Industry competition, credit spreads, and levered equity returns

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This paper examines the relation between industry competition, credit spreads, and levered equity returns. I build a quantitative model where firms make investment, financing, and default decisions subject to aggregate and idiosyncratic risk. Firms operate in heterogeneous industries that differ by the intensity of product market competition. Higher competition reduces profit opportunities and increases default risk for debtholders. Equityholders are protected against default risk due to the option value arising from limited liability. In equilibrium, competitive industries are characterized by higher credit spreads, but lower expected equity returns. I find strong empirical support for these predictions across concentration terciles.

1 Introduction

Companies generate revenues by competing in product markets. While some firms enjoy monopoly power over the sale of their products, others face fierce competition. The intensity of competition, by affecting a firm's profit opportunities, influences both corporate decisions and asset prices. Recently, a growing number of studies have examined the relationship between product market structure and asset prices. Yet, the existing theoretical literature has largely focused on linking competition to unlevered equity risk. Also in the data, the effect of competition on equity returns is still debated, while its impact on credit spreads is limited.[1] The goal of this paper is to examine how industry competition *jointly* affects credit spreads and levered equity returns, and to assess the importance of these channels using a quantitative model.

To analyze these issues, I develop a production based asset pricing model that captures the rich interaction between a firm's competitive environment, optimal capital structure, default, and asset prices. The economy is populated by a large number of firms that operate in industries that differ in their degree of product market competition. They hire labor, accumulate capital, and compete with industry rivals in a Cournot-Nash framework. Each period, they choose the optimal capital structure mix by weighting the tax benefits of debt against the costs arising from default. Industry and macroeconomic quantities are obtained by aggregating individual firm decisions. Asset prices are determined in equilibrium by a representative household with recursive preferences.

I find that industry competition is associated with higher equilibrium credit spreads but lower equity risk. The intuition for this result comes from the effect of competition on the value of real options owned by the firm. Competitive firms have less valuable growth options, making them more exposed to idiosyncratic risk and default. Because default is costly and tends to occur in recessions, creditors demand a higher compensation for holding debt issued by competitive firms. Equityholders, however, are protected against default risk due to the option value arising from limited liability. The reduction in risk from the default option and the less valuable risky growth options make equity risk lower in competitive industries.

The value of a firm's growth options is determined by the net present value of expected future profits. The firm generates revenues by competing in product markets with other firms. Thus the value of the firm's growth options will reflect the degree of industry competition. In competitive

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[1]An exception is the recent empirical work of Valta (2012) who finds a positive relationship between competition and interests charged on bank loans.

industries, firms are relatively smaller and have less market power. Because they face a more elastic demand curve, they increase current and future production more in response to good news about productivity. These firms, however, do not reap large profits from their expansion because other firms in the industry also produce more. At the industry level, total supply increases, which puts a downward pressure on the industry product price and reduces each firm's revenues. Therefore in competitive industries, rivals' actions create an externality that decreases the value of a firm's growth options. This competitive externality channel reduces the risk of both levered and unlevered firms.

The reduction in growth opportunities also affects the firm value. In competitive industries, profit margins are thiner and firm valuation ratios are lower.[2] This makes competitive firms more exposed to idiosyncratic shocks, leading to an increase in the conditional probability of default. Investors are well-diversified, so that the limited liability acts as an insurance. For instance, if a firm gets hit by a large negative shock, the owner can walk away with a payoff of zero instead of incurring a large loss on her portfolio. Therefore competition, by increasing the relative importance of the default option, increases credit spreads, but decreases equity risk.

Another important effect of competition relates to the firm's capital structure decision. Competitive firms generate lower profits which reduces the expected tax shield, and also default more. Therefore competition makes debt relatively less attractive. The lower use of financial leverage mitigates the effect of competition on credit spreads. However, I find that the reduction in leverage is not sufficient to make credit spreads lower in competitive industries. This happens because the cost of default, i.e. the value lost in bankruptcy, is endogenously lower for competitive firms. In the end, competitive firms issue less, but more expensive debt.

To assess the quantitative importance of these channels, I calibrate the model to match a broad set of aggregate and industry moments. In the model, the only cross-sectional difference across industries is a parameter driving the intensity of industry competition. I estimate these to match a measure of market power obtained from industries sorted on concentration. Therefore, all remaining cross-sectional differences entirely stem from differences in industry competition.

I find that competition has significant effects on corporate decisions and asset prices. The difference in credit spreads between the high- and low-competition tercile is large. I test this

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[2]To more be precise, the reduction in growth options reduces both the cash-flows and the risk of the firm. These have opposite effects on the firm value. I find that the cash-flow channel dominates, so that in the end competition decreases the firm value.

prediction in the data using a panel of publicly traded corporate bond transactions and find strong empirical evidence. Firms in competitive industries pay 43bps more on their debt. These results are statistically significant and are robust to various measures of competition and controls. In terms of financing costs, this corresponds to firms paying an added $2.34M in interests each year. These estimates are consistent with Valta (2012) who finds that competitive firms pay higher interests on bank loans. The higher cost of debt leads competitive industries to use less financial leverage. In the model the difference in market leverage between the high- and low-competition tercile is -5.9%. These results accord with MacKay and Phillips (2005) who find that the average book leverage in more competitive industries is lower than in concentrated industries. More recently, Xu (2012) reaches similar conclusions using import penetration as an instrumental variable for competition. I further confirm these findings using summary statistics from my data sample. In short, the model prediction that competition leads firms to use less, but more expensive debt is strongly supported in the data, both qualitatively and quantitatively.

The model also provides quantitative predictions for the effect of competition on the cross-section of stock returns. I find that firms in the lowest competition tercile have a lower equity risk premium. These predictions are consistent with recent empirical evidence from Bustamante and Donangelo (2017) who find a positive relationship between excess stock returns, CAPM betas and industry concentration.[3] In contrast to equity risk, the model predicts that debt is *riskier* in competitive industries. The reason for this result is that although competitive firms have lower cash-flow risk, they default more. Since default occurs at times when the price of risk is high, this effect ultimately dominates, making debt riskier.

The option to default plays a key role in explaining the observed cross-sectional differences in asset prices across competition terciles. To gain further insight into the relation between competition and the option to default, I extend the benchmark model with time-varying volatility in idiosyncratic risk. Tougher competition brings the firm closer to default and increases the sensitivity of the option to default to volatility shocks. This sensitivity is reflected in credit spreads. In particular, higher competition magnifies the sensitivity of credit spreads to idiosyncratic shocks. I find strong support for this prediction in the data. A 1% increase in idiosyncratic volatility is associated with an *additional* 49bps to 72bps increase in credit spreads for competitive firms.

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[3]In contrast, Hou and Robinson (2006) find that competition *increases* expected returns using the population of firms in Compustat. A likely reason for this difference is that concentration measures based on public firms are biased because the decision of firms to be publicly listed is affected by the structure of the industry (e.g. Bustamante and Donangelo (2017)).

1.1 Literature review

The present paper contributes to the literature that links product market competition to firm risk and stock returns. Early empirical work by Hou and Robinson (2006) finds that competition increases expected stock returns using Compustat-based measures. Bustamante and Donangelo (2017) reach opposite conclusions using broader measures of concentration that include both public and private firms. The latter explain this discrepancy by noting that the decision to be publicly listed depends on industry characteristics, which can bias concentration measures. Aguerrevere (2009) examines how competition affects equity risk in a simultaneous-move oligopoly. Carlson, Dockner, Fisher, and Giammarino (2014) consider risk dynamics in a leader-follower equilibrium. Bustamante and Donangelo (2017), and Loualiche (2014) study the effects of entry on the cross-section of stock returns. Corhay, Kung, and Schmid (2015) links competition to time-varying risk premia and the term structure of equity returns. My work fills an important gap in this literature by analyzing how product market structure jointly affects the pricing and risk of corporate debt and levered equity.[4]

The literature in corporate finance and IO examining the interactions between capital structure and product markets is vast. While most prior studies have focused on the impact of capital structure on firm strategies in product markets,[5] a growing research (e.g. MacKay and Phillips (2005)) has highlighted the importance of industry competition on capital structure. Xu (2012) shows empirically that higher industry competition decreases the use of leverage. Valta (2012) shows that more competitive firms face a higher cost of bank loans.[6] The present paper makes an important contribution by investigating the effects of industry competition on the quantity and pricing of debt in a joint framework. In addition, the empirical findings extend those of Valta (2012) for the public debt market and provide new empirical evidence on the relation between competition, idiosyncratic volatility, and credit spreads.

My work also builds on the literature in economics and finance embedding dynamic capital structure decision[7] into equilibrium asset pricing models. Hackbarth, Miao, and Morellec (2006) highlights the importance of macroeconomic conditions for firm financing conditions and credit

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[4]Other related papers include Garlappi (2004), Hackbarth and Morellec (2008), Hoberg and Phillips (2010), Ortiz-Molina and Phillips (2014), and Bustamante (2015).

[5]Some examples are Brander and Lewis (1986), Bolton and Scharfstein (1990), Chevalier (1995), Phillips (1995), Lambrecht (2001), and Campello (2003).

[6]Also related is Miao (2005) that investigates the interaction between industry dynamics and capital structure in a model with entry and exits.

[7]See Strebulaev and Whited (2011) for a recent literature review.

spreads in a risk-neutral framework. Building on their work, several papers have tried to rationalize the credit spread puzzle by generating variations in the market price of risk over the business cycle. Chen, Collin-Dufresne, and Goldstein (2009) accomplishes this using the habits formation model, while Bhamra, Kuehn, and Strebulaev (2009) adopts the long-run risk framework of Bansal and Yaron (2004). Chen (2010) shows how countercyclical variations in default losses helps generating a significant bond risk premia.[8] In these papers, the state-price density or endowment process is assumed to be exogenous.

In a recent paper, Gilchrist and Zakrajšek (2011) show that corporate bond risk premia contains important information about the business cycles. Motivated by these findings, a growing body of literature now attempts to connect corporate bond risk premium to the economy. This is especially important as most of the production-based asset pricing literature has focused on linking the macroeconomy to equity risk premia.[9] Recent contributions include Gomes, Jermann, and Schmid (2013) who incorporate long-term nominal debt into a standard DSGE model to quantify the importance of nominal rigidity through a debt deflation channel. Miao and Wang (2010) adopt a similar setup and show how long-term debt amplifies business cycle fluctuations. Several other papers have proved successful at generating significant credit risk premium in production models: Gourio (2013) uses disaster risk, Gomes and Schmid (2010) model heterogeneous firms, and Favilukis, Lin, and Zhao (2013) highlights the importance of labor frictions. My work contributes to this literature by departing from the assumption of perfect competition and by examining how the product market structure affects credit spreads in the cross-section.

Finally, the paper relates to studies linking equity volatility to corporate credit spreads, e.g. Campbell and Taksler (2003). A series of recent paper documents the tight connection between competition and idiosyncratic volatility (e.g. Gaspar and Massa (2006) and Irvine and Pontiff (2009)). In this paper, I contribute to the literature by showing, both theoretically and empirically, how competition can amplify credit spread's exposure to idiosyncratic risk. Importantly, I also document that the increased exposure to idiosyncratic volatility translates into lower equity risk premium for competitive industries.

The paper is organized as follows. Section 2 develops a simple two-period model where I derive closed form solution to study the effects of competition on asset prices. Section 3 extends the

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[8]Other related studies include Almeida and Philippon (2007), Davydenko and Strebulaev (2007), Elkamhi, Ericsson, and Jiang (2011).

[9]Some examples are Jermann (1998), Boldrin, Christiano, and Fisher (2001), Kaltenbrunner and Lochstoer (2010), Kung and Schmid (2015)

simple model into a quantitative model. In section 4, I discuss the baseline calibration. Section 5 investigates some of the model's quantitative implications for the cross-section of asset prices. Section 6 presents several empirical tests and is followed by a few concluding remarks in section 7.

2   A simple model

This section develops a simple, two-period model to highlight some of the key economic channels through which competition affects the pricing of equity and debt. These ingredients are then incorporated in a more quantitative setting in the next section.

2.1   Economic environment

Consider an oligopolistic industry that is populated by n value-maximizing firms. These firms strategically compete in product markets in a Cournot-Nash setup. They choose the quantity of output to maximize the value of the firm, taking production decisions of other firms as given. For simplicity, I assume the existence of a risk-neutral representative investor whose time discount factor β is used to price all securities. The timeline of events is as follows. In period 0, the firm hires labor after observing the realization of an aggregate technology shock. The firm finances itself by issuing one-period debt and equity. In period 1, the firm makes optimal production decisions after which it is hit by an idiosyncratic shock. Shareholders then have the option to declare bankruptcy. If no default occurs, the firm pays its debt obligations, and distribute all residual claim as dividend. The firm then disappears from the economy.

To be more specific, each firm in the industry produces an identical good $y_{i,t}$. The total demand for the industry is given by the following downward-sloping demand curve,

$$Y_t = P_t^{-\nu} \, \mathcal{Y}_t \tag{1}$$

where ν is the elasticity of demand for the industry good, P_t is the equilibrium industry good price, $Y_t = \sum_{i=1}^{n} y_{i,t}$ is the total industry output, and $\mathcal{Y}_t$ is an aggregate demand term, taken as given by the firm.[10]

The firm produces output using labor l_t that is rented in competitive markets at a wage rate

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[10]To facilitate the exposition, the i-subscript is dropped, unless it is necessary to avoid confusion.

of W_t. The production technology is assumed to be linear in labor,

$$y_t = A \, l_t \tag{2}$$

where A is a persistent (i.e. lasts two periods) technology shock capturing all systematic risk in the economy.

In period 0, the firm decides on its optimal capital structure by issuing one-period defaultable debt b and equity (negative dividends). Debt is attractive because of the tax deductibility of interest rates but is costly because default entails deadweight loss. In particular, when the value of the firm becomes negative, shareholders walks away with a payoff of zero, and debtholders get nothing. Denoting the unit price of debt by q, the value of the firm debt to creditors is,

$$q = \beta \Phi(z^\star)(1 + C) \tag{3}$$

where $\Phi(z^\star)$ is the probability of survival of the firm (to be determined later), and C is the coupon payment. Essentially, Eq. 3 says that the value of debt today is the expected payoff, discounted by the state-price density, β.

