Capital Structure under Imperfect Product Market Competition: Theory and Evidence

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Abstract

We show how product market competition affects capital structure by developing a tractable model that embeds the tradeoff between the tax benefits and bankruptcy costs of debt in an industry equilibrium setting with heterogeneous, imperfectly competitive firms. Different determinants of competition—fixed production costs and product substitutability—have contrasting implications for the effects of competition on firm leverage. Firms in more competitive industries with greater product substitutability are more leveraged, whereas firms in more competitive industries with lower fixed production costs have lower leverage. We show robust support for these predictions in our empirical analysis of U.S. nonfinancial firms.

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1 Introduction

A key stylized fact that emerges from the empirical literature on capital structure is that leverage is strongly determined by a firm’s industry. One of the principal attributes of an industry is its competitive environment that is itself shaped by distinct industry primitives such as fixed costs of production or the elasticity of substitution between products. For example, industries with higher fixed operating costs discourage entry and are, therefore, expected to feature less intense product market competition. Industries with more substitutable products are characterized by more competition because goods produced by firms are closer substitutes. As they affect market competition through different channels, these distinct industry primitives could, in principle, lead to contrasting effects of market competition on firms’ capital structures. Prior empirical studies, however, typically employ unidimensional proxies for product market competition such as industry concentration, which is itself endogenously determined by more fundamental industry characteristics. Theoretical research that informs empirical investigations also largely abstracts away from how different determinants of product market competition influence firms’ capital structures.

Does “product market competition” have an unambiguous effect on firm leverage regardless of how it is shaped by industry primitives? If not, how do different determinants of product market competition influence firms’ capital structure choices, and why? We address these questions by developing a tractable model that embeds the tradeoff between the tax benefits and bankruptcy costs of debt in an industry equilibrium setting with heterogeneous firms. We show that firms in more competitive industries with greater product substitutability have higher leverage ratios, but firms in industries that are more competitive due to lower fixed costs of production have lower leverage ratios. The novel implication of our results, therefore, is that leverage varies in contrasting directions with the intensity of product market competition depending on the channel through which product market competition changes.

\footnote{For example, many empirical studies, such as Bradley et al. (1984), Frank and Goyal (2008), and Lemmon et al. (2008), show that the median industry leverage is the most important determinant of firm leverage.}
We show robust empirical evidence consistent with these predictions. Overall, our study emphasizes the importance of examining capital structure choices in a unified equilibrium framework that accommodates different determinants of product market competition and empirically disentangling their contrasting implications for firm leverage.

In our industry equilibrium model, ex ante identical firms enter the market by making a fixed capital investment that they finance through debt and equity after which their heterogeneous productivities are realized. A firm’s production cost has fixed and variable components with the variable component determined by the firm’s productivity. Firms make production decisions and generate profits from which they make debt, tax and dividend payments. The industry is monopolistically competitive (Dixit and Stiglitz (1977)). That is, firms offer differentiated, imperfectly substitutable products for which they enjoy monopolies, but take the aggregate price index—a weighted average of the prices charged by all firms—as given (i.e., they ignore the impact of their own prices on the prices of other firms) when they make their output and pricing decisions. Firms declare bankruptcy if their realized productivities are sufficiently low that their resulting earnings are insufficient to make debt payments. Creditors then take control of the firms with bankruptcy costs being incurred. Entering firms rationally anticipate the likelihood of bankruptcy when they make their ex ante financing decisions.

The unique industry equilibrium is endogenously determined by two key conditions: (i) the free entry condition, which implies that the value of an entering firm equals the initial capital investment; and (ii) the bankruptcy condition, which implies that the equity value of a firm equals zero at the bankruptcy threshold. As in the tradeoff theory of capital structure, the optimal debt level is determined by the condition that the expected marginal tax advantage of debt equals the expected marginal bankruptcy cost. Because it depends on the probability that a firm is solvent, the expected tax benefit of debt is determined by the mass of the firm productivity distribution above the endogenous bankruptcy threshold. Similarly, the expected cost of debt depends on the mass of the productivity distribution
below the bankruptcy threshold. Consequently, the expected marginal cost of debt relative to its tax benefit and, therefore, the optimal leverage depend crucially on the shape of the firm productivity distribution. We analyze the equilibrium and derive our main implications for the effects of product market characteristics on firm leverage. Under a condition on the hazard rate of the productivity distribution, which holds for empirically observed Pareto or “power law” distributions (e.g., Gabaix (2016)), we show that firm leverage is higher in industries with higher fixed production costs (or industry operating leverage) and higher product substitutability.

The intuition for our results hinges on the observation that industries with higher fixed costs or product substitutability feature more skewed firm profit distributions with more productive firms generating disproportionately greater profits than less productive firms. Entering firms’ leverage choice reflects the trade-off between the tax advantages of debt, which firms obtain when their realized productivities are high, and the bankruptcy costs of debt, which firms incur when their realized productivities are low. Consequently, the effect of a greater skew in the ex post firm profit distribution (arising from higher fixed production costs or product substitutability) on the ex ante debt level choice depends on the relative masses of the upper and lower tails of the productivity distribution. The debt capacity and, therefore, the optimal debt level increase if entering firms expect that their profits when their realized productivities are high outweigh their profits when their realized productivities are low. The condition on the hazard rate of the firm productivity distribution, which is satisfied by power law distributions, ensures that this is, indeed, the case. Hence, the optimal debt level is higher in industries with higher fixed production costs or product substitutability.

The key product market mechanism that emerges from our results, therefore, is that industry primitives affect financial leverage through their impact on the post-entry (or ex post) equilibrium distribution of profits among heterogeneous firms. The reasons that higher fixed costs or product substitutability result in more skewed firm profit distributions are as follows. For a given aggregate price index, higher fixed costs of production lower the profit of
each firm. The free entry condition then implies that the endogenously determined aggregate price index must be higher to ensure that the average ex post profit of firms, which is rationally anticipated by entering firms, equals the initial investment. A higher aggregate price index benefits higher productivity firms more as they are better able to exploit the higher price index to garner greater market shares relative to less productive firms. Consequently, with higher fixed costs, the equilibrium profit of firms with productivities above a threshold increases, while the profit of firms with productivities below the threshold decreases. A higher product substitutability also leads to a transfer of wealth from less productive to more productive firms, but for a different reason. In industries with more substitutable products, ceteris paribus, consumer demand is more responsive to prices. More productive firms can, therefore, capture disproportionately higher market shares and rents by charging lower prices than less productive firms. Hence, firm profit increases more disproportionately with firm productivity in industries with greater product substitutability.

In standard trade-off models of capital structure that abstract away from a firm’s product market interactions, the firm’s leverage choice is determined by its expected profit distribution that is specified exogenously. In our model, the realized distribution of firm profits is endogenously determined in an industry equilibrium framework. The trade-off between the tax benefits and bankruptcy costs of debt is influenced by the skewness of the expected firm profit distribution that is itself shaped by distinct industry primitives such as fixed production costs and the product substitutability. As discussed above, although a decrease in the fixed production cost or an increase in the product substitutability both increase the intensity of product market competition, they have opposing effects on the skewness of the firm profit distribution and, therefore, contrasting implications for capital structure. Hence, the novel predictions of our analysis stem from disentangling the impacts of distinct determinants of product market competition on the endogenous profit distribution of firms and, thereby, capital structures.

Our key implications—the positive effects of the fixed production cost and the product substitutability—
substitutability on firm leverage—are robust to an extension of the model to a dynamic (continuous-time) framework in which the market size and firm productivities vary stochastically over time. Our results also hold when we modify the model to distinguish between industry-level and firm-level fixed costs of production or operating leverages. In particular, the industry-level operating leverage is positively associated with firm leverage as in our basic model, while the firm-level operating leverage is negatively related, which is consistent with prior empirical evidence. Importantly, while the former relation stems from the effects of product market competition, the latter arises from the substitutability between firm-level financial and operating leverages. Finally, the implications we derive in our basic model with fixed bankruptcy costs are also robust to a framework that incorporates general bankruptcy costs that include fixed and variable components.

Our results have important empirical implications. First, higher industry-level fixed costs of production are typically expected to hamper product market competition, while greater product substitutability intensifies competition. We show that, in equilibrium, leverage increases with both fixed costs and product substitutability. Thus, it is likely that empirical analyses of how leverage varies with the intensity of product market competition can provide conflicting evidence depending on which underlying industry parameter the proposed empirical proxy for competition is capturing. As our theory demonstrates, the conflicting results are not a puzzle, but rather arise naturally from a model that explicitly incorporates multiple determinants of product market competition among firms. Second, our result that firm financial leverage is positively related to the industry operating leverage, but negatively related to the firm-level operating leverage, provides a much more nuanced picture relative to prior empirical studies that focus solely on the latter relation. The relation between capital structure and industry operating leverage captures the effects of product market competition, whereas the relation between capital structure and firm-level operating leverage stems from the substitutability between debt payments and firm-level operating costs.

We test the empirical implications of our theory in the standard Compustat panel of U.S.
non-financial firms over the 1982-2014 period. For robustness, we consider three alternate industry classifications of firms: (i) the three-digit standard industry classification (SIC); (ii) the four-digit SIC classification; and (iii) the Hoberg-Phillips (2010) industry classification. We construct industry-level proxies for product substitutability and fixed production costs using the Compustat Segments database. Following previous literature (e.g., Nevo (2001) and Karuna (2007)), we measure product substitutability using the industry average price-cost margin. As in Kahl et al. (2014), we measure industry operating leverage by the sensitivity of the industry average operating costs to the industry average sales taking into account the trends in the growth rates of the industry sales and operating costs.

Consistent with our hypotheses, we find robust evidence that firm financial leverage is higher in industries with higher product substitutability and/or higher industry operating leverage. Both estimates are quantitatively significant. A one standard deviation increase in the product substitutability corresponds to an about 4.2% increase in a firm’s book leverage relative to the sample average leverage ratio. The corresponding change in a firm’s leverage with industry operating leverage is similar in magnitude and statistical significance. We obtain these results after controlling for firm-specific operating leverage, whose negative association with financial leverage reflects financial conservatism of high fixed cost firms as documented by previous studies (e.g., Kahl et al. (2014) and Chen et al. (2013)). Hence, our results show that industry-level and firm-level operating leverages have opposing relations with financial leverage. Because they do not disentangle industry- and firm-level operating leverages in their specifications, prior empirical studies do not find the contrasting relations with firms’ financial leverages that we show in our analysis. Our results caution against using industry-level variables as proxies for individual (firm-level) determinants of capital structure since point estimates on industry aggregates can capture equilibrium effects that are not present in firm-level variables. Overall, our empirical results suggest that industry equilibrium forces have economically and statistically significant implications for corporate capital structure.
Our results are also robust to using Census of Manufacturers data, which include establishment level data from all public and private firms in manufacturing industries. Further, we provide additional evidence in support of the channels through which product market characteristics affect capital structure in our theory. In particular, our model suggests that the skewness of profits (or revenues) should be higher in industries with higher operating leverages and product substitutability. Consistent with these predictions, we find that the skewness of industry profits is, indeed, increasing in both product substitutability and industry operating leverage.

Finally, we carry out additional tests inspired by the analysis of Heider and Ljungqvist (2015), who argue that exogenous variation in state corporate income taxes can empirically identify the trade-off considerations in firm-level debt policy. Our model predicts that the tax sensitivity of leverage is greater in industries with higher product substitutability or fixed costs. We test this prediction by examining how firms’ leverage adjustments to staggered changes in state-level corporate taxes vary with product market characteristics. We show strong support for our prediction. Consistent with Heider and Ljungqvist (2015), we find that firms undertake a significant increase in leverage in response to tax increases, but do not reduce leverage following tax cuts. However, the average effect masks significant heterogeneity across industries with the largest increases in leverage coming from industries with high product substitutability and/or high industry operating leverages. Overall, our empirical analysis provides robust evidence in support of our theoretical predictions for the effects of different determinants of product market competition on inter-industry variation in firm leverage.

2 Related Literature

Our study contributes to the theoretical and empirical literatures that examine the relation between capital structure and product market competition. On the theory side, we
build upon the literature that links firms’ financial and real decisions in industry equilibrium models. One strand of the literature examines firms’ capital structure choices in imperfectly competitive, oligopolistic industries with *homogeneous* firms (e.g., Brander and Lewis (1986), Maksimovic (1988), and Lyandres (2006)). These studies highlight the commitment effect of debt, where a firm’s choice of higher debt serves to commit the firm to undertake a more aggressive product market strategy. Another strand of the literature studies firms’ capital structure choices in *perfectly competitive* industries with a large number of heterogeneous firms that face an exogenously specified industry-level downward sloping demand curve (Maksimovic and Zechner (1991), Fries et al. (1997), and Miao (2005)).

