market leaders does not occur gradually over an extended period; rather, market leaders are displaced rapidly and disruptively (e.g., Christensen, 1997). For instance, Apple and Samsung displaced Nokia and Motorola as new market leaders in the mobile phone industry over a brief period.

from both the agreed customer base scheme (M_1^C, M_2^C) in the first stage and the agreed pricing scheme (P^C, P^C) in the second stage. Specifically, in the second stage, as for the simple model in Section 4, firms can deviate from the tacitly agreed scheme on coordinated prices by setting a price lower than P^C by an infinitesimal margin. Such a deviation would change firms' expected demand per unit of customer base C_1 and C_2 according to the within-industry demand function (17). In the first stage, firms can deviate from the tacitly agreed scheme on coordinated customer base levels M_1^C and M_2^C by developing a larger customer base. Such a deviation would suppress the highest price that firms can charge according to the cross-industry demand function (16).

In response to deviant behavior, the rival will retaliate in the second stage within the same period if the deviation occurs in the first stage, and will retaliate in the next period if the deviation occurs in the second stage. The retaliation is reverting to a non-collusive equilibrium featuring zero profits. Consequently, the deviation will never take place in the first stage. This is because, in response to a firm's deviation in the first stage, the rival immediately retaliates in the second stage by implementing a zero-profit non-collusive strategy and making the first-stage deviation nonprofitable. By contrast, similar to the simple model in Section 2, the deviation can occur in the second stage. To ensure that the second-stage deviation would not happen on the equilibrium path, the coordinated log profitability levels (θ_1^C, θ_2^C) must ensure that the benefit of deviating from P^C in the second stage is lower than the cost of deviation, as captured by the IC constraints, which are identical to equation (7) in the simple model.

Given P^C , firms always have incentives to increase their customer bases, but they face the constraint of $P^C \leq \bar{P}$ where \bar{P} is decreasing in the two firms' total customer base (equation (16)). As a result, the constraint is always binding in equilibrium, that is, $P^C = \bar{P}$, implying that

$$P^C = a - \varepsilon(M_1^C + M_2^C). \quad (18)$$

Thus, according to the definition of θ_i^C and (18), the following identities must hold:

$$e^{\theta_i^C} = [a - \varepsilon(M_1^C + M_2^C)]M_i^C, \quad \text{with } i \in \{1, 2\}. \quad (19)$$

It is clear from (18) and (19) that (θ_1^C, θ_2^C) is sufficient to determine both (M_1^C, M_2^C) and P^C in the collusive equilibrium.

The collusive equilibrium is formally characterized by the following proposition. The proof is in Online Appendix 1.10.

Proposition 3.3 (Collusive Equilibrium). *The equity and debt values of firm i in the collusive*

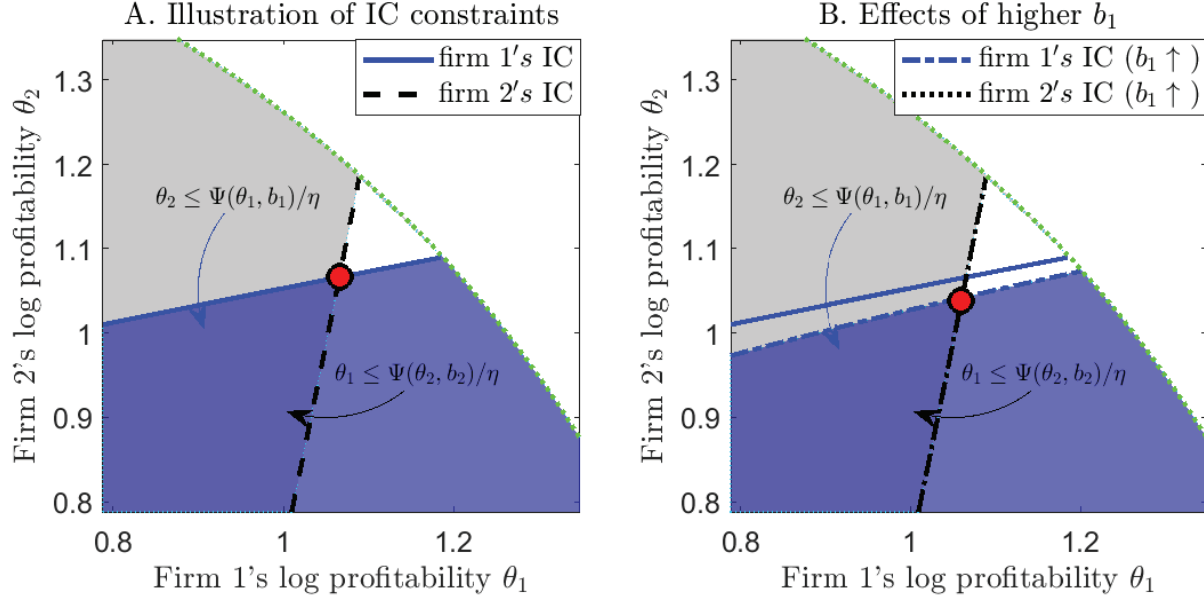


Figure 5. Illustration of the characterization of collusive equilibria and IC constraints in the extended simple model. In panel A, we consider the symmetric case with $b_1 = b_2 = \ln(1.5)$. In panel B, we set $b_1 = \ln(2)$ and $b_2 = \ln(1.5)$. Other parameter values are set at $a = 5$, $\varepsilon = 1$, $\tau = 0.35$, $\bar{\varphi} = 0.2$, $\rho = \exp(-20.5)$, $\eta = 21$, and $\nu = 0.3$.

equilibrium are specified as in the simple model except for replacing θ^C with θ_i^C :

$$E_i^C(b_i, b_j) = (1 - \tau) \left(e^{\theta_i^C} - e^{b_i} \right) \lambda^C(\theta_i^C, b_i)^{-1}, \quad (20)$$

$$D_i^C(b_i, b_j) = e^{b_i} \lambda^C(\theta_i^C, b_i)^{-1}, \quad (21)$$

where θ_i^C is the log profitability of firm i in the collusive equilibrium. We focus on the collusive equilibrium in which (θ_1^C, θ_2^C) is the unique Pareto efficient point of the following IC region in the log-profitability space:

$$\mathcal{C} \equiv \{(\theta_1, \theta_2) : \theta_i \leq \Psi(\theta_j, b_j)/\eta, \text{ with } i \neq j \in \{1, 2\}\}, \quad (22)$$

for b_1 and b_2 such that \mathcal{C} is not empty. The function $\Psi(\theta, b)$ has an identical expression as (11) in the simple model. Consequently, θ_1^C and θ_2^C are solutions of the equations below:

$$\theta_i^C = \Psi(\theta_j^C, b_j)/\eta, \text{ with } i \neq j \in \{1, 2\}. \quad (23)$$

Similar to the simple model, the log profitability levels θ_1^C and θ_2^C are complementary to each other. Recall that $\theta_1^C = \theta_2^C$ must hold in equilibrium in the simple model due to the predetermined customer bases. Here, the complementarity is a result of $\Psi(\theta, b)$ being strictly increasing in θ .

Now, we use Figure 5 to illustrate the central idea of Proposition 3.3. In panels A and B, the region to the southwest of the dotted line is the feasible region, that is, any pair (θ_1, θ_2) to the northeast of the dotted line is not achievable in equilibrium (i.e., the coupled equations in (19) have no solution in terms of (M_1^C, M_2^C)). In panel A, we consider the symmetric case with $b_1 = b_2$. Firm 1's IC constraint is satisfied for the region below the solid line, while firm 2's IC constraint is satisfied for the region to the left of the dashed line. Therefore, the overlapping area of firm 1's and firm 2's IC regions consists of all collusive equilibria with the grim trigger strategy. The large dot at the intersection of the solid and dashed lines represents the unique Pareto efficient collusive equilibrium, denoted by (θ_1^C, θ_2^C) in Proposition 3.3. Panel B considers the case in which b_1 increases, while b_2 is fixed. The dash-dotted lines are new IC constraints. Firm 1's IC constraint shifts downward, whereas firm 2's IC constraint does not change. The large dot at the intersection of the new IC constraints represents the unique Pareto efficient collusive equilibrium, in which both firms have lower profitability than they would obtain in the equilibrium illustrated in panel A. Thus, similar to the simple model in Section 2, the extended simple model can generate the feedback and contagion effects. To avoid repeating the same results, we present them in Online Appendix 1.13.

3.3 Capital Structure Under Strategic Competition

Our primary goal in considering the extended simple model is to illustrate the impact of strategic competition on capital structure choices. Following Leland (1994), we assume that firm i optimally chooses its log coupon b_i to maximize its initial firm value, and b_i remains unchanged afterwards.¹⁹ Each firm maximizes its own value by optimally choosing its leverage, taking the rival's leverage choice as given. The firms do not choose their capital structures to jointly maximize the total value of the industry.

Definition 3.1. *The best response function $\mathbf{b}_i(b_j)$ is defined as follows:*

$$\mathbf{b}_i(b_j) \equiv \operatorname{argmax}_{b_i} V_i^C(b_i, b_j), \quad \text{with } i \neq j \in \{1, 2\}. \quad (24)$$

The equilibrium leverage choices (b_1^C, b_2^C) are determined by the following condition:

$$b_i^C = \mathbf{b}_i(b_j^C), \quad \text{with } i \neq j \in \{1, 2\}. \quad (25)$$

¹⁹Models with a dynamic capital structure (e.g., Goldstein, Ju and Leland, 2001; Hackbarth, Miao and Morellec, 2006; Bhamra, Kuehn and Strebulaev, 2010b; Chen, 2010) allow firms to optimally issue more debt when current cash flows surpass a threshold, which helps generate stationary default rates under a general-equilibrium setup. Adopting the static optimal capital structure makes the model more tractable but does not change the main insights or results of this paper.

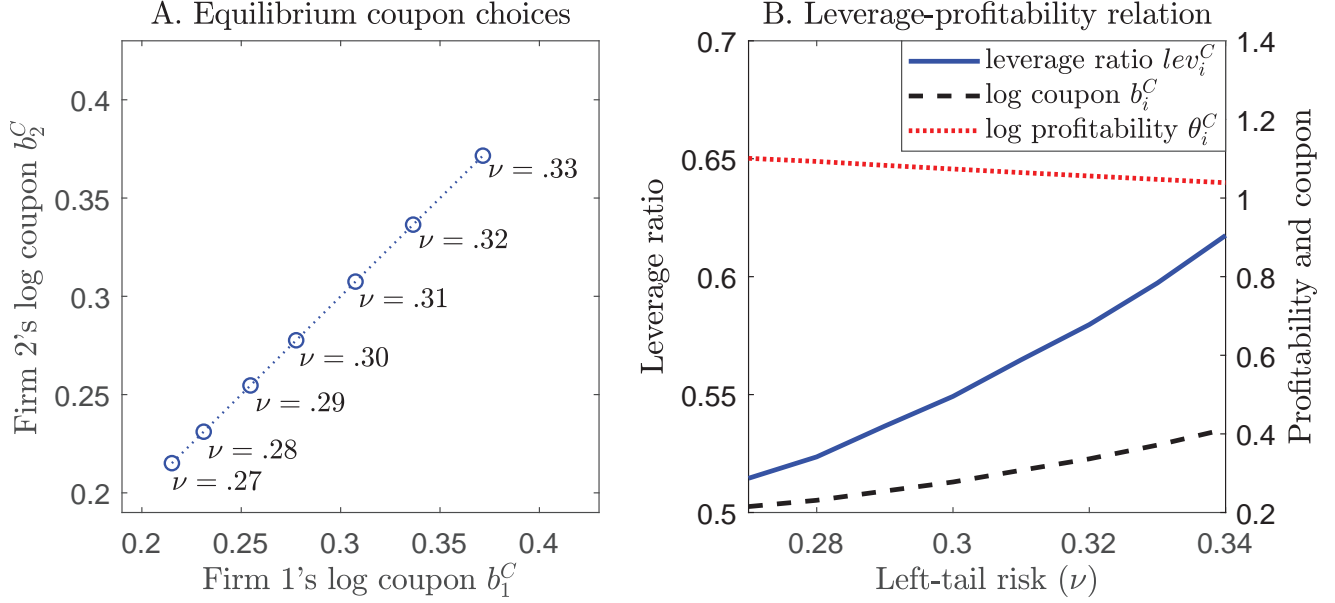


Figure 6. Illustration of the impact of idiosyncratic left-tail risk on financial leverage and product pricing decisions. We set $a = 5$, $\varepsilon = 1$, $\tau = 0.35$, $\bar{\varphi} = 0.2$, $\rho = \exp(-20.5)$, and $\eta = 21$.

Profitability-Leverage Puzzle. As a key contribution, we show that the competition-distress feedback effect rationalizes the profitability-leverage puzzle. The following proposition formalizes this result and the proof is in Online Appendix 1.11.