2.2 Individual firm's problem

The objective of the firm is to maximize the market value to shareholders V_j, by choosing labor, and the optimal capital structure:

$$V_j = \max_{l_0, l_1, i, b} \, d_0 + \beta E_0[\max\{d_1, 0\}] \tag{4}$$

subject to the total demand for the industry good (Eq. 1), the market value of corporate debt (Eq. 3), and production decisions of other firms. Note that the second max operator captures the limited liability option of shareholders. The firm dividends are defined as the free cash-flows generated by the firm. Because of the finite nature of the firm, there will be no debt issuance in

period 1. The real dividend in each period is given by,[11]

$$d_0 = P_0 y_0 - W_0 l_0 + qb \tag{5}$$

$$d_1 = P_1 y_1 - W_1 l_1 - z\bar{l} - (1 + C(1 - \tau))b_1 \tag{6}$$

where $(1 - \tau)$ captures the tax advantage of interest payments, and z is a mean-zero, idiosyncratic shock assumed to be uniformly distributed on $[-a/2, a/2]$. The idiosyncratic shock z is multiplied by the average size of a firm in the industry, $\bar{l} = \frac{1}{n}\sum_{i=1}^{n} l_{i,t}$ to avoid that competitive industries be mechanically more exposed to z shocks. In the following, I denote the cumulative distribution of z by $\Phi(.)$, and the associated probability distribution function by $\phi(.)$. The idiosyncratic cash-flow shock z captures, in a reduced form, all heterogeneity across firms and is the key ingredient that drives firms to default. In particular, the bankruptcy decision consists of a threshold rule where shareholders declare bankruptcy as soon as z is larger than a default threshold $z^\star$, where $z^\star$ is such that $d_1(z^\star) = 0$.

2.3 Equilibrium

In the model, all firms are the same except for the idiosyncratic shock realizations. Because this cost enters as a fixed cost, all firms make identical decisions. Therefore the model admits a unique symmetric Nash equilibrium, where all firms maximize their firm value, taking rivals' actions as given. To close the labor market, I assume that the total labor supply in the industry is equal to 1. I leave the derivation of the solution to the appendix.

The equilibrium is described by a set of three equations, one optimality condition for labor, one for debt, and an optimal default threshold. This implies the following equilibrium profit margin:

$$PM = \frac{h}{\nu} \tag{7}$$

where $h = \sum_{i=1}^{n}(y_{i,t}/Y_t)^2$ is the industry Herfindahl-Hirschman concentration index. h^{-1} is a measure of industry competition. Note that the firm profit margin is increasing in industry concentration. Intuitively, when competition is tougher, a single firm has less control on the industry

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[11]All nominal variables, except for the output price, are normalized by the equilibrium industry price. It is assumed to be taken as given by the individual firm.

price P_t, and faces a more elastic demand curve.[12] Therefore higher competition drives each individual firm to produce more. At the industry level, all firms produce more so that the increased industry production puts a downward pressure on revenues and reduces the firm profits.

2.4   Competition, corporate policies and asset prices

This section examines the effect of industry competition on equilibrium corporate policies, credit spreads and equity. Proposition 1 summarizes several key results.

Proposition 1. *An increase in industry competition: (i) increases the expected default probability, (ii) decreases financial leverage, (iii) decreases equity value, and (iv) increases credit spreads.*[13]

Proof. See appendix   □

To understand the intuition behind these results note that, as shown in Eq. 7, competition erodes firms' profit margins. This makes competitive firms more exposed to idiosyncratic cash-flows shocks and increases the expected probability of default. Creditors are rational and discount the value of corporate bonds issued by competitive firms. Consequently, equilibrium credit spreads rise. In response to the more expensive cost of debt, shareholders cut on leverage. However, the reduction in leverage is not sufficient to decrease credit spreads because equity holders are willing to accept additional cost of financing to capture some of the tax benefits of debt. In the end, competitive firms earn lower profits, default more, and generate less tax shield from leverage, making their equity value lower.

Another measure of interest is equity risk. More formally, equity risk can be measured by the firm conditional beta β_i, calculated as the elasticity of equity with respect to the systematic shock A.[14] It can be shown that the conditional beta is composed of three components (see appendix for

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[12]To be more specific, the elasticity of demand for an individual firm is $\eta_{y_j,P} = \frac{\nu}{h}$.

[13]Note that I'm working under the assumption that $\beta > 0$, $C > 0$, $\tau > 0$, $\nu > 1$. Also, note that these results hold quite generally for all distribution functions $\Phi(.)$ such that $\frac{\Phi(z)}{\phi(z)}$ is increasing in z. This is the case for most standard distribution functions such as normal, uniform, etc.

[14]To be more precise, the risk premium on the asset is $\beta_i \times \lambda$, where λ is the market price of the systematic risk. In this simple model, the price of risk is null because of the risk-neutrality assumption. Therefore exposure to the A shock is not risky per se. The model could easily be augmented to have a positive price of risk without changing the qualitative results. To keep exposition as simple as possible I abstract from this and keep referring to β_i as capturing equity risk.

details),

$$\beta_i = 1 - \underbrace{\frac{\beta \int_{z^\star}^{\overline{z}} z \, d\Phi(z)}{V_j}}_{\text{Default option}} + \underbrace{\frac{\beta \tau C}{1 + (1 - \tau)C} \frac{\Phi(z^\star) z^\star}{V_j}}_{\text{Tax shield}} \tag{8}$$

The first term is the equity beta of an unlevered firm without idiosyncratic shocks. It is equal to one because the firm value is linear in A. The second term captures the effect of default on equity risk. This term is negative, that is, the option to default decreases equity beta. The intuition is that the limited liability of shareholders acts as an insurance against bad states of the world, making equity safer. Finally, the third term captures the risk coming from the expected tax-shield. This term contributes positively to β_i because the net benefit of debt is procyclical.

In contrast to credit spreads, industry competition *decreases* equity risk. The reason for this result is two-fold. First, because competitive firms face a higher likelihood of default, their limited liability option is more valuable. This decreases equity risk through a *default option* channel. Second, because competition reduces the use of debt, they are less exposed to the risk stemming from the expected tax-shield. This further decreases equity risk through a *leverage* channel. So far, we have abstracted from investment, a key ingredient in the benchmark model. Allowing firms to invest in extra capacity leads to an additional effect of competition on the value of growth options, which I refer to as the *competitive externality* channel. I discuss this third channel in the next section.

2.5   Investment

The previous section illustrates how competition, by reducing the *level* of profits, makes firm more exposed to idiosyncratic cash-flow shocks. Competition increases credit spreads because the likelihood of default is higher. Yet, it reduces equity risk because the default option becomes more valuable and competitive firms use less financial leverage. In this section, I discuss how allowing for investment gives rise to another effect of competition on asset prices; namely, competition decreases the *riskiness* of the firm by decreasing the value of risky growth options.

The intuition is as follows. Firms in competitive industries face a more elastic demand curve. Consequently, they increase investment relatively more in response to positive news about productivity. At the industry level, all firms adopt a similar strategy such that total industry output

increases. This puts a downward pressure on the output price (see Eq. 1). In the end, competitive firms produce more and sell at a cheaper price. Because the marginal product of capital is decreasing, competitive industries are characterized by lower future profits, which reduces the value of the firm growth options. Therefore when investment is allowed, feedback effects from industry rivals curtail potential profit opportunities from investment, and decreases the firm exposure to aggregate risk. I refer to this effect as the *competitive externality* channel.[15]

The simple model has highlighted several channels through which competition affects levered equity returns and credit spreads. In the next section, I build a production-based asset pricing model to quantitatively assess the strengths of each these channels.

3   Benchmark model

This section extends the simple model into a quantitative general equilibrium model. I use this framework to quantify the importance of strategic interactions as a driver of the cross-section of asset prices. The economy is populated by a large number of firms that operate in various industries. These firms strategically compete in product markets within an industry and finance through debt and equity. They accumulate productive capital through investment, employ labor, choose the optimal equity/debt mix dynamically and have the option to default. All financial claims are held by a representative household with recursive preferences. I begin with a description of the economic environment faced by a firm and derive the optimal production, financing, and default decisions. Then, I close the model by specifying a final good producer and a household sector and characterize the symmetric equilibrium. Throughout the section, I use the subscript i to denote an individual firm, and j to denote an industry.

3.1   Industry competition

An industry is defined as a group of n_j firms that produce an identical product. Each period, the industry receives a total demand for its product equal to $Y_{j,t}$. The industry demand is assumed to

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[15]The idea that rivals' actions can reduce own-firm risk arises in other setups. For instance, Carlson, Dockner, Fisher, and Giammarino (2014) obtain similar results in a dynamic duopoly model where firms have the option to invest in additional capacity (intensive margin). More recently, Bustamante and Donangelo (2017) uses procyclical entry threat (extensive margin).

be a decreasing function of the product price:[16]

$$Y_{j,t} = \tilde{P}_{j,t}^{-\nu} \, \mathcal{Y}_t \tag{9}$$

where $\mathcal{Y}_t$ is an aggregate demand term, $\tilde{P}_{j,t} = P_{j,t}/\mathcal{P}_t$ is the industry product price relative to the aggregate price index, and ν is the elasticity of demand for industry goods.

Firms meet the industry demand by strategically competing with others in the industry. More specifically, I assume that firms play a Cournot game in each period, that is, firms produce the quantity of product that maximizes the value of the firm, taking production decisions of other firms and the total industry demand as given. As we will see later, an implication of the Cournot setup is that the degree of competition in product markets is an increasing function of the number of firms in the industry.

3.2 Production and profits

The firm supplies industry products using capital and labor in a standard Cobb-Douglas production technology. Aggregate changes in profit opportunities are captured by the productivity process A_t, which is assumed to be common across all firms in the economy and is the only source of aggregate risk. Denoting the firm's production by $y_{i,j,t}$:

$$y_{i,j,t} = k_{i,j,t}^{\alpha} \left(A_t l_{i,j,t} \right)^{1-\alpha} \tag{10}$$

$$\Delta a_{t+1} = \mu + g_t + \sigma_a \epsilon_{a,t+1} \tag{11}$$

$$g_t = \rho_g g_{t-1} + \sigma_g \epsilon_{g,t} \tag{12}$$

where $\Delta a_t = \log(A_t/A_{t-1})$, and

$$\begin{bmatrix} \epsilon_{a,t+1} \\ \epsilon_{x,t+1} \end{bmatrix} \sim iid\,\mathcal{N} \left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \right). \tag{13}$$

The low-frequency component in productivity, g_t, is used to generate long-run risk as in Bansal and Yaron (2004).[17]

The firm hires labor in competitive markets for a real wage of W_t and sell its products at a

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[16]I provide a micro-funded industry structure at the end of the section that rationalizes this specification.
[17]Other studies using this type of productivity process include Croce (2014), Kung and Schmid (2015), and Kung (2015).

unit price of $P_{j,t}$. Each period and after the sales are realized, the firm's after tax profit is hit by a firm-specific shock. These shocks summarize, in a reduced form, all heterogeneity across firms within an industry. Denoting the firm's real after-tax profit by $\Pi_{i,j,t}$,

$$\Pi_{i,j,t} = (1-\tau)\left(\tilde{P}_{j,t}\, y_{i,j,t} - W_t\, l_{i,j,t}\right) - z_{i,j,t}\, \bar{k}_{j,t} \tag{14}$$

where τ is the corporate tax rate, and $\bar{k}_{j,t}$ is the average size of a firm in the industry.[18] The firm-specific shock is assumed to be normally distributed, $z_{i,j,t} \sim iid\,\mathcal{N}(0,\sigma_z)$, and the corresponding cumulative and density distribution functions are denoted by $\Phi(.)$ and $\phi(.)$, respectively.

The competitive environment in which a firm operates will affect revenues earned in product markets and in turn shape all the firm's decisions. To see this point more clearly, consider the following expression characterizing the firm's revenues,[19]

$$\tilde{P}_{j,t}\, \tilde{y}_{i,j,t} = \left(\underbrace{\frac{1}{n_j}\, \tilde{y}_{i,j,t}}_{\text{firm}} + \underbrace{\frac{n_j-1}{n_j}\, \tilde{y}_{j,t}^{-}}_{\text{rivals}}\right)^{-\frac{1}{\nu}} \tilde{y}_{i,j,t} \tag{15}$$

where $\tilde{y}_{j,t}^{-}$, is the average output produced by competitors in the industry. This expression says that the industry price depends on a weighted average between the individual firm production and the total production of the firm's rivals. Importantly, the relative importance of the two components is determined by the number of firms in the industry, n_j. In concentrated industries (small n_j), each individual firm has a larger effect on the industry price, which is reflected in a steeper demand curve. In contrast, in competitive industries (large n_j), an individual firm faces a more elastic demand curve and variations in the equilibrium price are mostly driven by competitors. These differences in the price elasticity of demand across industries will be an important determinant of a firm's profit opportunities and impact both the level and risk of the firm cash-flows. These considerations will have important implications for asset prices.

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[18]I multiply the idiosyncratic shock by $\bar{k}_{j,t}$ for two reasons. First, it ensures that idiosyncratic risk does not become trivially small along the balanced growth path. Second, because competitive firms are on average smaller, multiplying by the average size prevents that competitive firms are mechanically more exposed to idiosyncratic risk. Note that $\bar{k}_{j,t}$ is assumed to be taken as given by the firm.

[19]This expression is obtained by replacing for $P_{i,j,t}$ using the industry product demand in Eq. 9. Tilde output variables are normalized by the average demand factor, $\bar{\mathcal{Y}}_{j,t} = \mathcal{Y}_t/n_j$.

3.3 Financing

Each period, after observing the realizations of all shocks, equity holders have the option to declare bankruptcy. When bankruptcy is declared, equity holders leave with a payoff of zero and creditors take over the firm, after paying a deadweight bankruptcy cost. If no default happens, the firm pays its debt obligations, which consist of the interest and the principal due on outstanding debt, i.e. $((1 - \tau)C + 1) b_{i,j,t}$. Note the the coupon payment, C, is paid after tax because interest rates are tax deductible. The firm then chooses its new optimal capital structure by weighting the expected tax benefits of debt against the expected costs arising from default. It issues an amount $b_{i,j,t+1}$ of new one-period debt, sold to creditors at a market price of $q_{i,j,t}$ per unit. Therefore, the net cash flow from debt financing activities is

$$b_{i,j,t+1} \, q_{i,j,t} - ((1 - \tau)C + 1) \, b_{i,j,t} - \psi_b(b_{i,j,t}, b_{i,j,t+1}) \tag{16}$$

where $\psi_b(b_{i,j,t}, b_{i,j,t+1})$ is function that captures all costs associated with adjustments to leverage.[20]

3.4 Investment

The firm accumulates capital for production in the next period through investment, $i_{i,j,t}$. The stock of productive capital accumulates as follows,

$$k_{i,j,t+1} = (1 - \delta_k)k_{i,j,t} + \Gamma\left(\frac{i_{i,j,t}}{k_{i,j,t}}\right)k_{i,j,t} \tag{17}$$

where δ_k is the depreciation rate of capital, and $\Gamma(.)$ captures the idea that capital accumulation is subject to adjustment costs. As in reality, it is assumed that the firm can deduct depreciated capital from taxable income. The net cash flows from investment activities is

$$-i_{i,j,t} + \tau \delta_k k_{i,j,t} \tag{18}$$

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[20]Note that adjustment costs to leverage are mainly specified for quantitative reasons. Absent these costs, the firm would aggressively change leverage is response to shocks, leading to counterfactually high leverage volatility. One could obtain financing frictions in other ways. For instance Jermann and Quadrini (2012) assume quadratic adjustment costs for dividends, and Gomes, Jermann, and Schmid (2013) use long-term nominal debt.