We complement studies in both streams of the literature, and serve as a bridge between them, by developing an industry equilibrium model with a large number of heterogeneous firms engaged in imperfect (monopolistic) product market competition. Each firm faces a downward-sloping demand curve that is endogenously determined via product differentiation. In particular, price markups and, therefore, firm profits are directly influenced by the demand elasticity or the degree of product substitutability. Because entering firms’ capital structure choices rationally anticipate their ex post profits, the demand elasticity affects capital structure through its effects on the ex post distribution of firm profits and, thereby, ex ante firm value. In contrast, demand elasticity does not affect capital structure in frameworks with perfectly competitive firms because markups are zero so that the demand elasticity is irrelevant for firms’ capital structure choices. Hence, the incorporation of imperfect product market competition in our framework plays a central role in generating one of our key novel implications; the effect of the product substitutability on capital structure. Further, the presence of firm heterogeneity in our framework is also an important distinguishing feature relative to the first stream of the literature above that assumes homogeneous firms. As the intuition for our results clarifies, the effects of product market characteristics (fixed production costs and product substitutability) on leverage stem from their impacts on the ex post distribution of profits among heterogeneous firms.
On the empirical side, our results showing the opposing implications of different determinants of product market competition—the industry operating leverage and product substitutability—for firm leverage have not been demonstrated in previous literature. Prior empirical studies typically examine the effects of empirical proxies for product market competition on capital structure, but do not distinguish between different dimensions of product market competition. MacKay and Phillips (2005) show that financial leverage is higher in more concentrated industries (proxied by the Herfindahl–Hirschman Index). Lyandres (2006) documents a positive relation between firm leverage and the extent of competitive interaction among firms as proxied by the number of rivals as well as estimates of the effect of firms’ actions on their rivals’ marginal profits. Ovtchinnikov (2010) and Xu (2012) show that firms reduce leverage in response to shocks such as deregulation and import penetration that significantly increase the intensity of product market competition.

Our study contributes to the above literature by showing that empirical investigations of the effect of product market competition on capital structure should appropriately disentangle different channels through which product market competition is affected. We demonstrate that distinct determinants of product market competition—fixed costs of production and product substitutability—have diametrically opposing effects on firm leverage. Further, the contrasting effects of industry-level and firm-level operating leverages on capital structure that we predict and document highlight the importance of examining capital structure choices within industry equilibrium models as industry variables can have equilibrium effects on firm-level choices that are not captured by firm-level relationships. Prior empirical studies do not examine the simultaneous relations between firms’ financial leverage ratios and industry- and firm-level operating leverages so they cannot generate the differing relationships that we show in our empirical analysis.
3 Baseline model

We develop a simple model of an industry with a continuum of heterogeneous firms. Ex ante identical firms enter the market by making a fixed capital investment that they finance through a combination of equity and debt. Firms’ productivities are then realized. A firm’s production cost has two components: a fixed component that is independent of the firm’s output, and a variable component that varies with its output and is determined by its productivity. After their productivities are realized, firms make their production decisions and generate profits (revenues net of production costs) from which they make debt, tax and dividend payments. We normalize the discount rate of firms to zero. In Section 5, we show that our main implications are robust to an extension of the model to an infinite horizon, multiperiod framework in which firm productivities and industry characteristics vary over time.

3.1 Model setup

Firms are engaged in monopolistic competition, and produce a continuum of imperfectly substitutable goods with each firm specializing in the production of a single good (Dixit and Stiglitz (1977)).

3.1.1 Consumer preferences

The representative consumer has “constant elasticity of substitution” (CES) preferences for consumption of the continuum of goods produced by the industry. The preferences are described by the utility function $U = \left[ \int_\Omega q(\omega)^\rho d\omega \right]^\frac{1}{\rho}$, where $0 < \rho < 1$, $\Omega$ is the set of available goods, and $\omega$ is a finite measure on the Borel $\sigma$-algebra of $\Omega$. Let $R$ be the total expenditure of the representative consumer on goods produced in the industry that can be interpreted as the industry (or market) size. As shown by Dixit and Stiglitz (1977), if $p(\omega)$ is the price of good $\omega$, then the consumer’s demand $q(\omega)$ for good $\omega$ is downward-sloping.
and given by

\[ q(\omega) = U \left( \frac{P}{p(\omega)} \right)^{\frac{1}{1-\rho}}. \]  \hspace{1cm} (1)

In the above, \( P \) is the aggregate price index; a weighted average of the prices charged by all firms. It is given by

\[ P = \left[ \int_{\Omega} p(\omega) \rho^{\omega-1} d\omega \right]^{\frac{\rho}{1-\rho}}. \]  \hspace{1cm} (2)

Further, we can write the representative consumer’s total expenditure as \( R = PU \). By (1), for \( i \neq j \),

\[ \frac{q(\omega_i)}{q(\omega_j)} = \left( \frac{p(\omega_j)}{p(\omega_i)} \right)^{\frac{1}{1-\rho}}, \]  \hspace{1cm} (3)

so that \( \sigma \equiv \frac{1}{1-\rho} > 1 \) is the elasticity of substitution or product substitutability between any two goods in the market.

### 3.1.2 Firm entry and production

There is an unbounded pool of ex ante identical prospective firms who can enter the industry. Each firm needs to make an initial capital investment that can be financed by a combination of debt and equity. A firm’s revenue and costs are proportional to the investment. As all output variables scale with the investment, we hereafter normalize it to one without loss of generality. (Alternatively, we measure all variables in units of the investment.) Upon entry, each firm randomly draws its productivity \( \alpha \in [\alpha_L, \infty) \) from a continuous distribution with density \( g(\alpha) \) where \( \alpha_L > 0 \) is the minimum possible productivity level. The cumulative distribution of firm productivity is \( G(\alpha) \).

A firm’s production cost has fixed and variable components, and is represented by an affine function of its output \( q \): \( c(\alpha) = f + q/\alpha \), where \( f > 0 \) is the fixed production cost that is the same for all firms, and we interpret as the industry-level fixed cost of production or operating leverage. The industry-level parameter, \( f \), captures the significant inter-industry variation in fixed production costs. Each firm’s realized productivity \( \alpha \) determines its marginal cost of production: \( mc(\alpha) = 1/\alpha \). Firms compete monopolistically in the sense
that each firm produces a differentiated good for which it enjoys a monopoly with the constant price elasticity of demand \( \sigma \), but takes the aggregate price index \( P \) as given in choosing the price for its product (see (1)). It then follows that the profit-maximizing firm with the realized productivity \( \alpha \) chooses the product price,

\[
p(\alpha) = \frac{1}{\rho \alpha} = \frac{\sigma}{(\sigma - 1)\alpha}.
\]  

(4)

Because \( \rho < 1 \), the product price is greater than the firm’s marginal production cost, \( \frac{1}{\alpha} \), so the firm charges a proportional markup,

\[
\frac{p - mc}{mc} = p(\alpha)\alpha - 1 = \frac{1}{\sigma - 1}.
\]  

(5)

In industries with more substitutable or less differentiated products, which are characterized by higher values of \( \sigma \), the industry-level price markups are lower. By (1), (2), (3) and (4), the firm’s revenue and operating profit are

\[
r(\alpha) = R(P \rho \alpha)^{\sigma - 1},
\]

\[
\pi(\alpha) = \frac{R(P \rho \alpha)^{\sigma - 1}}{\sigma} - f.
\]

(6)

(7)

For future reference, we note that firm revenue and profit are increasing in firm productivity. Further, firm revenue and profit increase more disproportionately with firm productivity in industries with greater product substitutability. The intuition is as follows. Under monopolistic competition, more productive firms can exploit their lower variable costs of production by charging lower prices and, thereby, capturing larger market shares and rents. In industries where products are more substitutable, the capacity of less productive firms to obtain market shares via product differentiation declines. As a result, more productive firms are able to garner even greater rents. Hence, firm revenue and profit increase more disproportionately with firm productivity in industries with less product differentiation.
3.1.3 Capital structure

Firms finance their capital investment through equity and debt that is due when firms’ cash flows are realized. Since firms are ex ante (prior to entry) identical, they choose identical capital structures. Our general model in Section 5 allows for ex ante firm heterogeneity so that firms with different ex ante productivities choose different capital structures.

Accordingly, let the face value of debt be $D$, which is the amount that a firm must pay back its debt holders if it is able to do so at the end of the third period (i.e., there is limited liability for shareholders). As firms make debt, tax and dividend payments to shareholders from their realized operating profits at the end of the third period, it follows from (7) that the after-tax payoff to the firm’s shareholders is $(1 - \tau)(\pi(\alpha) - D)$, where $\tau$ is the constant effective corporate tax rate. Since shareholders are protected by limited liability, the firm is insolvent if its realized productivity $\alpha$ is below the bankruptcy threshold, $\alpha_B$, that solves

$$
\pi_E(\alpha_B) = (1 - \tau)(\pi(\alpha_B) - D) = 0,
$$

(8)

where we denote the residual payoff to shareholders (the equity payoff) by $\pi_E(\cdot)$. If the realized productivity is $\alpha \geq \alpha_B$, the firm is solvent and its equity payoff is $\pi_E(\alpha) = (1 - \tau)(\pi(\alpha) - D)$. If $\alpha < \alpha_B$, the firm goes bankrupt, and control of the firm transfers to creditors with shareholders obtaining no payoff. Although the bankrupt firm continues to operate in the product market, it incurs some deadweight losses.

The bankruptcy payoff to debt holders is

$$
\pi_D(\alpha) = (1 - \tau)[\pi(\alpha) - \zeta],
$$

(9)

where $0 < \zeta < 1$ is the fixed bankruptcy cost. In Appendix D, we show that our results extend to a setting with a general bankruptcy cost that includes fixed and proportional components. The market value of debt, which is the amount the firm is able to raise through
debt financing, rationally anticipates the likelihood of bankruptcy and is given by

\[
\text{Debt Value} = D \int_{\alpha_B}^{\infty} g(\alpha)d\alpha + \int_{\alpha_L}^{\alpha_B} \pi_D(\alpha)g(\alpha)d\alpha \\
= D [1 - G(\alpha_B)] + \int_{\alpha_L}^{\alpha_B} (1 - \tau)[\pi(\alpha) - \zeta]g(\alpha)d\alpha.
\] (10)

In the above, we assume for simplicity that the relevant parameter values are such that it is profitable for firms with the lowest productivity, \(\alpha_L\), to produce and remain active, that is, \(\pi(\alpha_L) \geq \zeta\). We can allow for \(\pi(\alpha_L) < \zeta\) so that some firms are immediately liquidated upon entry, but this entails additional notational complexity without altering our results.

When each potential entrant makes its entry decision, it takes into account the possibility that it may go bankrupt if its realized productivity is below the bankruptcy threshold (\(\alpha < \alpha_B\)). As in the tradeoff theory of capital structure, the optimal debt level trades off the tax advantages of debt against the bankruptcy costs incurred by firms with realized productivities below the bankruptcy threshold. Since we normalize the initial capital investment of an entering firm to one, the entrant’s optimal debt level choice solves the following optimization problem:

\[
D^* = \arg \max_{0 \leq D \leq 1} \left[ \int_{\alpha_L}^{\infty} \pi_E(\alpha)g(\alpha)d\alpha + \int_{\alpha_L}^{\alpha_B} (1 - \tau)[\pi(\alpha) - \zeta]g(\alpha)d\alpha \right] \\
+ D [1 - G(\alpha_B)] + \int_{\alpha_L}^{\alpha_B} (1 - \tau)[\pi(\alpha) - \zeta]g(\alpha)d\alpha
\] (11)

where the equity payoff is

\[
\pi_E(\alpha) = 1_{\alpha \geq \alpha_B}(1 - \tau)(\pi(\alpha) - D).
\] (12)

In the above, the indicator function equals one for the solvency region (if \(\alpha \geq \alpha_B\)) or zero
for the bankruptcy region (if $\alpha < \alpha_B$), and $D_0$ is given by (10).