Proposition 3.4 (Negative Profitability-Leverage Relation). *As idiosyncratic left-tail risk ν increases, the best response functions $\mathbf{b}_1(b_2)$ and $\mathbf{b}_2(b_1)$ shift up. Thus, as ν increases, the equilibrium log coupons b_1^C and b_2^C increase, the equilibrium market leverage ratio $lev_i^C(b_i^C, b_j^C)$ increases, and the equilibrium log profitability $\theta_i^C(b_i^C, b_j^C)$ decreases, with $i \neq j \in \{1, 2\}$.*

Panel A of Figure 6 illustrates the result of Proposition 3.4 that an increase in idiosyncratic left-tail risk ν shifts up both best response functions $\mathbf{b}_1(b_2)$ and $\mathbf{b}_2(b_1)$, thereby raising their intersection point (b_1^C, b_2^C) . Panel B shows that, as ν increases, the leverage ratio $lev_i^C(b_i^C, b_j^C)$ increases, whereas log profitability θ_i^C decreases.

Not only does Proposition 3.4 show how the competition-distress feedback effect rationalizes the observed profitability-leverage puzzle, but it also offers a novel insight into the tradeoff theory of optimal capital structure — the competition-distress feedback effect imposes an additional source of “financial distress costs,” which are incurred to raise leverage. Under traditional tradeoff theory, when a firm raises its leverage, its default probability increases immediately, and thus its financial distress costs also increase due to the ex-post efficiency losses of bankruptcy. Our theory adds a new source of financial distress costs to traditional tradeoff theory. Specifically, we show that an increase in the default probability endogenously reduces the capacity for tacit collusion, thus suppressing the firms’ profitabil-

ity, which in turn leads to the competition-distress feedback loop as illustrated in Figure 4 and Propositions 2.5 and OA.2. Such feedback effects create an additional source of financial distress costs.²⁰

Traditional tradeoff theory appears to conflict with the observed negative relationship between profitability and financial leverage because it assumes that a firm’s capital structure choice is independent of the actions or financial conditions of its peers in the same industry. Recent evidence suggests an important spillover effect of industry rivals’ actions on a firm’s distress level (e.g., Leary and Roberts, 2014; Dou, Johnson and Wu, 2022). Proposition 3.4 shows that industries with higher idiosyncratic left-tail risk (i.e., a higher ν) have higher leverage ratios lev_1^C and lev_2^C , but lower log profitability θ_1^C and θ_2^C ; as a result, profitability and financial leverage are negatively correlated across industries. The reason is that firms in an industry with higher idiosyncratic left-tail risk face a higher likelihood of default and thus find it harder to tacitly collude, which leads to lower profitability. Meanwhile, these industries face a weaker competition-distress feedback effect and thus have lower financial distress costs, which leads to higher optimal financial leverage. In Section 6.4, we provide direct empirical tests of the proposed economic mechanism, under which the heterogeneous idiosyncratic left-tail risk of industries plays a vital role in generating the negative association between profitability and financial leverage in the cross-section of industries.

Excessive Leverage Relative to the Industry’s Optimal Leverage. Under the collusive form of competition, firms do not internalize the impact of their leverage choices on their rivals in the same industry, although they tacitly collude on profitability. As a result, the optimal levels of leverages, which are chosen separately by each firm to maximize individual firm values in a decentralized manner, do not maximize the total market value of the whole industry (i.e., the sum of the values of the firms in the industry).

In particular, the financial contagion effect means that an increase in one firm’s leverage reduces the market value of its rivals in the same industry through a reduction in profit margins and an increase in default probability (see Propositions 2.4 and OA.1). This negative externality implies that the optimal leverage ratios chosen separately by individual firms are likely to be excessively high from the perspective of an industry-level financial planner.²¹ The theoretical setting of an industry-level financial planner is relevant in reality. For instance, in some industries, major firms have the same institutional investors as common owners. The common owners can influence these firms’ leverage decisions so that they are jointly chosen

²⁰Even when the recovery rate is 100% in bankruptcy, the new channel of financial distress costs based on the competition-distress feedback loop holds (see panel A of Figure 11).

²¹An “industry-level financial planner” differs from an “industry-level social planner” because we assume that the former only makes joint decisions on the capital structure of all firms in a given industry, rather than on corporate operations, such as production and product prices.

to maximize the total market value of the firms, although the common owners may not be able to control the firms' production or price-setting decisions.

When a planner jointly chooses leverage levels for both firms, we can define the optimal leverage from an industry perspective as follows:

$$(\bar{b}_1^C, \bar{b}_2^C) \equiv \underset{b_1, b_2}{\operatorname{argmax}} V_1^C(b_1, b_2) + V_2^C(b_2, b_1). \quad (26)$$

Proposition 3.5 (Excessive Leverage). *Under the collusive form of competition, firm leverage is excessively high from an industry perspective, that is, $b_i^C \geq \bar{b}_i^C$ for $i \in \{1, 2\}$.*

4 Full-Fledged Quantitative Model

The simple models developed in Sections 2 and 3 above are based on simplifying assumptions to ensure analytical tractability and closed-form solutions. However, they are not applicable for evaluating the quantitative magnitude of the feedback and contagion effects. In this section, we develop a full-fledged quantitative model that further generalizes the extended simple model in Section 3 along several dimensions. First, the full-fledged quantitative model allows the firm-specific demand dynamics to follow a sequentially dependent process similar to Leland (1994), rather than the i.i.d. process of the simple models. Consequently, the firms' distance-to-default becomes a persistent state variable. Second, the full-fledged quantitative model allows firms to produce differentiated goods, which means that unlike the simple models, firms can set different prices in equilibrium. Third, the full-fledged quantitative model allows firms to make default decisions optimally according to endogenous default boundaries, as in Leland (1994), rather than following exogenously specified default boundaries. Fourth, the full-fledged quantitative model allows for partial recoveries of debt and industry structure changes when default occurs. Specifically, by varying the size of the entrant firms, we analyze industries with different levels of entry barriers to elucidate how entry threats affect rivals' predatory pricing behaviors.

We solve the full-fledged quantitative model numerically. Our goal is threefold. First, we show that the core economic mechanism and its implications highlighted in the simple models remain robust in the full-fledged quantitative model with general and realistic specifications. Second, when parameters are calibrated to match the data moments, the full-fledged quantitative model illuminates the quantitative strength of the mechanism, allowing us to better evaluate its empirical relevance. Finally, the full-fledged quantitative model enables us to study important theoretical implications that are beyond the capacity of the simple models such as the effect of entry barriers on predatory pricing behaviors.

4.1 Model Formulation

The model describes an infinite-horizon economy with continuous time $t \geq 0$ and two firms within the same industry. The continuously compounded risk-free rate is $r_f \geq 0$. At $t = 0$, firms are financed by external equity and long-term consol debt at coupon rate e^{b_i} . Firms engage in Bertrand competition over every instant of time.

Product Market Competition and Cash Flows. Similar to the simple models, firm i 's earnings intensity after interest expenses over $[t, t + dt)$ is

$$\varepsilon_{i,t} = (P_{i,t} - \omega)\tilde{C}_{i,t} - e^{b_i}, \quad \text{with } \tilde{C}_{i,t} = e^{z_{i,t}}C_{i,t}, \quad (27)$$

where $\tilde{C}_{i,t}$ is the demand level, $P_{i,t}$ is the price, ω is the marginal cost of production, and $z_{i,t}$ is the firm-specific demand intensity for firm $i \in \{1, 2\}$. The timeline of a firm's decisions and actions within every instant of time can be summarized as follows. A firm first observes its demand intensity, then names its price and receives the demand for its goods. Next, the firm uses its operating cash flows to make interest payments, and then decides whether to default. Finally, if it chooses not to default, the firm pays taxes and distributes the remaining cash flows to its shareholders as dividends. Specifically, firm i 's earnings intensity after interest expenses and taxes is $(1 - \tau)\varepsilon_{i,t}$, where the corporate tax rate is $\tau \in (0, 1)$.

Within every instant of time $[t, t + dt)$, firms simultaneously name their prices $P_{1,t}$ and $P_{2,t}$, knowing that they face downward-sloping within- and cross-industry demand functions. Once prices are set, the demand levels $\tilde{C}_{1,t}$ and $\tilde{C}_{2,t}$ are determined according to the following demand system. To characterize how industry demand \tilde{C}_t depends on the industry-level price index P_t , we follow the literature (e.g., [Hopenhayn, 1992](#); [Pindyck, 1993](#); [Caballero and Pindyck, 1996](#)) and postulate a downward-sloping isoelastic industry demand curve:

$$\tilde{C}_t = e^{a_t} P_t^{-\epsilon}, \quad (28)$$

where $e^{a_t} \equiv \sum_{i=1}^2 e^{z_{i,t}}$ is the industry-level demand intensity and the coefficient $\epsilon > 1$ captures the industry-level price elasticity of demand.²²

Next, we introduce the demand system for differentiated goods within an industry. Given industry-level demand \tilde{C}_t and price index P_t , consumers decide on a basket of differentiated

²²To microfound such an isoelastic industry demand curve, consider a continuum of industries that exist in the economy and produce differentiated industry-level composite goods. The elasticity of substitution across industry-level composite goods is ϵ and the preference weight for an industry-level composite good is equal to e^{a_t} ([Dou, Ji and Wu, 2021b](#)). The CES utility function that embodies the aggregate preference for diversity over differentiated products can be further microfounded by the characteristics (or address) model and discrete choice theory (e.g., [Anderson, Palma and Thisse, 1989](#)).

goods, which are produced by the two firms, based on the prices $P_{1,t}$ and $P_{2,t}$ charged by firms 1 and 2, respectively. Specifically, industry-level demand \tilde{C}_t equals a Dixit-Stiglitz constant elasticity of substitution (CES) aggregator:

$$\tilde{C}_t = \left[\sum_{i=1}^2 (e^{z_{i,t}-a_t})^{\frac{1}{\eta}} \tilde{C}_{i,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad (29)$$

where $\tilde{C}_{i,t}$ is consumers' demand for firm i 's goods, the parameter $\eta > 1$ captures the elasticity of substitution among goods produced by the two firms in the same industry. Intuitively, the weight $e^{z_{i,t}-a_t}$ captures consumers' relative preference for firm i 's goods. We assume that $\eta \geq \epsilon > 1$, meaning that goods within the same industry are more substitutable than those across industries.²³

From the CES aggregator, the firm-level demand curve immediately follows. Specifically, given the prices $P_{i,t}$ for $i = 1, 2$ and industry-level demand \tilde{C}_t , the demand for firm i 's goods $\tilde{C}_{i,t}$ can be obtained by solving a standard expenditure minimization problem:

$$\tilde{C}_{i,t} = e^{z_{i,t}-a_t} \left(\frac{P_{i,t}}{P_t} \right)^{-\eta} \tilde{C}_t, \quad \text{with the price index } P_t = \left[\sum_{i=1}^2 e^{z_{i,t}-a_t} P_{i,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}. \quad (30)$$

All else equal, the demand for firm i 's goods $\tilde{C}_{i,t}$ increases with consumers' relative preference $e^{z_{i,t}-a_t}$ for firm i 's goods in equilibrium. A larger $e^{z_{i,t}-a_t}$ implies that firm i 's price $P_{i,t}$ has a greater influence on the price index P_t . Because $\tilde{C}_{i,t} = e^{z_{i,t}-a_t} C_{i,t}$, the demand curves at the industry level (28) and the firm level (30) yield:

$$C_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{-\eta} P_t^{-\epsilon}. \quad (31)$$

The short-run price elasticity of demand for firm i 's goods is

$$-\frac{\partial \ln \tilde{C}_{i,t}}{\partial \ln P_{i,t}} = \underbrace{\mu_{i,t} \left[-\frac{\partial \ln \tilde{C}_t}{\partial \ln P_t} \right]}_{\text{cross-industry}} + \underbrace{(1 - \mu_{i,t}) \left[-\frac{\partial \ln(\tilde{C}_{i,t}/\tilde{C}_t)}{\partial \ln(P_{i,t}/P_t)} \right]}_{\text{within-industry}} = \mu_{i,t}\epsilon + (1 - \mu_{i,t})\eta, \quad (32)$$

where $\mu_{i,t}$ is the (revenue) market share of firm i , which equals $\mu_{i,t} = e^{z_{i,t}-a_t} (P_{i,t}/P_t)^{1-\eta}$. Equation (32) shows that the short-run price elasticity of demand is given by the average of η and ϵ , weighted by the firm's market share $\mu_{i,t}$. When its market share $\mu_{i,t}$ shrinks

²³For example, the elasticity of substitution between the Apple iPhone and the Samsung Galaxy is likely to be much higher than that between a cell phone and a cup of coffee. This assumption is consistent with those in the literature (e.g., Atkeson and Burstein, 2008; Corhay, Kung and Schmid, 2020a; Dou, Ji and Wu, 2021a).

(grows), within-industry (cross-industry) competition becomes more relevant for firm i , so its price elasticity of demand depends more on η (ϵ). There are two extreme cases, $\mu_{i,t} = 0$ and $\mu_{i,t} = 1$. In the former case, 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 . In the latter case, firm i monopolizes the industry, and its price elasticity of demand is exactly ϵ .