3.5 Equity value

Equity holders have the right to the firm dividends so long as the firm is in operation. The dividend is equal to the firm free cash-flows that is, the operating profit, plus the cash flows from financing and investment activities,

$$d_{i,j,t} = \Pi_{i,j,t} - i_{i,j,t} + \tau\delta_k k_{i,j,t} - ((1-\tau)C+1)\, b_{i,j,t} + q_{i,j,t} b_{i,j,t+1} - \psi_{b,i,j,t} \qquad (19)$$

The objective of the manager is to maximize the value of the firm to shareholders. Equity is owned by the representative household, thus the household intertemporal marginal rate of substitution, $M_{t,t+s}$, is used to discount future dividends. Denoting the vector of industry state variables by $\Upsilon_{j,t} \equiv \left\{ \mathcal{Y}_t, g_t, \Delta a_t, \bar{k}_{j,t}, \{y_{k,j,t}\}_{k=1, k\neq j}^{n_j} \right\}$, and the vector containing all the firm's controls by $\mathcal{F}_{i,j,t} \equiv \{b_{i,j,t+1}, i_{i,j,t}, k_{i,j,t+1}, l_{i,j,t}\}$, the equity value is:

$$V_E\left(b_{i,j,t}, k_{i,j,t}, z_{i,j,t}, \Upsilon_{j,t}\right) = \max\left\{ \max_{\mathcal{F}_{i,j,t}} V\left(b_{i,j,t+1}, k_{i,j,t+1}, z_{i,j,t+1}, \Upsilon_{j,t+1}\right), 0 \right\}, \qquad (20)$$

where the optimization is done subject to the total demand for the industry product (Eq. 9), the capital accumulation relation (Eq. 17), and the market price of debt $q_{i,j,t}$. $V(.) = d_{i,j,t} + E_t\left[M_{t,t+1} V_E\left(b_{i,j,t}, k_{i,j,t}, z_{i,j,t}, \Upsilon_{j,t}\right)\right]$ is the firm continuation value, i.e. the value of the equity without the option to default at time t. Note that the first max operator captures the limited liability of shareholders.

3.6 Optimal default

When the continuation value of the firm becomes negative, shareholders declare bankruptcy and leave with a payoff of zero. Because the firm value in additive in the idiosyncratic shock, the default decision consists in finding the threshold value $z_{i,j,t}^{\star}$ that makes the continuation value null, and to declare bankruptcy as soon as $z_{i,j,t} > z_{i,j,t}^{\star}$. Solving for $z_{i,j,t}^{\star}$, we have

$$z_{i,j,t}^{\star} = \frac{V\left(b_{i,j,t}, k_{i,j,t}, 0, \Upsilon_j\right)}{\bar{k}_{j,t}} \qquad (21)$$

The expression characterizing the optimal default highlights the tight link between default and the continuation value of the firm. In particular, at times of high valuation default rates are low, making default endogenously countercyclical. Importantly, the degree of industry competition, by

affecting the value of the firm, will affect the conditional default probability, and impact the firm's optimal decisions and asset prices.

3.7 Debt value

When the firm defaults, creditors gain control over the firm's assets after paying a one time bankruptcy cost equal to $\xi\%$ of the firm value. They then become owner of an unlevered firm and collect the firm's dividend in the current period. Corporate bonds are held by the representative household and are thus valued using the equilibrium pricing kernel $M_{t,t+1}$. The value of newly issued debt to creditors is

$$q_{i,j,t}b_{i,j,t+1} = E_t M_{t,t+1} \left\{ \begin{array}{c} \Phi(z^\star_{j,t+1})(C+1)b_{i,j,t+1} \\ +(1-\xi)\int_{z^\star_{j,t+1}}^{\bar{z}} V\left(0, z_{j,t+1}, \Upsilon_{t+1}\right) d\Phi(z_{j,t+1}) \end{array} \right\} \tag{22}$$

The first term inside the brackets is the payment when the firm survives multiplied by the probability of survival. It is equal to the coupon payment plus the principal. The second term is the bondholders payoff when the firm defaults, multiplied by the probability of default.

3.8 Optimal firm decisions

The objective of the manager is to make a series of operating, financing and investment decisions to maximize the value of the firm. In this section, I provide the set of equilibrium conditions that characterizes the firm's optimal decisions. The detailed problem and derivations of the first order conditions are relegated to Appendix B.

The optimal capital structure decision is given by the first order condition with respect to $b_{i,j,t+1}$,

$$q_{i,j,t} + \frac{\partial q_{i,j,t}}{\partial b_{i,j,t+1}} b_{i,j,t+1} = E_t M_{t,t+1} \Phi(z^\star_{j,t+1}) \left[(1-\tau)C + 1\right] + \Delta\psi_{b,t} \tag{23}$$

where $\Delta\psi_{b,t}$[21] is the net adjustment cost associated with issuing an amount $b_{i,j,t+1}$ of debt. This condition means that in equilibrium, the firm equates the marginal benefits (left-hand side) to the marginal costs (right-hand side) of debt. More specifically, issuing an additional unit of debt provides shareholders with an additional payoff equal to $q_{i,j,t}$, adjusted to take into account the decrease in debt value due to the increased probability of default. The cost of issuing an additional

---

[21]In particular, $\Delta\psi_{b,t} = \frac{\partial \psi_{b,t}}{\partial b_{i,jt+1}} + E_t M_{t,t+1} \Phi(z^\star_{j,t+1}) \frac{\partial \psi_{b,t+1}}{\partial b_{i,jt+1}}$.

unit of debt is the after-tax interest rate, plus the principal due in the next period, plus the change in issuance costs. The bankruptcy costs are multiplied by the probability of survival as shareholders have the option to walk away in the next period.

The optimal investment decision is given by the investment Euler equation, which equates the marginal benefits to the marginal costs of an additional unit of capital,

$$\Lambda_t^K = E_t M_{t,t+1} \left(1 + \vartheta_{i,j,t+1}\right) \left\{ d'_{k,i,j,t+1} + \Lambda_{t+1}^K \left[1 - \delta_k + \Gamma_{i,j,t+1} - \Gamma'_{i,j,t+1}\left(\frac{i_{t+1}}{k_{t+1}}\right)\right]\right\} \tag{24}$$

where $\vartheta_{i,j,t+1} = \phi(z^\star_{i,j,t+1})\frac{b_{i,j,t+1}}{(1-\tau)\bar{k}_{j,t}}(\tau C + \xi[(1-\tau)C+1]) - \xi(1 - \Phi(z^\star_{i,j,t+1}))$ and Λ_t^K is the Lagrange multiplier on the capital accumulation equation and represents the shadow value of a marginal unit of capital (Tobin's Q). The two terms inside the brackets in Eq. 24 represents the expected increase in dividend and capital gains from investing a marginal unit of capital today.[22] The multiplicative term $(1 + \vartheta_{i,j,t+1})$ captures the distortion arising from the leverage decision. More specifically, investing today increases future dividends and thereby decreases the probability of default (first term in $\vartheta_{i,j,t+1}$). However, because bankruptcy is costly, there is a chance that the invested unit is partially lost in the next period (second term). Note that the standard investment Euler equation is a particular case where $\vartheta_{i,j,t+1} = 0$.

3.9   Final goods and households

This section specifies a final goods sector and a household sector. The final goods producer provides a micro-foundation for the industry demand used in Eq. 9, while the household sector endogenizes variations in the price of risk and labor supply over the business cycle.

Final Goods   The final consumption good is produced by a representative firm operating in a perfectly competitive market. The firm uses a continuum of industry goods $Y_{j,t}$ as input in a CES production technology. To keep the number of industries finite, it is assumed that the economy is composed of a continuum of N different industry types equally distributed on the $[0,1]$ interval,

$$\mathcal{Y}_t = \left(\int_0^1 Y_{j,t}^{\frac{\nu-1}{\nu}} \, dj\right)^{\frac{\nu}{\nu-1}} = \left(\frac{1}{N}\sum_{i=1}^N Y_{j,t}^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}} \tag{25}$$

---

[22]Specifically, $d'_{k,i,j,t} = (1-\tau)\tilde{P}_{j,t}\left[1 - \frac{1}{\nu}\frac{y_t}{Y_{j,t}}\right]\alpha\frac{y_t}{k_t} + \tau\delta_k$

where ν is the elasticity of substitution between goods of different industries.

Solving the profit maximization problem for the final good firm (see Appendix C) yields the following inverse demand function for industry j's product,

$$Y_{j,t} = \tilde{P}_{j,t}^{-\nu}\, \mathcal{Y}_t \qquad (26)$$

where $\tilde{P}_{j,t} = P_{j,t}/\mathcal{P}_t$, and $\mathcal{P}_t = \left(\int_0^1 P_{j,t}^{1-\nu}\right)^{\frac{1}{1-\nu}}$ is the aggregate price index. This expression is the same as the industry demand function specified in Eq. 9.

Households   I assume the existence of a representative household with recursive utility over a bundle of consumption $\mathcal{C}_t$ and leisure $(1 - \mathcal{L}_t)$ as in Croce (2014),

$$U_t = \left\{ \tilde{C}_t^{1-\frac{1}{\psi}} + \beta E_t \left[U_{t+1}^{1-\gamma} \right]^{\frac{1-\frac{1}{\psi}}{1-\gamma}} \right\}^{\frac{1}{1-\frac{1}{\psi}}} \qquad (27)$$

$$\tilde{C}_t = \mathcal{C}_t^{\varphi}(A_{t-1}(1 - \mathcal{L}_t))^{1-\varphi} \qquad (28)$$

where γ is the coefficient of relative risk aversion, ψ is the elasticity of intertemporal substitution, β is the subjective discount factor, and φ drives the total amount of hours worked. Note that leisure is multiplied by productivity A_{t-1} to ensure balanced growth.

To finance her consumption stream, the representative household collects wages by supplying specialized labor $L_{j,t}$ to industry j. In addition, the household has access to financial markets where she can invest in stocks, and corporate bonds in all industries as well as government bonds. The total position held in equities is denoted by $\mathcal{Q}_t$, while the total amount invested in corporate and government bonds is denoted by $\mathcal{B}_{t+1}^c$ and $\mathcal{B}_{t+1}^g$, respectively. The real (normalized by $\mathcal{P}_t$) budget constraint of the household is

$$\mathcal{C}_t + \underbrace{\left[\mathcal{B}_{t+1}^c + \mathcal{B}_{t+1}^g + \mathcal{Q}_t\right]}_{\text{Position in securities}} = \mathcal{W}_t\mathcal{L}_t + \underbrace{\left[\mathcal{R}_t^c\mathcal{B}_t^c + \mathcal{R}_t^f B_t^g + \mathcal{R}_t^d\mathcal{Q}_{t-1}\right]}_{\text{Proceeds from securities}} - \mathcal{T}_t \qquad (29)$$

where $\mathcal{W}_t\mathcal{L}_t = \frac{1}{N}\sum_{j=1}^N W_{j,t}L_{j,t}$ is the total labor income, $\mathcal{R}_t^f$ is the risk-free return on government bonds bought in the previous period, and $\mathcal{R}_t^d$ and $\mathcal{R}_t^c$ are the total returns on the equity and corporate debt portfolio. These returns are defined in the next section. $\mathcal{T}_t$ are lump-sum government

taxes.[23]

Solving the household problem yields a set of Euler equation to price all securities in the economy. The equilibrium one-period pricing kernel is

$$M_{t,t+1} = \beta \left(\frac{\mathcal{C}_{t+1}}{\mathcal{C}_t} \right)^{-1} \left(\frac{\tilde{C}_{t+1}}{\tilde{C}_t} \right)^{1-\frac{1}{\psi}} \left(\frac{U_{t+1}}{E_t \left(U_{t+1}^{1-\gamma} \right)^{\frac{1}{1-\gamma}}} \right)^{\frac{1}{\psi}-\gamma} \tag{30}$$

The household labor supply condition for each industry is,

$$W_{j,t} = \left(\frac{1}{\varphi} - 1 \right) \frac{\mathcal{C}_t}{(1 - \mathcal{L}_t)}, \tag{31}$$

The wage is independent of j because the household works indifferently across all industries.

3.10 Equilibrium and aggregation

The fixed cost specification for the idiosyncratic shock makes all firms ex-ante identical. Besides, in case of bankruptcy, the firm is transferred to debt-holders who make the same decisions as surviving firms. Therefore, the only cross-sectional difference across firms comes from the realization of the firm-specific shock $z_{i,j,t}$. In the aggregate, the law of large numbers applies to each type of industry and we only need to keep track of the measure of surviving firms each period, $\Phi(z_{j,t}^\star)$.[24] Consequently, each industry admits a symmetric Nash equilibrium and the i-subscript can be dropped. In the symmetric equilibrium, the model has $2 \times N + 2$ state variables; two endogenous state variables for each industry $(k_{j,t}, b_{j,t})$, and two exogenous variables $(g_t, \Delta a_t)$ for the economy.

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[23]To close the model, I assume the existence of a government whose objective is to set $\mathcal{T}_t$ to maintain a zero deficit. Therefore the net supply of government debt is zero and household taxes amounts to the total corporate tax subsidy of interests net of corporate tax collection.

[24]A big advantage of this specification is that one can obtain an exact aggregation for the firm distributions without having to rely on the Krusell and Smith (1998) algorithm (e.g. Miao and Wang (2010), Gomes, Jermann, and Schmid (2013)).