### 3.2 Equilibrium conditions

An equilibrium is characterized by (i) a mass $M^*$ of producing firms (and hence $M^*$ differentiated products); (ii) an aggregate price index $P^*$; (iii) the optimal capital structure choice of entering firms that is determined by the debt level $D^*$; and (iv) the threshold $\alpha_{B}^*$ of firm productivity below which firms are insolvent. Given that the industry is monopolistically competitive, firms make their optimal capital structure choices and production decisions taking the aggregate price index $P^*$ as given. We now describe the equilibrium conditions.

First, the bankruptcy (B) condition specifies that the equity payoff must be zero at the bankruptcy threshold $\alpha_{B}^*$, that is,

$$B : \pi_{E}^*(\alpha_{B}^*) = (1 - \tau)(\pi(\alpha_{B}^*) - D^*) = 0. \tag{13}$$

Next, the free entry (FE) condition ensures that each entering firm’s market value prior to entry is equal to the initial capital investment, that is,

$$FE : 1 = \int_{\alpha_L}^{\infty} \pi_{E}^*(\alpha)g(\alpha)d\alpha + D^* \int_{\alpha_{B}^*}^{\infty} g(\alpha)d\alpha + \int_{\alpha_{B}^*}^{\alpha_{B}^*} \pi_{D}^*(\alpha)g(\alpha)d\alpha, \tag{14}$$

where $\int_{\alpha_L}^{\infty} \pi_{E}^*(\alpha)g(\alpha)d\alpha$ and the sum of the second and third terms on the R.H.S. above are the equity and debt values when the optimal debt level $D^*$ is chosen. The equity and debt values rationally incorporate the likelihood of bankruptcy.

Finally, the mass of producing firms, $M^*$, is determined by the product market clearing (PMC) condition. This condition requires that the aggregate revenue of firms operating in the market must equal the total consumer expenditure (i.e., market size), $R$, that is,

$$PMC : R = M^* \int_{\alpha_L}^{\infty} r(\alpha)g(\alpha)d\alpha. \tag{15}$$
By (6) and (15), the equilibrium mass $M^*$ of producing firms is given by

$$M^* = (P^* p)^{1-\sigma} \left[ \int_{\alpha_L}^{\infty} \alpha^{\sigma-1} g(\alpha) d\alpha \right]^{-1}. \tag{16}$$

4 The equilibrium and testable implications

We now characterize the equilibrium and derive the main testable implications of the model. We proceed via backward induction by first characterizing the product market equilibrium for a given debt level, and then determining the optimal debt level.

4.1 Product market equilibrium for given debt level

Suppose firms choose a debt level $D$. We first re-express the bankruptcy (B) and free entry (FE) conditions in a convenient form that facilitates the characterization of the equilibrium (e.g., see Melitz (2003)). Define the average firm revenue and profit of all firms as follows.

$$\bar{r} \equiv \int_{\alpha_L}^{\infty} r(\alpha) g(\alpha) d\alpha, \tag{17}$$

$$\bar{\pi} \equiv \frac{\bar{r}}{\sigma} - f, \tag{18}$$

where (18) follows from (6), (7) and (17). We can re-express the average firm revenue as $\bar{r} = r(\bar{\alpha})$, where

$$\bar{\alpha}^{\sigma-1} \equiv \int_{\alpha_L}^{\infty} \alpha^{\sigma-1} g(\alpha) d\alpha, \tag{19}$$

and the revenue function, $r(.)$, is given by (6). For a given level of debt, $D$, the bankruptcy (B) and free entry (FE) conditions, (13) and (14), can be viewed as two different functional relations linking the average profit level $\bar{\pi}$ with the bankruptcy threshold $\alpha_B$. 
Figure 1: Determination of the equilibrium bankruptcy threshold, $\alpha_B^*$, and average profit, $\bar{\pi}$, for a given debt level $D$

**Proposition 1 (B and FE conditions)**

Suppose firms choose a debt level $D$. The bankruptcy (B) and free entry (FE) conditions can be expressed as follows.

$$\bar{\pi} = \left[ \left( \frac{\bar{\alpha}}{\alpha_B} \right)^{\sigma^{-1}} - 1 \right] f + \left( \frac{\bar{\alpha}}{\alpha_B} \right)^{\sigma^{-1}} D, \quad (20)$$

$$\quad (1 - \tau)\bar{\pi} + \tau [1 - G(\alpha_B)] D - (1 - \tau)G(\alpha_B)\zeta = 1. \quad (21)$$

As shown in Figure 1, it follows from (20) and (21) that, in the space of ordered pairs, $(\alpha_B, \bar{\pi})$, the B curve is decreasing, but the FE curve is increasing. The equilibrium bankruptcy threshold and average profit level, which must satisfy the B and FE conditions, are thus uniquely determined by the intersection of the two curves.

The following proposition shows how two key product market characteristics—the product substitutability, $\sigma$, and the fixed production cost, $f$—influence the product market equilibrium for a given debt level $D$. The results help to understand the intuition for our main testable implications for the effects of product market characteristics on capital structure.

**Proposition 2 (Characteristics of the product market equilibrium)**

Suppose firms choose a debt level $D$. The endogenous bankruptcy threshold, average firm
profit, and average firm revenue increase with the fixed cost of production $f$ and the elasticity of substitution $\sigma$, while the mass of firms decreases.

By (20), an increase in the fixed cost of production, $f$, or the product substitutability, $\sigma$, increases the average firm profit for each possible value of the bankruptcy threshold, that is, the B curve shifts to the right as shown in Figure 2. By (21), the FE curve is, however, unaffected. It then immediately follows that the equilibrium bankruptcy threshold and average firm profit both increase with $f$ and $\sigma$. By (18), an increase in $f$ or $\sigma$ and the resulting increase in the average firm profit combine to increase the average firm revenue. By (15) and (17), the mass of firms, $M^*$, equals the market size, $R$, divided by the average firm revenue, $\bar{r}$. Hence, the mass of firms declines with $f$ and $\sigma$.

4.2 Optimal debt level

We now examine the optimal ex ante financing choices of entering firms, who anticipate the ex post product market equilibrium. For a given debt level, $D$, let $\alpha_B(D)$ denote the endogenous bankruptcy threshold that is determined in equilibrium of the product market as shown above. The firm’s optimal financing problem (11) leads to the following necessary
condition (assuming an interior optimal choice of debt level, that is, $0 < D^* < 1$):

\[
\text{marginal benefit of debt} = \tau[1 - G(\alpha_B(D^*))] - \tau D^* + (1 - \tau)\zeta g(\alpha_B(D^*))\alpha_B'(D^*) = 0. \tag{22}
\]

As shown by (22), the marginal benefit of debt is determined by the tax rate multiplied by the mass $1 - G(\alpha_B(D^*))$ of the productivity distribution to the right of the bankruptcy threshold, $\alpha_B(D^*)$, because this is the region where the firm is solvent and enjoys the full tax benefits of debt. The marginal cost of debt depends on the density $g(\alpha_B(D^*))$ of the productivity distribution at the bankruptcy threshold, and the marginal change in the bankruptcy threshold $\alpha_B'(D^*)$. The intuition is that the expected change in the firm’s bankruptcy cost stemming from an increase in its debt level is determined by the change in its likelihood of bankruptcy. The following proposition characterizes the optimal debt level.

**Proposition 3 (Optimal debt level)**

*If the optimal choice of debt level by entering firms satisfies $0 < D^* < 1$, then it solves*

\[
D^* = \frac{\tau(\sigma - 1)f - (1 - \tau)\zeta \Lambda(\alpha_B(D^*))}{\tau[\Lambda(\alpha_B(D^*)) - (\sigma - 1)]}, \tag{23}
\]

*where*

\[
\Lambda(\alpha) = \frac{\alpha g(\alpha)}{1 - G(\alpha)}. \tag{24}
\]

*If there is no solution to the above equation satisfying $0 < D^* < 1$, then either $D^* = 0$ or $D^* = 1$.*

Hereafter, we restrict consideration to parameter constellations for which the equation (23) has an interior solution. By (23), the optimal debt level depends on the product market characteristics; the product substitutability $\sigma$ and the fixed production cost $f$. Further, by (13) and (14), the endogenous bankruptcy threshold is itself influenced by the product market characteristics. Consequently, the product market characteristics directly affect the
debt level as well as indirectly influence it via the bankruptcy threshold.

4.3 Product market characteristics and capital structure

We now derive our main results concerning the effects of product market characteristics on capital structure. Given the equilibrium debt level, $D^*$, determined by (23), the corresponding book leverage ratio is the ratio of the amount of debt outstanding to the book value of an entering firm at time zero. Because we normalize the initial capital investment required for entry to one, the book value of an entering firm equals one. Further, the free entry condition ensures that the ex ante (prior to entry) market value of each entering firm equals the initial capital investment. Accordingly, the equilibrium debt level, $D^*$, coincides with the book and market leverage ratios in our discussion.

Proposition 4 (Product market characteristics and leverage)

If $\Lambda'(\alpha) \leq 0$, then the book and market leverage ratios increase with the fixed cost of production $f$ and the elasticity of substitution $\sigma$.

The intuition for the proposition hinges on the observation that an increase in the fixed production cost or product substitutability leads to a more skewed firm profit distribution with more productive firms generating disproportionately greater profits than less productive firms. The reasons are as follows. For a given aggregate price index, a higher fixed cost of production lowers the profit of each firm. The free entry condition, (14), then implies that the endogenously determined aggregate price index must be higher to ensure that the average ex post profit of firms equals the initial investment. In other words, a higher fixed cost of production discourages firm entry and, thus, leads to less intense product market competition as indicated by the increase in the aggregate price index. By (7), a higher aggregate price index has a greater positive effect on the profits of more productive firms relative to less productive ones. This is because, even though each firm enjoys a monopoly in its product, firms still compete for consumers as consumer demand for each firm’s product depends on its
price relative to other products (see (1)). Thus, more productive firms, which can set lower prices, are better able to exploit the increase in the aggregate price level to garner greater market shares. It then follows from (7) and (14) that a higher fixed cost of production leads to the equilibrium profit of firms with productivities above a threshold to increase, while the profit of firms with productivities of firms below the threshold decrease. In other words, a higher fixed cost leads to a transfer of wealth from less productive firms to more productive firms.

A higher product substitutability also leads to a transfer of wealth from less productive to more productive firms, but for different reasons. In industries with more substitutable products, ceteris paribus, consumer demand is more responsive to prices (see (3)). More productive firms can, therefore, capture disproportionately higher market shares and rents by charging lower prices than less productive firms. Hence, the firm profit-productivity relation is more disproportionate in industries with greater product substitutability.

As discussed above, industries with higher fixed production costs or product substitutability feature more skewed firm profit distributions. Entering firms’ leverage choice reflects the trade-off between the tax advantages of debt and bankruptcy costs. Consequently, the effect of a greater skew in the firm profit distribution on the ex ante debt level choice depends on the relative masses of the upper and lower tails of the firm productivity distribution. The debt capacity and, therefore, the optimal debt level increase if a firm’s profits when its realized productivity is high outweighs its profit when its realized productivity is low. The condition in Proposition 4 ensures that this is, indeed, the case so that the optimal debt level is higher in industries with higher fixed costs or product substitutability, ceteris paribus.

If firm productivity has a Pareto or power law distribution, that is,

\[ G(\alpha) = 1 - k\alpha^{-\gamma}, \]

where \( k \) and \( \gamma \) are positive constants, then the condition of the proposition is, indeed,
satisfied. Under the Pareto distribution, our model suggests that the observed skewness of firm profits should be higher in industries with higher product substitutability \((\sigma)\) and fixed production costs \((f)\). As shown in Figure 3, intra-industry profit skewness is indeed strongly increasing in both product substitutability and industry-level fixed costs of production (see Section 6 for details on the construction of industry variables). The evidence in Figure 3 is consistent with the considerable empirical evidence that firm size follows a Pareto distribution (Gabaix and Landier (2008), Gabaix (2016)). In our model, it follows from (6) and (7) that firm size (measured by revenue or profit) follows a power law distribution if and only if firm productivity also follows a power law distribution. Accordingly, we expect that the condition of Proposition 4 holds in the data.

An interesting and novel implication of Proposition 4 is that the effects of product market competition on capital structure crucially depend on the channel through which competition is affected. More specifically, our results imply that an increase in the fixed cost of production, which has the effect of decreasing competition among firms by discouraging firm entry, increases firm leverage. However, an increase in the product substitutability \(\sigma\), which has the effect of increasing competition among firms as consumer demand is more responsive to their relative prices, also has the effect of increasing leverage. In other words, an increase in the intensity of product market competition could have contrasting effects on leverage depending on the channel through which product market competition changes.