The firm-specific demand intensity $z_{i,t}$ follows a process with intertemporal dependence:

$$e^{-z_{i,t}} dz_{i,t} = gdt + \zeta dW_t + \sigma dW_{i,t} - dJ_{i,t}, \quad (33)$$

where the parameter g captures the firm's expected growth rate, the standard Brownian motion W_t ($W_{i,t}$) captures aggregate (idiosyncratic) demand shocks, and the Poisson process $J_{i,t}$ with intensity ν captures idiosyncratic left-tail jump shocks in firm i 's cash flows. Firm i exits the industry upon the occurrence of a Poisson shock.²⁴ The shocks W_t , $W_{i,t}$, and $J_{i,t}$ are mutually independent. The coefficient ν captures idiosyncratic left-tail risk.

Several points regarding the shocks are worth mentioning. First, the aggregate Brownian shock W_t in equation (33) is an economy-wide or industry-wide demand shock. Second, the idiosyncratic Brownian shocks, $W_{1,t}$ and $W_{2,t}$, are firm-specific demand shocks. Idiosyncratic shocks are needed for the model to quantitatively match the default frequency and generate a nondegenerate cross-sectional distribution of market shares in the stationary equilibrium. Third, the idiosyncratic left-tail jump shocks, $J_{1,t}$ and $J_{2,t}$, play a crucial role in our theory and empirical results. Idiosyncratic left-tail risk has been proven useful in explaining credit spreads and credit default swap index (CDX) spreads (e.g., [Delianedis and Geske, 2001](#); [Collin-Dufresne, Goldstein and Yang, 2012](#); [Kelly, Manzo and Palhares, 2018](#); [Seo and Wachter, 2018](#)).

In the rest of this section, we focus on illustrating firms' problems under the risk-neutral (Q) measure. Specifically, let γ be the market price of risk for the aggregate shock W_t . Equation (33) can be written as:

$$e^{-z_{i,t}} dz_{i,t} = (g - \zeta\gamma)dt + \zeta dW_t^Q + \sigma dW_{i,t} - dJ_{i,t}, \quad \text{with } dW_t^Q = \gamma dt + dW_t, \quad (34)$$

where dW_t^Q captures the aggregate shocks under the risk-neutral measure. We refer to γ as the "discount rate" in this paper. In [Section 5.2](#) and [Online Appendix 3.3.2](#), we study the role of γ in determining the endogenous distressed competition mechanism. In [Online Appendix 4](#), we further elucidate the asset pricing implications of the distressed competition mechanism by developing a full-fledged quantitative model with aggregate shocks that drive

²⁴Our specification is close to that of [Seo and Wachter \(2018\)](#), who calibrate a disastrous idiosyncratic jump of almost -100% , under which a firm's exit is certain.

time-varying γ_t .

Endogenous Profits and Externalities. Now, we characterize the profitability function. Firm i 's operating profits are

$$(P_{i,t} - \omega) \tilde{C}_{i,t} = \Pi_i(\theta_{i,t}, \theta_{j,t}) e^{z_{i,t}}, \quad \text{with } \Pi_i(\theta_{i,t}, \theta_{j,t}) \equiv \omega^{1-\varepsilon} \theta_{i,t} (1 - \theta_{i,t})^{\eta-1} (1 - \theta_t)^{\varepsilon-\eta}, \quad (35)$$

where $\theta_{i,t}$ and θ_t represent the firm-level and industry-level profit margins,

$$\theta_{i,t} \equiv \frac{P_{i,t} - \omega}{P_{i,t}} \quad \text{and} \quad \theta_t \equiv \frac{P_t - \omega}{P_t}, \quad (36)$$

and it directly follows from equation (30) that the relation between $\theta_{i,t}$ and θ_t is

$$1 - \theta_t = \left[\sum_{i=1}^2 e^{z_{i,t} - a_t} (1 - \theta_{i,t})^{\eta-1} \right]^{\frac{1}{\eta-1}}. \quad (37)$$

Equation (35) shows that firm i 's profits depend on its rival j 's profit margin $\theta_{j,t}$ through the industry's profit margin θ_t . This reflects the externality of firm j 's profit margin decisions. For example, holding firm i 's profit margin fixed, if firm j cuts its profit margin $\theta_{j,t}$, the industry's profit margin θ_t will drop, which will reduce the demand for firm i 's goods $C_{i,t}$ (see equation (31)), compromising firm i 's profits. Below, we explain the Nash equilibrium, which determines the profit margin strategies $(\theta_{1,t}, \theta_{2,t})$.

Financial Distress. Firm i can optimally choose to file for bankruptcy and exit when its equity value drops to zero because of negative shocks to the demand intensity $z_{i,t}$. As in the simple models, to maintain tractability, a new firm enters the industry only after an incumbent firm exits. However, the new firm has an initial demand intensity $e^{z_{new}} = \kappa e^{z_{j,t}} > 0$ and an optimally chosen coupon rate $e^{b_{new}}$. The parameter $\kappa > 0$ captures the size of the new entrant relative to the surviving incumbent firm j . Intuitively, a larger κ reflects a higher entry threat to the incumbent. Upon entry, the dynamic game of industry competition, which we describe in Section 4.2 below, is "reset" to a new one between the surviving incumbent firm and the new entrant

4.2 Nash Equilibrium

Non-Collusive Equilibrium. The two firms in an industry play a supergame (Friedman, 1971), in which the stage games of setting profit margins are continuously played and

infinitely repeated with exogenous and endogenous state variables varying over time. All strategies depend on “payoff-relevant” states $z_t \equiv \{z_{1,t}, z_{2,t}\}$ in the state space \mathcal{Z} , as in Maskin and Tirole (1988a,b).

Specifically, the non-collusive equilibrium is characterized by a profit-margin-setting scheme $\Theta^N(\cdot) = (\theta_1^N(\cdot), \theta_2^N(\cdot))$, which is a pair of functions defined in the state space \mathcal{Z} , such that firm i 's equity value $E_i^N(z_t)$ is maximized by choosing the profit margin $\theta_i^N(z_t)$, under the assumption that its rival j will stick to the non-collusive profit margin $\theta_j^N(z_t)$.

We denote by $z_i^N(z_{j,t})$ firm i 's endogenous default boundary with respect to $z_{i,t}$ in the non-collusive equilibrium; importantly, the endogenous default boundary of firm i depends on its rival's demand intensity $z_{j,t}$. Following the recursive formulation in dynamic games for characterizing the Nash equilibrium (e.g., Pakes and McGuire, 1994; Ericson and Pakes, 1995), we formulate the optimization problems, conditioning on $z_{i,t} > z_i^N(z_{j,t})$ for $i \neq j \in \{1, 2\}$, as a pair of Hamilton-Jacobi-Bellman (HJB) equations:

$$r_f E_i^N(z_t) dt = \max_{\theta_{i,t}} (1 - \tau) \left[\Pi_i(\theta_{i,t}, \theta_{j,t}^N) e^{z_{i,t}} - e^{b_i} \right] dt + \mathbb{E}_t^Q[dE_i^N(z_t)], \quad (38)$$

where $i \neq j \in \{1, 2\}$, $\mathbb{E}_t^Q[\cdot]$ represents the expectation under the risk-neutral measure conditioning on the information set up to t , $\theta_{i,t}^N \equiv \theta_i^N(z_t)$, and $\Pi_i(\theta_{i,t}, \theta_{j,t}^N)$ is defined in (35). The coupled HJB equations provide the solutions for the non-collusive profit margins $\theta_1^N(z_t)$ and $\theta_2^N(z_t)$.

At the default boundary $z_i^N(z_{j,t})$ of firm i , the equity value of firm i is equal to zero (i.e., the value matching condition), and the optimality of the default boundary implies the smooth pasting condition:

$$E_i^N(z_t) \Big|_{z_{i,t}=z_i^N(z_{j,t})} = 0 \quad \text{and} \quad \frac{\partial}{\partial z_{i,t}} E_i^N(z_t) \Big|_{z_{i,t}=z_i^N(z_{j,t})} = 0, \quad \text{respectively.} \quad (39)$$

As $z_{i,t} \rightarrow +\infty$, firm i becomes an industry monopoly, which sets an asymptotic boundary condition (see Online Appendix 3.7). The value matching and smooth pasting conditions in (39) ensures that the smooth-pasting condition with respect to $z_{j,t}$ holds in equilibrium, i.e., $\frac{\partial}{\partial z_{j,t}} E_i^N(z_t) \Big|_{z_{i,t}=z_i^N(z_{j,t})} = 0$. This property may not hold generally in other corporate liquidity models with multiple state variables and multiple boundaries (e.g., Chao and Ward, 2022; Chen et al., 2022; Kakhbod et al., 2022). We provide detailed proofs and discussions in Online Appendix 3.6.

Competition Under Tacit Collusion. Our main focus is the collusive equilibrium, which is sustained using the non-collusive equilibrium as a punishment strategy. Firms tacitly collude

with each other in setting higher profit margins, with any deviation potentially triggering a switch to the non-collusive equilibrium.

In the collusive equilibrium, strategies not only depend on “payoff-relevant” states $z_t \equiv \{z_{1,t}, z_{2,t}\}$, but also on a pair of indicator functions that track whether either firm has previously deviated from the collusive agreement, as in [Fershtman and Pakes \(2000, p. 212\)](#).²⁵ Consider a generic collusive equilibrium in which the two firms follow a collusive profit-margin-setting scheme. If one firm deviates from the collusive profit-margin-setting scheme, then with a probability of ζdt over $[t, t + dt)$, the other firm will implement a punishment strategy, under which it will forever set the non-collusive profit margin. We use an idiosyncratic Poisson process $N_{i,t}$ with intensity ζ to characterize whether a firm can successfully implement a punishment strategy after the rival’s deviation.²⁶ Thus, a higher ζ makes the threat of punishment more credible, which reduces incentives to deviate and enables collusion at higher profit margins.

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

$$E_i^N(z) \leq E_i^C(z), \text{ for all } z \in \mathcal{Z}, \text{ and} \quad (\text{PC}) \quad (40)$$

$$E_i^D(z) \leq E_i^C(z), \text{ for all } z \in \mathcal{Z}, \quad (\text{IC}) \quad (41)$$

where $i \in \{1, 2\}$, $E_i^D(z)$ is firm i ’s equity value if it chooses to deviate from collusion, and $E_i^C(z)$ is firm i ’s equity value in the collusive equilibrium.

We denote by $\underline{z}_i^C(z_{j,t})$ firm i ’s endogenous default boundary with respect to $z_{i,t}$ in the collusive equilibrium. Conditional on $z_{i,t} > \underline{z}_i^C(z_{j,t})$ for $i \neq j \in \{1, 2\}$, the value functions $E_i^C(z)$ satisfy the following coupled HJB equations:

$$r_f E_i^C(z_t) dt = (1 - \tau) [\Pi_i(\theta_{i,t}^C, \theta_{j,t}^C) e^{z_{i,t}} - e^{b_i}] dt + \mathbb{E}_t^Q [dE_i^C(z_t)], \quad (42)$$

subject to the PC constraint (40) and the IC constraint (41),

where $i \neq j \in \{1, 2\}$, $\theta_{i,t}^C \equiv \theta_i^C(z_t)$, and $\Pi_i(\theta_{i,t}, \theta_{j,t})$ is defined in (35).

The optimal default boundaries, $\underline{z}_1^C(z_{2,t})$ and $\underline{z}_2^C(z_{1,t})$, are endogenously determined by

²⁵For notational simplicity, we omit the indicator states of historical deviations.

²⁶One interpretation of $N_{i,t}$ is that, with a probability of $1 - \zeta dt$ over $[t, t + dt)$, the deviator can persuade its rival not to enter the non-collusive equilibrium over $[t, t + dt)$. Ex-post renegotiations can occur because the non-collusive equilibrium is not renegotiation-proof or “immune to collective rethinking” ([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 the indeterminacy of outcomes (e.g., [Simon and Stinchcombe, 1989](#); [Bergin and MacLeod, 1993](#)).

the following value matching and smooth pasting conditions:

$$E_i^C(z_t) \Big|_{z_{i,t}=\underline{z}_i^C(z_{j,t})} = 0 \quad \text{and} \quad \frac{\partial}{\partial z_{i,t}} E_i^C(z_t) \Big|_{z_{i,t}=\underline{z}_i^C(z_{j,t})} = 0, \quad \text{respectively.} \quad (43)$$

The boundary condition at $z_{i,t} \rightarrow +\infty$ is identical to that in the non-collusive equilibrium. This is because when $z_{i,t} \rightarrow +\infty$, firm i is essentially an industry monopoly and there is no benefit from collusion.

Equilibrium Deviation Values. We denote by $\underline{z}_i^D(z_{j,t})$ firm i 's endogenous default boundary with respect to $z_{i,t}$ if firm i deviates from collusion and its rival j continues to follow the collusive profit-margin-setting scheme. Conditional on $z_{i,t} > \underline{z}_i^D(z_{j,t})$ for $i \neq j \in \{1, 2\}$, the value functions $E_i^D(z)$ satisfy the following coupled HJB equations:

$$\begin{aligned} r_f E_i^D(z_t) dt = \max_{\theta_{i,t}} (1 - \tau) [\Pi_i(\theta_{i,t}, \theta_{j,t}^C) e^{z_{i,t}} - e^{b_i}] dt \\ - \zeta [E_i^D(z_t) - E_i^N(z_t)] dt + \mathbb{E}_t^Q [dE_i^D(z_t)], \end{aligned} \quad (44)$$

where $i \neq j \in \{1, 2\}$, $\theta_{i,t}^C \equiv \theta_i^C(z_t)$, and $\Pi_i(\theta_{i,t}, \theta_{j,t})$ is defined in (35).