Asset returns The return on equity and corporate debt in industry j are defined in a standard way and account for the proportion of firms that defaults,

$$
\begin{aligned}
\mathcal{R}_{j,t}^d &= \frac{\int_{\underline{z}}^{z_{j,t}^\star} [d_{j,t} + Q_{j,t}]\, d\Phi(z)}{Q_{j,t-1}} \\
\mathcal{R}_{j,t}^c &= \frac{\Phi(z_{j,t}^\star)(C+1)b_{j,t} + \int_{z_{j,t+1}^\star}^{\overline{z}} (1-\xi)V_{j,t}^U\, d\Phi(z)}{q_{j,t-1}b_{j,t}}
\end{aligned}
\tag{32}
$$

where $Q_{j,t} = V_{j,t} - d_{j,t}$ is the ex-dividend value of equity in industry j, and $V_{j,t}^U$ is the equity value cum-dividend of an unlevered firm.

Aggregate resource constraint Using the definition for the returns (32) earned in financial markets and imposing market clearing on all markets.[25] The aggregate resource constraint (29) becomes,

$$
\mathcal{Y}_t = \mathcal{C}_t + \mathcal{I}_t + (\Psi_{b,t} + \Xi)\, \eta
\tag{33}
$$

where $\mathcal{I}_t = \frac{1}{N}\sum_{i=1}^N I_{j,t}$ is aggregate investment, $\Psi_{b,t} = \frac{1}{N}\sum_{i=1}^N \psi_b(b_{i,j,t}, b_{i,j,t+1})$ is the amount of resources spent in debt adjustments, and $\Xi = \frac{1}{N}\sum_{i=1}^N \left(\int_{z_{j,t+1}^\star}^{\overline{z}} \xi V_{j,t}(0,z)\, d\Phi(z) \right)$ is the aggregate resource lost in bankruptcy. Some of these losses may come in the form of restructuring expenses and may represent a source of income for the representative family. This effect is captured through parameter $\eta \in [0,1]$. The special case of $\eta = 0$ is one where both default and debt adjustments causes no loss of resources at the aggregate level.

3.11 Industry markups

In the symmetric Nash equilibrium, the market clearing price consists of a fixed markup over the marginal cost of production (see appendix for details). Importantly, the equilibrium markup μ_j is an increasing function of industry concentration:

$$
\mu_j = \left(1 - \frac{h_j}{\nu}\right)^{-1}
\tag{34}
$$

---

[25]In particular, I impose that the representative household holds all equity claims, and buys all corporate debt issued by corporations: $\mathcal{B}_{t+1}^c = \frac{1}{N}\sum_{j=1}^N q_{j,t}b_{j,t+1}$. Furthermore, the net supply of government bonds is zero: $\mathcal{B}_{t+1}^g = 0$, and the labor and goods supply equal their respective demands.

where h_j is the Herfindahl-Hirschman index in industry j. The intuition for this relation is that as competition increases, each firm becomes relatively smaller and its own decisions have less effect on total industry output. Therefore firms increasingly behave like price takers, which brings their marginal cost of production closer to the output price and decreases the price markup.

4   Model parametrization

This section describes the calibration of the benchmark model. I start by specifying functional forms for the adjustment costs and follow by describing the calibration of the parameters driving the cross-section of industries. The aggregate parameters are then calibrated in two steps. First, standard real business cycles parameters as well as preference parameters are set to values from the existing literature. The remaining parameters are obtained by minimizing the distance between moments simulated from the model and identifying moments from the data. All parameters values are summarized in Table 1.

4.1   Functional forms

The capital adjustment cost function, $\Gamma(.)$, is modeled following Jermann (1998),

$$\Gamma(x) = \frac{\alpha_1}{1 - 1/\zeta_k} x^{1-1/\zeta_k} + \alpha_{2,k} \tag{35}$$

where $\alpha_{1,k}$ and $\alpha_{2,k}$ are determined such that there is no adjustment cost in the deterministic steady state.

The debt adjustment cost is assumed to be quadratic,

$$\psi(\tilde{b}_{t+1}, \tilde{b}_t) = \frac{\chi_b}{2} \left(\tilde{b}_{t+1} - \tilde{b}_t \right)^2 \bar{k}_{j,t} \tag{36}$$

where $\tilde{b}_t$ is corporate debt normalized by the average industry size $\bar{k}_{j,t}$, and χ_b is a parameter capturing the magnitude of the cost to change leverage. Note that this specification ensures that the debt adjustment cost has no impact on the deterministic steady state.

4.2 Industry parameters

All model parameters are the same across industries, except for h_j, which determines the degree of competition within the industry. The objective is to generate cross-sectional differences in industry competition in line with the data, while keeping the model relatively tractable. To achieve this, I proceed as follows. I model three types of industries and set the degree of competition in industry 2 to produce an equilibrium markup of 30%, a standard value in the IO literature (e.g. Jaimovich and Floetotto (2008)). The remaining two parameters are calibrated so that the difference in markup between industry 1 and 3 equals 12.55%, which is the empirical spread obtained by sorting industries into terciles based on industry competition.[26] The resulting calibration implies a price elasticity for the firm's product of 3.76 and 5.22 in the low- and high-competition industry, respectively.

4.3 Aggregate parameters

The preference parameters governing the representative agent risk tastes are standard in the long-run risk literature, e.g. Bansal and Yaron (2004). The elasticity of intertemporal substitution (ψ) and the coefficient of relative risk aversion (γ), are set to 2 and 10, respectively. This parameter choice implies that the representative agent prefers an early resolution of uncertainty, and thus price long-run risk positively. Furthermore, a high IES is important to get a positive relation between firm valuation ratios and growth, which is key to generate countercyclical default rates as in the data. The subjective discount factor β is set to 0.99, implying a risk-free rate in the steady state of 4% per annum. The relative preference for labor, φ, is such that the household works 1/3 of her time endowment in the steady state.

On the technology side, the capital share α is set to 0.33, and the depreciation rate of capital δ_k is set to 2.0%. These are standard values in the macroeconomics literature that are designed to match steady-state evidence. The productivity process is calibrated to consistent with empirical evidence from Croce (2014). The persistence of the long run risk is set to imply a annual persistence of 0.9 while the conditional annualized volatility of the short- and long-run productivity shocks are $\sigma_a = 1.875\%/4$ and $\sigma_g = 0.1\sigma_a$, respectively. μ drives the mean growth rate and is picked to

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[26]I use two proxies for industry competition and take the average spread in markups across these two measures to calibrate the model. The first measure is the sales-based Herfindahl-Hirschman Index (HHI) published by the U.S. Census. The second measure is the price-to-cost margin (PCM) obtained from the NBER-CES Manufacturing Industry Database. For additional details on these measures, refer to Section 6.1.

generate a growth rate of consumption in the steady state of 1.80% per annum. The elasticity of substitution across industries ν is set to 1.001, following Jaimovich and Floetotto (2008). Finally, I set C to 7%/4 to match the average coupon payment in my data sample (see Table 5), and assume that default and debt adjustment costs entails no loss of resources at the aggregate level, i.e. $\eta = 0$.

The remaining five aggregate parameters, namely $\Theta = [\sigma_z, \xi, \chi_b, \zeta_k, \tau]$ are chosen to minimize the distance between a vector of identifying moments from the data, $\hat{m}$, and the same moments generated from model simulations, $m(\Theta)$. Mathematically, I obtain the parameter estimates by solving,

$$\hat{\Theta} = \underset{\Theta}{\operatorname{argmin}} \left[\hat{m} - m(\Theta)\right]' \tilde{W}^{-1} \left[\hat{m} - m(\Theta)\right] \tag{37}$$

where $\tilde{W}$ is a weighing matrix set to the identity matrix. Simulated moments are computed over a sample of 25,000 observations, with a burning period of 1,000 quarters.

The first empirical target is the quarterly average default rate. Since the idiosyncratic shock is an important driver of default at the firm level, this moment is a good candidate to pin down σ_z. I use a quarterly mean default rate of 0.25% to match the Moody's average annual default rate of 1% per year. To identify the average default loss, ξ, I follow Chen (2010) and target a mean recovery rate on defaulted bonds of 41.40%. Although the statutory corporate tax rate is observable, τ may capture additional benefits of using leverage over equity (e.g. agency concerns, issuance cost, etc.). I thus decide to estimate this parameter and discipline its magnitude, by matching a mean aggregate book-to-asset ratio of 0.40 as in Gourio (2013). The curvature of capital adjustment costs, ζ_k, is chosen to generate a large investment volatility consistent with the data. The final parameter χ_b mainly affects the speed to which firms change their leverage in response to aggregate productivity shocks. I discipline this parameter using the standard deviation of aggregate book-leverage.

The parameter estimates and the identifying moments are reported in Table 2. Overall, the estimation matches the target moments very well, with parameters broadly consistent with prior research. For instance the estimate for ξ suggests that a firm is expected to lose 48% of its value in default, an estimate that accords with evidence from Glover (2016). Furthermore, the tax benefits of debt, proxied by the corporate tax rate, has a value of 34%, very close to the U.S. statutory corporate tax rate of 35%.

5   Quantitative analysis

This section investigates the quantitative importance of competition as a determinant of the cross-section of asset prices. Aggregate macroeconomic and asset pricing moments are first examined, followed by industry-specific moments. The model is then used to generate additional predictions on the relation between credit spreads and competition that are tested empirically in the next section.

5.1   Aggregate moments

Panel A of Table 3 reports key business cycle moments from the calibrated model and the associated data moments. Overall, the calibrated model provides a good fit to macroeconomic fluctuations. The model generates an average aggregate investment-output ratio of 21%. The consumption growth dynamics, which drive the quantity of aggregate risk, are quite close to the data. The model also replicates the correlations across key business cycle variables, namely the procyclicality of consumption, labor, and realized stock returns.

Figure 1 describes the model dynamics by means of impulse response functions. An increase in productivity, both short- and long-run, increases consumption growth and lead to fall in the discount factor m. This response is especially pronounced for the long-run productivity shock because of the recursive utility assumption which makes agents particularly averse to news about the long-run. On the production side, the higher productivity increases firms' profit opportunities, leading to an increase in firm valuation ratios and a positive realized market return.[27] As the continuation value of firms increases, less firms find it optimal to declare bankruptcy, leading to a fall in aggregate default and a persistent drop in credit spreads. The model also generates pro-cyclical aggregate equity payout and countercyclical debt payout, consistent with recent evidence by Jermann and Quadrini (2012).

Panel B of Table 3 reports several key asset pricing moments obtained from simulated model data. Because stocks offer low returns when the price of risk is high (see Figure 1), agents require a significant risk compensation for holding equity. Consequently, the model generates a large equity risk premium of about 4.35% per annum, and produces substantial variations in excess

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[27]A critical parameter assumption for this result to hold with long-run productivity shocks is that the elasticity of substitution ψ is sufficiently high. This guarantees that the substitution effect dominates the income effect so that agents find it optimal to invest in the firm when long-run productivity rises.

returns. On the credit side the model produces, an aggregate credit spread of 71bps, somewhat lower than its empirical counterpart of 90bps. As in the data, credit spreads are counter-cyclical. The contemporaneous correlation between the aggregate credit spread and output growth is -0.36 in the data and -0.44 in the model.

The countercyclicality of default rates (see Figure 1) leads to a bond risk premium because bond tend to pay less in recessions. In the model, the credit spread premium is around 12bps.[28] Although empirical estimates are quite noisy, the credit risk premium in the model is on the lower range of values reported in the literature. Two reasons can explain this. First there exists strong empirical evidence suggesting that other factors contribute to this spread such as taxation (e.g. Elton, Gruber, Agrawal, and Mann (2001)), or liquidity (e.g. Ericsson and Renault (2006), and Chen, Lesmond, and Wei (2007)). Second, the model abstracts from ingredients that have proved useful to generating a large credit risk premia. For instance, Gourio (2013) assume the existence of disaster risk, Bhamra, Kuehn, and Strebulaev (2010) use long-term debt and time-varying uncertainty, while Chen (2010) uses countercyclical recovery rates. In unreported results, I find that allowing for countercyclical idiosyncratic risk helps raise the credit risk premium to 30bps without changing any of the model implications.

5.2 Industry moments

I now examine the importance of competition for asset prices by looking at industry-specific moments. The first two columns of Table 4 report model simulated moments for the high- and low-competition industry, while the last two columns compare the spreads in the model against the data. The model generates substantial cross-sectional differences in default probabilities and credit spreads. More specifically, competitive firms have a higher conditional probability of default, which reflect in a higher equilibrium credit spread. The magnitude of the difference in the model is 76bps, quite close to the empirical spread.

The model also produces a large spread in equity risk across industries. I find that the less competitive industry is associated with higher expected returns than the more competitive industry - both in the model and the data. This is also consistent with recent findings from Bustamante and Donangelo (2017) who documents a positive relationship between excess returns, CAPM betas,

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[28]Formally, the credit spreads premium is defined as the difference between the yield on a risky bond minus the yield of riskless security that pays the expected bond payoff.

and measures of industry concentration. The magnitude of the concentration premium is -2.62% in the model vs. 1.77% in the data. Less competitive firms are more risky because a larger portion of their value come from risky growth options. In contrast, competitive firms have a more valuable option to default, which acts as an insurance and reduces equity risk.

To see this point more clearly, Figure 2 compares the response to a positive long-run productivity shock in the high- vs. low-competition industry. Firms in competitive industries face a more elastic demand curve and increase production more when productivity rises. At the industry level, supply gets higher, which puts a downward pressure on the industry product price, through the competitive externality channel of Eq. 15. This effect dampens the increase in profits and make dividends less procyclical. At the same time, firm's continuation values rise, leading to a drop in the conditional probability of default. Because competitive firms are closer to default, the value of their default option falls relatively more, which further dampens the effect of productivity on equity value. Taken together, these forces make stock returns in concentrated industries more procyclical and lead to a positive concentration premium.

In contrast to equity risk, the model predicts that debt issued by competitive firms is riskier. In Figure 2, the realized return on corporate bonds $r_i^b - r_f$ is more procyclical in competitive industries. The reason for this result is that although competitive firms have lower cash-flow risk, they default more on average. I find that the second effect ultimately dominates, leading to a negative concentration premium for corporate bonds. Effectively, industry competition leads to a transfer of risk from equityholders to debtholders, through the default option.