## 5 General Model

In our baseline model, firms are ex ante identical and choose the same debt level. In the data, however, firms have different leverage levels even within the same industry. Further, firms alter their leverage levels over time. We now extend our model to a multi-period setting with ex ante firm heterogeneity.

Consider an infinite horizon, discrete time model with dates \(0, 1, 2, \ldots\). Consider an arbi-
trary period, \([t, t+1]\). At date \(t\), there is a continuum of firms with productivities drawn from a distribution \(H_t(.)\) with density \(h_t(.)\) that can vary over time. Consider a firm with ex ante productivity \(\beta\). The firm needs to finance a capital investment, \(I_t\), that can vary over time. After making the capital investment, the firm experiences a multiplicative productivity shock \(\alpha\) so that the resulting productivity of the firm is \(\beta\alpha\). The shock is drawn from a distribution \(G_t(.|\beta)\) with density \(g_t(.|\beta)\) that has support \((\alpha_L, \infty)\). The distribution can vary over time and depend on the ex ante productivity level \(\beta\).

5.1 Consumer Preferences

The representative consumer’s preferences are as in the baseline model except that we allow for the market size and product substitutability to vary arbitrarily over time. Specifically, consumer preferences are described by the utility function \(U_t = \left[\int_{\Omega_t} q_t(\omega) p_t(\omega) d\omega\right]^{\frac{1}{\rho_t}}\), where \(0 < \rho_t < 1\), \(\Omega_t\) is the set of available goods, and \(\omega\) is a finite measure on the Borel \(\sigma\)-algebra of \(\Omega_t\). Let \(R_t\) be the industry (or market) size. Then

\[
q_t(\omega) = U_t \left[\frac{P_t}{p_t(\omega)}\right]^{\frac{1}{1-\rho_t}}. \tag{26}
\]

\[
P_t = \left[\int_{\Omega_t} p_t(\omega)^{\frac{\rho_t}{1-\rho_t}} d\omega\right]^{\frac{1-\rho_t}{\rho_t}}. \tag{27}
\]

\[
R_t = P_t U_t \tag{28}
\]

\[
\sigma_t = \frac{1}{1-\rho_t} \tag{29}
\]
5.2 Firm Entry and Production

In addition to the firms from the previous period, there is an unbounded pool of prospective new firms who can enter the industry. A firm that enters the industry draws a productivity $\beta$ from the same distribution $H_t(.)$ of existing firms. As in the baseline model, a firm’s revenue and costs are proportional to the required capital investment $I_t$ so we can normalize it to one without loss of generality.

Consider a firm with ex post (that is, post investment) productivity $\beta \alpha$. The firm’s production cost $c(\beta \alpha) = f_t + \frac{\sigma}{\beta \alpha}$, where $f_t > 0$ is the fixed production cost that can vary arbitrarily over time. As in the baseline model, firms compete monopolistically in each period. The profit-maximizing firm with the realized productivity $\beta \alpha$ chooses the product price,

$$p_t(\beta \alpha) = \frac{1}{\rho_t \beta \alpha} = \frac{\sigma_t}{(\sigma_t - 1)\beta \alpha}. \quad (30)$$

The firm’s revenue and operating profit are

$$r_t(\beta \alpha) = R_t (P_t \rho_t \beta \alpha)^{\sigma_t - 1}, \quad (31)$$
$$\pi_t(\beta \alpha) = \frac{R_t (P_t \rho_t \beta \alpha)^{\sigma_t - 1}}{\sigma_t} - f_t. \quad (32)$$

5.3 Capital structure

In contrast with the baseline model, the debt issued by a firm could vary with its ex ante productivity level, $\beta$. Suppose that the firm issues debt with face value $D$. If the firm’s ex post productivity is $\beta \alpha$, the after-tax payoff to the firm’s shareholders is $(1 - \tau_t)(\pi_t(\beta \alpha) - D)$, where $\tau_t$ is the constant effective corporate tax rate in period $t$. The firm is insolvent if its productivity shock $\alpha$ is below the bankruptcy threshold, $\alpha_B(\beta)$, that solves

$$\pi_E(t, \beta \alpha_B(t, \beta)) = (1 - \tau_t)(\pi_t(\beta \alpha_B(t, \beta)) - D) = 0, \quad (33)$$
Note that the bankruptcy level depends on time and the ex ante productivity level \( \beta \). The bankruptcy payoff to debt holders is

\[
\pi_D(t, \beta \alpha) = (1 - \tau_t)[\pi_t(\beta \alpha) - \zeta_t],
\]

where \( 0 < \zeta_t < 1 \) is the fixed bankruptcy cost in period \( t \). The expectation at the beginning of period \( t \) (that is, before the realization of the productivity shock) of the end-of-period payoff to debtholders is

\[
\begin{align*}
\text{solvency region} & \quad \text{bankruptcy region} \\
D \int_{\alpha \in A_t(t, \beta)} g_t(\alpha | \beta) d\alpha + & \quad \int_{\alpha \in A_t} \pi_D(t, \beta \alpha) g_t(\alpha | \beta) d\alpha \\
= & \quad D [1 - G_t(\alpha_B(t, \beta) | \beta)] + \int_{\alpha \leq \alpha_B(t, \beta)} (1 - \tau_t)[\pi_t(\beta \alpha) - \zeta_t] g_t(\alpha | \beta) d\alpha.
\end{align*}
\]

It is easy to see that it is optimal for the firm to solve a “period by period” optimization problem where it choose its debt level for the period, \( D_t^*(\beta) \) to maximize the expected end-of-period payoff to the firm; equityholders plus debtholders. The optimal debt level, therefore, solves the following optimization problem:

\[
D_t^*(\beta) = \arg \max_{0 \leq D \leq 1} \left\{ \begin{array}{c}
\text{expected equity payoff} \\
\int_{\alpha_L}^{\infty} \pi_E(t, \beta \alpha) g_t(\alpha | \beta) d\alpha + \\
\text{expected debt payoff} \\
+ D [1 - G_t(\alpha_B(t, \beta) | \beta)] + \int_{\alpha \leq \alpha_B(t, \beta)} (1 - \tau_t)[\pi_t(\beta \alpha) - \zeta_t] g_t(\alpha | \beta) d\alpha
\end{array} \right\}
\]

where the equity payoff is

\[
\pi_E(t, \beta \alpha) = \mathbf{1}_{\alpha \geq \alpha_B(t, \beta)}(1 - \tau_t)(\pi_t(\beta \alpha) - D_t(\beta)).
\]
level $\beta$.

5.4 Bankruptcy and free entry equilibrium conditions

Analogous to Section 3.2, we have the following bankruptcy and free entry equilibrium conditions.

$$B : \pi_E^*(t, \beta \alpha_B^*(t, \beta)) = (1 - \tau_t)(\pi_t(\beta \alpha_B^*(t, \beta)) - D_t^*(\beta)) = 0.$$  \hspace{1cm} (38)

$$FE : 1 = \int_{\alpha_L}^{\infty} \pi_E^*(t, \beta \alpha) g_t(\alpha \mid \beta) d\alpha + D_t^*(\beta),$$  \hspace{1cm} (39)

Note that, in contrast with the baseline model, we have a bankruptcy and free entry condition for each ex ante productivity level $\beta$.

5.5 The Equilibrium

We can proceed as in Section 4 by expressing the product market equilibrium for given debt level choices by firms with different ex ante productivity levels in terms of the the average firm revenue and profit of firms at a given ex ante productivity level, that is,

$$\bar{r}_t(\beta) \equiv \int_{\alpha_L}^{\infty} r_t(\beta \alpha) g_t(\alpha \mid \beta) d\alpha,$$  \hspace{1cm} (40)

$$\bar{\pi}_t(\beta) \equiv \frac{\bar{r}_t(\beta)}{\sigma} - f_t,$$  \hspace{1cm} (41)

where (41) follows from (6), (7) and (40). We then obtain the following generalization of Proposition 1

Proposition 5 (B and FE conditions)

The bankruptcy (B) and free entry (FE) conditions for firms with ex ante productivity level $\beta$. 

26
β can be expressed as follows.

\[
\tilde{\pi}_t^*(\beta) = \left[\left(\frac{\hat{\alpha}}{\alpha_B^*(t, \beta)}\right)^{\sigma_t-1} - 1\right] f_t + \left(\frac{\hat{\alpha}}{\alpha_B^*(t, \beta)}\right)^{\sigma_t-1} D_t^*(\beta),
\]

(42)

\[
(1 - \tau_t)\tilde{\pi}_t^*(\beta) + \tau_t \left[1 - G_t(\alpha_B^*(t, \beta)|\beta)\right] D_t^*(\beta) - (1 - \tau_t)G_t(\alpha_B^*(t, \beta)|\beta)\zeta_t = 1.
\]

(43)

Proceeding as in Section 4.1, the bankruptcy threshold and average profit level for the firms with ex ante productivity level β are uniquely determined by the above two conditions. As in Section 4.2, we can then characterize the optimal debt level choice by firms with ex ante productivity β.

**Proposition 6 (Optimal debt level)**

The optimal debt level choice by firms with ex ante productivity β solves

\[
D_t^*(\beta) = \frac{\tau(\sigma_t - 1)f_t - (1 - \tau_t)\zeta_t\Lambda_t(\alpha_B^*(t, \beta)|\beta)}{\tau_t[\Lambda_t(\alpha_B^*(t, \beta)|\beta) - (\sigma_t - 1)]},
\]

(44)

where

\[
\Lambda_t(\alpha|\beta) = \frac{\alpha g_t(\alpha|\beta)}{1 - G_t(\alpha|\beta)}.
\]

(45)

If there is no solution to (44) satisfying \(0 < D_t^*(\beta) < 1\), then either \(D_t^*(\beta) = 0\) or \(D_t^*(\beta) = 1\).

**5.6 Product market characteristics and capital structure**

By arguments very similar to those in Section 4.3, we obtain the following proposition.

**Proposition 7 (Product market characteristics and leverage)**

If \(\Lambda_t'(\alpha|\beta) \leq 0\), then a firm’s debt level and, therefore, its book leverage in period t increases with the fixed cost of production \(f_t\) and the elasticity of substitution \(\sigma_t\) in the period.

The intuition for the above proposition is very similar to that of Proposition 4. The proposition shows that the implications of the baseline model extend to the general dynamic setting where firm leverage ratios can vary within an industry. Hence, we have inter-industry and intra-industry variation in leverage ratios. Further, in the general model, the fixed cost of
production in an industry—the industry operating leverage—and the product substitutability can vary over time. The proposition, therefore, leads to the following two testable hypotheses.

**Hypothesis 1.** A firm’s leverage ratio in any period increases with the operating leverage of the industry during that period.

**Hypothesis 2.** A firm’s leverage ratio in any period increases with the product substitutability of the industry during that period.

6 Empirical analysis

As shown in subsection 4.3, our model predicts that leverage ratios are higher in industries with higher product substitutability and/or higher industry operating leverage. It is important to emphasize that our implications are *cross-sectional* in that they pertain to *inter-industry variation* in leverage ratios. We first discuss the construction of our key empirical proxies for product substitutability and industry operating leverage. We then present empirical evidence on the inter-industry variation in firm leverage with industry-level product market characteristics: the elasticity of product substitution and the fixed production costs. Finally, we document the relation between the tax sensitivity of leverage and product market characteristics.

6.1 Data and descriptive statistics

Our firm-level sample consists of U.S. companies covered by the Compustat database in the 1982–2014 fiscal years. To identify a firm’s primary industry sector, we use a firm’s historical SIC codes (SICH) from Compustat. If the historical code is missing, we use the historical SIC code of its largest segment from Compustat’s Segment database. We employ the firm’s earliest available industry classification if the historical SIC code of the firm’s largest segment is also unavailable for earlier years. If a firm’s industry is not identified from the Compustat historical code or the segment information, we use the firm’s current primary
We exclude all regulated utilities (SIC 4900-4999) and financial firms (SIC 6000-6999) as their capital structure is regulated. We also exclude quasi-governmental and non-profit firms (SIC 9000-9999). To reduce measurement error for industry variables, we exclude firms in industries classified as “miscellaneous” (SIC codes ending in 9). We also exclude firms involved in major mergers that are identified by Compustat footnote code AB (Frank and Goyal, 2009). We require that all firm-years have data for book assets, and our multivariate analyses implicitly require that data be available for other relevant variables. We also require that book leverage lie in the closed unit interval. To mitigate the effect of outliers in the data, we winsorize other ratio variables at the 1% and 99% quantiles.