The optimal default boundaries, $\underline{z}_1^D(z_{2,t})$ and $\underline{z}_2^D(z_{1,t})$, are endogenously determined by the value matching and smooth pasting conditions:

$$E_i^D(z_t) \Big|_{z_{i,t}=\underline{z}_i^D(z_{j,t})} = 0 \quad \text{and} \quad \frac{\partial}{\partial z_{i,t}} E_i^D(z_t) \Big|_{z_{i,t}=\underline{z}_i^D(z_{j,t})} = 0, \quad \text{respectively.} \quad (45)$$

The boundary condition at $z_{i,t} \rightarrow +\infty$ is identical to that in the non-collusive equilibrium.

Two points require discussion. First, the PC constraint (40) can become binding in the collusive equilibrium, triggering the two firms to switch to the non-collusive equilibrium. The endogenous switch captures the endogenous outbreak of price wars. We assume that once the two firms switch to the non-collusive equilibrium, they will stay there forever.²⁷ Endogenous switching from the collusive to the non-collusive equilibrium because of increased financial distress (i.e., higher leverage ratios) is one of our model's key differences from that of [Dou, Ji and Wu \(2021a\)](#), in which firms are financed wholly by equity and never suffer from financial distress. In their model, the PC constraint is never binding because higher profit margins always lead to higher equity values in the absence of financial distress costs owing to costly default or exit.

²⁷As the firm that proposes switching to the non-collusive equilibrium is essentially deviating, we assume that the two firms will not return to the collusive equilibrium. We make this assumption to be consistent with our specification for the punishment strategy.

Second, there exist infinitely many elements in the set of incentive compatible collusion agreements, \mathcal{C} , and hence infinitely many collusive equilibria. We focus on a subset of \mathcal{C} , denoted by $\bar{\mathcal{C}}$, consisting of all profit-margin-setting schemes $\Theta^C(\cdot)$ such that the IC constraints (41) are binding state by state, that is, $E_i^D(z_t) = E_i^C(z_t)$ for all $z_t \in \mathcal{Z}$ and $i \in \{1, 2\}$.²⁸ The subset $\bar{\mathcal{C}}$ is nonempty because it contains the profit-margin-setting scheme in the non-collusive equilibrium. We further narrow our focus to the ‘‘Pareto-efficient frontier’’ of $\bar{\mathcal{C}}$, denoted by $\bar{\mathcal{C}}_p$, consisting of all pairs of $\Theta^C(\cdot)$ such that there does not exist another pair $\tilde{\Theta}^C(\cdot) = (\tilde{\theta}_1^C(z_t), \tilde{\theta}_2^C(z_t)) \in \bar{\mathcal{C}}$ such that $\tilde{\theta}_i^C(z_t) \geq \theta_i^C(z_t)$ for all $z_t \in \mathcal{Z}$ and $i \in \{1, 2\}$, with strict inequality held for some i and z_t .²⁹ Our numerical algorithm is similar to that of [Abreu, Pearce and Stacchetti \(1990\)](#).³⁰ Deviation never occurs on the equilibrium path. The one-shot deviation principle ([Fudenberg and Tirole, 1991](#)) makes it clear that the collusive equilibrium characterized above is subgame perfect.

Debt Value. The debt value equals the sum of the present value of cash flows that accrue to debtholders until the occurrence of an endogenous default or an idiosyncratic left-tail jump shock (i.e., exogenous displacement), whichever occurs first, plus the recovery value. We follow the literature on dynamic debt models (e.g., [Mello and Parsons, 1992](#); [Leland, 1994](#); [Hackbarth, Miao and Morellec, 2006](#)) and set the recovery value of endogenous default to a fraction $\delta \in (0, 1)$ of the firm’s unlevered asset value, $A_i^C(z_t)$, which is the value of an all-equity firm. In the collusive equilibrium, the unlevered asset value $A_i^C(z_t)$ is similarly determined by equations (38) to (45) with the IC and PC constraints satisfied, except that we set $b_i = 0$ and remove the default boundary conditions (39), (43), and (45).

The value of debt in the non-default region of the collusive equilibrium (i.e., $z_{i,t} > \underline{z}_i^C(z_{j,t})$ for $i \neq j$), denoted by $D_i^C(z_t)$, can be characterized by the following coupled HJB equations:

$$r_f D_i^C(z_t) dt = e^{b_i} dt + \mathbb{E}_t^Q[dD_i^C(z_t)], \quad \text{for } i = 1, 2, \quad (46)$$

²⁸This equilibrium refinement is similar in spirit to [Abreu \(1988\)](#), [Alvarez and Jermann \(2000, 2001\)](#), and [Opp, Parlour and Walden \(2014\)](#)

²⁹One can show that the ‘‘Pareto-efficient frontier’’ is nonempty based on the fundamental theorem of the existence of Pareto-efficient allocations (e.g., [Mas-Colell, Whinston and Green, 1995](#)), as $\bar{\mathcal{C}}$ is nonempty and compact, and the order that we consider is complete, transitive, and continuous.

³⁰Alternative methods include those of [Pakes and McGuire \(1994\)](#) and [Judd, Yeltekin and Conklin \(2003\)](#), who use similar ingredients to this paper in their solution method. Proving the uniqueness of the equilibrium under our selection criterion is beyond the scope of this paper. We use different initial points in our numerical algorithm and find robust convergence to the same equilibrium. We provide rigorous proof of the uniqueness in the simple models of Sections 2 and 3.

with the following boundary conditions:

$$D_i^C(z_t) \Big|_{z_{i,t}=z_i^C(z_{j,t})} = \delta A_i^C(z_t) \Big|_{z_{i,t}=z_i^C(z_{j,t})} \quad \text{and} \quad \lim_{z_{i,t} \rightarrow +\infty} D_i^C(z_t) = \frac{e^{b_i}}{r_f + \nu}. \quad (47)$$

In equation (47), the first condition is the recover value to debtholders at the default boundary. The second condition captures the asymptotic behavior of debt when $z_{i,t} \rightarrow \infty$; in this case, the default risk of firm i arises only from the idiosyncratic left-tail jump shock, which occurs at a rate of ν .

Optimal Coupon Choice. We now illustrate the optimal initial coupon choice of firms at $t = 0$. The log coupon rates b_1 and b_2 are optimally determined in the Nash equilibrium, as in the extended simple model in Section 3. The best response function $\mathbf{b}_i(b_j)$ is defined as follows:

$$\mathbf{b}_i(b_j) \equiv \operatorname{argmax}_{b_i} V_i^C(z_0; b_i, b_j), \quad \text{with } i \neq j \in \{1, 2\}, \quad (48)$$

where the initial firm value is $V_i^C(z_0; b_i, b_j) \equiv E_i^C(z_0; b_i, b_j) + D_i^C(z_0; b_i, b_j)$. The equilibrium leverage (b_1^C, b_2^C) is determined by the following condition:

$$b_i^C = \mathbf{b}_i(b_j^C), \quad \text{for } i \neq j \in \{1, 2\}. \quad (49)$$

5 Quantitative Results

5.1 Calibration and Parameter Choices

Panel A of Table 1 presents the externally calibrated parameters. The risk-free rate is set at $r_f = 5\%$, following [Chen et al. \(2018\)](#). The within-industry elasticity of substitution is set at $\eta = 15$, and the cross-industry price elasticity of demand at $\epsilon = 2$, which are broadly consistent with the calibration and estimation in the IO and international trade literature (e.g., [Harrigan, 1993](#); [Head and Ries, 2001](#); [Atkeson and Burstein, 2008](#)). We set $g = 1.8\%$, $\gamma = 0.4$, and $\zeta = 10\%$ as in [He and Milbradt \(2014\)](#), which implies a drift of $g - \zeta\gamma = -2.2\%$ under the risk-neutral measure (see equation (34)). The tax rate effectively captures the tax-shield benefit of debt in our model. We thus set $\tau = 20\%$ following the literature.³¹ We normalize the two firms in the same industry to have unit consumer demand intensity

³¹Following [Graham \(2000\)](#), [Chen \(2010\)](#) calibrates a corporate tax rate of 35%, a personal dividend income tax rate of 12%, and a personal interest income tax rate of 29.6%. The implied effective tax rate for the net tax-shield benefit of debt is $1 - (1 - 35\%)(1 - 12\%)/(1 - 29.6\%) = 18.75\%$.

Table 1: Calibration and parameter choices.

Panel A: Externally determined parameters.					
Parameter	Symbol	Value	Parameter	Symbol	Value
Risk-free rate	r_f	5%	Within-industry elasticity	η	15
Industry price elasticity	ϵ	2	Growth rate of cash flows	g	1.8%
Market price of risk for W_t	γ	0.4	Volatility of aggregate shocks	ζ	10%
Tax rate	τ	20%	Relative size of new entrants	κ	0.3
Initial demand intensity	$z_{1,0}, z_{2,0}$	0	Idiosyncratic left-tail risk	ν	0

Panel B: Internally calibrated parameters and targeted moments.					
Parameter	Symbol	Value	Moments	Data	Model
Recovery ratio of assets	δ	47%	Average leverage ratio (Baa rated)	34%	36%
Volatility of idiosyncratic shocks	σ	24%	10-year default rate (Baa rated)	4.9%	4.8%
Marginal cost of production	ω	3.21	Average net profitability	3.9%	3.9%
Punishment rate	ξ	9%	Average gross profit margin	31.4%	29.7%

initially, i.e., $z_{1,0} = z_{2,0} = 0$. The parameter κ is inversely related to entry barrier because a smaller κ leads to a smaller new entrant relative to the size of the surviving incumbent (i.e., a smaller κ leads to a weaker entry threat). As a benchmark, we calibrate $\kappa = 0.3$, indicating that the new entrant is initially 30% of the size of the surviving incumbent. In Section 5.2, we show that the behavior of predatory pricing, as a strong form of contagion effects, becomes particularly prevalent when κ is sufficiently low (i.e., when the entry barrier is high). We set $\nu = 0$ in our benchmark calibration, and in Section 5.3 we analyze how the cross-industry dispersion in ν explains the observed negative relation between profitability and leverage ratios across industries.

The remaining parameters are calibrated by matching the relevant moments summarized in panel B of Table 1. When constructing the model moments, we simulate one industry for 20 years.³² We then compute the model counterparts of the data. For each moment, the table reports the average value of 100,000 independent simulations. We set $\delta = 47\%$ so that the model-implied average leverage ratio (i.e., the debt-to-asset ratio) is 36%, consistent with the data.³³ We set the volatility of idiosyncratic shocks at $\sigma = 24\%$ to match the 10-year

³²We focus on the initial 20 years of simulation because our model has a static capital structure, i.e., coupons are optimally chosen at $t = 0$ and firms are not allowed to adjust their coupons until the occurrence of default. We emphasize that although our model allows for a stationary distribution in the long run, it is achieved by the exit and entry assumption rather than by the dynamic leverage adjustment that is adopted in models of dynamic capital structure (e.g., Goldstein, Ju and Leland, 2001).

³³The implied average bond recovery rate (i.e., the defaulted bond price divided by its promised face value) is close to 41% according to the estimate of Chen (2010) based on Moody's corporate default recovery rates from 1920 to 2008. It is slightly higher than the 37% that Dou et al. (2021a) estimate for the average debt recovery rate of U.S. large bankrupt firms from 1996 to 2014, and slightly higher than the 34.39% that Dou,

default rate of 4.9% estimated by [Chen \(2010\)](#). The marginal cost of production ω is a scaling parameter, which does not affect the model’s quantitative implications. We calibrate its value at $\omega = 3.21$ to match the average net profitability of 3.9% estimated in our sample. We set the punishment rate $\xi = 9\%$ so that the average gross profit margin implied by the model is 29.7%, consistent with the value in our sample. In the data, net profitability and gross profit margins are measured following [Dou, Ji and Wu \(2021a\)](#).

Our calibrated model implies a credit spread of 97 basis points, lower than the credit spread for investment-grade bonds in the data, which is known as the credit spread puzzle. In our model, the credit risk premium generated by the aggregate shock W_t is not high enough. The literature (e.g., [Chen, Collin-Dufresne and Goldstein, 2008](#)) indicates that it is crucial to account for time-varying discount rates and countercyclical default boundaries in the model to generate a credit spread for investment-grade bonds consistent with the data. In [Online Appendix 4](#), we extend the full-fledged quantitative model by incorporating these ingredients to generate a sufficiently sizable credit spread that matches the data.

5.2 Impact of Market Structure

Through the lens of the calibrated quantitative model, we quantify the competition-distress feedback effect and the financial contagion effect through distressed competition in [Online Appendices 3.2](#) and [3.3](#). In this subsection, we evaluate how the feedback and contagion effects alter as the market structure of industries varies.