Table 4 also reports valuation and leverage ratios. In equilibrium, competitive industries are characterized by higher average book-to-market ratios. This happens because competition reduces firm's growth opportunities, bringing the firm market value closer to the value of assets in place. The model also predicts that concentrated industries use more financial leverage. Intuitively, more concentrated industries have higher firm valuation and enjoy a better buffer against idiosyncratic cash-flow shocks. This lowers the probability of default and increases the expected tax benefits, making debt more attractive. These results accord with a recent study by Xu (2012) who documents a strong negative relationship between competition and leverage, using import penetration as an instrumental variable.[29]

The calibrated model generates substantial variations across industries sorted on competition

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[29]MacKay and Phillips (2005) also find that competition decreases book leverage by about 3.6%. The relation between book-to-market and competition has also been documented by Bustamante and Donangelo (2017).

that are in line with earlier studies and matches the data quantitatively. More generally, these results highlight the quantitative importance of strategic interactions as a driver of the cross-section of asset prices and firm decisions.

5.3   Idiosyncratic risk and corporate spreads

The previous results have highlighted the key role played by idiosyncratic risk in driving the cross-section of credit spreads. In order to gain further insight into this relationship, I extend the benchmark model with time-varying volatility in idiosyncratic risk. In particular, I assume that the volatility of $z_{j,t}$ follows a persistent process in logs:

$$\ln(\sigma_{z_{j,t}}) = \rho_{\sigma_z} \ln(\sigma_{z_{j,t-1}}) + \sigma_{\sigma_z} \epsilon_{\sigma,j,t} \tag{38}$$

where $e_{\sigma,j,t} \sim iid \, \mathcal{N}(0,1)$.

To understand the effect of time-varying idiosyncratic risk, it is useful to remember that corporate debt can be modeled as a default-free bond minus a put option on the firm assets (e.g. Merton (1974)). A rise in firm volatility increases the value of the put option to default, which lowers the value of debt and leads to an increase in credit spreads. Firms in competitive industries have a more valuable option to default. Therefore the effects of an increases in $\sigma_{z_{j,t}}$ on credit spreads should be larger for more competitive firms.

Figure 3 confirms this intuition using impulse response functions.[30] In response to higher idiosyncratic risk, default rates and credit spreads increase. To alleviate the increase in risk, firms try to cut on debt but adjusting leverage is costly. This leads to a small, persistent decrease in debt-to-assets that is not sufficient to avoid the sharp increase in default probability. Importantly, while credit spreads in both industries rise, the reaction in competitive industries is much larger.

6   Empirical analysis

In this section, I formally test two new empirical predictions of the model namely, credit spreads in competitive industries are higher, and more sensitive to idiosyncratic volatility shocks. I also describe the two empirical proxies of industry competition and provide details on the bond sample

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[30]The idiosyncratic risk process is calibrated as follows; $\rho_{\sigma_z} = 0.6$, and $\sigma_{\sigma_z} = 4\%$ which implies an annualized standard deviation of idiosyncratic industry volatility of 10% (e.g. Campbell, Lettau, Malkiel, and Xu (2001)).

construction.

6.1 Industry competition measures

In the model, competitive industries are characterized by lower industry concentration, and lower average price markup. Motivated by these predictions, I use two empirical proxy for competition. The first proxy is the sales-based Herfindahl-Hirschman Index (HHI) published by the U.S. Census of Manufactures. More formally, HHI is defined as follows,

$$\text{HHI}_j = \sum_{i=1}^{N_j} s_{i,j}^2 \tag{39}$$

where $s_{i,j}$ is the sales market share of firm i in industry j. The U.S. Census HHI data is available for manufacturing industries and covers both public and private firms, making it a better proxy for industry concentration than Compustat-based measures (e.g. Ali, Klasa, and Yeung (2009)). Since the HHI data is updated every five years, industry-year observations for subsequent years are forward-filled.[31]

The second competition measure is the price-to-cost margin (PCM), which proxies for industry markup. Following Allayannis and Ihrig (2001), the PCM is defined as:

$$\text{PCM}_{j,t} = \frac{\text{Sales}_{j,t} + \Delta \text{Inventory}_{j,t} - \text{Payroll}_{j,t} - \text{Cost of Material}_{j,t}}{\text{Sales}_{j,t} + \Delta \text{Inventory}_{j,t}} \tag{40}$$

where the j-subscript denotes a particular industry. The data at the 4-digit SIC level is obtained from the NBER-CES Manufacturing Industry Database and is available annually for manufacturing firms. As for HHI, the NBER-CES database covers both public and private firms. Throughout the rest of the paper, I define an industry by using the 4-digit SIC industry classification. Also, following the litterature I define competition as a dummy equal to one if HHI or PCM is in the lowest tercile of the yearly sample distribution and zero otherwise. This specification will facilitate the economic interpretation of the regression coefficient and mitigate measurement errors.

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[31]Since 1997, the U.S. Census provides HHI at the 6-digit NAICS level. I convert the HHI measure to 4-digit SIC levels using the same methodology as Ali, Klasa, and Yeung (2009) and use the concordance tables available on the U.S. Census website to link NAICS to SIC codes.

6.2 Bond sample data

The data on corporate bond prices is from the National Association of Insurance Commissioners (NAIC) bond transaction file. The NAIC file records all public corporate bond transactions by life insurance companies, property and casualty insurance companies, and Health Maintenance Organizations. While the NAIC database might seem non exhaustive, it does represent a substantial portion of the corporate bond market as noted in Bessembinder, Maxwell, and Venkataraman (2006). The sample period for the study is 1995-2014 because the coverage of sales transactions only starts in 1995.

The NAIC bond transactions table is linked to the Mergent Fixed Income Securities Database (FISD) to obtain bond specific information such as the maturity, coupon rate, etc. To be part of the sample, bonds must be issued by a U.S. firm and pay a fixed coupon. Following Campbell and Taksler (2003), I also eliminate bonds with special bond features such as put, call, exchangeable, asset backed, and convertible. I only keep bonds with an investment-grade rating because insurance companies are often forbidden to invest in speculative-grade bonds. The transaction data for these bonds are thus unlikely to be representative of the junk bond market.

Following Bessembinder, Kahle, Maxwell, and Xu (2009), I eliminate transactions smaller than $100,000 or those that involve the bond issuer. To eliminate potential data-entry errors, I also remove return reversals. A return reversal is defined as a return of more than 20% in magnitude immediately followed by a more than 20% return in the opposite direction. Besides I exclude observations with obvious data errors such as negative price or transaction dates occurring after maturity. In case there are several bond transactions in a day, the daily bond price is obtained by weighting each transaction price by its volume in face value.

Reported prices in the NAIC file are *clean* bond prices and accrued interests are added to get the full settlement prices, i.e. the bond *dirty* prices. Yields are computed by equating the dirty price to the present value of cash-flows and yield spreads are defined in excess of the benchmark treasury at the date of transaction. To get the benchmark treasury, I match the bond duration to the zero-coupon Treasury yields curve from Gürkaynak, Sack, and Wright (2007), linearly interpolating if necessary. Treasury yields with a maturity lower than 1 year are obtained from the CRSP risk-free series. Matching duration instead of maturity provides a more robust benchmark as coupon payments can vary greatly across issuers. When a firm has multiple bonds outstanding, I obtain a unique firm-date observation by face-value-weighting the bond-specific information. As a final

check and following Gilchrist and Zakrajšek (2011), I truncate the yield spreads in the sample to be between 5bps and 3,500bps and restrict the bond remaining maturity to be below 30 years.

Issuers' accounting information and stock prices are from the CRSP/Compustat Merged database and are matched using the 6-digit issuer CUSIP. To ensure that all information is included in asset prices, stock returns and bond yield spreads from July of year t to June of year $t+1$ are matched with accounting information for fiscal year ending in year $t-1$. Monthly yield spread observations are obtained by taking the average yield spread in a month.[32]

Table 5 gives summary statistics of the variables used in the empirical analysis. All statistics are calculated on the sample of firms used in the main tests. In Panel A, I report the average yield and yield spread, sorted by credit rating. The majority of bond transactions lie in the A-Baa rating, a pattern consistent with prior studies using the same data (e.g. Campbell and Taksler (2003)). Importantly, the bond sample mimics time series variations in aggregate credit spreads very well. This can be seen in Figure 4, which compares the time series of the average Baa yield spread obtained from the NAIC sample with that reported by Moody's. The two series follow a similar pattern with spikes in the 2000's and the financial crisis.

Panel B reports summary statistic for bond and firm characteristics. The issue size is positively skewed, and the average bond time to maturity is long, at about 10 years. Overall, bond summary statistics are similar to those of previous studies using public debt (e.g. Gilchrist and Zakrajšek (2011)). As for firm characteristics, the average firm size in the sample is fairly large, which is consistent with empirical evidence that firms issuing public debt are larger than firms using bank loans (e.g. Denis and Mihov (2003)).

Overall these results suggest that the NAIC bond transaction sample is quite representative of the investment-grade bond market.

6.3 Competition and the cross section of credit spreads

In this section, I use my corporate bond sample to test the first prediction of the model, i.e. credit spreads are higher in competitive industries. I start my investigation by looking at univariate sorts based on industry competition. I then check the robustness of my findings using panel regression models.

Table 6 shows empirical evidence for the relation between competition and the cross-section

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[32]Using the last transaction of the month instead of the average has no bearing on the results.

of asset prices using univariate sorts. The model predicts that industry competition is associated with higher credit spreads, but lower expected stock returns. Two proxies for competition are considered. Panel A measures competition using the U.S. Census HHI and Panel B uses the PCM measure for industry markups. Consistent with the model predictions, firms in competitive industries have higher credit spreads. The estimated difference ranges from 29bps to 74bps and is statistically significant in both cases. In contrast, the relation between competition and expected stock returns goes in the opposite direction. Firms in competitive industries command a lower equity risk premium, ranging from -1.33% to -2.20%, depending on the competition proxy.

The positive relation between competition and credit spreads might be explained by other firm-specific factors that correlates with the cost of debt. To further corroborate the model predictions, I specify the following regression model as in Valta (2012):

$$\text{cs}_{i,j,t} = \delta \times \text{Competition}_{j,t-1} + \beta\, \text{X}_{i,t-1} + \epsilon_{i,j,t} \tag{41}$$

where the subscripts i, j, and t denotes the firm, industry, and month of transaction, respectively. The dependent variables $\text{cs}_{i,j,t}$ is the credit spread, $\text{Competition}_{i,t-1}$ is a dummy equal to one if the firm is in the highest competition tercile and zero otherwise, and $\text{X}_{i,t-1}$ is a vector of controls. The parameter of interest is δ. It measures the additional cost of debt for firms operating in competitive industries. Credit spreads from July of year t to June of year $t+1$ are matched with accounting information for fiscal year ending in year $t-1$ to ensure that all information is included in asset prices at the time the transaction takes place. I also cluster all standard errors at the 4-digit SIC level.

The vector $\text{X}_{i,t-1}$ contains variables that control for various firm and bond characteristics. More specifically, I include firm size and leverage because larger firms and firms having lower financial leverage are likely to have lower credit spreads. In addition, I control for asset tangibility (e.g. Ortiz-Molina and Phillips (2014)), and operating leverage (e.g. Bustamante and Donangelo (2017)).[33] Bond characteristics may also vary across competition terciles. Therefore, I control for the bond time to maturity because longer maturity bonds are likely to be risker (e.g. Leland and

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[33]Leverage is [total long-term debt (DLTT) + debt in current liabilities (DLC)] to [total long-term debt (DLTT) + debt in current liabilities (DLC) + book equity]. Book equity is defined as [book value of stockholders' equity (CEQ) + balance sheet deferred taxes (TXDITC) - book value of preferred stock (PST)]. Tangibility is [total property, plant and equipment (PPENT)] over total asset (AT). Operating leverage is [cost of goods sold (COGS) + selling, general, and administrative expenses (XSGA)] over total assets (AT).

Toft (1996)). Bonds that pay higher coupon suffers from higher taxation (e.g. Elton, Gruber, Agrawal, and Mann (2001)), so I include the coupon rate. To control for bond-specific illiquidity I include the log amount outstanding because smaller issues are likely to be less liquid. Finally, I use time fixed effects to control for unobserved macroeconomic conditions.

Panel A of Table 7 presents the main regression results. I first estimate the panel without any controls and report the estimate in column 1. The coefficient of interest δ is both statistically and economically significant and has the expected sign. Market participants require an additional yield spread of 43bps on corporate bonds issued by competitive firms. In terms of financing costs, this corresponds to competitive firms paying an added \$2.34 million in interests, each year. The magnitude and statistical significance of δ survive the introduction of firm and bond controls (column 2) as well as the introduction of time fixed effects (column 3). In column 4 to 6, I present the results for the same three regression models but using industry markup as a measure of competition. All coefficients are of similar magnitude and are statistically significant, corroborating the empirical robustness of the relation between competition and credit spreads. Finally the last column estimates δ for the benchmark calibration. As expected, the coefficient is positive and statistically significant and has a magnitude comparable to the data.

6.4   Competition, idiosyncratic volatility, and credit spreads

This section takes the second model prediction to the data. More specifically, I test whether industry competition amplifies credit spread's exposure to idiosyncratic volatility shocks (see Figure 3). Accordingly, I augment the benchmark regression model as follows:

$$\text{cs}_{i,j,t} = \delta_0 \times \text{IVol}_{i,j,t-1} + \delta_1 \times \text{Competition}_{j,t-1} \times \text{IVol}_{i,j,t-1} + \beta \, \text{X}_{i,t-1} + \epsilon_{i,j,t} \tag{42}$$

where $\text{cs}_{i,j,t}$, $\text{Competition}_{i,t-1}$, and $\text{X}_{i,t-1}$ are defined as in the previous regression model,[34] and $\text{IVol}_{i,j,t-1}$ is a measure of idiosyncratic volatility. We are interested in parameter δ_1, which measures the additional sensitivity of credit spreads to idiosyncratic volatility in competitive industries.

Following Campbell and Taksler (2003), I proxy for idiosyncratic volatility using the standard deviation of daily excess returns, relative to the CRSP value-weighted index, for each firm's stock

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[34]I also include the Competition$_{i,t-1}$ dummy to ensure proper identification of the interaction term.

over the past 180 days. Although this method effectively assumes that all firms have a beta of one, it has the advantage of avoiding the need to estimate rolling CAPM regressions.[35] To ensure that all information is impounded in asset prices at the time the transaction takes place, I measure $IVol_{i,j,t-1}$ as of the month prior to the transaction date and cluster all standard errors at the 4-digit SIC level.