To construct the industry-level proxies for product market characteristics, we define an industry at the three-digit SIC level in the baseline analysis. For robustness, we later repeat our analysis by using alternate industry classifications including (i) the four-digit SIC classification; and (ii) the Hoberg-Phillips (2010) industry classification. As the Compustat Fundamentals Annual database reports a firm’s operating variables (such as sales and operating costs) only for its primary industry, we construct the industry variables using Compustat’s Segment database that reports a firm’s operating variables at the segment level. To capture industry characteristics reasonably, we retain observations in industries that have more than five firms each year.\textsuperscript{2} The final baseline sample consists of 73,007 firm-years for 8,236 distinct firms in 233 three-digit SIC code industries. We provide detailed definitions of our empirical variables in Appendix E.

\subsection*{6.1.1 Product market variables}

As noted above, we build our empirical proxies for product market characteristics using the Compustat Segment database. We start with all operating/business segments from the database and retain segments with positive sales and operating costs. We compute operating

\textsuperscript{2}Our results are robust to retaining industry observations that have at least two firms each year.
costs by subtracting operating profit/loss from sales reported in the Segment data. We define a product market (or industry) at the three-digit SIC level and compute product market variables using both single- and multi-segment firms’ sales and operating costs.

Following prior studies in the industrial organization literature (e.g., Nevo (2001), Karuna (2007)), and consistent with (5), our proxy for the degree of product substitutability in an industry (PSUB) is the negative of the average price-cost margin in the industry. Our model implies that a higher degree of product substitutability in an industry is associated with a greater price elasticity of demand, and hence, a lower price-cost margin for firms in that industry. We compute each firm’s segment-level price-cost margin by dividing the firm’s segment sales by the corresponding operating costs, and then compute the average segment-level price-cost margin across all firms operating in the industry. We take the negative of the resulting measure for ease of interpretation since the price-cost margin declines with the product substitutability.

To construct both industry-level and firm-level measures of operating leverage, we follow recent work examining how financial leverage is related to the firm-level operating leverage (e.g., Kahl et al (2014), Chen et al (2013), Du et al. (2014)). The firm-level measure captures the sensitivity of a firm’s operating costs to sales. Following Kahl et al. (2014), we first estimate firm-level operating leverage as the sensitivity of innovations in the growth rate of a firm’s operating costs to innovations in the growth rate of its sales using the following regression:

\[
\frac{X_{i,t} - E[X_{i,t}]}{X_{i,t-1}} = b_{i,t} \times \frac{S_{i,t} - E[S_{i,t}]}{S_{i,t-1}} + \varepsilon_{i,t}, \tag{46}
\]

where \(S_{i,t}\) and \(X_{i,t}\) represent sales and operating costs for firm \(i\) in period \(t\), respectively, and \(E[S_{i,t}] = S_{i,t-1} \left( \frac{S_{i,t-1}}{X_{i,t-1}} \right)^{1/2}\) and \(E[X_{i,t}] = X_{i,t-1} \left( \frac{X_{i,t-1}}{S_{i,t-1}} \right)^{1/2}\). Intuitively, this sensitivity captures the relative contribution of variable operating costs to the firm’s overall costs after taking into account the trends in the growth rates of sales and operating costs. The negative
of the coefficient on innovations in the sales growth rate, $-b_{i,t}$, is our measure of firm-level operating leverage (Firm\_OPLEV). Firm-level regressions in (46) use three years of innovations, which require that a firm have both positive sales and positive operating costs for the six years preceding each firm-year of interest. We use an analogous approach to construct a measure of industry-level operating leverage (Ind\_OPLEV) meant to capture the component of fixed operating costs that is common to all firms in an industry. To obtain Ind\_OPLEV, we run the regression in (46) for each industry $j$ in period $t$ using the time-series data of industry average sales and operating costs over the past six years, and then taking the negative of the regression coefficient $b_{j,t}$.

Finally, in all regressions we control for industry size by aggregating the segment-level sales of firms in the industry and then taking the natural log to adjust for the skewness of sales within an industry.

6.1.2 Leverage measures

In our regression analysis, the dependent variable is a firm’s leverage ratio. We employ four alternate measures of leverage in our analysis. Our main measure of leverage is a firm’s book leverage, measured as the ratio of total debt to total book assets. Book leverage captures the equilibrium debt level, $D^*$, in our model better than market leverage since it does not depend on ex-post market values of firms. Our second leverage measure is a firm’s long-term book leverage, measured as the ratio of long-term debt to total book assets. In the basic model of Section 3 as well as the extended model in Appendix B, firms issue long-term debt so the second measure could potentially be a better proxy of the debt level, $D^*$, in our model. Our third leverage measure adds the capitalized value of operating leases to

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3We also verify that our results hold when we use a longer time period (five years) to obtain both the firm-level and the industry-level operating leverage measures, which requires eight (instead of six) years of positive sales and operating costs for each firm- (or industry-) year. As our quantitative and qualitative results are very similar with these alternative measures, we use only the three-year measures in our baseline analysis to maximize sample size. Using the longer time period of five years reduces the sample size from 73,007 to 59,196 firm-year observations. However, since these alternative measures are more accurate than the baseline measures, we get slightly larger coefficient estimates in all specifications with the alternate measures.
total debt to capture the fact that operating leases are a large source of external finance for some firms (Eisfeldt and Rampini (2009)). Our fourth measure of leverage is a firm’s market leverage, measured as total debt divided by the market value of total assets.

6.1.3 Summary statistics

Table 1 shows the descriptive statistics of our main empirical variables. Panel A presents the number of observations, means, standard deviations, as well as the 25th, 50th, and 75th percentile values for firm-level leverage ratios in our sample. Panel B shows summary statistics for firm-level control variables used in our regression analysis. The summary statistics of these variables are largely consistent with those documented in the empirical literature on capital structure (e.g., Lemmon et al. (2008), Graham and Leary (2011)). Panel C presents summary statistics for our proxies for industry-level product market characteristics. The degree of product substitutability in an industry (PSUB) is measured by the negative of the average ratio of sales to operating costs across firms in the same segment. Its statistics suggest that the average and the median markup in our sample are about 1.7% and 3.5%. The average industry-level operating leverage (IndOPLEV) is -0.941, implying that, on average, industry operating costs increase by about 0.94% in response to a one percentage point increase in industry average sales, with a standard deviation of 0.256. Note that we obtain the sensitivity after taking into account the trends in the growth rates of industry sales and operating costs. The industry-level sensitivity of operating costs appears to be higher than the firm-level sensitivity (i.e., the negative of FirmOPLEV), which has a mean of 0.811 with a standard deviation of 0.409.

Panel D of Table 1 presents the pairwise correlation coefficients for book leverage (which is our main dependent variable) and the independent variables of interest. First, the correlation between the industry-level and firm-level operating leverages is positive but low, which implies that these measures tend to capture different fixed costs. Second, book leverage correlates negatively both with firm-level and industry-level operating leverages. Third, we
observe a positive correlation between PSUB and Market size and between Ind_OPLEV and Market size. The positive correlation between PSUB and Market size is consistent with the descriptive statistics of Karuna (2007). Lastly, the correlation matrix does not show very high correlations among the main independent variables, thereby mitigating the possibility of distortions created by multicollinearity.

6.2 Baseline regression results

To explore our testable predictions, we extend the standard leverage regressions (see, for example, Frank and Goyal (2009)) to include our measures of product substitutability (PSUB) and industry operating leverage (Ind_OPLEV). Specifically, we run the following firm-level panel regressions:

\[ y_{ijt} = \alpha_t + \beta_1 \text{PSUB}_{jt-1} + \beta_2 \text{Ind_OPLEV}_{jt-1} + \beta_3 \text{Firm_OPLEV}_{it-1} + \beta_4 X_{it-1} + \gamma_j (\text{or} \gamma_i) + \varepsilon_{it}, \]

(47)

where subscripts \( i, j, \) and \( t \) represent the firm, industry, and year, respectively. We include the firm-level operating leverage measure (Firm_OPLEV) as a control variable following recent empirical studies (Kahl et al. (2014), Chen et al. (2013), Du et al. (2014)) that document a negative relation between firm-level operating leverage (or operating inflexibility) and financial leverage.\(^4\) As we detail in a simple extension of our model in Appendix C, the inclusion of this measure captures the substitutability between a firm’s financial and operating leverages, which needs to be distinguished from our theoretical prediction on the positive relation between a firm’s financial leverage and the industry-level operating leverage. The vector, \( X_{it-1} \), is a set of standard controls that includes firm size, market-to-book ratio, profitability, asset tangibility, cash flow volatility, and an indicator of whether or not the firm pays a cash dividend (e.g., Frank and Goyal (2009)). We include year effects, \( \alpha_t \), to control for average variation in capital structure over time. Further, we include either industry or

\(^4\)In Chen et al. (2013), firm-level operating flexibility is measured by the sensitivity of cost to negative sales shocks, rather than abnormal sales shocks.
firm fixed effects, $\gamma_j$ or $\gamma_i$, in all our specifications to control for unobserved time-invariant heterogeneity across industries or firms. Finally, we evaluate statistical significance using standard errors clustered at the firm level.

Table 2 shows the results. The first two columns of the table show our baseline regression results with industry and firm fixed effects, respectively. Consistent with the predictions of our model, the estimated coefficients of PSUB and Ind_OPLEV are significantly positive in both specifications. In particular, the coefficients on PSUB are significant at the 1% confidence level. These estimates are also economically meaningful. For example, based on our estimates obtained after controlling for firm fixed effects in column (2), a one-standard deviation increase in PSUB corresponds to a 4.22% increase in the book leverage ratio relative to the sample average leverage ratio. Along similar lines, a one standard deviation increase in Ind_OPLEV is related to a 0.88% increase in book leverage relative to the sample average leverage ratio. The signs of the estimated coefficients of the other control variables are in line with the results obtained in other capital structure studies (e.g., Lemmon et al. (2008), Frank and Goyal (2009)). Both firm size and asset tangibility are positively associated with book leverage, while market-to-book ratio, profitability, and dividend payer are negatively related to book leverage.

The results in Table 2 suggest that industry characteristics matter for firms’ leverage choices. Consistent with our model’s predictions, both the product substitutability and industry operating leverage are positively correlated with a firm’s financial leverage, even though they affect product market competition among firms in the industry in opposite directions. These results suggest that different proxies for “industry competitiveness” might be positively or negatively related to a firm’s capital structure, depending on which underlying industry primitive these proxies tend to capture.

Consistent with our prediction, industry operating leverage (Ind_OPLEV) is positively related to a firm’s book leverage. In contrast, firm-level operating leverage (Firm_OPLEV) is negatively related to the firm’s book leverage. The coefficient of Firm_OPLEV is also
significant at the 1\% confidence level, and a one-standard deviation increase in this variable is related to an 1.41\% decrease in book leverage relative to the sample average leverage ratio.

In our baseline specification that includes both multi-segment and single-segment firms, we implicitly assume that a multi-segment firm’s leverage choice depends on the product market characteristics of its primary industry. To address potential distortions that may arise if the leverage choices of multi-segment firms are influenced by the product market characteristics of different industries in which they operate, we re-run regression (47) using the sample of single-segment firms only. The estimated coefficients in columns (3) and (4), which are quite similar to the baseline results in columns (1) and (2), confirm that book leverage increases with product substitutability as well as industry-level operating leverage. We conclude that our baseline results are unlikely to be distorted by systematic differences between multi-segment and single-segment firms.

6.3 Robustness tests

In this subsection, we explore the robustness of our baseline results to alternate measures of leverage and industry characteristics. We also show that our results are robust to employing alternate industry classifications.

6.3.1 Alternate measures of leverage

We now explore the robustness of our empirical results to alternate measures of leverage—long term book leverage, total book leverage (debt plus leases, scaled by the sum of book assets and leases), and market leverage—as the dependent variables. In Table 3, we report the results of re-estimating regression (47) by replacing book leverage on the left-hand side with each of the alternate measures of leverage, respectively. The results show that the estimated coefficients of PSUB and Ind\textsubscript{OPLEV} remain positive and statistically significant in these regressions. We note though that, in the case of market leverage, the statistical significance of the firm-level operating leverage disappears even though its sign is still negative.
The finding of the weaker association of firm-level operating leverage with market leverage is similar to the results in Kahl et al. (2014).