Price Elasticity of Demand. The cross-industry price elasticity of demand, ϵ , reflects the extent to which the products of an industry are substitutable with those of other industries. Focusing on the collusive equilibrium, panel A of [Figure 7](#) illustrates how the industry price elasticity of demand influences the competition-distress feedback effect. One way to measure the magnitude of the feedback effect is to examine the sensitivity of profit margins to changes in the discount rate γ , as defined in [\(34\)](#). Intuitively, a rise in γ would effectively increase leverage as it would suppress the equity value more than the debt value, and according to [Propositions 2.5](#) and [OA.2](#), the magnitude of the resulting decrease in profit margins reflects the strength of the competition-distress feedback effect.

The solid (dashed) line in panel A of [Figure 7](#) plots the profit-margin beta to the discount rate γ under the duopoly market structure with industry’s price elasticity of demand set at $\epsilon = 2(2.5)$ and the number of market leaders set at $n = 2$. Relative to the baseline case

[Wang and Wang \(2022\)](#) estimate for the average recovery rate of U.S. firms’ senior unsecured and subordinate bonds based on the NYU-Salomon Center Default database from 2000 to 2019. [Collin-Dufresne, Goldstein and Yang \(2012\)](#) and [Seo and Wachter \(2018\)](#) use a 40% recovery rate in normal times to match CDX spreads.

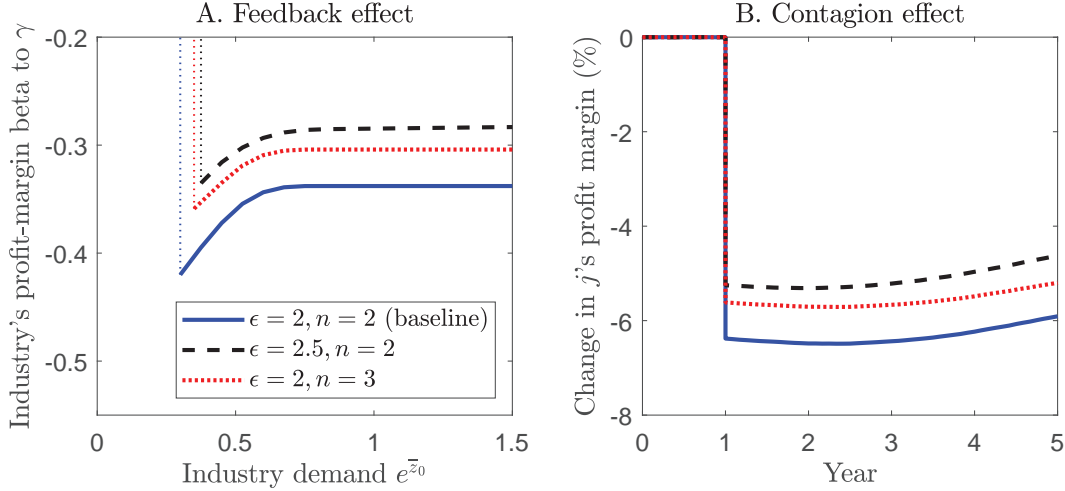


Figure 7. Feedback and contagion effects under various market structures. In panel A, the industry's profit-margin beta at $t = 0$ is approximated by $\beta^\theta(\bar{z}_0) \equiv \theta^C(\bar{z}_0; \gamma_H) / \theta^C(\bar{z}_0; \gamma_L) - 1$, where $\gamma_L = 0.4$, $\gamma_H = 0.9$, and firms have identical demand intensity $z_{1,0} = z_{2,0} = \bar{z}_0$ for expository purposes. The three vertical dotted lines represent firms' default boundaries corresponding to each market structure with $\gamma = \gamma_H$. In both panels, firms' coupon rates corresponding to each market structure are set at e^{b^C} , which is the optimal coupon rate in the collusive equilibrium when both firms have unit demand (i.e., $e^{\bar{z}_0} = 1$) and the discount rate is γ_L . Parameters are calibrated as in Table 1.

($\epsilon = 2, n = 2$), the profit-margin beta is less negative in the case with $\epsilon = 2.5$, especially when the industry is close to the default boundary (i.e., the dashed line is flatter than the solid line). Intuitively, firms find it harder to tacitly collude on high profit margins when the industry's price elasticity of demand is higher, because they would suffer more when the rival firm deviates due to a larger loss of industry-level demand. The weakened collusion capacity reduces the response of profit margins to changes in the distance-to-default, and thus dampens the competition-distress feedback loop, which in turn makes the profit-margin beta to γ less negative, especially when the industry is close to the default boundary.

To examine the impact of the industry's price elasticity of demand on the financial contagion effect, we conduct impulse-response experiments. In particular, we measure the within-industry contagion effect on profit margins by computing the percentage change in firm j 's profit margin, relative to the counterfactual scenario without shocks, in response to an unexpected idiosyncratic shock that increases the coupon rate of firm i at $t = 1$.³⁴ Panel B of Figure 7 shows that the contagion effect on profit margins becomes less significant as the industry's price elasticity of demand ϵ increases. Intuitively, the financial contagion effect through the distressed competition channel becomes weaker when ϵ is higher because the collusion capacity declines.

³⁴That is, firm i 's coupon rate e^{b_i} increases unexpectedly from e^{b^C} to $e^{b_i^{shock}}$. The value of $e^{b_i^{shock}}$ is chosen so that firm i 's leverage ratio increases by 10% at $t = 1$, similar to the experiment described for Figure 3 in Online Appendix 3.2.

Number of Market Leaders. The number of market leaders reflects the extent to which the industry is concentrated among the major players. Panel A of Figure 7 illustrates how the number of market leaders in an industry influences the competition-distress feedback effect in the collusive equilibrium. The dotted line plots the profit-margin beta to the discount rate γ under the market structure with $(\epsilon = 2, n = 3)$. Relative to the baseline case $(\epsilon = 2, n = 2)$, the profit-margin beta is less negative in the case with $n = 3$, especially when the industry is close to the default boundary (i.e., the dotted line is flatter than the solid line). Intuitively, it is harder for firms to tacitly collude on high profit margins when there are more firm, because a larger number of IC constraints need to be satisfied to sustain coordination. The weakened collusion capacity reduces the response of profit margins to changes in the leverage ratio, and thus dampens the competition-distress feedback loop. It thereby leads to a less negative profit-margin beta with respect to γ , especially when the industry is close to the default boundary. To examine the impact of industry concentration on the financial contagion effect, we conduct impulse-response experiments. Panel B of Figure 7 shows that the contagion effect on profit margins becomes less pronounced as industry concentration decreases, i.e., as n increases.

Entry Barriers and Predatory Pricing. Higher entry barriers lead to stronger competition-distress feedback and financial contagion effects, because a relatively healthy firm has stronger predatory incentives when its rival firm becomes more distressed in an industry with higher entry barriers. The central idea of the predatory pricing strategy is the attempt to gain monopolistic rents (or, in general, high market power) in the long run at the cost of a short-run increase in distress risk due to narrowed profit margins. Specifically, although the healthy firm that engages in predatory pricing behavior forces lower profit margins and higher distress risk on itself in the short run, once its major competitor is eliminated, in the long run, the firm will dominate the market and raise its profit margin to recoup the profits it lost during the period of predatory pricing. However, predatory pricing incentives are weak in industries with low entry barriers because major new competitors can easily enter the market.

In Figure 8, we show that our model can generate full-blown predatory price wars when $\kappa = 0$, which represents an industry with sufficiently high entry barrier that new entrants are negligible in size relative to incumbent firms. In particular, we consider a setting in which firms have unit initial demand intensity (i.e., $e^{z_{1,0}} = e^{z_{2,0}} = 1$). Holding firm j 's log coupon rate b_j at the optimal level b^C at $t = 0$ in the collusive equilibrium, panels A and B of Figure 8 demonstrate how varying firm i 's log coupon rate b_i influences the profit margins of firm i and j , respectively, as a function of firm i 's leverage ratio $lev_{i,0}$ at $t = 0$.

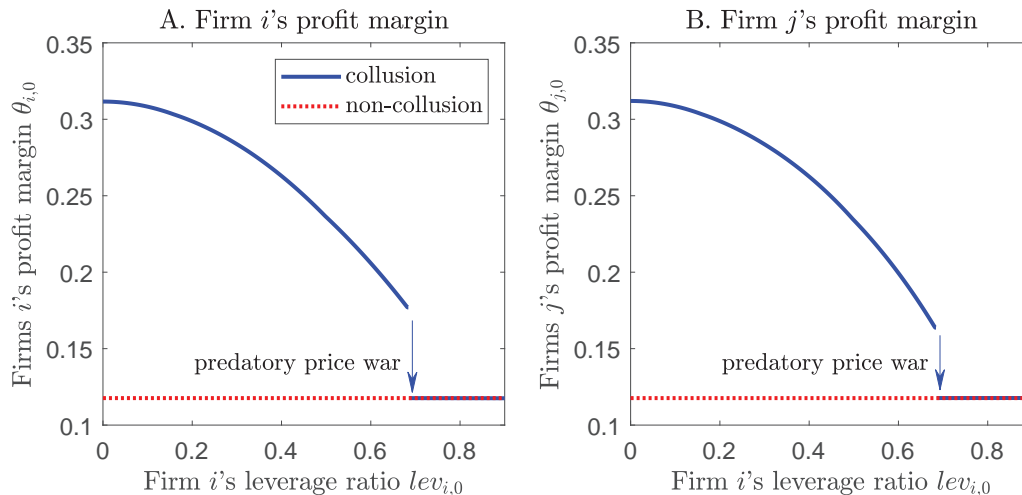


Figure 8. Predatory pricing behavior and full-blown predatory price war. The solid and dotted lines represent the collusive and non-collusive equilibrium, respectively. The vertical arrows represent the jump in collusive profit margins as the equilibrium endogenously switches from collusion to non-collusion when firm i 's leverage ratio is above a threshold (see Online Appendix 3.5 for more discussions). Parameters are calibrated as in Table 1 except for $\kappa = 0$.

As firm i 's leverage ratio $lev_{i,0}$ increases, both firms' profit margins decrease in the collusive equilibrium (shown by the solid lines in Figure 8). By contrast, the firms' profit margins remain unchanged in the non-collusive equilibrium (shown by the dotted lines in Figure 8). Notably, the firms' profit margins in the collusive equilibrium fall to the level of the non-collusive equilibrium when firm i 's leverage ratio $lev_{i,0}$ is greater than 0.68. This explains how the full-blown predatory price war occurs endogenously in our model. As we discuss in Online Appendix 3.5, firm j 's PC constraint (40) becomes binding when firm i 's leverage ratio $lev_{i,0}$ is above 0.68. As a result, firm j will choose not to collude with firm i . Intuitively, in this region, firm i is close to its default boundary, and thus, from firm j 's perspective, the optimal strategy is to drive its competitor out of the market, so that it can monopolize the industry and enjoy much higher profit margins in the future. This motivates firm j to wage a price war against firm i by abandoning the collusive agreement and switching to the non-collusive equilibrium. Thus, our model implies that the within-industry contagion effect on profit margins is more dramatic in industries with higher entry barriers.

We further study the central intertemporal tradeoff behind the predatory pricing strategy — the tradeoff between long-run monopolistic rents versus short-run distress risk — by examining the dynamic effects of financial contagion in the industry with $\kappa = 0$. Specifically, in Figure 9, we consider two distressed firms with the same initial demand intensity, $e^{z_{1,0}} = e^{z_{2,0}} = 0.5$, and high leverage ratios at $t = 0$.³⁵ At $t = 1$, there is an adverse distress

³⁵To generate predatory pricing behavior, it is not necessary for both firms to be distressed (e.g., in Figure 8, only firm i is distressed, not firm j). We consider initially distressed firms for illustrative purposes. Our results are related to Wiseman (2017), who shows that in a market with exits but no entries, the financially strong firm

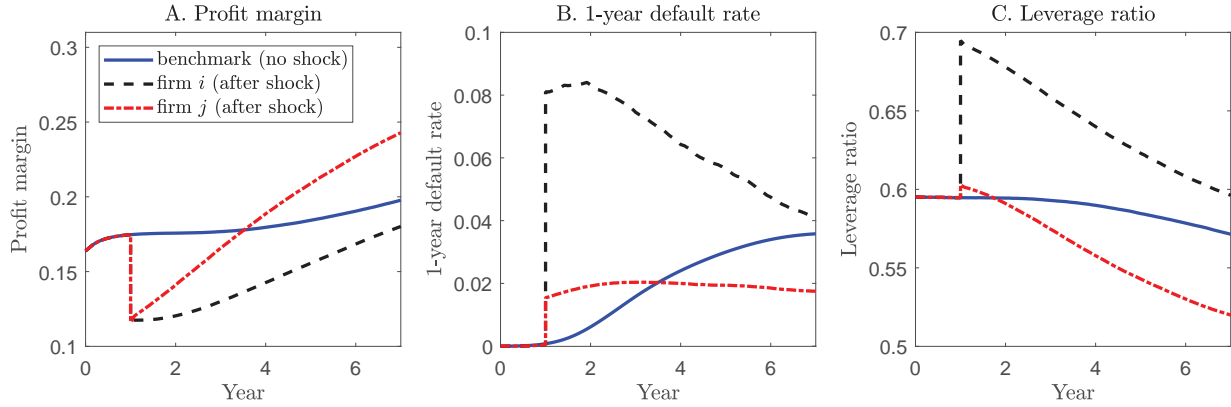


Figure 9. Predatory pricing as an extreme case of financial contagion in the short run. The solid lines in panels A, B, and C plot the average dynamics of one firm’s profit margin, 1-year default rate (i.e., the expected default rate over $[t, t + 1)$ conditional on no default up to t), and leverage ratio, based on 200,000 independent simulations of the benchmark case with no distress shock to firm i . The dashed and dash-dotted lines represent the average dynamics of firms i and j , respectively, in the scenario where firm i ’s log coupon rate increases unexpectedly from b^C to b_i^{shock} at $t = 1$ (i.e., firm i receives an unexpected distress shock), whereas firm j ’s log coupon rate is held at b^C for $t \geq 0$. The value of b_i^{shock} is chosen so that firm i ’s leverage ratio increases by 10% at $t = 1$, which equals the jump size of the dashed line at $t = 1$ in panel C. The initial demand intensities for both firms’ products are $e^{z_{1,0}} = e^{z_{2,0}} = 0.5$, so both are already distressed at $t = 0$. The initial log coupon rates at $t = 0$ are set at b^C , the optimal log coupon rate in the collusive equilibrium when both firms have unit initial demand intensity. Parameters are calibrated as in Table 1 except for $\kappa = 0$.

shock to firm i , which increases its leverage ratio by 10% (see the dashed line in panel C of Figure 9). Figure 9 plots the average impulse-response functions of the firms’ profit margins, 1-year default rate, and leverage ratios to the adverse distress shock over time.