Panel B of Table 7 presents the main regression output. Column 1 reports the coefficient estimates without controls. The interaction term has the expected sign, bonds issued by competitive firms are more sensitive to change in idiosyncratic volatility. In column 2, I control for firm and bond characteristics and include time fixed effect. The magnitude of δ_1 remains similar while statistical significance improves. These results are also robust to including firm fixed effects in column 3 or using industry markup to proxy for competition (columns 3 to 6). The estimated coefficient is large in all specifications. In economic terms, a 1 percentage point hike in idiosyncratic volatility causes an additional increase in credit spreads of 45bps to 52bps for firms in more competitive industries. Comparing these magnitudes to the coefficient on IVol, competitive firms are on average 67% more sensitive to idiosyncratic shocks. The last column presents model-based regressions. As expected from Figure 3, competition amplifies credit spread exposure to idiosyncratic shocks.

Overall these findings corroborate the model predictions and provide empirical support for the economic channel through which idiosyncratic volatility affects credit spreads via the option to default.

7   Conclusion

This paper develops a production-based asset pricing model to explore the effects of industry competition on the cross-section of credit spreads and levered equity returns. The model features two main sources of risks: aggregate and idiosyncratic. In equilibrium, competition affects asset prices by affecting the firm exposure to these risks. First, the *competitive externality* channel creates an externality from peers' actions that reduces the value of a firm's growth options. This effect reduces firm risk. Second, competition increases the firm exposure to idiosyncratic risk and leads to a *default option* effect. This further reduces the risk of equity and makes debt issued by competitive firms both less valuable and riskier. Therefore higher competition is associated with

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[35]Note however that all results stay robust to using alternative proxies for idiosyncratic risk, such as the residual of a rolling market model.

higher equilibrium credit spreads, but lower equity risk premium. As a result of their competitive disadvantage in issuing debt, firms in competitive industries substitute equity for debt. Ultimately, competitive firms issue less, but more expensive debt.

The model is calibrated to match a set of aggregate moments and to replicate cross-sectional differences in industry markups across concentration terciles. Because the only difference across industries is the intensity of competition, the model offers a compelling laboratory to quantify the importance of product market structure. I find that competition has large effects on corporate decisions and asset prices. The magnitudes across competition terciles for equity returns and financial leverage accords with the existing empirical literature. I verify additional model predictions using a panel of publicly traded corporate bond transactions and find that product market competition increases average credit spreads by 45bps. Also, credit spreads in more competitive industries are more sensitive to idiosyncratic risk. These results are robust to the inclusions of various controls and alternative measures of competition.

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Parameter	Description	Model
A. <u>Preferences</u>		
β	Subjective discount factor	0.99
ψ	Elasticity of intertemporal substitution	2
γ	Risk aversion	10
B. <u>Production</u>		
α	Capital share	0.33
δ_k	Depreciation rate of capital stock	2.00%
ζ_k	Capital adjustment cost parameter	6.96†
C. <u>Productivity</u>		
4μ	Mean of Δa_t	1.80%
ρ^4	Persistence of Δa_t	0.90
$\sqrt{4}\sigma_a$	Conditional volatility of a_t	1.88%
$\sqrt{4}\sigma_g$	Conditional volatility of g_t	0.19%
D. <u>Finance</u>		
C	Coupon payment	7%/4
ξ	Bankruptcy costs	48.44%
σ_z	Volatility idiosyncratic shock	0.63†
τ	Corporate tax rate	33.76%†
χ_b	Debt adjustment cost parameter	0.48†
E. <u>Industry parameters</u>		
ν	Elasticity of substitution across industries	1.001
νh_{low}^{-1}	Elast. of demand in low concentr. industry	5.2150†
νh_{hig}^{-1}	Elast. of demand. in high concentr. industry	3.7567†

Table 1: Benchmark quarterly calibration. This table reports the parameter values used in the benchmark quarterly calibration of the model. $\dagger$ denotes a parameter estimated by matching moments.

TABLE 2: SIMULATED METHODS OF MOMENTS ESTIMATES

Target moment	Data	Model	Estimates
Quarterly default rate	0.25%	0.26%	$\sigma_z = 0.633$
Average bond recovery	0.41	0.40	$\xi = 48.44\%$
Book leverage	0.40	0.45	$\tau = 33.76\%$
Standard deviation of book leverage	0.09	0.08	$\chi_b = 0.48$
Investment-to-consumption vol.	4.38	4.23	$\zeta_k = 6.96$

Table 2: SMM estimates and empirical targets. This table reports the empirical targets, model moments, and corresponding parameters estimates obtained from the matching moments procedure.

TABLE 3: AGGREGATE BUSINESS CYCLE AND ASSET PRICING MOMENTS

Moment	Data	Model	Moment	Data	Model
A. Business cycle					
$E(I/Y)$	0.20	0.21	$corr(\Delta c, \Delta y)$	0.39	0.58
$E(\Delta c)$	1.80	1.80	$corr(\Delta l, \Delta y)$	0.75	0.56
$\sigma(\Delta c)$	1.42	1.45	$corr(\Delta c, rx_e)$	0.25	0.78
$\sigma_{\Delta c}/\sigma_{\Delta y}$	0.64	0.81	$ACF_1(\Delta y)$	0.35	0.11
$\sigma_{\Delta i}/\sigma_{\Delta c}$	4.38	4.23†	$ACF_1(\Delta c)$	0.32	0.26
$\sigma_{\Delta l}$	1.70%	0.95%	$ACF_1(i-k)$	0.86	0.97
B. Asset prices					
$E(r_m - r_f)$	5.84	4.35	$\sigma(r_m - r_f)$	17.87	8.25
$E(cs)$	90bps	71bps	$\sigma(cs)$	42bps	19bps

Table 3: Aggregate Macro and Asset Pricing moments. This table reports aggregate macroeconomics and asset pricing moments from the model and the data. Δy, Δc, Δl, Δi denotes output growth, consumption growth, labor growth, and investment growth respectively. I/Y is investment over GDP, $i-k$ is the log investment-to-capital ratio, $r_m - r_f$ is the aggregate stock market excess return, and cs is the aggregate credit spread. Model moments are calculated by simulating the model for 25,000 quarters, with a 1,000 quarters burning period. Aggregate quantities are obtained by summing up industry-level data, aggregate returns and credit spreads are equally-weighted. Growth rates, and returns moments are annualized percentage, credit spreads are in annualized basis point units. † denotes a SMM target moment.

Table 4: Industry variables

	Simulated moments		H-L	
	High	Low	Model	Data
Industry markup	$0.237^{\dagger}$	$0.363^{\dagger}$	$-0.126^{\dagger}$	-0.126
$E(cs)$	113bps	37bps	76bps	52bps
$E(r_i^e - r_f)$	2.96%	5.58%	-2.62%	-1.77%
$E(r_i^b - r_f)$	13bps	9bps	4bps	-
Book to market	0.611	0.524	0.086	0.076
Market leverage	0.174	0.233	-0.059	-0.032
Default rate	0.40%	0.13%	0.27%	-

Table 4: Industry moments. This table reports model simulated moments sorted on competition terciles. Model moments are calculated by simulating the model for 25,000 quarters, with a 1,000 quarters burning period. Data moments are obtained as follows: Industry markup is defined in Eq. 40; excess returns, and credit spreads are obtained by taking the average values across the two competition measures in the univariate sorts of Table 6, market leverage, and book to market is obtained from Compustat. Market leverage is obtained as the ratio of the book value of debt divided by the sum of the market value of equity and the book value of debt. $r_i^e - r_f$ is the return on equity in excess of the risk-free rate. $r_i^b - r_f$ is the return on corporate debt in excess of the risk-free rate. $\dagger$ denotes a SMM target moment.

Table 5: Summary statistics

Panel A: Yields per rating category

Rating	Yield	Yield Spread	N
Aaa	4.91	72.97	390
Aa	5.96	94.09	587
A	6.16	145.64	2415
Baa	6.52	183.05	1590

Panel B: Bond and firm characteristics

	Mean	SD	Q1	Median	Q3
I. Bond characteristics					
Yield (%)	6.18	1.84	5.32	6.42	7.20
Credit spread (bps)	146	144	70	105	177
Time to maturity (years)	10.28	7.24	4.35	8.53	15.38
Coupon (%)	7.00	1.25	6.54	7.00	7.72
Issue size (millions)	544	574	200	350	700
Credit rating	A	-	Baa	A	A
II. Firm characteristics					
Tangibility	0.31	0.17	0.18	0.27	0.40
Book leverage	0.42	0.18	0.30	0.40	0.50
Asset (log millions)	9.28	1.15	8.48	9.32	10.19
Operating leverage	0.80	0.38	0.56	0.73	0.91

Table 5: Summary statistics. This table gives summary statistics for the NAIC sample that uses the Census HHI as a measure of industry competition. Panel A presents the sample average of corporate yields and yield spreads by credit rating. Panel B reports the mean, standard deviation, the median, and the first and third quartile for a series of bond and firm's characteristics. Credit spreads are defined as the bond yield in excess a government bond with equal duration, time to maturity is the difference between the maturity of the bond and the transaction date, coupon is the annualized coupon rate, issue size is the total principal issued of the bond, tangibility is total property, plant and equipment over total asset, book leverage is defined as total long term debt plus debt in current liabilities over book equity plus total long term debt plus debt in current liabilities, asset size is defined as total assets, operating leverage is defined as cost of goods sold plus selling, general, and administrative expenses over total assets.

TABLE 6: UNIVARIATE ANALYSIS

	High	Low	H-L
A. Concentration (HHI)			
Credit spread	174bps	145bps	29bps***
$E[r_i - r_f]$	15.64%	16.97%	-1.33%***
B. Markup (PCM)			
Credit spread	181bps	107bps	74bps***
$E[r_i - r_f]$	15.29%	17.49%	-2.20%***

Table 6: Univariate analysis. This table reports the average credit spread and expected return for subsamples of the data sorted on measures of industry competition. Panel A measures competition using the U.S. Census HHI, and Panel B uses the NBER-CES Price-to-Cost margin. The High (Low) column reports the means for the highest (lowest) competition tercile. The credit spread is defined as bond yield in excess of a government bond with equal duration. $E[r_i - r_f]$ is the average expected stock return predicted the CAPM for each competition portfolio. Conditional CAPM betas are estimated using rolling yearly observations, and are corrected for non-synchronous trading following Dimson (1979). Expected returns are obtained as the product of the conditional beta and the average market risk premium over the sample. The sample period is 1995-2014. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively for the test of differences.

TABLE 7: PANEL REGRESSIONS

Panel A: Competition and credit spreads

| | Concentration (HHI) | | | Markup (PCM) | | | Model |
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Competition	42.62*	47.60*	44.63*	55.42**	48.84**	46.06*	63.03***
	(1.82)	(2.00)	(1.94)	(2.28)	(2.02)	(2.00)	(9.85)
Controls		X	X		X	X	
Time FE			X			X	
N	4887	4887	4887	5205	5205	5205	5000
R^2	0.02	0.10	0.33	0.04	0.09	0.32	0.74

Panel B: Competition, idiosyncratic volatility, and credit spreads

| | Concentration (HHI) | | | Markup (PCM) | | | Model |
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Competition × IVol	59.10	49.13*	45.31**	72.35*	63.53*	51.77***	18.36***
	(1.59)	(1.67)	(2.19)	(1.96)	(1.98)	(2.71)	(2.85)
IVol	48.88***	71.15***	67.95***	44.65***	69.11***	76.08***	13.98***
	(4.80)	(5.50)	(3.78)	(5.57)	(5.86)	(3.80)	(3.18)
Controls		X	X		X	X	
Time FE		X	X		X	X	
Firm FE			X			X	
Observations	4887	4887	4887	5205	5205	5205	5000
R^2	0.23	0.48	0.62	0.24	0.47	0.60	0.80

Table 7: Panel regressions. This table reports the coefficient estimates from two panel regressions studying the relation between industry competition and credit spreads. Panel A examines the effect of competition on the level of credit spreads. Panel B examines how competition amplifies the effect of firm-specific risk on credit spreads. Columns 1-3 measure competition using the U.S. Census HHI, and columns 4-6 use the NBER-CES Price-to-Cost margin. The last column presents model regressions. Competition is measured by a dummy equal to 1 if the firm is in the lowest tercile of concentration or markup in the year prior to the transaction date. IVol is calculated as the moving standard deviation of the individual stock return in excess of the CRSP value-weighted index over the past 180 days. Competition × IVol is the interaction term between the competition dummy and IVol. Controls include log-asset, book leverage, asset tangibility, operating leverage, bond time to maturity, coupon rate, and the log-amount outstanding. For additional details on variables construction, refer to the empirical analysis section. A dummy for competition is also included in the controls for Panel B. I report t-stats calculated over standard errors clustered at the 4-digit SIC level in parentheses below the coefficient estimates. Significance at the 10%, 5%, and 1% level is indicated by *, **, and ***, respectively.
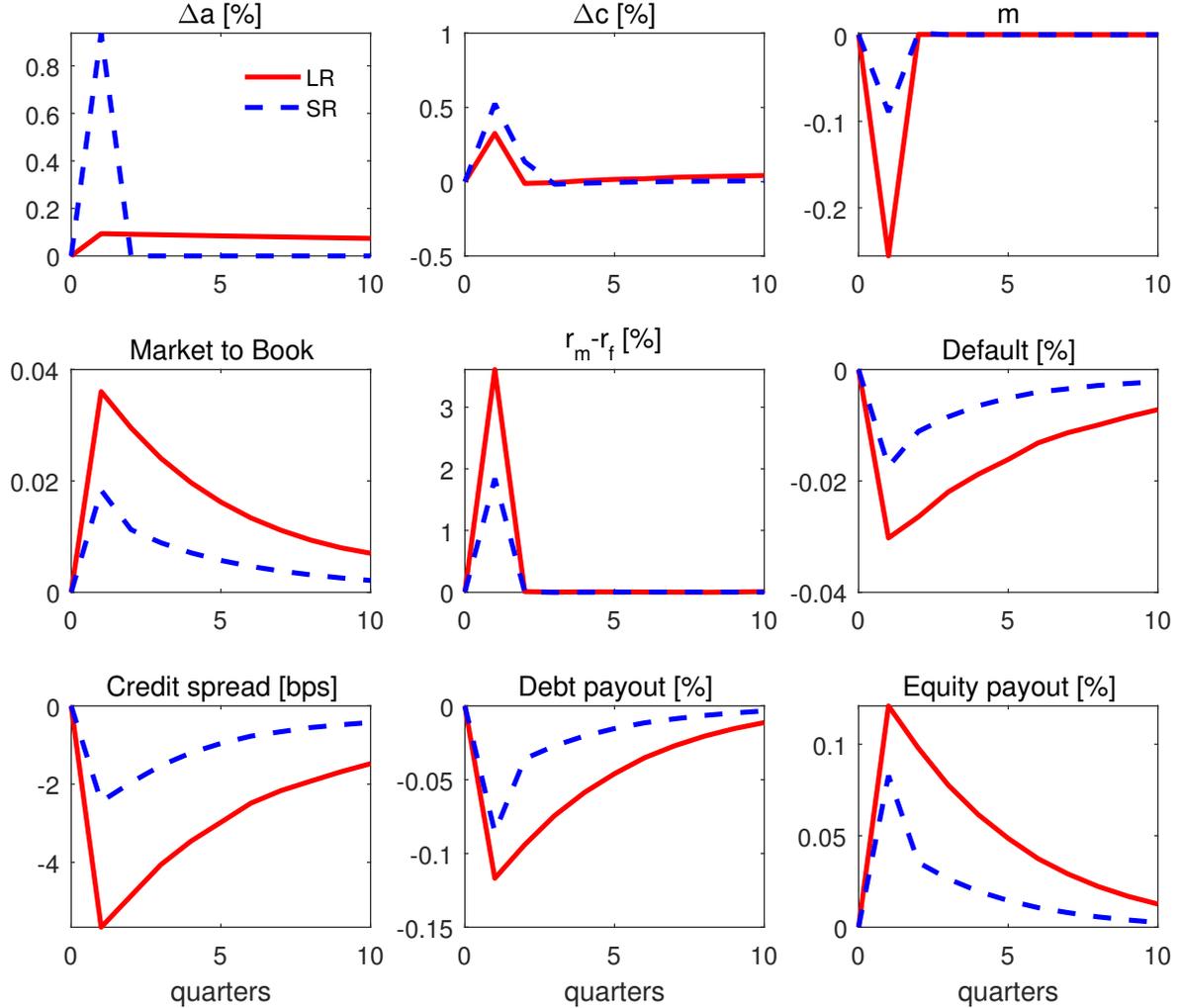
Figure 1: Aggregate variables impulse-response functions. This figure plots the impulse-response function to a positive long-run (red solid) and short-run (blue dashed) productivity shock for productivity growth (Δa), consumption growth (Δc), the stochastic discount factor (m), the aggregate Market to Book ratio, the aggregate stock market excess return ($r_m - r_f$), the aggregate default probability, the aggregate credit spread, and the aggregate debt and equity payout. The plots are calculated as deviation from the steady state. Units, when applicable, are specified next to the plot title.