6.3.2 Alternate industry variables

In our baseline specifications, we construct all industry variables using the Compustat Segment database. As the Segment database reports operating variables (such as sales and operating costs) and industry classification for all segments of a firm, it allows us to capture industry variables more accurately than the Compustat Fundamentals Annual database, which reports a firm’s operating variables only for its primary industry. However, not all firms included in the Fundamentals Annual database appear in the Segment database. This discrepancy is due to focused firms that do not report business segments. To verify that our results are not driven by unobserved differences between firms in the Segment database and firms that do not report business segments, we additionally include the latter firms’ sales and operating costs in our sample, treating them as single-segment firms, and recompute all industry variables. The estimation results for book leverage, reported in Column (1) of Table 4, are very similar to the baseline results in Table 2.

Next, a potential concern with our Compustat-based measures is that the Compustat sample does not include the universe of firms within a particular industry because it leaves out many private firms that may influence competition in their industries (Karuna (2007), Ali et al. (2008)). To address this concern, we use the Census of Manufacturers data compiled by the U.S. Census Bureau for the period 1981-2009, which include establishment-level data from all public and private firms in manufacturing industries (three-digit SIC codes ranging from 201 to 399). A drawback of the Census data is that it reports an industry’s sales and variable costs but not operating profits. As a result, in the Census data, we are unable to obtain operating costs (i.e., the difference between sales and operating profits). Although the Census data does report a detailed breakdown of the components of variable costs such as materials, production workers’ wages, total pay and energy, it offers no information on
fixed operating costs, which is critical to capture industry operating inflexibility. Thus, we use the Census data to construct measures of PSUB and Market size, but not those of operating leverage. For fixed costs—both firm and industry-level—we continue to use the variables constructed from the Compustat Segment database. Columns (2) and (3) show the regression results. To construct PSUB using the Census data, we measure variable costs by the sum of material costs, pay, and energy in Column (2), and by the sum of material costs and production workers’ wages in Column (3). In both columns, the positive coefficient estimates on PSUB and OPLEV remain significant, whereas the negative estimates of firm-level operating leverage become insignificant.

6.3.3 Alternate industry classifications

The measures in our baseline analysis are constructed using the three-digit SIC industry classification to define industry membership. There are clearly trade-offs in the choice between coarser and finer industry classifications. An overly coarse partition may end up pooling together unrelated industries, but a finer partition may be subject to misclassification. Our choice to use the three-digit SIC classification in the baseline measures is a compromise between these two concerns. In this subsection, we examine the robustness of our results to constructing all industry variables using two alternate industry classifications.

First, we use a finer industry partition and define industry membership based on the four-digit SIC classification. Using the Compustat Segment database, we recompute all our industry variables at the four-digit SIC level, which is the most granular industry classification in Compustat. The results, reported in Column (4) of Table 4, are very similar to the baseline results in Table 2, both in economic and statistical significance.

Next, to address concerns that the SIC industry classification is imprecise, we replace the three-digit SIC grouping with a text-based fixed industry classification (FIC) as in Hoberg and Phillips (2010), which builds on firms’ business descriptions in 10-K annual filings. In particular, we use Hoberg and Phillips’ FIC-400 to define industries, which results in a similar
number of industries as in the three-digit SIC classification in our sample. Since this industry classification is based on the entire firm’s 10-K filing, it is not available by business segment as in our baseline analysis. Thus, we compute measures of product substitutability, market size, and industry operating leverage using firms’ sales and operating costs from the Compustat’s Fundamentals Annual data, rather than the Segment database. As shown in Column (5) of Table 4, the results are robust to using the Hoberg-Phillips industry classification.

6.4 Product market characteristics and tax effects

In this subsection, we empirically test the predictions of our theory for the effects of taxes as summarized in Proposition 3. Specifically, we predict that the tax sensitivity of firm leverage increases with the industry product substitutability and fixed production costs.

In Table 5, we follow the difference-in-differences approach in Heider and Ljungqvist (2015) and examine the effect of a corporate tax increase in the state in which a firm is headquartered on its long-term leverage (treated sample) relative to firms in the same industry but headquartered in other states and hence not affected by the tax increase (control sample)). In Column (1), we first show the benchmark result without product market variables. This benchmark regression corresponds to the baseline results reported in Column (1) of Table 3 in Heider and Ljungqvist (2015). Consistent with their baseline results, treated firms increase long-term leverage in response to a tax increase relative to control firms, but do not reduce leverage following a tax cut.

We then re-estimate this difference-in-differences regression by incorporating our product market variables (PSUB and Ind_OPLEV) and their interactions with the tax increase and the tax cut dummy variables. Columns (2)-(4) show the results with industry, state, and industry-year and state fixed effects, respectively. Based on the estimated coefficients of the interaction terms between the tax increase dummy variable (TAX Increase) and the product market variables (PSUB and Ind_OPLEV), we find that firms’ financial leverage respond more strongly to a tax increase when they operate in an industry with high fixed costs or
product substitutability, consistent with the predictions of our model.

7 Conclusions

We theoretically and empirically show how product market competition affects capital structure. We build a tractable industry equilibrium model in which firms engaged in imperfect product market competition choose their capital structure based on the trade-off between the tax benefits of debt and bankruptcy costs. In the model, firms’ financial and real decisions are jointly determined, and are driven by the underlying industry primitives such as the fixed costs of production and the elasticity of substitution between the products of firms in the industry. We show that firms in more competitive industries with greater product substitutability have higher leverage ratios. By contrast, firms in industries with lower fixed costs of production (or industry operating leverages), which are expected to feature more intense product market competition by encouraging entry, have lower leverage ratios. An increase in the intensity of product market competition, therefore, has contrasting effects on leverage depending on the channel through which product market competition changes.

We show significant support for the testable hypotheses from the model in our empirical analysis of U.S. nonfinancial firms. In particular, the positive relation between a firm’s debt ratio and the industry-level operating leverage, which arises due to the effects of product market competition, contrasts sharply with a negative relation between a firm’s debt ratio and the firm-level operating leverage, which stems from the substitutability between firm-level financial and operating leverages. Overall, our study emphasizes the importance of examining capital structure choices in an equilibrium framework that accommodates different determinants of product market competition as well as empirically disentangling their potentially contrasting implications for capital structure.
References


Appendix A: Proofs

Proof of Proposition 1

We can rewrite the bankruptcy condition as

\[ \pi(\alpha_B) = D \]

\[ \Rightarrow \frac{R(P\rho\alpha\sigma - 1)}{\sigma} = f + D \]

\[ \Rightarrow \frac{R(P\rho\bar{\alpha}\sigma - 1)}{\sigma} = f + D \]

\[ \Rightarrow (\bar{\pi} + f)\left(\frac{\alpha_B}{\bar{\alpha}}\right)^{\sigma - 1} = f + D \]

which follows from (17), (18), and (19). The last equation above leads to (20).

Similarly, we can rewrite the free entry condition as

\[ \int_{\alpha_L}^{\infty} \pi(\alpha)g(\alpha)d\alpha + D_0 = 1 \]

\[ \Rightarrow \int_{\alpha_L}^{\infty} (1 - \tau)\pi(\alpha)g(\alpha)d\alpha + \int_{\alpha_B(D)}^{\infty} \tau Dg(\alpha)d\alpha - \int_{\alpha_B(D)}^{\alpha_B(D)} (1 - \tau)\zeta g(\alpha)d\alpha = 1 \]

where the second equality above follows from (10) and (12). The above leads to (21) where we use the definition of \( \bar{\pi} \) from (17) and (18), as well as the fact that \( G(\alpha_L) = 0 \) and \( G(\infty) = 1 \) as \( G \) is the cumulative productivity distribution with support \([\alpha_L, \infty)\). Q.E.D.

Proof of Proposition 2

For a given level of debt \( D \), the endogenous bankruptcy threshold and average firm profit are uniquely determined by the the bankruptcy (B) and free entry (FE) conditions, (20) and (21). As shown by the two conditions, for each possible value of the bankruptcy threshold, the B curve shifts to the right in response to an increase in \( f \) or \( \sigma \), but the FE curve is unaffected. It then immediately follows that the equilibrium bankruptcy threshold and average firm profit both increase with \( f \) and \( \sigma \). By (18), an increase in \( f \) or \( \sigma \) and the resulting increase in the average firm profit combine to increase the average firm revenue. By (15) and (17), the mass of firms, \( M^* \), equals the market size, \( R \), divided by the average firm revenue, \( \bar{\pi} \). Hence, the average firm revenue increases with \( f \) and \( \sigma \), whereas the mass of firms decreases. Q.E.D.

Proof of Proposition 3

As shown by (??), each entering firm chooses its debt level by solving the following problem:

\[ \max_{0 \leq D \leq 1} \int_{\alpha_L}^{\infty} (1 - \tau)\pi(\alpha)g(\alpha)d\alpha + \int_{\alpha_B(D)}^{\infty} \tau Dg(\alpha)d\alpha - \int_{\alpha_L}^{\alpha_B(D)} (1 - \tau)\zeta g(\alpha)d\alpha, \]

where the argument of the bankruptcy threshold, \( \alpha_B(D) \), explicitly indicates its dependence
on the debt level as shown by (8).

The first-order condition (FOC) of (A3) for the optimal debt level, $D^*$, is

$$\tau[1 - G(\alpha_B(D^*))] - [\tau D^* + (1 - \tau)\zeta]g(\alpha_B(D^*))\alpha'_B(D^*) = 0,$$

which equates the marginal tax benefit of debt and the marginal cost of bankruptcy. We assume a range of parameter values in which we have an interior optimal debt level, $0 < D^* < 1$, so that the FOC (A4) is necessary. By the definition of the bankruptcy threshold in (8), we have

$$\alpha'_B(D^*) = \frac{1}{\pi'(\alpha_B(D^*))}.$$  \hspace{1cm} (A5)

By (7), the marginal firm profit with respect to productivity is

$$\pi'(\alpha) = \rho R(P)\rho^{-1}\alpha^{\sigma-2} = \frac{\rho R(P)\rho\alpha}{\sigma - 1}(\pi(\alpha) + f).$$  \hspace{1cm} (A6)

We then rewrite the FOC as

$$\tau - [\tau D^* + (1 - \tau)\zeta] \frac{h(\alpha_B(D^*))}{\pi'(\alpha_B(D^*))} = 0,$$

$$\Rightarrow \tau(\sigma - 1)(D^* + f) - [\tau D^* + (1 - \tau)\zeta]\Lambda(\alpha_B(D^*)) = 0,$$

where $h(\alpha) \equiv \frac{g(\alpha)}{1 - G(\alpha)}$ and $\Lambda(\alpha) \equiv h(\alpha)\alpha$. The second equation above follows from (A6), which is evaluated at the bankruptcy threshold so that $\pi(\alpha_B) = D$. As a result, the optimal debt level $D^*$ from the necessary condition solves

$$D^* = \frac{\tau(\sigma - 1)f - (1 - \tau)\zeta\Lambda(\alpha_B(D^*))}{\tau[\Lambda(\alpha_B(D^*)) - (\sigma - 1)]}. $$  \hspace{1cm} (A8)

Q.E.D.

**Proof of Proposition 4**

Denote the function on the L.H.S. of (A7) by $\psi(D^*, f, \sigma)$. By the implicit function theorem,

$$\frac{\partial D^*}{\partial f} = -\frac{\partial\psi/\partial f}{\partial\psi/\partial D}|_{D=D^*}. $$  \hspace{1cm} (A9)

By the second order condition for an interior optimal debt level, we know that $\psi(D^*, f, \sigma < 0$ holds generically. It, therefore, suffices to show that $\frac{\partial\psi(D^*)}{\partial f} > 0$. We have

$$\frac{\partial\psi(D^*)}{\partial f} = \tau(\sigma - 1) - [\tau D^* + (1 - \tau)\zeta]\Lambda'(\alpha_B(D^*))\frac{\partial\alpha_B(D^*)}{\partial f}. $$  \hspace{1cm} (A10)

By the result of Proposition 2, $\frac{\partial\alpha_B(D^*)}{\partial f} > 0$. It then follows that the R.H.S. above is positive if $\Lambda'(\alpha) \leq 0$. 43
Similarly,
\[ \frac{\partial D^*}{\partial \sigma} = -\frac{\partial \psi}{\partial \sigma} \bigg|_{D=D^*}. \]  
It again suffices to show that \( \frac{\partial \psi(D^*)}{\partial \sigma} > 0 \). From (A7), we have
\[ \frac{\partial \psi(D^*)}{\partial \sigma} = \tau(D^* + f) - \tau D^* + (1 - \tau)\zeta \Lambda'(\alpha_B(D^*)) \frac{\partial \alpha_B(D^*)}{\partial \sigma}. \]  
By the result of Proposition 2, \( \frac{\partial \alpha_B(D^*)}{\partial \sigma} > 0 \). It then follows that the R.H.S. above is positive if \( \Lambda'(\alpha) \leq 0 \). Q.E.D.