Specifically, the solid line in panel A of Figure 9 plots the profit margin in the absence of the adverse distress shock. When the distress shock hits firm i at $t = 1$, both firms significantly reduce their profit margins. The dash-dotted line indicates that firm j significantly lowers its profit margin by 5.9 percentage points at $t = 1$, which further reduces firm i ’s profits by suppressing the industry-level profit margin. This peer effect further reinforces the effect of the initial distress shock to firm i by increasing the default rate of firm i , which in turn increases the likelihood of firm j gaining market power in the future, allowing it to charge high profit margins and high rents. Indeed, as shown by the dash-dotted line in panel A of Figure 9, firm j ’s profit margin keeps increasing significantly over time to surpass the level in the benchmark case (the solid line, which does not have the initial distress shock to firm i) after year 3.

As an important economic insight, we find that after firm i experiences an idiosyncratic distress shock, its rival firm j will benefit in the long run, on average; in the short run, however, firm j must aggressively reduce its profit margin to wage a predatory price war. Dou, Johnson and Wu (2022) provide causal evidence, based on granular data, of may wage a price war against the weak firms until only one firm survives the industry.

predatory pricing behavior by the rival firm and the resulting effect on its distress level. The intertemporal tradeoff of firm j 's predatory pricing can be clearly illustrated by the evolution of its short-term default risk. Panel B of Figure 9 plots the 1-year default rate, which represents the expected default probability over $[t, t + 1)$ conditional on not defaulting, up to t . Comparing the solid and dash-dotted lines, we observe that by conducting predatory pricing, firm j 's 1-year default rate is higher after the shock to firm i than it is in the benchmark case where there is no distress shock at $t = 1$. This is because firm j chooses to set much lower profit margins immediately after the shock (see the dash-dotted line in panel A); however, on average, in the long run (after 3 years) firm j attains a lower 1-year default rate because its short-run predatory behavior increases the likelihood that the shocked firm (i.e., firm i) will default, allowing firm j to gain monopoly rents in the future.

5.3 Capital Structure Under Strategic Competition

Profitability-Leverage Puzzle. In Section 3.3, we use the extended simple model to show that the competition-distress feedback effect of strategic competition can rationalize the profitability-leverage puzzle (see Proposition 3.4). In this section, we show that the same result can be generated by our full-fledged quantitative model, due to the same intuitions discussed in Section 3.3. We consider two industries with low ($\nu_L = 0$) and high ($\nu_H = 0.1$) levels of idiosyncratic left-tail risk. Panel A of Figure 10 shows that when $e^{z_{1,0}} = e^{z_{2,0}} = 1$, firm i 's profit margin in the industry with ν_L is higher than that in the industry with ν_H by 14.1 percentage points at $t = 0$. In panel B of Figure 10, we compare the optimal leverage ratio in the two industries. The industry with ν_H has an optimal leverage ratio of 43%, which is higher than the industry with ν_L by 6.2% ($= 43\% - 36.8\%$). Taking the results in panels A and B of Figure 11 together, our model implies that industries with higher profitability are associated with lower leverage ratios.

Costly Leverage Due to the Feedback Effect. When determining its optimal amount of debt issuance, a firm is aware that increasing its leverage ratio will lead to lower collusive profit margins and cash flows; thus, it behaves more cautiously and adopts a relatively low leverage ratio ex ante. We now conduct experiments to gauge the quantitative significance of this feedback effect on the optimal capital structure. Consider two symmetric firms with initial demand intensities $e^{z_{1,0}} = e^{z_{2,0}} = 1$ and optimal log coupon rates $b_1 = b_2 = b^C$ in the collusive equilibrium. The solid, dashed, and dash-dotted lines in panel A of Figure 11 plot firm i 's value $V_{i,0}$ as a function of its leverage ratio $lev_{i,0}$ at $t = 0$ in the baseline model with collusive profit margins, the model with profit margins fixed at the values corresponding to unlevered firms, and the model with collusive profit margins but zero bankruptcy costs (i.e.,

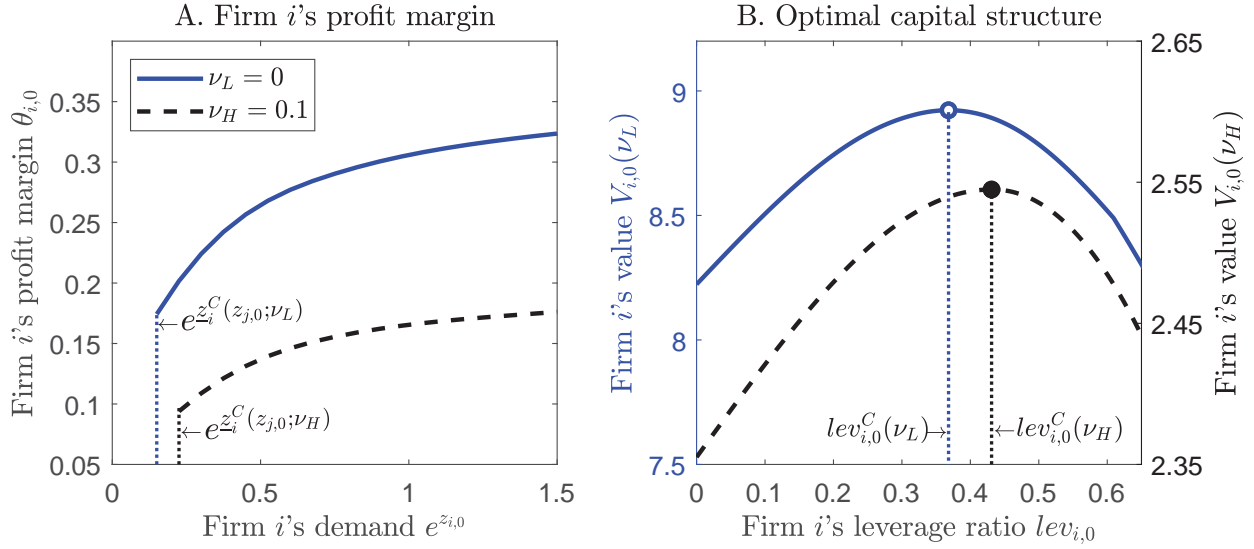


Figure 10. Higher idiosyncratic left-tail risk leads to lower profitability but higher optimal leverage. In both panels, the solid and dashed lines represent industries with low ($\nu_L = 0$) and high ($\nu_H = 0.1$) levels of idiosyncratic left-tail risk, respectively. Panel A plots the profit margin $\theta_{i,0}$ of firm i as a function of $e^{z_{i,0}}$, holding $e^{z_{j,0}} = 1$ unchanged and both firms' coupon rates unchanged at the optimal level at time $t = 0$. The vertical dotted lines represent the default boundaries of firm i in the corresponding industries. Panel B plots the total value $V_{i,0}$ of firm i as a function of its leverage ratio $lev_{i,0}$, by varying firm i 's log coupon rate b_i while holding firm j 's coupon rate unchanged at the optimal level and initial demand intensities at $e^{z_{1,0}} = e^{z_{2,0}} = 1$ unchanged. Parameters are set according to Table 1.

$\delta = 100\%$), respectively. The total values of firm i in the three models are maximized at the corresponding optimal leverage ratios, which are characterized by the three vertical dotted lines in panel A of Figure 11, respectively.

In the baseline model with collusive profit margins (the solid line), the optimal leverage ratio is 36.8%. In the model with profit margins fixed at the values corresponding to unlevered firms (the dashed line), the competition-distress feedback does not exist because, by assumption, firm i 's profit margin and cash flows are not affected by its leverage ratio. It is evident that firm i 's optimal leverage ratio increases from 36.8% to 44.3% in the absence of the competition-distress feedback loop, indicating that the feedback effect reduces the optimal leverage ratio by a sizable amount, approximately 7.5% ($= 44.3\% - 36.8\%$). In the model with collusive profit margins but zero bankruptcy costs (the dash-dotted line), the firm still incurs a fairly large cost for raising its leverage, even though there is no bankruptcy cost. Specifically, it is evident that firm i increases its optimal leverage ratio from 36.8% to 42.9% due to lower bankruptcy costs.³⁶ However, under our calibration, the increase in optimal leverage ratios due to the elimination of bankruptcy costs ($42.9\% - 36.8\% = 6.1\%$) is smaller than that due

³⁶In both our model and the standard model of Leland (1994), zero bankruptcy costs do not imply an optimal leverage ratio of 100%. This is because the tax deductibility of coupon payments is lost when the default risk induced by leverage is too high. Thus, it is optimal for the firm to choose a leverage ratio that is not too high to avoid bearing too much default risk.

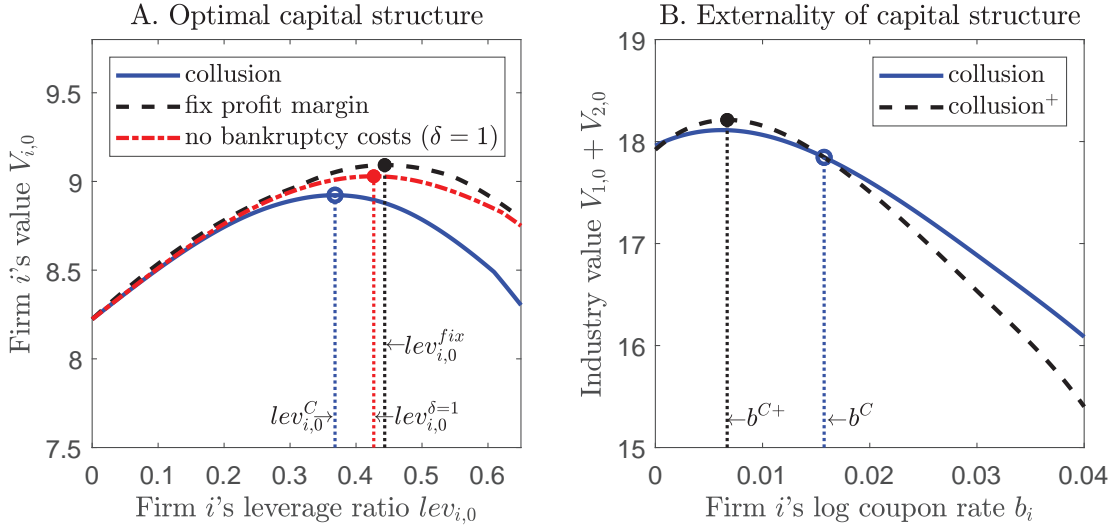


Figure 11. Implications of feedback and contagion on optimal capital structure. In panel A, we consider two symmetric firms with $e^{z_{1,0}} = e^{z_{2,0}} = 1$ and optimal log coupon rates $b_1 = b_2 = b^C$ in the collusive equilibrium. Holding firm j 's log coupon rate at b^C , by varying firm i 's log coupon rate b_i , we generate variations in firm i 's leverage ratio ($lev_{i,0}$) along the x-axis. The solid line plots the total value of firm i , $V_{i,0}$, as a function of its leverage ratio $lev_{i,0}$. The dashed line plots firm i 's value in the model with profit margins fixed at the values corresponding to unlevered firms (i.e., with no competition-distress feedback). The dash-dotted line plots the total value of firm i in the model with collusive profit margins but zero bankruptcy costs (i.e., $\delta = 100\%$). In panel B, we consider two symmetric firms with $e^{z_{1,0}} = e^{z_{2,0}} = 1$. The solid line plots the industry's value ($\sum_{i=1}^2 V_{i,0}$) as a function of firm i 's log coupon rate b_i in the collusive equilibrium, holding $b_j = b^C$ unchanged. The right vertical dotted line represents b^C . The dashed line represents the industry's value as a function of firm i 's (or firm j 's) log coupon rate b_i in the collusion+ equilibrium, holding $b_i = b_j$. The left vertical dotted line represents the log coupon rate b^{C+} that maximizes the industry's value. Parameters are set according to Table 1.

to the elimination of the competition-distress feedback loop ($44.3\% - 36.8\% = 7.5\%$). This suggests that the large bankruptcy costs emphasized in the traditional tradeoff theory of capital structure (e.g., Leland, 1994) are not a precondition for generating large financial distress costs that make leverage costly. Importantly, our model shows that the competition-distress feedback loop is an equally important mechanism that makes leverage costly and thus reduces firms' optimal leverage ratios.