FIGURE 2: INDUSTRIES IMPULSE-RESPONSE FUNCTIONS
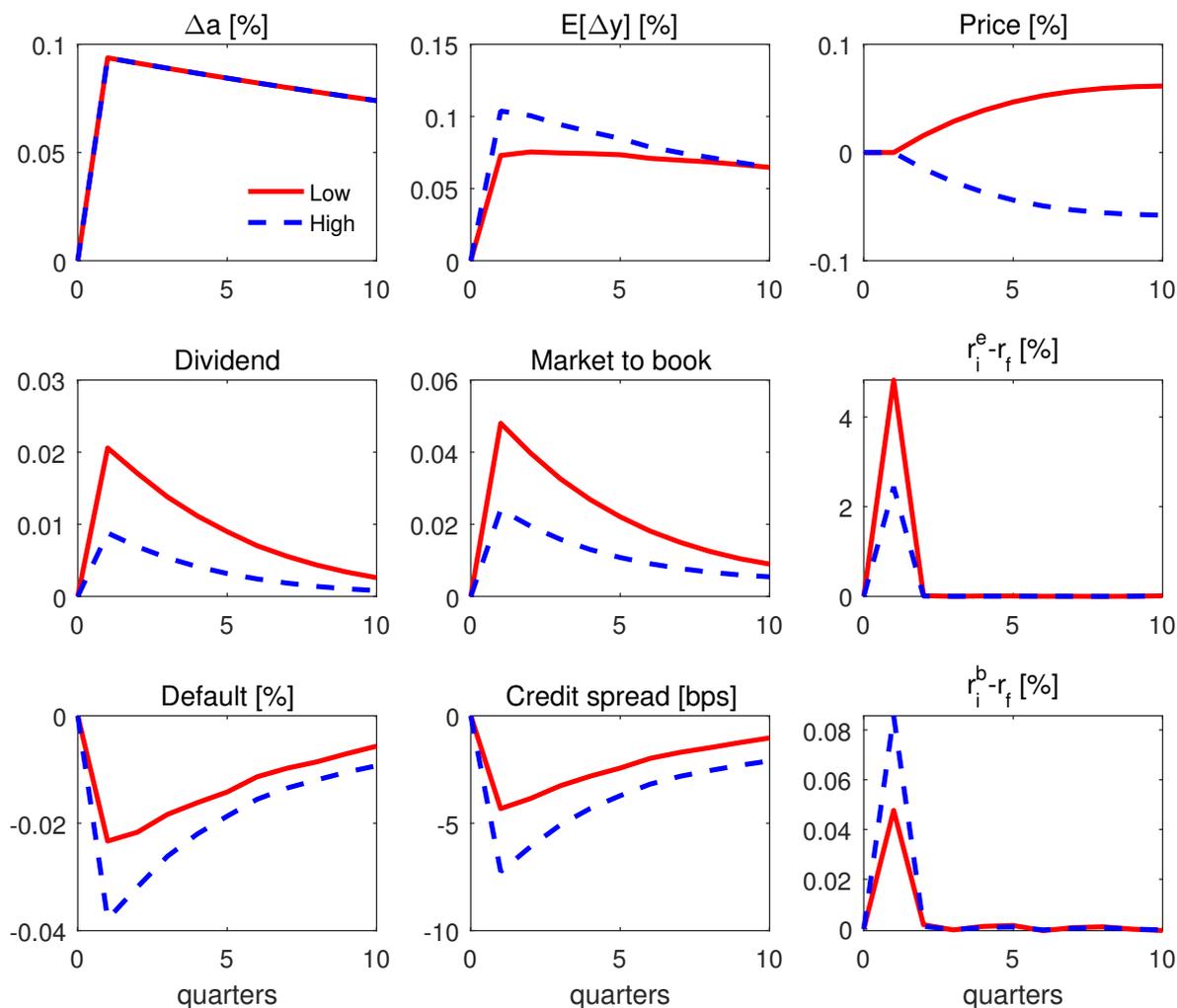
Figure 2: Industry variables impulse-response functions. This figure plots the impulse-response functions to a positive long-run productivity shock for industries that differ in their degree of product market competition. The responses in the low-competition industry are plotted in red solid while those in the high-competition industry are plotted in dashed blue. Δa denotes productivity growth, $E[\Delta y]$ is the expected output growth, price is the industry output price relative to the aggregate price index, $r_i^e - r_f$ is the realized industry stock excess return, and $r_i^b - r_f$ is the realized industry bond excess return. The plots are calculated as deviation from the steady state. Units, when applicable, are specified next to the plot title.
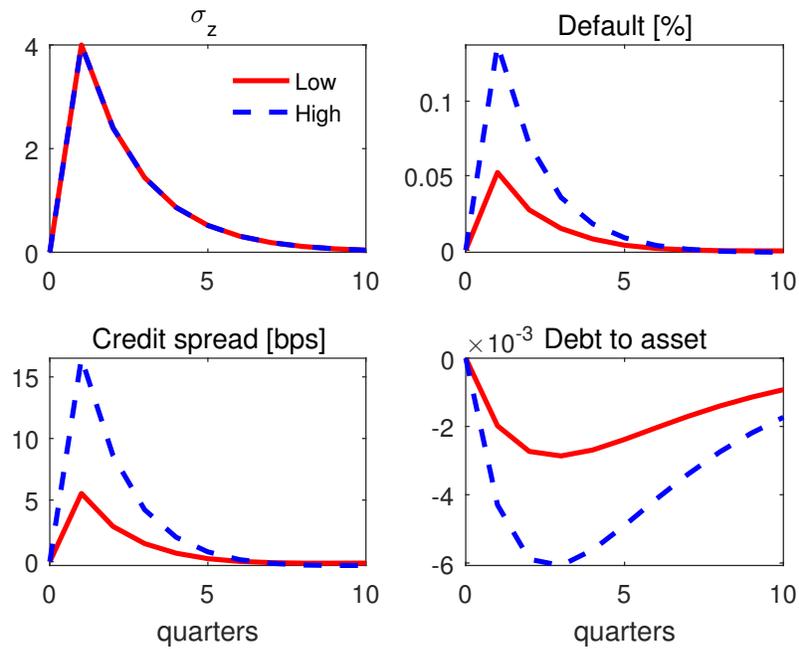
Figure 3: Impact of an increase in idiosyncratic risk. This figure plots the impulse-response functions to a positive idiosyncratic volatility shock for industries that differ in their degree of product market competition. The responses in the low-competition industry are plotted in red solid while those in the high-competition industry are plotted in dashed blue. σ_z denotes the volatility of the idiosyncratic shock. The plots are calculated as deviation from the steady state. Units, when applicable, are specified next to the plot title.

FIGURE 4: BAA SPREAD FROM NAIC SAMPLE AND MOODY'S
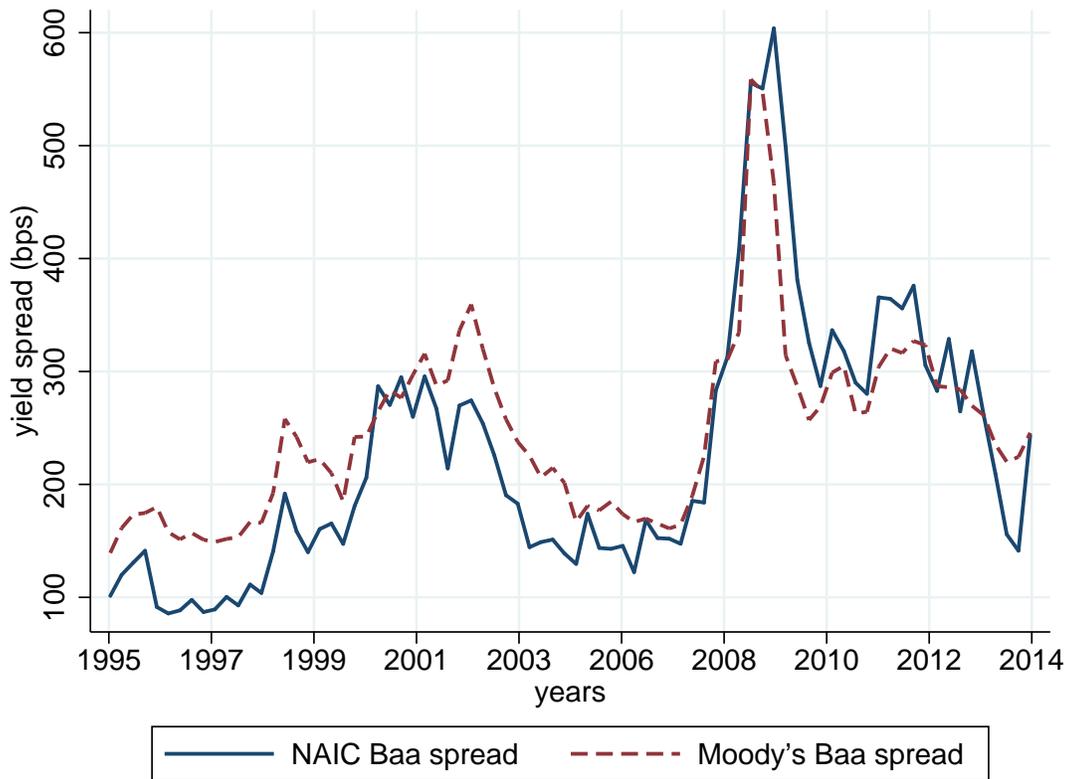
Figure 4: Baa spread time-series for Moody's and the NAIC panel data. This figure plots the average Baa bond spreads from Moody's against the average Baa spread from the benchmark bond data sample. Yield spreads are in basis points. Bonds from NAIC are in U.S. dollars and have no special features (call, put, convertibility, etc.).

A A simple model: derivation details

A.1 Firm's problem

First, note that shareholders declare default as soon as the value of the firm turns negative. In period 1, the value of the firm is simply d_1. Therefore the default threshold is the value $z^\star$ that solves $d_1(z^\star) = 0$, that is

$$z^\star = (P_1 y_1 - W_1 l_1 - (1 + (1 - \tau)C)b) \, \bar{l}^{-1} \tag{43}$$

Substituting for the price using the inverse demand schedule (Eq. 1), and using the valuation of corporate debt (Eq. 3), and the default threshold (Eq. 43) into the firm's problem, the objective of the firm manager becomes

$$V_j = \max_{l_0, l_1, b_1} \mathcal{Y}_0^{\frac{1}{\nu}} \left(\sum_{i=1}^n y_{i,0} \right)^{-\frac{1}{\nu}} y_{i,0} - W_0 l_0 - (1 + (1 - \tau)C)b_0 + \beta \Phi(z^\star)(1 + C)b_1 + \beta \int_{\underline{z}}^{z^\star} (z^\star - z) \, d\Phi(z) \, \bar{l} \tag{44}$$

Applying Leibniz' rule, the first order necessary conditions with respect to l_t, and b_1 are

$$W_t = \mathcal{Y}_0^{\frac{1}{\nu}} \left(\sum_{i=1}^n y_{i,0} \right)^{-\frac{1}{\nu}} \frac{y_{i,0}}{l_{i,0}} \left(1 - \frac{1}{\nu} \frac{y_{i,0}}{\sum_{i=1}^n y_{i,0}} \right) \tag{45}$$

$$\Phi(z^\star)\tau C = \phi(z^\star)(1 + (1 - \tau)C)(1 + C)\frac{b}{\bar{l}}$$

Each firm in the industry faces the same problem and differs only by the realization of the idiosyncratic shock z. Because this cost enters as a fixed cost, it doesn't affect individual firm decisions so that the industry admits a unique symmetric Nash equilibrium in which all firms make identical decisions. The i-subscript can be dropped and $\bar{l} = l$. Imposing the market clearing on the goods market that demand must equal supply in equilibrium, we have $ny_t = Y_t = \mathcal{Y}_t$. Imposing market clearing on the labor market, i.e. $nl_t = 1$, the set of FOCs becomes

$$W = \left(1 - \frac{h}{\nu} \right) A \tag{46}$$

$$\Phi(z^\star)\tau C = \phi(z^\star)(1 + (1 - \tau)C)(1 + C)\tilde{b}$$

where $h = \sum_{i=1}^n (y_{i,t}/Y_t)^2 = 1/n$ is the Herfindahl-Hirschman index of the industry, and $\tilde{b} = b/\bar{l}$ is a measure of leverage (debt over the firm size).