**Proof of Proposition ??**

In (??), the constant \( A \) and the bankruptcy trigger \( \phi_B(\theta) \) are determined by the value matching and smooth pasting conditions
\[ A\phi_{B}^{\eta^-} + \frac{(1 - \tau)\phi_B}{r - \mu} - \frac{(1 - \tau)f}{r} - \frac{(1 - \tau)\theta}{r} = 0, \]
\[ \eta^- A\phi_{B}^{\eta^-} + \frac{(1 - \tau)\phi_B}{r - \mu} = 0. \]  
From the above, we see that
\[ \phi_B = -\frac{\eta^-}{r(1 - \eta^-)}(\theta + f), \]
\[ A\phi_{B}^{\eta^-} = -\frac{(1 - \tau)\phi_B}{r - \mu} = \frac{1 - \tau}{r(1 - \eta^-)}(\theta + f). \]  
In (??), the constant \( B \) is determined by the boundary condition
\[ D(\phi_B) = B\phi_{B}^{\eta^-} + \frac{\theta}{r} = D_{\text{bankrupt}}(\phi_B) = C\phi_{B}^{\eta^-} + \frac{(1 - \tau)\phi_B}{r - \mu} - \frac{(1 - \tau)f}{r} - \frac{(1 - \tau)\zeta}{r}. \]  
The constant \( C \) in (??) and the liquidation threshold, \( \phi_L \), are determined by the value matching and smooth pasting conditions,
\[ D_{\text{bankrupt}}(\phi_L) = 0; \frac{dD_{\text{bankrupt}}}{d\phi}(\phi_L) = 0. \]  
Let \( \alpha_B^*(\theta) \) solve the equation, \( \phi_0(\alpha_B^*(\theta)) = \phi_B(\theta) \), that is, \( \alpha_B^*(\theta) \) is the realized firm productivity at date 0 below which a firm is bankrupt. From the above, we have
\[ \theta^* = \arg\max_{\theta} \int_{\alpha_L}^{\alpha_B^*(\theta)} \left[ C(\phi_0(\alpha))^\eta^- + \frac{(1 - \tau)\phi_0(\alpha)}{r - \mu} - \frac{(1 - \tau)f}{r} - \frac{(1 - \tau)\zeta}{r} \right] g(\alpha) d\alpha \]
\[ + \int_{\alpha_B^*(\theta)}^{\infty} \left[ (A + B)(\phi_0(\alpha))^\eta^- + \frac{(1 - \tau)\phi_0(\alpha)}{r - \mu} - \frac{(1 - \tau)f}{r} + \frac{\tau\theta}{r} \right] g(\alpha) d\alpha. \]
The firm-specific fixed production cost, \( K \), is randomly drawn from an identical distribution subject to the borrowing constraint. That is, the firm will borrow up to what it can generate in the second production period (the after-tax profit net of the fixed production cost):

\[
\tilde{D} \leq (1 - \tau)\pi_2(\alpha) = (1 - \tau) \left[ \frac{R(P_\alpha)\sigma^{-1}}{\sigma} - \eta \right]. \tag{A17}
\]
Due to no uncertainty the firm faces, the firm’s incentive to issue new debt $\tilde{D}$ comes solely from the tax advantage of debt, so that $\tilde{D}^* = (1 - \tau) \pi_2(\alpha)$. We thus note that the firm’s new debt choice is firm-specific as it depends both on its productivity $\alpha$ and fixed production cost $\eta$. Due to the borrowing constraint, if the firm faces a higher fixed production cost, it has to choose a lower debt level. This negative association between borrowing and firm-specific fixed production cost is aligned with the traditional view of the financial conservatism of high fixed cost firms. That is, firms with high fixed costs should choose lower leverage because they would experience low cash flows if sales are low. Even though we do not include a firm-specific uncertainty in the second period, the borrowing constraint essentially captures this aspect. This simple formalization with the additional debt choice simply supports our empirical tests including the firm-level operating leverage measure as another control variable.

One way to interpret this framework is as an abstraction of a multi-period framework. A firm enters the market by financing the initial investment and realizes its productivity. In each subsequent period, it must make additional investments after which it experiences firm-specific fixed cost. One can think of the initial debt level chosen by ex-ante identical firms as the “long-term” average debt level in response to industry shocks. In the presence of firm-specific shocks, the firm’s debt choice in each period differs from the “long-term” average debt level declines with the firm-specific fixed cost subject to the borrowing constraint in each period.

### Appendix C: General bankruptcy costs

In this Appendix, we modify the basic model in Section 3 to incorporate both fixed and proportional bankruptcy costs and show that our main implications are unaffected. The setup is as in Section 3 except that the payoff to debtholders in bankruptcy is

$$\pi_D(\alpha) = (1 - \tau) \left[ (1 - \theta) \pi(\alpha) - \zeta \right], \quad (A18)$$

where $0 < \theta < 1$ is the proportional bankruptcy cost that reduces the firm’s net profit and $\zeta$ is the fixed bankruptcy cost. The market value of debt at date zero is now given by

$$D_0 = D \int_{\alpha_B}^{\infty} g(\alpha) d\alpha + \int_{\alpha_L}^{\alpha_B} \pi_D(\alpha) g(\alpha) d\alpha$$

$$= D [1 - G(\alpha_B)] + \int_{\alpha_L}^{\alpha_B} (1 - \tau) \left[ (1 - \theta) \pi(\alpha) - \zeta \right] g(\alpha) d\alpha. \quad (A19)$$

As in the proofs for the basic model with fixed bankruptcy costs, we first characterize the B and FE conditions, (13) and (14), as two different functional relations linking the average profit level $\bar{\pi}$ with the bankruptcy threshold $\alpha_B$ for a given level of debt, $D$. Specifically, we can rewrite the B condition as
\[
\bar{\pi} = \left[ \left( \frac{\bar{\alpha}}{\alpha_B} \right)^{\sigma-1} - 1 \right] f + \left( \frac{\bar{\alpha}}{\alpha_B} \right)^{\sigma-1} D,
\]  
(A20)

where \(\bar{\pi}\) and \(\bar{\alpha}\) are defined by (17), (18), and (19). Similarly, we can rewrite the free entry condition as

\[
1 = (1 - \tau)\bar{\pi} + \tau [1 - G(\alpha_B)] D - (1 - \tau)G(\alpha_B)\zeta - \int_{\alpha_L}^{\alpha_B} (1 - \tau)\theta\pi(\alpha)g(\alpha)d\alpha
\]

\[
= (1 - \tau)\bar{\pi} + \tau [1 - G(\alpha_B)] D - (1 - \tau)G(\alpha_B)\zeta
- \int_{\alpha_L}^{\alpha_B} (1 - \tau)\theta \left[ \left( \frac{\alpha}{\bar{\alpha}} \right)^{\sigma-1} \bar{\pi} - \left( 1 - \left( \frac{\alpha}{\bar{\alpha}} \right)^{\sigma-1} \right) f \right] g(\alpha)d\alpha,
\]  
(A21)

where \((\alpha/\bar{\alpha}) < 1\) for \(\alpha_L \leq \alpha \leq \alpha_B\). The above implies that, in the space of ordered pairs, \((\alpha_B, \bar{\pi})\), the B curve is decreasing, but the FE curve is increasing. The equilibrium bankruptcy threshold and average profit level, which must satisfy the B and FE conditions, are thus uniquely determined by the intersection of the two curves (A20) and (A21) as in the basic model. Further, as shown by the two conditions, both the B and FE curves shift to the right with an increase in \(f\) or \(\sigma\). Thus, the equilibrium bankruptcy threshold increases with \(f\) and \(\sigma\), that is, \(\frac{\partial \alpha_B(D)}{\partial f} > 0\); \(\frac{\partial \alpha_B(D)}{\partial \sigma} > 0\).

We now consider each entering firm’s choice of its optimal debt level \(D^*\).

\[
D^* = \arg \max_{0 \leq D \leq 1} \int_{\alpha_L}^{\alpha_B} \pi_E(\alpha)g(\alpha)d\alpha + \int_{\alpha_L}^{\alpha_B} Dg(\alpha)d\alpha + \int_{\alpha_L}^{\alpha_B} \pi_D(\alpha)g(\alpha)d\alpha - D_0 - 1
\]

\[
= \arg \max_{0 \leq D \leq 1} \int_{\alpha_B(D)}^{\infty} (1 - \tau)\pi(\alpha)g(\alpha)d\alpha + \int_{\alpha_B(D)}^{\infty} \tau Dg(\alpha)d\alpha + \int_{\alpha_L}^{\alpha_B(D)} \pi_D(\alpha)g(\alpha)d\alpha,
\]  
(A22)

which leads to the following FOC for the optimal debt level, \(D^*\),

\[
\tau[1 - G(\alpha_B(D^*))] - [\tau D^* + (1 - \tau)\theta \pi(\alpha_B(D^*))] + (1 - \tau)\zeta g(\alpha_B(D^*)) \alpha_B'(D^*) = 0.
\]  
(A23)

By the definition of the bankruptcy threshold with any level of debt \(D\) in (8), we have

\[
\alpha_B'(D^*) = \frac{1}{\pi'(\alpha_B(D^*))}.
\]  
(A24)

By (7), the marginal firm profit with respect to productivity \(\alpha\) is

\[
\pi'(\alpha) = \rho R(P\rho)^{\sigma-1}\alpha^{\sigma-2} = \frac{\rho R(P\rho\alpha)^{\sigma-1}}{\alpha} = \frac{(\sigma - 1)}{\alpha}(\pi(\alpha) + f).
\]  
(A25)
We then rewrite the FOC as
\[ \tau(\sigma - 1)(D^* + f) - [\tau D^* + (1 - \tau)\theta D^* + (1 - \tau)\zeta] \Lambda(\alpha_B(D^*)) = 0. \] (A26)

The optimal debt level \( D^* \) from the necessary condition satisfies
\[ D^* = \frac{\tau(\sigma - 1)f - (1 - \tau)\zeta \Lambda(\alpha_B(D^*))}{(\tau + (1 - \tau)\theta) \Lambda(\alpha_B(D^*)) - \tau(\sigma - 1)}. \] (A27)

Finally, we examine the effects of product market characteristics on \( D^* \). Denote the function on the L.H.S. of (A26) by \( \psi(D^*, f, \sigma) \). By the implicit function theorem,
\[ \frac{\partial D^*}{\partial f} = -\frac{\partial \psi / \partial f}{\partial \psi / \partial D} \bigg|_{D=D^*}. \] (A28)

By the second order condition for an interior optimal debt level, \( \frac{\partial \psi(D^*)}{\partial D} < 0 \) holds generically. It, therefore, suffices to show that \( \frac{\partial \psi(D^*)}{\partial f} > 0 \). We have
\[ \frac{\partial \psi(D^*)}{\partial f} = \tau(\sigma - 1) - [\tau D^* + (1 - \tau)\theta D^* + (1 - \tau)\zeta] \Lambda'(\alpha_B(D^*)) \frac{\partial \alpha_B(D^*)}{\partial f}. \] (A29)

As discussed above, \( \frac{\partial \alpha_B(D^*)}{\partial f} > 0 \). It then follows that the R.H.S. above is positive if \( \Lambda'(\alpha) \leq 0 \).