Excessive Leverage Relative to the Industry's Optimal Leverage. As shown by Proposition 3.5 in Section 3.3, due to the financial contagion effect, an increase in one firm's debt level has a negative externality on its rival firm's value, implying that there is excessive debt from an industry's perspective. We quantitatively evaluate this inefficiency in the firms' choice of capital structure. Consider two symmetric firms with initial demand intensities $e^{z_{1,0}} = e^{z_{2,0}} = 1$. The solid line in panel B of Figure 11 plots the industry's value $\sum_{i=1}^2 V_{i,0}$ in the collusive equilibrium as a function of firm i 's log coupon rate b_i , holding $b_j = b^C$, where b^C is the optimal log coupon rate in the collusive equilibrium when both firms have

unit initial demand. It is evident that the vertical dotted line, which represents b^C , does not maximize the industry's value even though it is the optimal log coupon rate that maximizes each firm's value in the collusive equilibrium. The solid line is downward sloping in the local region around b^C , indicating that the industry's value would be higher if firm i chooses a log coupon rate below b^C .

Next, we solve the optimal coupon rate that maximizes the industry's value. Instead of each firm choosing its own coupon rate non-cooperatively in a Nash equilibrium (see equations (48) and (49)), we require the industry to jointly choose the two firms' log coupon rates b_i and b_j to maximize the industry's value $\sum_{i=1}^2 V_{i,0}$, thus internalizing the externality of debt choice. As opposed to the collusive equilibrium, we label this equilibrium the collusive⁺ equilibrium. Because we focus on symmetric firms ($e^{z_{1,0}} = e^{z_{2,0}} = 1$), the optimal coupon rate that maximizes the industry's value must be the same for both firms. As an illustration, the dashed line in panel B of Figure 11 plots the industry's value as a function of firm i 's (or firm j 's) log coupon rate, holding $b_i = b_j$. The vertical dotted line represents the optimal log coupon rate b^{C+} that maximizes the industry's value, which implies a leverage ratio of 18.7% for the industry, much lower than the leverage ratio of 36.8% in the collusive equilibrium, corresponding to the choice of the log coupon rate b^C . Thus, from an industry's perspective, both firms take on an excessive level of debt in the collusive equilibrium, which negatively affects their competitors' values due to financial contagion and a reduced capacity for collusion.

6 Empirical Tests

Although our main contribution is theoretical rather than empirical, in this section we conduct some empirical analyses to support the main theoretical implications. In a companion paper, [Dou, Johnson and Wu \(2022\)](#) provide extensive causal evidence for the contagion effects based on granular data, such as Nielsen data on product prices and SCHEDULES data on local natural disasters.

6.1 Data and Empirical Measures

We obtain firm-level accounting data from Compustat. Our analysis focuses on strategic competition among a few oligopolistic firms that produce close substitutes. Therefore, we use SIC4 codes to define industries following the literature.³⁷ We exclude all financial firms

³⁷Examples include [Hou and Robinson \(2006\)](#), [Gomes, Kogan and Yogo \(2009\)](#), [Frésard \(2010\)](#), [Giroud and Mueller \(2010\)](#), [Giroud and Mueller \(2011\)](#), [Bustamante and Donangelo \(2017\)](#), and [Dou, Ji and Wu \(2021a,b\)](#).

and utility firms (i.e., SIC codes 6,000 – 6,999 and 4,900 – 4,999, respectively). Following the literature (e.g., Frésard, 2010), we require that an industry-year pair has at least 10 firms to be included in our analysis. This ensures that the industry-level variables are well behaved. On average, there are 123 industries in a year and 26.6 firms in an industry.

Profit Margin Measures. We construct the profit margin of industry i in year t , denoted by $\theta_{i,t}$, using the industry’s net profits divided by its sales. Furthermore, we construct the normalized profit margin $\hat{\theta}_{i,t}$ for each industry i in year t using the industry’s profit margin $\theta_{i,t}$ divided by its median profit margin across years. The year-on-year changes in $\hat{\theta}_{i,t}$ capture changes in profit margins as a fraction of the industry’s median profit margin.³⁸

Distance-to-Default Measure. We construct a distance-to-default measure following the Merton model for the purpose of testing the competition-distress feedback and financial contagion effects. Specifically, we use (i) the book value of a firm’s debt, computed as short-term debt plus one half of long term debt, (ii) the total value of a firm’s assets, estimated by the sum of the firm’s book value of debt and its market value of equity, (iii) the risk-free rate, and (iv) the volatility of the market value of a firm’s assets, approximated by the volatility of its deleveraged equity returns. The distance-to-default measure for industry i and period t , denoted by $DD_{i,t}$, is the average firm-level distance-to-default measure of all firms in the same industry i weighted by their sales.

Measure of Discount Rates. The empirical proxy for discount rates is based on the smoothed earnings-price ratio motivated by return predictability studies (e.g., Campbell and Shiller, 1988, 1998; Campbell and Thompson, 2008) and is obtained from Robert Shiller’s website. In our regression analyses, the discount rate in month t , denoted by $Discount_rate_t$, is calculated by fitting a time-series regression of 12-month-ahead market returns to the smoothed earnings-price ratio and then taking the fitted value at the end of month t . We construct discount-rate shocks, denoted by $\Delta Discount_rate_t$, as the residuals of AR(1)

³⁸To test the feedback and contagion effects, it is necessary to use the percentage change in profit margins in response to discount-rate shocks rather than the level change in profit margins because our theory suggests that the percentage change (not the level change) is larger in more distressed industries. The level change in profit margins is not a correct metric for cross-industry comparisons because our theory suggests that more distressed industries have a lower level of profit margin. Thus, even if more distressed industries have a larger percentage change in profit margins in response to discount-rate shocks, the level change in their profit margins can be larger or smaller than that of less distressed industries. The change in $\hat{\theta}_{i,t}$ captures the change in profit margins normalized by the industry’s median profit margin level. Thus, it adjusts for cross-industry differences in profit margin levels and better reflects the percentage change in profit margins. We cannot directly use the year-on-year percentage change in profit margins of an industry in our empirical tests because about 20% of the industry-year observations for $\theta_{i,t}$ are negative, which means that their percentage change in profit margins is not well defined.

time-series regressions, which are extracted at an annual or a quarterly frequency for the estimation of profit-margin betas.

Measure of Idiosyncratic Shocks. We construct firm-level idiosyncratic shocks, denoted by $Idio_Shock_{j,t}$, for firm j in period t , using two methods for robustness: for the first method (M1), we follow [Gabaix \(2011\)](#) and construct $Idio_Shock_{j,t}$ using firms' sales growth less average cross-sectional sales growth; for the second method (M2), we use the time-series regression residuals of firms' sales growth on average cross-sectional sales growth.

Measure of Ex-Ante Idiosyncratic Left-Tail Risk. We construct a measure of idiosyncratic left-tail risk in two steps. First, we construct a measure of the realized frequency of idiosyncratic left-tail jump shocks for each industry i and year t , denoted by $Idio_Tail_Freq_{i,t}$. Specifically, for each firm j in year t , we measure cash flow by the firm's net income divided by its 1-year lagged total assets, and we further measure the firm's idiosyncratic cash flow by subtracting its industry-level cash flow, which is constructed by the average cash flow of all firms within the industry. We then construct the realized frequency of idiosyncratic left-tail jump shocks $Idio_Tail_Freq_{i,t}$ as the sales-weighted fraction of firms (within the industry) whose cash flows are below the 10th percentile cutoff of the distribution of firm-level cash flows across all firm-year observations. We further project the realized frequency of idiosyncratic left-tail jump shocks in year $t + 1$ to industry characteristics in year t by estimating the following panel regression using industry-year observations between 1971 and 2021:

$$Idio_Tail_Freq_{i,t+1} = \alpha + \beta X_{i,t} + \epsilon_{i,t+1}, \quad (50)$$

where $X_{i,t}$ is a vector of industry-level variables, constructed as the sales-weighted average of the firm-level variables used by [Campbell, Hilscher and Szilagyi \(2008\)](#) in estimating firms' failure probability.³⁹ We then construct an ex-ante measure for the idiosyncratic left-tail risk of each industry i in month t based on the predictive component of (50), as follows:

$$v_{i,t} = \hat{\alpha} + \hat{\beta} X_{i,t}. \quad (51)$$

³⁹We report the estimates in Online Appendix 6.2. The firm-level variables include firm's net income over market value of total assets (*NIMTA*), log of firm's gross excess return over value-weighted S&P 500 return (*EXRET*), square root of the sum of squared firm's stock returns over a 3-month period (*SIGMA*) annualized, log of firm's market equity over the total valuation of S&P 500 (*RSIZE*), firm's stock of cash and short-term investments over the market value of total assets (*CASHMTA*), market-to-book ratio of the firm (*MB*), and log of firm's price per share winsorized above \$15 (*PRICE*). We do not include total liabilities over market value of total assets (*TLMTA*) in $X_{i,t}$ to avoid the creation of a mechanical relation between our measure of idiosyncratic left-tail risk and the industry's leverage ratio. One of our main empirical results is that industries' exposure to idiosyncratic left-tail risk can explain the negative profitability-leverage relationship across industries (see Section 6.4). The empirical results are robust to the inclusion of *TLMTA* to estimate specification (50).

Table 2: Implications of the competition-distress feedback effect on profit margins.

	(1)	(2)	(3)	(4)
	$\Delta\hat{\theta}_{k,t}$		$\Delta\hat{\theta}_{k,t}$	
	Yearly data		Quarterly data	
$DD_{i,t}$	All firms	Top six firms	All firms	Top six firms
$\Delta Discount_rate_t$	12.656**	14.345**	13.977**	11.039**
	[2.12]	[2.02]	[2.07]	[2.30]

Note: This table reports the difference in the profit-margin beta to the discount rate across groups of industries sorted on the distance-to-default measure ($DD_{i,t}$). The regression specification is described in (52). In columns (1) and (2), we sort industries into quintiles and report the differences in the profit-margin beta between quintile group 5 (high $DD_{i,t}$) and quintile group 1 (low $DD_{i,t}$). In columns (1) and (2), we construct industry-level variables using all firms and the top six firms (ranked by sales) in the industry using yearly data, respectively. In columns (3) and (4), we perform the same analyses as those in columns (1) and (2), except that we use quarterly data rather than yearly data. The number of observations is 53 for columns (1) and (2), and 212 for columns (3) and (4). The sample spans the period from 1969 to 2021. All variables are in annualized percentage units. The t -statistics reported in brackets are robust to heteroskedasticity and autocorrelation. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

6.2 Competition-Distress Feedback Effects on Profit Margins

Our model implies that industry-level profit margins load negatively on the discount rate, and more so in industries where firms are closer to their default boundaries (see panel A in both Figure 7), because the strength of the competition-distress feedback effect increases as firms become close to their default boundaries. To test this implication, we sort industries into five quintile groups based on the distance-to-default measure ($DD_{i,t}$). We then examine the profit-margin beta to the discount rate by running the following time-series regression using yearly observations for each quintile group k sorted on $DD_{i,t}$:

$$\Delta\hat{\theta}_{k,t} = \alpha_k + \beta_k \Delta Discount_rate_t + \epsilon_{k,t}, \quad (52)$$

where the dependent variable $\Delta\hat{\theta}_{k,t}$ is the year-on-year change in group- k 's normalized profit margin $\hat{\theta}_{k,t}$, which is the equal-weighted average of the normalized profit margin of all industries in quintile group k .

Column (1) of Table 2 shows that the difference in the profit-margin beta to the discount rate between the quintile groups of industries with high (quintile group 5) and low (quintile group 1) distance-to-default is positive and statistically significant. This shows that the profit margins of industries with low $DD_{i,t}$ (quintile group 1) are more negatively exposed to discount-rate shocks, which is consistent with the prediction of our model. In terms of economic magnitude, our estimates indicate that for a one percentage-point increase in the discount rate, the decrease in the normalized profit margin of quintile group 1 sorted on the

distance-to-default measure is about 13 percentage points greater than that of quintile group 5. The result is robust if we focus on the top six firms (ranked by sales) in the industry when constructing the industry-level profit margins (column (2)) or when we use quarterly data on profit margins and discount rates (columns (3) and (4)).