The price-elasticity of demand $\eta_{y,P}$ in the symmetric equilibrium is obtained using Eq. 1,

$$\eta_{y,P} = -\frac{\frac{\partial y_{i,t}}{y_{i,t}}}{\frac{\partial P_t}{P_t}} = \frac{\nu}{h} \tag{47}$$

A.2 Proof of proposition 1

Proof. First, note that I assume that $z^\star$ is an interior solution on the interval $[-a/2, a/2]$.[36] In addition, under the assumption that z is uniformly distributed on $[-a/2, a/2]$, the cumulative distribution function is

$$\Phi(x) = \begin{cases} 0 & x < -a/2 \\ \frac{1}{a}\left(x + \frac{a}{2}\right) & -a/2 \leq x \leq a/2 \\ 1 & x < a/2 \end{cases} \tag{48}$$

and the associated probability density function is $\phi(x) = \frac{1}{a}$. Using the set of equilibrium conditions (46), and the default threshold (43), the equilibrium default threshold is given by

$$z^\star = \left(\frac{hA}{\nu} - \frac{a}{2}\frac{\tau C}{(1+C)}\right)\left(1 + \frac{\tau C}{(1+C)}\right)^{-1} \tag{49}$$

To prove the effect of competition on the expected default probability, I take the partial derivative of $z^\star$ with respect to h,

$$\frac{\partial z^\star}{\partial h} = \frac{A}{\nu}\left(1 + \frac{\tau C}{1+C}\right)^{-1} \tag{50}$$

which is positive. Therefore an increase in competition (decrease in h) decreases the optimal default threshold and the survival probability of the firm, $\Phi(z^\star)$.

To see the effect on debt, note that the equilibrium leverage is given by

$$\tilde{b} = \left(z^\star + \frac{a}{2}\right)\frac{\tau C}{(1+(1-\tau)C)(1+C)} \tag{51}$$

The result follows from the fact that $z^\star$ is increasing in h.

Next, the equilibrium firm value over labor is

$$\tilde{V}(A) = \frac{hA}{\nu} - (1+(1-\tau)C)\tilde{b}_0 + \beta\left[\Phi(z^\star)(1+C)\right]\tilde{b}_1(z^\star) + \beta\int_{\underline{z}}^{z^\star}[z^\star - z]\,d\Phi(z) \tag{52}$$

where $\tilde{b}_1(z^\star)$ is the optimal leverage. Plugging the optimal policy for $\tilde{b}(z^\star)$ and taking the partial derivative

---

[36]This is without loss of generality as one can always find a value for a such that it holds.

with respect to h,

$$\frac{\partial \tilde{V}(A)}{\partial h} = \frac{A}{\nu} + \beta \left\{ \frac{\tau C \Phi(z^\star)}{(1+(1-\tau)C)} \left[2 - \frac{\Phi(z^\star)\phi'(z^\star)}{\phi^2(z^\star)} \right] + \Phi(z^\star) \right\} \frac{\partial z^\star}{\partial h}$$
$$= \frac{A}{\nu} \left(1 + \beta \Phi(z^\star) \frac{1+C}{1+(1-\tau)C} \right) \tag{53}$$

where the second line is obtained using the expression for $\frac{\partial z^\star}{\partial h}$ in Eq. 50. The term inside the parentheses is strictly positive, implying that the firm value is a increasing function of concentration and therefore a decreasing function of competition.

Finally, the credit spread is defined as $cs = (1+C)/q - \beta^{-1}$, therefore

$$\frac{\partial cs}{\partial h} = -\frac{(1+C)}{q^2} \frac{\partial q}{\partial h} = -\beta \phi(z^\star) \frac{(1+C)^2}{q^2} \frac{\partial z^\star}{\partial h} < 0 \tag{54}$$

where the inequality sign follows from Eq. 50.

$\square$

A.3 Conditional equity beta

Proof. Formally, the conditional equity beta is measured as the elasticity of V_j with respect to A,

$$\beta_i = \frac{d \log \tilde{V}_j(A)}{d \log A} = \frac{Ah}{\nu} \left(1 + \beta \Phi(z^\star) \frac{1+C}{1+(1-\tau)C} \right) \frac{1}{\tilde{V}(A)}$$
$$= \frac{1 + \beta \Phi(z^\star) \frac{1+C}{1+(1-\tau)C}}{1 + \frac{\nu}{hA} \frac{a\beta}{2} \Phi^2(z^\star) \left(\frac{\tau C + 1 + C}{1+(1-\tau)C} \right)} \tag{55}$$

Taking the partial derivative of β_i with respect to h is somewhat more involved, however, it can be shown that a sufficient condition for $\frac{\partial \beta_i}{\partial h} > 0$ is $\tau < 1$, which is always the case. Therefore an increase in competition decreases the firm conditional beta. $\square$

To obtain the expression for the conditional equity beta in Eq. 8, note that the normalized value of the firm can be rewritten as

$$\tilde{V}_j(A) = \frac{Ah}{\nu}(1+\beta) - (1+(1-\tau))\tilde{b}_0 + \beta \left[\Phi(z^\star)\tilde{b}_1 \tau C - (1 - \Phi(z^\star)) \frac{Ah}{\nu} \right] - \beta \int_{\underline{z}}^{z^\star} z \, d\Phi(z) \tag{56}$$

Rewriting the expression for the conditional equity beta (Eq. 55), I get

$$\beta_i = 1 + \frac{(1+(1-\tau)C)b_0}{V_j(A)} + \frac{\beta \tau C}{1+(1-\tau)C} \frac{\Phi(z^\star)z^\star}{V_j(A)} - \frac{\beta \int_{z^\star}^{\bar{z}} z \, d\Phi(z)}{V_j(A)} \tag{57}$$

B Shareholders' optimization problem

To keep notation readable, the (i, j)-subscript is omitted, unless necessary but all lower case variables should be understood as firm-specific variables.

Optimization problem Assuming that the firm doesn't default in the current period, and replacing for $\tilde{P}_{j,t}$ using the inverse demand schedule, the recursive representation of the Lagrangian for the shareholders' problem is

$$
\begin{aligned}
\mathcal{L}\left(b_t, k_t, z_t, \Upsilon_t\right) = {} & (1-\tau)(\mathcal{Y}_t^{\frac{1}{\nu}}\left(Y_{j,t}^- + y_t\right)^{\frac{-1}{\nu}} y_t - W_t l_t - z_{i,j,t}\bar{k}_{j,t}) - i_t + \tau\delta_k k_t \\
& - \left((1-\tau)C + 1\right) b_t + q_t b_{t+1} - \psi_b(b_t, b_{t+1}) \\
& + \Lambda_t^K\left((1-\delta_k)k_t + \Gamma\left(\frac{i_t}{k_t}\right) k_t - k_{t+1}\right) \\
& + E_t M_{t,t+1} \int_{\underline{z}}^{\bar{z}} \mathcal{L}\left(b_{t+1}, k_{t+1}, z', \Upsilon_{t+1}\right) d\Phi(z')
\end{aligned}
\tag{58}
$$

where $Y_{j,t}^- = \sum_{k=1,k\neq i}^{n_j} y_{k,j,t}$ is the total industry output produced by the firm's rivals, and Λ_t^K is the Lagrange multiplier on the capital accumulation equation. The set of first order necessary conditions are:

$$
\begin{aligned}
& [i_t] : \Lambda_t^K \Gamma_t' = 1 \\
& [l_t] : \tilde{P}_{j,t}\left[1 - \frac{1}{\nu}\frac{y_t}{Y_{j,t}}\right](1-\alpha)\frac{y_t}{l_t} - W_t = 0 \\
& [k_{t+1}] : q_{k,t}' b_{t+1} - \Lambda_t^K + E_t M_{t,t+1} \int_{\underline{z}}^{z_{t+1}^\star} \mathcal{L}_{k,t+1}' d\Phi(z') = 0 \\
& [b_{t+1}] : q_{b,t}' b_{t+1} + q_t - \psi_{b,2,t}' + E_t M_{t,t+1} \int_{\underline{z}}^{z_{t+1}^\star} \mathcal{L}_{b,t+1}' d\Phi(z') = 0
\end{aligned}
\tag{59}
$$

where I use the following notation: $\Gamma_t' = \partial\Gamma_t/\partial(i_t/k_t)$, $q_{k,t}' = \partial q_t/\partial k_{t+1}$, $q_{b,t}' = \partial q_t/\partial b_{t+1}$, $\mathcal{L}_{k,t}' = \partial\mathcal{L}_t/\partial k_t$, $\mathcal{L}_{b,t}' = \partial\mathcal{L}_t/\partial b_t$, $\psi_{b,1,t}' = \partial\psi_{b,t}/\partial b_t$, and $\psi_{b,2,t}' = \partial\psi_{b,t}/\partial b_{t+1}$. $\mathcal{L}_{k,t}'$ and $\mathcal{L}_{b,t}'$ are obtained by applying the enveloppe theorem,

$$
\begin{aligned}
\mathcal{L}_{k,t}' &= (1-\tau)\tilde{P}_{j,t}\left[1 - \frac{1}{\nu}\frac{y_t}{Y_{j,t}}\right]\alpha\frac{y_t}{k_t} + \tau\delta_k + \Lambda_t^K\left(1 - \delta_k + \Gamma_t - \Gamma_t'\frac{i_t}{k_t}\right) \\
\mathcal{L}_{b,t}' &= -\left((1-\tau)C + 1\right) - \psi_{b,1,t}'
\end{aligned}
\tag{60}
$$

Finally, $q_{k,t}'$ and $q_{b,t}'$ are obtained by taking partial derivatives of total debt value $q_t b_{t+1}$ with respect to

$b_t + 1$ and k_{t+1},[37]

$$q'_{b,t}b_{t+1} + q_t = E_t M_{t,t+1} \left[(C+1)\Phi(z^\star_{t+1}) + z^{\star'}_{b,t+1}\phi(z^\star_{t+1})b_{t+1}(\tau C + \xi[(1-\tau)C + 1]) \right]$$

$$q'_{k,t}b_{t+1} = E_t M_{t,t+1} \left[z^{\star'}_{k,t+1}\phi(z^\star_{t+1})b_{t+1}(\tau C + \xi[(1-\tau)C + 1]) + (1-\xi)\int_{z^\star_{t+1}}^{\bar{z}} \mathcal{L}'_{k,t+1}\, d\Phi(z') \right] \tag{61}$$

where

$$z^{\star'}_{k,t} = \frac{\mathcal{L}'_{k,t}}{(1-\tau)\bar{k}_{j,t}}$$

$$z^{\star'}_{b,t} = \frac{\mathcal{L}'_{b,t}}{(1-\tau)\bar{k}_{j,t}} \tag{62}$$

Note that Eq. 24 is obtained by replacing for $z^{\star'}_{k,t}$ and $q'_{k,t}$ in the capital FOC.

Symmetric equilibrium   Because each firm is ex-ante identical and the i.i.d. shock enters as a fixed costs, all firms make the same decisions and the model admits a symmetric Nash equilibrium in each industry. In particular, we have $y_{i,j,t} = y_{j,t}$, $Y_{j,t} = n_j y_{j,t}$, $l_{i,j,t} = l_{j,t}$, $k_{i,j,t} = k_{j,t} = \bar{k}_{j,t}$, and $b_{i,j,t} = b_{j,t}$.

Price markups   Using the first order condition with respect to labor, and the symmetric property of the equilibrium,

$$\tilde{P}_{j,t}\left(1 - \frac{h_j}{\nu}\right) = \frac{W_t}{(1-\alpha)\frac{y_{j,t}}{l_{j,t}}} \tag{63}$$

where $h_j = 1/n_j$ is the Herfindahl-Hirschman index. The right-hand-side is the firm real marginal cost of production. Defining the price markup to be the price set by the firm over marginal cost, the price markup is,

$$\mu_{j,t} = \left(1 - \frac{h_j}{\nu}\right)^{-1} \tag{64}$$

C   Derivation of inverse demand schedule

The final goods firm solves the following profit maximization problem

$$\max_{Y_{j,t}\in[0,1]} \mathcal{P}_t \left(\int_0^1 Y_{j,t}^{\frac{\nu-1}{\nu}}\, dj \right)^{\frac{\nu}{\nu-1}} - \int_0^1 P_{j,t}Y_{j,t}\, dj \tag{65}$$

---

[37]It is implicitly assumed that although creditors inherit an unlevered firm in bankruptcy, the debt adjustment cost is paid on the leverage level at the time of bankruptcy.

where $\mathcal{P}_t$ is the price of the final good (taken as given), $Y_{j,t}$ is the amount of input bought from industry j, and $P_{j,t}$ is the unit price of that input, $j \in [0,1]$.

The first-order condition with respect to $Y_{j,t}$ is

$$\mathcal{P}_t \left(\int_0^1 Y_{j,t}^{\frac{\nu-1}{\nu}} \, dj \right)^{\frac{\nu}{\nu-1}-1} Y_{j,t}^{-\frac{1}{\nu}} - P_{j,t} = 0 \tag{66}$$

which can be rewritten as

$$Y_{j,t} = \mathcal{Y}_t \left(\frac{P_{j,t}}{\mathcal{P}_t} \right)^{-\nu} \tag{67}$$

Using the expression above, for any two industries $j, k \in [0,1]$,

$$Y_{j,t} = Y_{k,t} \left(\frac{P_{j,t}}{P_{k,t}} \right)^{-\nu} \tag{68}$$

Raising the expression above to the power of $\frac{\nu-1}{\nu}$, integrating over j and raising the expression to the power of $\frac{\nu}{\nu-1}$,

$$Y_{j,t} = \mathcal{Y}_t \left(\frac{P_{j,t}}{\left(\int_0^1 P_{j,t}^{1-\nu} \right)^{\frac{1}{1-\nu}}} \right)^{-\nu} \tag{69}$$

Using (67), I obtain the expression for the price index

$$\mathcal{P}_t = \left(\int_0^1 P_{j,t}^{1-\nu} \right)^{\frac{1}{1-\nu}} \tag{70}$$