Similarly,
\[ \frac{\partial D^*}{\partial \sigma} = -\frac{\partial \psi / \partial \sigma}{\partial \psi / \partial D} \bigg|_{D=D^*}. \] (A30)

It again suffices to show that \( \frac{\partial \psi(D^*)}{\partial \sigma} > 0 \). From (A7), we have
\[ \frac{\partial \psi(D^*)}{\partial \sigma} = \tau(D^* + f) - [\tau D^* + (1 - \tau)\theta D^* + (1 - \tau)\zeta] \Lambda'(\alpha_B(D^*)) \frac{\partial \alpha_B(D^*)}{\partial \sigma}. \] (A31)

As discussed in the above, \( \frac{\partial \alpha_B(D^*)}{\partial \sigma} > 0 \). It then follows that the R.H.S. above is positive if \( \Lambda'(\alpha) \leq 0 \). Q.E.D.

**Proof of Proposition ??**

By (A27), the increase in the optimal debt ratio due to a marginal increase in the effective tax rate is
\[ \frac{\partial D^*}{\partial \tau} = \frac{\Lambda(\alpha_B^*(D^*))[\sigma - 1)\theta f + \zeta(\Lambda(\alpha_B^*(D^*)) - (\sigma - 1))] - \tau(\sigma - 1)(\nu f - (1 - \tau)\zeta) \Lambda'(\alpha_B^*(D^*)) \frac{\partial \alpha_B^*(D^*)}{\partial \tau}}{(\nu \Lambda(\alpha_B^*(D^*)) - \tau(\sigma - 1))^2}, \] (A32)

where \( \nu \equiv \tau + (1 - \tau)\theta \). If the distribution of firm productivity is close to a power law distribution \( (\Lambda' \simeq 0) \), it is straightforward to see that the positive tax effect on firm leverage positively varies with the fixed production cost \( f \) and product substitutability \( \sigma \). Q.E.D.
Appendix D: Definition of variables

- Book leverage: \((\text{short-term debt (dlc) + long-term debt (dltt)})/\text{total assets (at)}\)
- Long-term book leverage: \((\text{long-term debt (dltt)}/\text{total assets (at)})\)
- Total book leverage: \((\text{short-term debt (dlc) + long-term debt (dltt) + operating lease value})/(\text{total assets (at) + operating lease value})\), where operating lease value is estimated as the rental expense \((x_{rent})\) plus the present value (using a 10% discount rate) of operating leases commitments \((mrc)\) for the next 5 years, that is, \(x_{rent} + \frac{1}{1.1} \times mrc_1 + \frac{1}{1.1^2} \times mrc_2 + \frac{1}{1.1^3} \times mrc_3 + \frac{1}{1.1^4} \times mrc_4 + \frac{1}{1.1^5} \times mrc_5\)
- Market leverage: \((\text{short-term debt (dlc) + long-term debt (dltt)})/(\text{short-term debt (dlc) + market value of equity})\), where market value of equity is stock price \((prcce_f)\) times common shares outstanding \((cshpri)\)
- Product substitutability (PSUB): the negative value of the industry average of price-cost margin \((\text{sales/operating costs})\)
- Market size: the log of industry sales, where industry sales is computed as the sum of sales for firms operating in the industry that is deflated by the GDP deflator
- Industry operating leverage \((\text{Ind.OPLEV})\): the negative value of the sensitivity of innovations in growth rates of industry average operating costs to innovations in growth rates of industry average sales using the past three years of innovations (see Kahl et al. (2014) for details)
- Firm-level operating leverage \((\text{Firm.OPLEV})\): the negative value of the sensitivity of innovations in growth rates of a firm’s operating costs to innovations in growth rates of its sales using the past three years of innovations
- Firm size: the log of total assets \((\text{at})\), where total assets are deflated by the GDP deflator
- Market-to-book ratio: the market value of total assets scaled by the book value of total assets \((\text{at})\), where the market value of total assets is market equity \((prce_f \times cshpri)\) + long-term and short-term debt \((\text{dltt+dlc})\) + preferred stock liquidating value \((\text{pstkl})\) – deferred taxes and investment tax credits \((\text{txditc})\)
- Profitability: return on assets \((\text{ROA})\), which is computed as operating income before depreciation \((\text{oibdp})/\text{total assets (at)}\) minus the industry average return on assets
- Asset tangibility: net PPE \((\text{property, plant and equipment; ppent})/\text{total assets (at)})\)
- Cash flow volatility: the standard deviation of historical return on assets over the 10 years (requiring at least 3 years of data)
- Dividend payer: a dummy variable equals one if total cash dividend declared on common shares \((\text{dvc})\) is positive and zero otherwise
Appendix F: Figures and Tables

Figure 3: Industry profit skewness.
These figures show unconditional correlations between within-industry skewness of operating profit and industry product market variables PSUB (Figure (a)) and Ind_OPLEV (Figure (b)) in our baseline sample of Compustat firms from 1982 to 2014. Industries with higher values of PSUB and Ind_OPLEV have greater product substitutability and higher fixed costs of production, respectively. Industries are defined at the three-digit Standard Industrial Classification (SIC) level. All variables are defined in Appendix E. The scatter plots are constructed using 20 bins for each variable.
Table 1: Summary statistics.

Our baseline sample consists of all non-financial and unregulated firms in the Compustat database from 1982 to 2014. This table presents summary statistics for firm-level leverage and other variables as well as industry-level variables of product market characteristics. We define an industry at the three-digit Standard Industrial Classification (SIC) level in the baseline analysis. All variables are defined in Appendix E. When constructing the variables, we convert all dollar items into 2009 dollars using the GDP deflator index from the Bureau of Economic Analysis (BEA). Panel A presents the number of the observations, mean, standard deviation, and the distribution of firm-level leverage ratios, which are dependent variables in our panel regressions. Panel B presents summary statistics of firm characteristics. Panel C shows summary statistics of product market characteristics that are our main independent variables. Finally, Panel D shows the correlation coefficients between book leverage and product market variables as well as firm-level operating leverage variables.

### Panel A: Leverage variables

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<th>p75</th>
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<tbody>
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<td>0.206</td>
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<td>0.201</td>
<td>0.356</td>
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<tr>
<td>Long-term book leverage</td>
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<td>0.177</td>
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<tr>
<td>Total book leverage</td>
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### Panel B: Firm variables

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<td>Firm_OPLEV</td>
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<td>-0.891</td>
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<td>Cash flow volatility</td>
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### Panel C: Industry variables

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<tr>
<td>Firm_OPLEV</td>
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<td>0.057</td>
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<td>0.100</td>
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Table 2: Product market characteristics and book leverage.

We run firm-level panel regressions of book leverage on product market characteristics as well as other control variables over the period 1982-2014. We define an industry at the three-digit SIC level. All variables are defined in Appendix E. In all regressions, we lag independent variables by one year and include year fixed effects. Columns (1) and (2) report the baseline regression results for all firms (both multi-segment and single-segment firms) in the industry by including industry and firm fixed effects, respectively, whereas columns (3) and (4) report the regression results only for single-segment firms. Standard errors, reported in parentheses, are adjusted for within-firm clustering. Significance at the 10%, 5%, and 1% level is indicated by *, **, and *** , respectively.

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<th>(4)</th>
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<td>0.072***</td>
<td>0.045**</td>
<td>0.070***</td>
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<td>(0.015)</td>
<td>(0.018)</td>
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<td>Ind_OPLEV</td>
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<td>0.008**</td>
<td>0.009**</td>
<td>0.009**</td>
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<td>(0.004)</td>
<td>(0.003)</td>
<td>(0.004)</td>
<td>(0.004)</td>
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<td>(0.004)</td>
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<tr>
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<td>(0.002)</td>
<td>(0.003)</td>
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<tr>
<td>Firm size</td>
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<td>0.014***</td>
<td>0.022***</td>
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<td>(0.003)</td>
<td>(0.001)</td>
<td>(0.003)</td>
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<tr>
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<td>-0.006***</td>
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<td>(0.007)</td>
<td>(0.007)</td>
<td>(0.008)</td>
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<td>0.007</td>
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<td>(0.006)</td>
<td>(0.004)</td>
<td>(0.006)</td>
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<tr>
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<td>-0.085***</td>
<td>-0.015***</td>
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<tr>
<td>Firm FE</td>
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<td>Yes</td>
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<td>49,489</td>
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<td>0.641</td>
<td>0.230</td>
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</table>
Table 3: Product market characteristics and other leverage ratios.

This table presents the results of firm-level panel regressions over the period 1982-2014 using alternate leverage measures: long-term book leverage (column (1)), total book leverage (column (2)), and market leverage (column (3)). We define an industry at the three-digit SIC level. In all the regressions, we lag independent variables by one year and include firm and year fixed effects. All variables are defined in Appendix E. Standard errors, reported in parentheses, are adjusted for within-firm clustering. Significance at the 10%, 5%, and 1% level is indicated by *, **, and ***, respectively.

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<th>Variables</th>
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<th>Market leverage (3)</th>
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<tr>
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<td>(0.014)</td>
<td>(0.015)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Ind_OPLEV</td>
<td>0.007**</td>
<td>0.007**</td>
<td>0.011***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.004)</td>
</tr>
<tr>
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<td>-0.003</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.002)</td>
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<tr>
<td>Firm_OPLEV</td>
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<td>-0.007***</td>
<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.003)</td>
<td>(0.003)</td>
</tr>
<tr>
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<td>0.009***</td>
<td>0.040***</td>
</tr>
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<td>(0.003)</td>
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<td>Market-to-book</td>
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<td>-0.005***</td>
<td>-0.011***</td>
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<td>(0.001)</td>
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<tr>
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<td>(0.008)</td>
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<td>(0.016)</td>
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<td>0.014*</td>
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<td>73,736</td>
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<td>Adjusted $R^2$</td>
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Table 4: Product market characteristics and book leverage: alternate industry variables.

This table presents the results of additional robustness checks. The dependent variable is book leverage. Column (1) shows the results with the industry variables constructed using firm-year observations only included in Compustat’s annual database as well as those in its segment database. Columns (2) and (3) show the results using PSUB and Market size measures constructed from the Census of Manufactures data compiled by the U.S. Census Bureau for the period 1981-2009 (three-digit SIC codes ranging from 201 to 399). These two regressions use alternate PSUB variables by measuring operating costs as the sum of material costs, pay, and energy in Column (2) and as the sum of material costs and production workers’ wages in Column (3). Columns (4) and (5) present the results using the alternative industry classifications: the four-digit SIC level (Column (4)) and Hoberg-Phillips (HP) (2010) 10-K Text-based Fixed Industry Classification (Column (5)). In all regressions, we lag independent variables by one year, and include firm and year fixed effects. All variables are defined in Appendix E. We report standard errors in parentheses that are adjusted for within-firm clustering. Significance at the 10%, 5%, and 1% level is indicated by *, **, and ***, respectively.

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<td>(0.006)</td>
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<td>-0.003***</td>
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<td>-0.005***</td>
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<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.006)</td>
<td>(0.012)</td>
</tr>
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<td>Asset tangibility</td>
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<td>0.145***</td>
<td>0.158***</td>
<td>0.130***</td>
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<td>(0.022)</td>
<td>(0.016)</td>
<td>(0.023)</td>
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<td>0.021</td>
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<td>(0.015)</td>
<td>(0.006)</td>
<td>(0.019)</td>
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<td>Dividend payer</td>
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<td>0.638</td>
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</table>
Table 5: Product market characteristics and tax effects.

This table examines whether firms change their long-term book leverage differently in response to a tax change depending on the product market characteristics of the industry in which they operate. We define an industry at the three-digit SIC level. We follow the difference-in-differences approach in Heider and Ljungqvist (2015) that exploits staggered changes in U.S. state corporate income taxes. The dependent variable is the change in a firm’s long-term book leverage, and Tax Increase (Tax Cut) is a dummy variable that equals one if there was a tax increase (cut) in state of the firm’s headquarters in that year. All variables, except product market variables, are in first differences. Column (1) shows the results without the product market variables, whereas the remaining columns show the results for specifications that include the product market variables and their interaction with the tax increase and tax cut indicators. Columns (2)-(4) include industry, industry and state, and industry-year fixed effects, respectively. Standard errors, reported in parentheses, are adjusted for within-firm clustering. Significance at the 10%, 5%, and 1% level is indicated by *, **, and *** respectively.

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<th>(2)</th>
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<td>Tax Increase</td>
<td>0.024**</td>
<td>0.111**</td>
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<td>(0.046)</td>
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<td>(0.028)</td>
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<td>Tax Increase*IndOPLEV</td>
<td>0.028**</td>
<td>0.028**</td>
<td>0.029*</td>
<td>0.029*</td>
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<td>(0.013)</td>
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<td>-0.015**</td>
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<td>-0.017*</td>
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