6.3 Contagion Effects on Profit Margins

Our model predicts that an adverse idiosyncratic shock to a market leader (i.e., an increase in the distress level of a market leader) is likely to make other market leaders within the same industry cut their profit margins (see Propositions 2.4 and OA.2, panel B of both Figures 7 and 8, and panel A of Figure 9). To test this prediction, we split the top six firms (ranked by sales) in each industry into three groups based on the distance-to-default measure ($DD_{i,t}$) in each year. Group L contains the two firms with the lowest financial distress level (i.e., the highest $DD_{i,t}$), and group H contains the two firms with the highest financial distress level (i.e., the lowest $DD_{i,t}$). We run the following panel regression using industry-year observations:

$$\widehat{\theta}_{i,t}^{(L)} = \sum_{k \in \{H,L\}} \beta_k Idio_Shock_{i,t}^{(k)} + \sum_{s=1}^5 \gamma_s \widehat{\theta}_{i,t-s}^{(L)} + \delta_t + \ell_i + \epsilon_{i,t}, \quad (53)$$

where the independent variable $Idio_Shock_{i,t}^{(k)}$ is the idiosyncratic shock of group $k \in \{L, H\}$ in industry i and year t , defined as the average firm-level idiosyncratic shocks (i.e., $Idio_Shock_{j,t}$) in group k weighted by firms' lagged sales in the previous year. Our regression specification (53) controls for idiosyncratic shocks to firms in group L (i.e., $Idio_Shock_{i,t}^{(L)}$), the lagged profit margins of firms in group L (i.e., $\widehat{\theta}_{i,t-s}^{(L)}$ for $s = 1, \dots, 5$), and time and industry fixed effects.⁴⁰

The coefficient β_H captures the effect of idiosyncratic shocks to firms in group H (i.e., firms that are more financially distressed) on the profit margin of firms in group L (i.e., firms that are financially healthier), reflecting the contagion effect on profit margins. Column (1) of Table 3 shows that the coefficient β_H is positive and statistically significant for the idiosyncratic shocks constructed using both methods $M1$ and $M2$, indicating that positive idiosyncratic shocks to group H robustly increase the profit margin of group L .

According to the estimates based on the method $M1$, in response to a one percentage-point positive idiosyncratic shock in the sales growth of group H , the profit margin of group L increases by 0.643% of its median profit margin. For large idiosyncratic shocks, the

⁴⁰The results remain robust if we add controls for industry-level sales or idiosyncratic shocks to firms in the middle group ($Idio_Shock_{i,t}^{(M)}$).

Table 3: Financial contagion effect on profit margins within an industry.

	(1)	(2)	(3)	(4)
			$\hat{\theta}_{i,t}^{(L)}$	
		Sorted on level of entry threats		
$Idio_Shock_{i,t}^{(H)}$	All	Low	High	High–Low
M1	0.643** [2.54]	1.131*** [2.73]	0.232 [1.11]	–0.899** [–2.17]
M2	0.778*** [2.92]	1.338*** [2.97]	0.242 [0.92]	–1.096** [–2.23]

Note: This table studies the effect of financial contagion on profit margins within an industry. The coefficient β_H in specification (53) captures the contagion effect of idiosyncratic shocks to firms in group H (financially distressed firms) on the profit margin of firms in group L (financially healthy firms). Column (1) presents the estimated β_H based on the full sample. Columns (2) and (3) present the estimated β_H for industries facing low and high entry threat, respectively. Column (4) shows the difference between columns (2) and (3). $M1$ and $M2$ represent the two methods used to construct firms' idiosyncratic shocks, as explained in Section 6.1. The number of observations is 3,247 for $M1$ and 3,233 for $M2$. The sample spans the period from 1969 to 2021. All variables are in annualized percentage units. The t -statistics reported in brackets are robust to heteroskedasticity and autocorrelation. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

estimate indicates that a two standard deviation increase in the sales growth of group H would increase the profit margin of group L by 14% of its median profit margin, which is sizable given that the standard deviation of group H 's sales growth is about 11 percentage points.

Our model further predicts that the contagion effect on profit margins is more pronounced in industries with lower entry threats (i.e., higher entry barriers) because rival firms are likely to have greater predatory incentives. We test this prediction by splitting industries into two groups, based on whether their industry-level entry costs are higher than the median value across industries. Because sunk entry costs mainly arise from the construction costs of business premises (e.g., Sutton, 1991; Karuna, 2007; Barseghyan and DiCecio, 2011), we measure industry-level entry costs using the median 5-year trailing average of the net total property, plant, and equipment of firms within each industry in each year. Intuitively, in industries with high entry costs, market followers need to incur high setup costs to become new market leaders, implying that incumbent market leaders in the industry face low entry threats. Thus, we classify industries with entry costs that exceed the median value into the group with low entry threats. Consistent with our model's prediction, columns (2) – (4) of Table 3 show that the contagion effect on profit margins is significantly stronger in industries with lower entry threats. The difference in the coefficient β_H , summarized in column (4), is negative and statistically significant.

Table 4: Profitability-leverage anomaly (portfolio sorting results).

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Leverage ratios across industries sorted on profit margins $\theta_{i,t}$						
$\theta_{i,t}$	Q1 (low)	Q2	Q3	Q4	Q5 (high)	Q5–Q1
$lev_{i,t}$	0.314*** [15.75]	0.269*** [18.27]	0.232*** [18.62]	0.202*** [23.96]	0.188*** [20.51]	–0.127*** [–9.51]
Panel B: Leverage ratios across industries sorted on idiosyncratic left-tail risk $v_{i,t}$						
$v_{i,t}$	Q1 (low)	Q2	Q3	Q4	Q5 (high)	Q5–Q1
$lev_{i,t}$	0.157*** [15.49]	0.205*** [17.12]	0.240*** [17.77]	0.271*** [17.08]	0.336*** [19.19]	0.179*** [9.30]
Panel C: Leverage ratios across industries double sorted on $v_{i,t}$ and $\theta_{i,t}$						
$\theta_{i,t}$	Q1 (low)	Q2	Q3	Q4	Q5 (high)	Q5–Q1
$lev_{i,t}$	0.262*** [14.27]	0.262*** [19.41]	0.242*** [20.73]	0.214*** [24.07]	0.224*** [19.12]	–0.038** [–2.62]

Note: This table presents the portfolio sorting results for the profitability-leverage anomaly before and after controlling for idiosyncratic left-tail risk. In panels A and B, we perform single-sort analyses. Specifically, we sort industries into quintiles on $\theta_{i,t}$ and $v_{i,t}$ in panels A and B, respectively. We report the leverage ratio of each quintile portfolio, which is the average $lev_{i,t}$ of industries within the portfolio. In panel C, we perform double-sort analyses, where we first sort industries into quintiles based on $v_{i,t}$, and then further sort the industries within each quintile portfolio into quintiles based on $\theta_{i,t}$. The sample is yearly and spans the period from 1976 to 2021. The number of observations is 5,375 for panel A and 5,333 for both panels B and C. All numbers are in annualized percentage units. The t -statistics reported in brackets are robust to heteroskedasticity and autocorrelation. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

6.4 Profitability-Leverage Anomaly

Our model implies that the industry-level profitability-leverage anomaly can be explained by the dispersion in the level of idiosyncratic left-tail risk across industries. Specifically, industries with a lower level of idiosyncratic left-tail risk have higher profitability because firms within the industry have higher capacity for tacit collusion; however, in such industries, the competition-distress feedback effect is stronger, which motivates firms to choose lower leverage ratios. This theoretical result is formally summarized in Proposition 3.4 in Section 3 and quantitatively demonstrated in Figure 10 in Section 5.3.

We test this prediction empirically in Table 4. We construct the leverage ratio of industry i in year t , denoted by $lev_{i,t}$, as the industry’s debt value divided by the sum of its debt value and market value of equity, where the industry’s debt value is the sum of its short-term debt and long-term debt. Panel A presents the leverage ratios of five quintile industry portfolios sorted on industry profit margins $\theta_{i,t}$. Similar to the firm-level patterns documented in

Table 5: Profitability-leverage anomaly (regression results).

	(1)	(2)	(3)	(4)
	Fama-MacBeth regression		Panel regression	
$\theta_{i,t}$	-0.786*** [-3.25]	-0.307 [-1.56]	-0.283*** [-3.60]	-0.058 [-0.66]
$\nu_{i,t}$		1.181*** [6.93]		0.972*** [8.72]
Observations	5,375	5,333	5,375	5,333

Note: This table studies the profitability-leverage anomaly before and after controlling for idiosyncratic left-tail risk across industries. Columns (1) and (2) conduct a Fama-MacBeth regression. In column (2), we report the time-series average of the estimate of $\hat{\beta}_{1,t}$ obtained from the following cross-sectional regression in each year t : $lev_{i,t} = \alpha_t + \beta_{1,t}\theta_{i,t} + \epsilon_{i,t}$. In column (2), we additionally control for $\nu_{i,t}$ by running the following regression: $lev_{i,t} = \alpha_t + \beta_{1,t}\theta_{i,t} + \beta_{2,t}\nu_{i,t} + \epsilon_{i,t}$. Columns (3) and (4) conduct a panel regression. In column (3), we report the estimate of $\hat{\beta}_1$ by running the following regression using industry-year observations: $lev_{i,t} = \alpha + \beta_1\theta_{i,t} + \epsilon_{i,t}$. In column (4), we additionally control for $\nu_{i,t}$ by running the following regression: $lev_{i,t} = \alpha + \beta_1\theta_{i,t} + \beta_2\nu_{i,t} + \epsilon_{i,t}$. The sample is yearly and spans the period from 1976 to 2021. All numbers are in annualized percentage units. The t -statistics reported in brackets are robust to heteroskedasticity and autocorrelation. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

the literature, industries with high profitability (i.e., industries in quintile group 5 (Q5 in the table)) have significantly lower leverage ratios than industries with low profitability (i.e., industries in quintile group 1 (Q1 in the table)). Moreover, the leverage ratio $lev_{i,t}$ monotonically decreases from 0.314 to 0.188 as the profit margin $\theta_{i,t}$ increases from Q1 to Q5.

In panel B of Table 4, we sort industries based on the measure of idiosyncratic left-tail risk $\nu_{i,t}$. We show that industries with high idiosyncratic left-tail risk (i.e., industries in Q5) have significantly higher leverage ratios than industries with low idiosyncratic left-tail risk (i.e., industries in Q1). Moreover, the leverage ratio $lev_{i,t}$ monotonically increases from 0.157 to 0.336 as the level of idiosyncratic left-tail risk $\nu_{i,t}$ increases from Q1 to Q5. This empirical finding supports our model's prediction (see Proposition 3.4 and Figure 10). Panel C of Table 4 performs double-sort analyses, where we first sort industries into quintiles based on $\nu_{i,t}$. Then, for the industries within each quintile portfolio, we further sort them into quintiles based on $\theta_{i,t}$. Comparing panels A and C of Table 4, it is evident that the difference in leverage ratios between industry portfolios sorted on the profit margin $\theta_{i,t}$ (Q5–Q1 in column (6)) increases significantly from -0.127 to -0.038 after controlling for idiosyncratic left-tail risk, and the absolute value of the t -statistics decreases from 9.51 to 2.62. Thus, the data suggest that industries' differential exposure to idiosyncratic left-tail risk alone can explain a major part of the industry-level profitability-leverage anomaly.

Complementary to the portfolio-sorting analyses, we perform regression analyses in

Table 5. We first perform a Fama-MacBeth regression in columns (1) and (2). In column (1), it is evident that a negative and significant relationship between profitability and leverage exists across industries. Moving from column (1) to (2), the estimated coefficient on $\theta_{i,t}$ increases from -0.786 to -0.307 and becomes statistically insignificant after controlling for idiosyncratic left-tail risk. Moreover, the coefficient on $v_{i,t}$ is positive and statistically significant in column (2). In columns (3) and (4), we perform a panel regression, which further shows that the strong negative relationship between profitability and leverage across industries becomes statistically insignificant after controlling for idiosyncratic left-tail risk $v_{i,t}$.

7 Conclusion

This paper investigates the dynamic interactions between endogenous strategic competition and financial distress. We develop the first elements of a tractable dynamic framework for distressed competition by incorporating a supergame of strategic rivalry into a dynamic model of long-term defaultable debt. In our model, firms tend to compete more aggressively when they are in financial distress, and the intensified competition, in turn, diminishes the profit margins of all firms in the industry, pushing some further into distress. Thus, the endogenous distressed competition mechanism implies novel competition-distress feedback and financial contagion effects.

Our study raises interesting questions for future research. Equity issuance is costless in our model but costly in reality. The costless issuance of equity is a simplification widely adopted in standard credit risk models. Do firms compete more aggressively when they become more liquidity constrained, but not yet more financially distressed? We focus on frictions related to debt financing, but equity financing frictions should also be investigated. Extending the model to incorporate external equity financing costs and allowing firms to hoard cash, as in Bolton, Chen and Wang (2011, 2013), Dou et al. (2021b), and Dou and Ji (2021), would be interesting for future research. In addition, our paper highlights an important source of cash flow risk — endogenous competition risk — that depends on industries' market structures. Extending the model to study the joint determination of optimal capital structure and risk management, as in Rampini and Viswanathan (2010, 2013), is another potentially fruitful research area.

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